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JAN 1985 90p

SYSTEM FAILURE

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ETI SPECIAL REPORT–WE LOOK AT THE BUGS IN CIVIL, MILITARY AND SPACE TECHNOLOGY

Distortion meter project

Sub-resonant active bass speaker to build

Introducing the new MC680P2 single-chip microcomputer

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TAKE COMPLETE CONTROL OF YOUR MUSIC with the MCS-1

professional quality MIDI-controlled sampling unit

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

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

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

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

Specification

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

Storage time at 32 KHz sampling rate: 2 seconds.

Storage time at 8 KHz sampling rate: 8 seconds.

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

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

Audio Bandwidth: Variable from 12 KHz to 300 Hz.

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

Programmable wide range sinewave sweep generator.

MIDI control range: 5 octaves.

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

Digital Delay Line

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

KIT £499 + VAT

BUILT £699 + VAT

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Portway Industrial Estate,
Andover, Hants SP10 3ET.
Telephone: 0264 64455

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JANUARY 1985 VOL 14 NO 1

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Jerry Fowler: Technical Illustrator
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Jim Connell: Chairman

PUBLISHED BY:
Argus Specialist Publications Ltd.,
1 Golden Square, London W1R 3AB.
DISTRIBUTED BY:
Argus Press Sales & Distribution Ltd.,
12-18 Paul Street, London EC2A 4JS
(British Isles)
PRINTED BY:
The Garden City Press Ltd.
COVERS DESIGNED BY:
MM Design & Print.
COVERS PRINTED BY:
Alabaster Passmore.

OVERSEAS EDITIONS and their EDITORS	
	AUSTRALIA — Roger Harrison
	CANADA — Halvor Moorshead
	GERMANY — Udo Wittig
	HOLLAND — Anton Kriegsman

ABC Member of the Audit Bureau of Circulation

☐ Subscription Rates. UK £15.00 including postage. For further details and Airmail rates etc, see the Readers' Services page.

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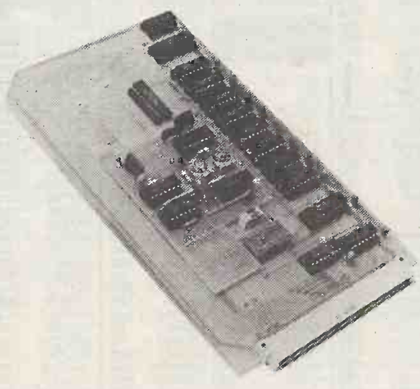
Telex 8811896.

FEATURES

The AEW Nimrod — failed it's trials.

PROJECTS



INFORMATION

WATFORD ELECTRONICS

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ELECTROLYTIC CAPACITORS: (Values in uF) 500v; 10uf **52**; 47 **78p**; 63V: 0.47, 1.0, 1.5, 2.2, 3.3, 4.7 **8p** 10 **10p**; 15, 22 **12p**; 33 **15p**; 47 **12p**; 68 **20p**; 100 **19p**; 220 **26p**; 1000 **70p**; 2200 **99p**; 50V: 68 **20p**; 100 **17p**; 220 **24p**; 40V: 22 **9p**; 33 **12p**; 330, 470 **32p**; 1000 **48p**; 2200 **90p**; 25V: 1.5, 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: 47, 68, 100 **9p**; 125 **12p**; 330 **16p**; 470 **20p**; 680 **34p**; 1000 **27p**; 1500 **31p**, 2200 **26p**; 4700 **72p**.

TAG-END CAPACITORS: 64V: 2200 **139p**; 3300 **198p**; 4700 **245p**; 50V: 2200 **110p**; 3300 **184p**; 40V: 4700 **180p**; 25V: 2200 **90p**; 3300 **98p**; 4000, 4700 **98p**; 10,000 **320p**; 15,000 **345p**; 16V: 22,000 **350p**.

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

POLYESTER RADIAL LEAD CAPACITORS: 250V
10n, 15n, 22n, 27n **6p**; 33n, 47n, 68n, 100n **8p**; 150n, 220n **10p**; 330n, 470n **15p**; 680n **19p**; 1u5 **40p**; 2u2 **48p**.

FEED-THROUGH CAPACITORS
1000pF/450V **10p**

SIEMENS pcb
Type Miniature poly Capacitors
250V
1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 10n, 15n **7p**
18n, 22n, 27n, 33n, 39n, 47n **8p**
39n, 56n **12p**
82n, 100n **11p**
100V
100n, 120n **10p**
150n, 180n **12p**
220n, 270n **15p**
330n, 390n **20p**
470n, 560n **26p**
680n **30p**
1uF **34p** 2u2 **50p**

TANTALUM BEAD CAPACITORS
35V: 0.1uF, 0.22, 0.33 **15p** 0.47, 0.68, 1.0, 1.5 **16p**; 2.2, 3.3 **18p**; 4.7, 6.8 **22p** 10 **28p**; **16V:** 2.2, 3.3 **16p**; 4.7, 6.8, 10 **18p**; 15, **36p**; 22 **45p**; 33, 47 **50p**; 100 **95p**; **10V:** 15, 22, **26p**; 33, 47 **50p**; 100 **80p**; **6V:** 100 **55p**.

POTENTIOMETERS: Carbon Track, Rotary 0.25W Log & LIN Values, 470R; 1K & 2K (Linear only)

Single Gang		**35p**
5K — 2M	Single Gang Log & Lin	**35p**
5K — 2M	Single Gang DP Switch	**95p**
5K — 2M	Double Gang	**99p**

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

SLIDER POTENTIOMETERS
0.25W log and linear values 60mm
5K — 500K single gang **80p**
Graduated Bezels for above **45p**

CERAMIC CAPACITORS 50V:
Range: 0.5pF to 10nF **4p.** 15nF, 22nF 33nF; 47nF **5p.** 100nF/300V **7p.** 200nF/6V **8p.**

PRESET POTENTIOMETERS
0.1W Miniature Vertical or Horizontal, 100R to 4M7 **8p**
0.25W Larger 100R to 3M3 Horz **12p**
0.25W Larger 200R to 4M7 Vertical **12p**

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

SILVER MICA (Values in pF)
2, 3.3, 4.7, 6.8, 8.2. 10, 12, 15, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180pF **15p each**
200, 220, 250, 270, 300, 330, 360, 390, 470, 800, 800, 820 **21p each**
100, 1200, 1800, 2200 **30p each**
3300, 4700pF **80p**

MINIATURE TRIMMERS Capacitors
2-6pF 2-10pF **22p;** 2-25pF; 5-65pF **30p;** 10-88pF **36p.**

Hitachi 256K DRAM £49

2764 250ns £4.70

27128 250ns £16

RESISTORS Carbon Film, miniature, Hi-Stab, 5%.

	RANGE	Val	1-99	100 +
0.25W	2Ω2 — 10M	E24	3p	1p
0.5W	2Ω2 — 4M7	E12	3p	1p
1W	2Ω2 — 10M	E12	6p	4p
2% Metal Film	51Ω — 1M	E24	6p	4p
1% Metal Film	51Ω — 1M	E24	5p	4p

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

RESISTORS NETWORK S.I.L.
7 Commoned: (8 pins) 100Ω, 680Ω, 1K 2k2, 4K7, 10K, 47K, 100K **25p**
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K & 100K **26p.**

DIODES

AA119	15
AA129	20
AAY30	15
BA100	15
BAX	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	60

VARICAPS

BA102	50
BB105B	40
BB106	40
BB109B	45
MVAM2	105

BRIDGE RECTIFIERS

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	66
6A/100V	83
6A/400V	96
10A/200V	215
10A/600V	296
25A/200V	240
25A/600V	396
BY164	56
VM18 DIL	50

ZENERS

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

TRIACS

3A200V	54
3A400V	56
8A100V	60
8A400V	69
8A800V	115
12A100V	78
12A400V	82
12A800V	136
16A100V	103
16A400V	106
16A800V	220
25V500V	220
25A800V	296
T2800	125

75 SERIES

75107/8	96
75110	90
75114/5	150
75121/2	130
75150	125
75154	125
75158	150
75159	195
75160	420
75162	650
75182/4	99
75188/9	100
75322	140
75324	360
75325	00
75361/3	150
75365	00
75450	86
75451/2	52
75454	70
75491/2	65

SCR THYRISTORS

5A/40V	32
5A400V	40
5A600V	48
8A300V	60
8A600V	90
12A100V	78
12A400V	96
12A800V	188
BT106	150
BT116	180
C106D	36
TIC44	24
TIC45	29
TIC47	36
2N5062	32
2N5064	38
2N4444	130

DIAC

ST2	25

COMPUTER ICs

2102L	160	81LS97	175	SFF9364	800
2114	325	81LS98	175	SP0256	850
2147	395	8202	£25	SPO256AL2	475
2516	350	8205	225	TCJ3101J	£13
2532	400	8212	495	TMS2716-3V	725
25L32	450	8214	495	TMS4047	100
2564	700	8216	200	TMS4164	395
26501	75	8224	350	TMS4416-2	595
2716-5V	350	8226	350	TMS4500	£12
2732-4	450	8228	270	TMS4500	£14
2764-250	475	8236	00	TMS4532-3	350
27C64	1095	8243	550	TMS5100	600
27128-250	£16	8250	£11	TMS6011	500
"NEW" 256K "D" RAM 150NS	£49	8251A	795	TMS9914	895
3242	675	8253	1750	TMS9927	£14
4027	95	8255	650	TMS9928	£20
4116-200n	125	8256AC	£15	TMS9929	£20
4164-150n	425	8257-5	700	TMS9980	£20
4416-2	475	8259	700	TMS8995	£12
4532-3	250	8271	POA	ULN2003	75
4532-4	250	8272	£25	UPD7002	725
4816-100ns	250	8279	750	WD1691	£14
4864-15	425	8282	450	WD1770	£20
5514	250	8283	450	WD2143	850
6116-150	400	8284	550	Z80CPU 2.5	300
6116L-120	425	8288	£11	Z80ACPU 4M	375
6117-100n	575	8748	£55	Z80 CTC	285
6167-6	795	8T26A	99	Z8002CPU	00
6264L-15	£26	8T27	150	Z80A CTC	335
63A03	£14	8T31	350	Z80BCPU	£11
6402	350	8T95	90	Z80 DART	698
6502CPU	355	8T97N	90	Z80A DART	820
6502A	545	9602	220	Z80B	£11
6503	350	AM26LS31C	125	Z80 DMA	795
6503	650	AM26LS32A	125	Z80ADMA	925
6504	600	AM26LS33	150	Z80 PIO	325
6504 250	550	AM7910	£30	Z80A PIO	350
6505	650	AY-3-1015	300	Z80 SIO-1	850
6505	600	AY-5-1013	300	Z80A SIO	£9
6520PIA	175	CD4724	150	Z80ASIO-2	£9
6522VIA	340	COM8017	275		
6530	£11	COM8116	700		
6532RRIOT	650	D8748	£55		
6545RTC	899	DM8131	275		
6551ACIA	650	DP8303	450		
6592	00	DP8304	350		
6592PC	£20	DS3647	00		
6800	220	DS3691N	595		
6802	275	DS88LS120	495		
6803	850	DS8820	110		
6805	670	DS8830	198		
6808	520	DS8831	125		
6809	650	DS8832	250		
6810	175	E9364	800		
6821	175	E9365	£36		
68B21	220	FD1691	£15		
6840	375	FD1771	£15		
6843	800	FD1791	£22		
6845	650	FD1795	£28		
6845SP	750	HD26501	75		
6847	650	HD63AO3RP	£14		
6850	175	HM6845SP	755		
6852	250	IM6402	380		
6854	750	INS8060N	1250		
68B54	800	MC1488	100		
6859	£4	MC1489	100		
6875	500	MC14411	675		
68000	£30	MC14412	725		
8035	525	MC3242	590		
8080A	425	MC3446	250		
8085	£15	MC3447P	315		
8085A	950	MC3486	225		
8088	£15	MC3487	225		
8123	160	IM6402	350		
8131	475	MC6845	625		
8154	750	MC6846	625		
8155	750	MK3886-2M	£7		
8156	650	MM5260D	696		
81LS95	175	MM5303	636		
81LS96	175	MM5307	1275		
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		MM58174	875		
		MM74C922	420		
		RO-3-2513L	700		
		RO-3-2513U	650		
		SAA5050	875		

LINEAR ICs

555Cmos	95	CA3085	160	MC1303	96	TDA2004	300
702	75	CA3086	60	MC1304P	260	TDA2006	330
709C 8 pin	35	CA3089E	200	MC1310P	150	TDA2020	320
710	48	CA3090AQ	375	MC1445	250	TDA2030	190
741 8 pin	16	CA3123E	165	MC145106	695	TDB0791	420
747C 14 pin	70	CA3130	90	MC1455	50	TL170	50
748C 8 pin	30	CA3140	50	MC1458	35	TL430C	90
735 8 pin	185	CA3160	95	MC1469	300	TL507	110
810	158	CA3161	199	MC1494	694	TL509	110
9400CJ	375	CA3162	525	MC1495	350	TL061CP	40
ADC0808	885	CA3189	275	MC1496L	70	TL062CP	65
AY-1-1320	225	HA1336W	175	MC1596	225	TL064CN	98
AY-1-5050	99	HA1388	235	MC1648	290	TLO71CP	40
AY-1-5051	160	ICL7106	690	MC1709G	90	TLO72CP	76
AY-1-6720	210	ICL7107	975	MC3302	75	TL074CN	150
AY-3-1270	730	ICL7611	99	MC3401	50	TL081CP	35
AY-3-1350	350	ICL7660	248	MC3403	95	TL082CP	60
AY-3-8910	390	ICL8038CC	360	MC3404	85	TL083CP	75
Booklet for AY-3-8910	390	ICL8211A	750	MC3405	150	TL084CN	120
AY-3-8912	500	ICM7205A	1150	MC3422	00	TL091CP	60
AY-5-1317A	630	ICM7207	475	MC3423	80	UA2240	120
AY-5-1350	366	ICM7215	1050	MC3442	00	UA78540	230
CA3011	130	ICM7216AJ	£22	MC3487	00	ULN2003	90
CA3012	175	ICM7216C	£22	MC4016	00	ULN2004	90
CA3014	275	ICM7217A	750	MF10	350	ULN2283	100
CA3018	85	ICM7224	£11	MFC6040	75	ULN2803	190
CA3019	90	ICM7240	300	ML924	275	UPC575	275
CA3020	210	ICM7555	105	NE515	275	UPC1025H	375
CA3023	210	ICM7556	150	NE529	225	UPC1156H	295
CA3028A	130	LA3550	250	NE531	140	UPC1182	425
CA3035	255	LA4031P	340	NE543K	225	UPC1366	195
CA3036	270	LA4032	295	NE544	200	XR2206	375
CA3043	275	LA4400	350	NE555	25	XR2207	400
CA3045	385	LA4422	320	NE556	65	XR2211	575
CA3046	70	LC7130	320	NE558	170	XR2216	675
CA3048	220	LC7120	300	NE560	350	XR2266	360
CA3059	325	LC7137	350	NE562B	410	ZN414	80
CA3075	213	LF347	150	NE564	420	ZN419E	180
CA3080E	75	LF351	70	NE565A	120	ZN423E	130
CA3081	180	LF353	90	NE566	155	ZN424E	130
		LF355	90	NE567V	140	ZN425E	595
		LF356	90	NE570	410	ZN426E	200
		LF357	100	NE571	400	ZN427E	620
		LF398	495	NE5632	175	ZN428E	450
		LM10	325	NE5534A	160	ZN429E	245
		LM301A	30	OM335	750	ZN459	615
		LM307	45	RC4136D	60	ZN1034E	200
		LM308T	75	RC4558	60	ZN1040E	695
		LM311	60	S566B	225	ZNA234E	925
		LM318N	150	SAB3209	425		
		LM319	180	SAB3210	325		
		LM324A	45	SAB3271	485		
		LM334Z	115	SAB4209	585		
		LM335Z	135	SG3402	295		
		LM337	275	SL490	350		
		LM339	40	SL6270CD	150		
		LM348	60	SN76013	350		
		LM349	125	SN76227N	95		
		LM358	50	SN76477	470		
		LM377	210	SN76488	525		
		LM379	495	SP8629	350		
		LM380	120	SP0256AL	475		
		LM381N	175	TA7120	140		
		LM382	200	TA7204	150		
		LM384	225	TA7205	90		
		LM386	110	TA7222	150		
		LM387	200	TA7310	125		
		LM389	160	TAA621AX1	296		
		LM393	85	TAA661A	190		
		LM394CH	385	TAA700	275		
		LM558	170	TAA900	395		
		LM725CN	300	TAB1042	110		
		LM733	65	TAD100	159		
		LM1458	35	TBA120S	70		
		LM1871	300	TBA900	395		
		LM1889	350	TAB1042	110		
		LM2907	395	TAD100	159		
		LM2917	325	TBA120S	70		
		LM3900	70	TBA920Q	200		
		LM3909N	85	TBA990Q	350		
		LM3911	185	TCA220	350		
		LM3914	300	TCA270Q	350		
		LM3915	300	TCA280A	220		
		LM3916	300	TCA940	175		
		LM13600	150	TCA965	180		
		LS7220	260	TDA1004	350		
		M706B1	150	TDA1008	310		
		MS1513L	230	TDA1010	235		
		MS1515L	320	TDA1022	499		
		MS1516L	475	TDA1024	115		
		MB3712	200	TDA1034	350		
		MB3756	440	TDA1490	350		
		MC1204	250	TDA2002	325		
		MC1301	90	TDA2003	250		

TRANSISTORS

AC126/7	35	BC327	15	BF336/7	35	MPSU06	60	ZTX107/8	12	2N3820	60	2SC2335	200
AC141/2	35	BC337/8	15	BF394	40	MPSU52	65	ZTX109	12	2N3822/3	60	2SC2547	40
AC176	35	BC441/61	34	BF451	40	MPSU55	60	ZTX212	28	2N3866	90	2SC2612	200
AC187	35	BC477	40	BF494/5	40	MPSU56	60	ZTX300	13	2N3903/4	18	2SD234	74
AC188	35	BC516/7	40	BF594/5	30	OC26	170	ZTX302	16	2N3905/6	15	2SK45	80
ACY19/21	75	BC547/8	12	BFR39/40	30	OC28	220	ZTX303	25	2N3906	17	2SK28B	225
ACY22/41	75	BC549C	15	BFR41/79	25	OC35	50	ZTX304	17	2N4037	60	2SJ83	225
AD142	120	BC556/7	15	BFR80/81	25	OC36/41	75	ZTX326	30	2N4058	15	2SJ85	225
AD149	79	BC558/9	15	BFR98	105	OC42/75	75	ZTX451	23	2N4061/2	15	3N128	115
AD161	42	BCY39/40	85	BFX29	35	OC71/72	50	ZTX500	14	2N4264	30	3N140	115
AD162	42	BCY41/42	30	BFX81	45	OC75/76	55	ZTX501/2	15	2N4286	25	40315	90
AF115/6	80	BCY45	50	BFX84	35	OC81/82	50	ZTX503	18	2N4289	25	40316	95
AF188	80	BCY58/59	36	BFX85/6	35	OC83/84	70	ZTX504	25	2N4314	78	40324	100
AF124/26	70	BCY70/71	18	BFY50/51	30	OC170/71	75	ZTX531	125	2N4400	25	40326/7	70
AF139	40	1BCY72	25	BFY52	30	OC70	40	ZTX550	25	2N4427	80	40347	90
AF178	75	BCY78	30	BFY53	35	OC200	75	2N697	23	2N4871	55	40348	120
AF186	70	BD114	190	BFY55/56	56	TIP29A	32	2N699	40	2N5135/6	30	40360	60
AF239	55	BD121	95	BFY64	40	TIP29C	38	2N706A	25	2N5138	25	40361/2	70
BC107	12	BD124	115	BFY81	120	TIP30A	35	2N708	25	2N5172	25	40407/8	75
BC107B	14	BD131/32	65	BFY90	80	TIP30C	37	2N918	40	2N5179	45	40411	285
BC108	12	BD133	70	BRY39	50	TIP31A	38	2N1131/2	40	2N5180	45	40412	90
BC108B	14	BD135	45	BSX20	30	TIP31B	39	2N1302	45	2N5190/1	75	40467A	130
BC108C	14	BD136/37	40	BSX26/29	45	TIP31C	45	2N1307	70	2N5194	80	40468	85
BC109	12	BD138/39	40	BSY26	35	TIP32A	43	2N1671B	160	2N5305/8	30	40594	105
BC109B	14	BD140	40	BSY95	35	TIP32C	45	2N2180	325	2N5457/8	30	40603	110
BC109C	14	BD144/45	198	BU105	180	TIP33A	70	2N2219A	28	2N5459	30	40673	75
BC114/5	30	BD158	68	BU205	180	TIP33C	75	2N2220A	28	2N5485	36	40871/2	90
BC117/8	25	BD205/6	110	BU206	200	TIP34A	85	2N2221A	25	2N5777	45		
BC137/9	40	BD245	65	BU208	200	TIP34C	105	2N2222A	25	2N5879	180		
BC140	38	BD378	70	BUY69C	225	TIP35A	120	2N2368	25	2N6027	32		
BC142/3	38	BD434	70	MD8001	250	TIP35C	130	2N2369A	18	2SA671	250		
BC147	.12	BD517	75	MJ2955	90	TIP36A	130	2N2483/4	27	2SA715	75		
BC147B	15	BD645	80	MJE170	150	TIP36C	140	2N2646	46	2SC495	85		
BC148	12	BD695A	150	MJE180	150	TIP41A	50	2N2904/5	28	2SC496	85		
BC148B	15	BD696A	150	MJE340	54	TIP41B	52	2N2906/7	28	2SC1081	250		
BC149	12	BF115	45	MJE370	100	TIP42A	55	2N2907A	28	2SC1096	85		
BC149C	15	BF154/8	30	MJE371	100	TIP42B	58	2N2926G	10	2SC1162	45		
BC182L	10	BF167	35	MJE520	85	TIP120	70	2N3053	25	2SC1173	125		
BC183L	10	BF173	35	MJE521	96	TIP121/2	73	2N3054	55	2SC1306	100		
BC184	10	BF177	35	MJE2955	98	TIP141/2	120	2N3055	50	2SC1307	160		
BC184L	10	BF178	35	MJE3055	70	TIP147	120	2N3252	46	2SC1449	95		
BC186/7	28	BF179	40	MPF102	40	TIP2955	70	2N3441/2	140	2SC1678	140		
BC188 6/7	25	BF184/5	38	MPF103	30	TIP3055	70	2N3614/5	180	2SC1679	180		
BC12	10	BF194/5	12	MPF104	30	TIS43	50	2N3663	20	2SC1923	65		
BC212L	12	BF196/9	18	MPF105	30	TIS44/5	45	2N3702/3	10	2SC1945	225		
BC213	10	BF200	80	MPF106	40	TIS88A	50	2N3704/5	10	2SC1963	80		
BC213L	12	BF224A	40	MPSA05	30	TIS90/91	30	2N3706/7	10	2SC1957	80		
BC214	10	BF224B	40	MPSA08	30	UC	65	2N3708/9	10	2SC1969	160		
BC214L	12	BF245	50	MPSA12	32	VK1010	99	2N3713	140	2SC2028	85		
BC237/8	15	BF256A	45	MPSA55	30	VN10KM	70	2N3771	179	2SC2029	200		
BC256B	35	BF256B	50	MPSA56	30	VN46AF	95	2N3772	195	2SC2078	170		
307B	15	BF257/8	32	MPSA70	40	VN66AF	110	2N3773	210	2SC2091	85		
BC308	16	BF259	40	MPSU02	58	VN88AF	120	2N3819	35	2SC2314	86		
BC318	80	BF275	55	MPSU05	60	VN89AF	120			2SC2166	105		

RF CHOKES Miniature PCB type

1uH, 2u2, 4u7, 10u, 22u, 33u, 47u, 100u, 220u, 330u, 470u **30p**
1mH, 1m5, 2m2, 4m7, 10mH **35p**
22m, 33m, 43m **60p**
100m **75p**

TTL74

7400	25	7473	50	74297	175
7401	25	7474	45	74298	160
7402	25	7475	55	74351	180
7403	25	7476	45	74365	70
7404	30	7480	60	74366	70
7405	30	7481	175	74367	70
7406	40	7482	100	74368	70
7407	40	7483	100	74376	120
7408	25	7484	105	74390	100
7409	25	7485	100	74393	100
7410	25	7486	40	74426	60
7411	25	7489	200	74490	100
7412	25	7490	60		
7413	25	7491	70		
7414	60	7492	70		
7416	35	7493	50		
7417	35	7494	100		
7420	25	7495	60		
7421	50	7496	75		
7422	40	7497	200		
7423	35	74100	175		
7425	35	74104	70		
7426	40	74105	70		
7427	35	74107	45		
7428	35	74109	70		
7430	25	74110	55		
7432	30	74111	55		
7433	30	74112	170		
7437	30	74116	160		
7438	40	74118	110		
7440	30	74119	160		
7441	90	74120	90		
7442	65	74121	45		
7443	150	74122	65		
7444	100	74123	75		
7445	110	74125	60		
7446	110	74126	60		
7447	95	74128	55		
7448	110	74132	70		
7450	30	74136	50		
7451	30	74141	85		
7453	30	74142	235		
7454	30	74143	250		
7460	30	74144	250		
7470	50	74145	100		
7472	50	74147	160		
		74148	130		
		74150	170		
		74151	60		
		74153	70		
		74154	130		
		74155	75		
		74156	90		
		74157	75		
		74159	170		
		74160	100		
		74161	100		
		74162	100		
		74163	100		
		74164	110		
		74165	100		
		74166	130		
		74167	250		
		74170	190		
		74172	400		
		74173	130		
		74174	100		
		74175	100		
		74176	100		
		74177	110		
		74178	130		
		74179	130		
		74180	100		
		74181	300		
		74182	120		
		74184	170		
		74185	170		
		74190	120		
		74191	120		
		74192	120		
		74193	120		
		74194	100		
		74195	75		
		74196	120		
		74197	100		
		74198	200		
		74199	200		
		74221	200		
		74246	130		
		74247	120		
		74248	145		
		74249	175		
		74251	90		
		74259	150		
		74263	75		
		74265	60		
		74273	180		
		74276	130		
		74278	160		
		74279	80		
		74283	100		
		74284	440		
		74285	300		
		74286	80		
		74290	120		
		74293	80		

74C

74C244	150
74C245	150
74C373	180
74C374	425
74C922	625
74C923	645
74C925	650

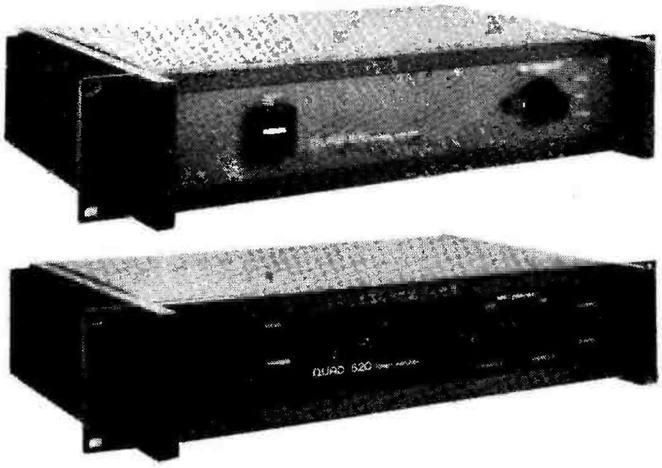
74S

S00	49	S74	70	S197	300
S02	40	S85	295	S201	250
S03	40	S86	100	S225	500
S04	40	S112	00	S226	350
S05	40	S113	00	S240	375
S08	40	S114	00	S241	375
S09	40	S124	300	S244	474
S10	40	S132	90	S251	225
S11	40	S133	50	S257	225
S15	60	S134	60	S258	225
S20	40	S135	110	S260	70
S22	40	S138	170	S262	£10
S30	60	S139	170	S287	200
S32	50	S140	60	S288	180
S37	50	S151	140	S289	200
S38	70	S153	140	S301	350
S40	40	S157	200	S365	250
S51	40	S158	190	S373	375
S64	40	S162	300	S374	375
S65	40	S163	300	S412	380
		S174	250	S470	325
		S175	300	S471	600
		S188	200	S472	400
		S189	225	S474	400
		S194	280	S475	425
				S571	300
				S573	450

74LS

LS00	25	LS75	45	LS195	75	LS356	200
LS01	25	LS76	40	LS196	85	LS363	150
LS02	25	LS78	40	LS197	85	LS264	150
LS03	25	LS83	70	LS221	85	LS365	50
LS04	25	LS85	80	LS240	95	LS366	50
LS05	25	LS86	35	LS241	95	LS367	50
LS08	25	LS90	50	LS242	95	LS368	50
LS09	25	LS91	90	LS243	95	LS373	100
LS10	25	LS92	55	LS244	95	LS374	100
LS11	25	LS93	50	LS245	160	LS375	70
LS12	25	LS95	70	LS247	105	LS377	130
LS13	35	LS96	90	LS248	105	LS378	110
LS14	55	LS107	45	LS249	105	LS379	130
LS15	25	LS109	45	LS251	75	LS380	310
LS19	45	LS112	45	LS253	75	LS382	310
LS20	25	LS113	40	LS256	175	LS384	460
LS21	25	LS114	40	LS257	75	LS385	330
LS22	25	LS122	70	LS258	75	LS386	50
LS24	55	LS123	100	LS259	125	LS390	80
LS26	25	LS124	125	LS260	70	LS393	100
LS27	25	LS125	50	LS261	100	LS395	110
LS28	25	LS126	50	LS266	60	LS396	300
LS30	25	LS132	60	LS273	120	LS398	195
LS32	50	LS133	50	LS275	350	LS399	135
LS33	25	LS135	28	LS279	70	LS445	125
LS37	25	LS136	50	LS280	185	LS447	80
LS38	30	LS138	60	LS283	80	LS465	140
LS40	25	LS139	60	LS290	80	LS490	150
LS42	55	LS145	115	LS292	850	LS540	140
LS47	90	LS147	165	LS293	80	LS541	140
LS48	90	LS148	130	LS294	999	LS624	155
LS49	100	LS151	70	LS295	140	LS629	130
LS51	30	LS153	70	LS297	850	LS640	200
LS52	25	LS154	200	LS298	100	LS641	150
LS54	30	LS155	70	LS299	225	LS645	195
LS55	30	LS156	70	LS320	210	LS668	90
LS63	55	LS157	60	LS322	360	LS669	90
LS73	30	LS158	60	LS323	360	LS670	170
LS74	35	LS160	70	LS324	150	LS673	890
		LS161	70	LS325	150	LS674	800
		LS162	70	LS326	290	LS678	275
		LS163	70	LS327	290	LS682	250
		LS164	80	LS347	120	LS684	350
		LS165	110	LS348	140	LS687	350
		LS166	150	LS352	110		
		LS168	140	LS353	110		
		LS169	125	LS355	220		
		LS170	160				
		LS173	100				
		LS174	100				
		LS175	70				
		LS181	190				
		LS183	190				
		LS190	85				
		LS191	85				
		LS192	85				
		LS193	85				
		LS194	75				

DIGEST



Professional Quads

Quad have produced a number of domestic hi-fi amplifier designs over the years, many of which have found their way into recording studios, theatres and other professional environments, but they have never produced an amplifier intended specifically for professional applications. Now, perhaps having noted the success of other companies who market Quad amplifiers in 19" rack format, Quad have introduced two rack-mounting amplifiers of their own, one single channel and one dual channel and both featuring XLR connectors for input and output.

The Quad 510 is a single channel power amplifier which can deliver at least 100 watts into any load from two to 100 ohms. A multiple-tapped output transformer allows it to match a range of loads including 70 and 100 volt lines and a plug-in card on the rear panel selects the appropriate taps. The input is 600 ohm bridging and both input and output are isolated so that amplifiers can be linked together to provide greater power outputs.

The 520 is a dual channel power amplifier which offers an output of 100 watts per channel into eight ohms and is available with optional balanced inputs. Both amplifiers use a refinement of the current-dumping concept which was used in the Quad 405 amplifier and for which the company received a Queen's Award for Technological Innovation. No specifications are quoted but the performance is said to meet the demands of the most critical listener and construction and reliability are said to be up to Quad's usual standards.

Quad Electroacoustics Ltd, St. Peters Road, Huntingdon, Cambridge PE18 7DB, tel 0480-52561.

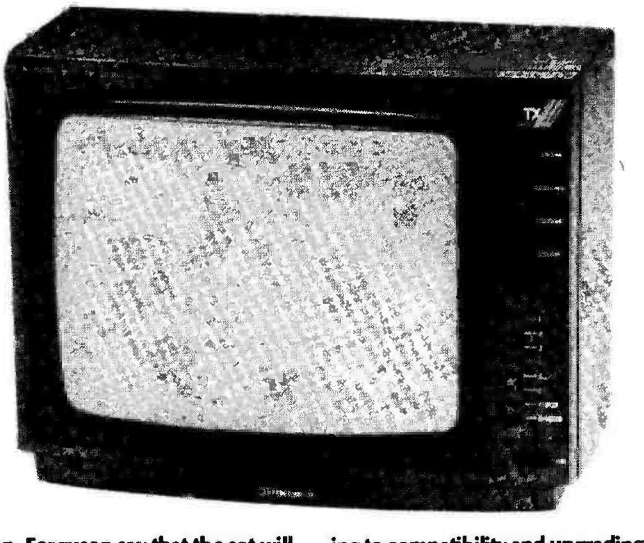
Ferguson Monitors Developments

In what they see as a response to the demands of the technological revolution, Ferguson have introduced a 14" colour television set which has RGB and composite video inputs as well as the usual UHF aerial input. The new set is said to be designed with home computers, video games and video recorders in mind and its features include the ability to operate from a 12 or 24V DC supply.

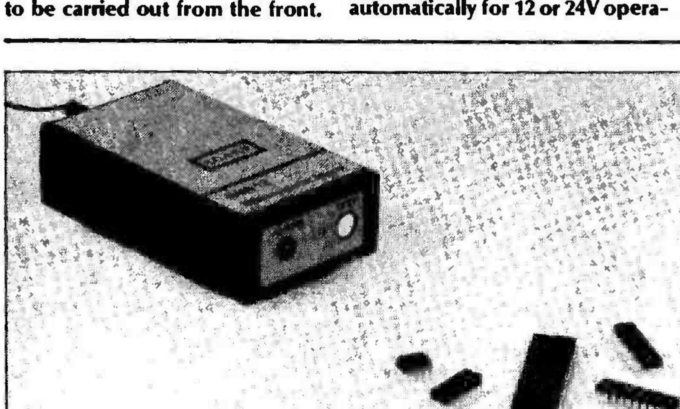
The MCO1 14" TX monitor colour television is based on Ferguson's existing TX90 chassis which is mains-isolated and features a fast warm-up CRT. Eight light-action switches select the TV channel or the RGB or composite video input, allowing the connectors to be left permanently in place at the rear of set and all switching to be carried out from the front. The tuning presets associated with the channel selectors are concealed behind a hinged panel at the front of the set. A 3.5 mm output socket allows the MC01 to be used with headphones and a fold-away aerial is also built-in.

The RGB input features automatic sync polarity sensing and accepts TTL and analogue input signals. The composite video input has an adjustable pre-set gain control to ensure optimum performance over a range of input signal levels and both inputs accept a sound signal for reproduction through the set loudspeaker. Special leads will be available to connect the MC01 to most popular makes of home computer and there will also be a range of leads for use with Ferguson Videostar video recorders.

The MC01 is described as compact and lightweight and is said to offer low energy consumption. An optional adaptor allows the set to run from battery or other low-voltage DC supplies and adjusts automatically for 12 or 24V operation. Ferguson say that the set will typically run for about eight hours from a fully-charged standard (40A/h) car battery.



The company have also established an advisory service which they say is designed to help dealers and customers with queries relating to compatibility and upgrading on home computers. The service can be contacted on 01-807 3060. Thorn EMI Ferguson Ltd, Cambridge House, Great Cambridge Road, Enfield, Middlsex EN1 1UL, tel 01-363 5353.



Static Alarm

Dage Eurosem have introduced a bench-top alarm unit which detects the presence of high voltage levels and gives an audible and visual warning. The alarm is intended for use wherever CMOS and other static-sensitive devices are being handled and requires no physical or electrical connection to the device or the operator.

The EVA-12 triggers when in the presence of voltages above 400V and will typically detect a hazard of 4 - 13kV (equivalent to a person walking across a vinyl floor) from a distance of between sixteen and thirty inches. The warning takes the form of an audible bleep and a flashing LED and continues for five seconds before the unit zeroes itself and returns to the alert mode. It measures 76 x 38 x 25mm (3 x 1.5 x 1") and runs from a 9V battery giving a typical operational life of six months.

For further information contact Dage (GB) Ltd, Eurosem Division, Rabans Lane, Aylesbury, Buckinghamshire HP19 3RG, tel 0296-33200.

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Hook-up 7/.2
11 Colours **3p**
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per 4oz reel
SWG 16 **80p**
SWG 18 **85p**
SWG 20 **95p**
SWG 22 **95p**
SWG 24 **95p**
EN COPPER
per 2oz Reel
SWG 14 **70p**
SWG 16 **80p**
SWG 18 **90p**
SWG 20 **90p**
SWG 22 **90p**
SWG 24 **105p**
SWG 26 **105p**
SWG 28 **105p**
SWG 30 **110p**
SWG 32 **110p**
SWG 34 **115p**
SWG 36 **125p**
SWG 38 **125p**
SWG 40 **150p**
FIGURE 8
Per metre
7/.25 **13p**
Coloured Ribbon
Per Foot
10 Way **20p**
20 Way **40p**
34 Way **80p**
MAINS
Per Metre
2 Core
Oval 3A **20p**
Round 6A **45p**
3 Core
Round 3A **35p**
Round 6A **50p**
Round 13A **60p**
POWER
1mm T&E **40p**
1.5mm T&E **45p**
2.5mm T&E **60p**
6mm T&E **150p**
TV Coax **40p**
SCREENED
Single Round **17p**
Twin Round **20p**
Figure 8 Min **20p**
Figure 8 Std **30p**
4 Core **70p**
SPIRAL WRAP
⅛" **15p**
¼" **20p**
½" **45p**

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CAPACITORS
PLATE CERAMIC
1.8pF-22nF **6p**
DISC
10pF **10p**
47pF **15p**
100pF **15p**
470pF **15p**
1000pF **11p**
2200pF **11p**
.01uF **5p**
.022uF **5p**
.047uF **8p**
.1uF **8p**
.47uF **15p**
POLYSTYRENE
22pF **13p**
47pF **8p**
68pF **8p**
100pF **8p**
150pF **8p**
220pF **8p**
330pF **8p**
470pF **8p**
560pF **8p**
680pF **8p**
1000pF **8p**
1500pF **8p**
2200pF **8p**
3300pF **8p**
4700pF **8p**
5600pF **10p**
6800pF **10p**
.01uF **14p**
.022uF **19p**
.047uF **25p**
.1uF **49p**
POLYESTER
.01uF **8p**
.015uF **8p**
.022uF **8p**
.033uF **9p**
.047uF **9p**
.068uF **9p**
.1uF **9p**
.15uF **15p**
.22uF **11p**
.33uF **16p**
.47uF **16p**
.68uF **26p**
1uF **28p**
2.2uF **49p**
ELECTROLYTIC
uF/V
1/63 **8p**
2.2/50 **9p**
4.7/63 **9p**
10/16 **8p**
10/25 **8p**
10/35 **10p**
10/63 **13p**
22/10 **8p**
22/16 **10p**
22/25 **10p**
22/35 **11p**
22/63 **15p**
47/10 **10p**
47/16 **11p**
47/25 **13p**
47/35 **15p**
47/63 **24p**
100/10 **11p**
100/16 **13p**
100/25 **15p**
100/35 **19p**
100/63 **25p**
220/16 **15p**
220/25 **20p**
220/35 **23p**
220/63 **33p**
470/16 **23p**
470/25 **27p**
470/35 **31p**
470/63 **46p**
1000/10 **24p**
1000/16 **29p**
1000/25 **41p**
1000/35 **45p**
1000/63 **75p**
2200/10 **39p**
2200/16 **46p**
2200/25 **55p**
2200/35 **74p**
3300/25 **74p**
3300/35 **92p**
4700/10 **59p**
4700/16 **74p**
4700/25 **103p**
NON-POLARISED
1uF **25p**
2.2uF **25p**
3.3uF **25p**
4.7uF **25p**
6.8uF **50p**
10uF **25p**
22uF **35p**
33uF **40p**
47uF **40p**
100uF **70p**

THOUSANDS OF OTHER CAPACITORS IN STOCK I.E. SILVERED MICA, 1% POLYSTYRENE, POLYCARBONATE, MYLAR, TANTALUM TRIMMER, VARIABLE etc. etc.

CRYSTALS
100k **460p**
1M **600p**
2M **220p**
3.2768M **POA**
4M **180p**
4.19304M **320p**
4.433619M **320p**
6.144M **130p**
10M **200p**
18.432M **270p**
26.54M **200p**
26.59M **200p**
26.64M **200p**
26.69M **200p**
26.74M **200p**
26.8M **200p**
26.995M **200p**
27.045M **200p**
27.095M **200p**
27.145M **200p**
27.195M **200p**
27.245M **200p**
27.255M **200p**

CONNECTORS
Cros Clips **10p**
Terminal Post **40p**
1mm Plug **20p**
1mm Socket **15p**
2mm Plug **20p**
2mm Socket **15p**
3mm Plug **20p**
3mm Socket **15p**
4mm Plug **15p**
4mm Socket **15p**
Phono Plug **11p**
Phono Link Skt **20p**
Jack Plug 2.5mm **15p**
Jack Plug 3.5mm **15p**
Jack Skt 2.5mm **15p**
Jack Skt 3.5mm **15p**
Jack Skt Line 2.5mm **25p**
Jack Skt Line 3.5mm **25p**
Jack Plug ¼" Mono **20p**
Jack Plug ¼" Stereo **30p**
Jack Skt ¼" Mono **25p**
Jack Skt ¼" Stereo **35p**
Jack Skt Line Mono **25p**
Jack Skt Line Stereo **30p**
Coax Plug **15p**
Coax Skt Surf **30p**
Coax Skt Flush **25p**
Coax Line Skt **45p**
Coax Coupler **45p**
Car Aerial Plug **15p**
FM Aerial Plug **20p**
NC Plug **100p**
BNC Round Skt **100p**
BNC Square Skt **100p**
BNC Free Skt **110p**
BNC Str. Adapt **140p**
BNC T Adapt **300p**
VHF Plug PL259 **50p**
VHF Plug PL259 **50p**
Small Reducer **20p**
Large Reducer **20p**
PL259 Rt Ang **90p**
VHF Round Skt **50p**
VHF Square Skt **50p**
Elbow Adapt **POA**
Straight Adapt **60p**
UHF T Adapt **160p**
Female T Adapt **160p**
XLR Line Plug **180p**
XLR Chassis Skt **330p**
XLR Line Skt **230p**
XLR Chassis Plug **160p**
DIN Plugs 2 pin **10p**
3 pin **15p**
4 pin **35p**
5 pin A **15p**
5 pin 240° **20p**
5 pin 360° **30p**
6 pin **40p**
7 pin **20p**
8 pin **60p**
DIN Skts 2 pin **10p**
3 pin **20p**
4 pin **15p**
5 pin A **15p**
5 pin B **20p**
6 pin **20p**
7 pin **20p**
DIN Line Skt 2 pin **15p**
5 pin **30p**
D-Type Plug 9W **80p**
15W **150p**
25W **150p**
DType Rt Ang Skt 9W **POA**
15W **POA**
25W **POA**
Plug 9W **POA**
15W **POA**
25W **POA**
Covers 9 **120p**
15 **120p**
25 **130p**
Latches 9 **30p**
15 **50p**
25 **60p**
Power Plug 2.1mm **15p**
2.5mm **15p**
IEC Line Skt **95p**
IEC Chassis Plug **90p**
IEC Chassis Skt **90p**
IEC Line Plug **70p**
Bulgin P429 **50p**
P646 **165p**
P430 **125p**
P649 **135p**
P650 **110p**
P635 **100p**
P636 **130p**
P551 **300p**
P552 **100p**
SA2403 **160p**
SA2404 **95p**
SA2190 **50p**
SA1862 **50p**
SA2111 **200p**
SA2019A **150p**
SA2020 **140p**
SA2367 **180p**
SA2368 **95p**

MANY OTHER CONNECTORS, ADAPTORS & LEADS IN STOCK

OPTO
LED Std Red **10p**
Green **18p**
Yellow **15p**
LED Min Red **10p**
Green **18p**
Yellow **18p**
LED WP Std **3p**
Min **3p**

LARGE RANGE OF PANEL LAMPHOLDERS, DE LUXE LED'S, etc. etc.

FUSEWARE
20mm Panel Holder **45p**
1¼" Panel Holder **59p**
20mm Chassis Holder **14p**
1¼" Chassis Holder **17p**
Lin Holder **14p**
Fuse Clips **3p**
20mm FUSES
100mA, 150mA, 250mA, 500mA, 1A, 1.5A, 2A, 3A, 5A **9p**
20mm Antisurge Fuses
500mA, 1A, 2A **12p**
1¼" FUSES
100mA, 150mA, 250mA, 500mA, 1A, 2A, 3A, 5A, 10A, 13A, 15A **9p**
1" Fuses 2,3,5,13A **15p**

RESISTORS
¼W 5% E24 **2p**
.4W 1% E24 **7p**
1W 5% E12 **10p**
3W 5% E12 **10p**
3W WW R22-1R **30p**
3W WW 2R2+ **20p**
7W WW **30p**
10W WW **35p**
25W WW **170p**
WW Pots 3W
High Quality **275p**
10R, 25R, 50R, 100R, 250R, 500R, 1K, 5K, 10K, 50K

SEMICONDUCTORS
SO EXTENSIVE IS THE RANGE OF LISTED SEMICONDUCTORS PLEASE SEND LARGE S.A.E. FOR DETAILS.
TRANSISTOR MOUNTS
TO3 **10p**
TO66 **10p**
DIL SOCKETS
8 pin **9p**
14 pin **11p**
16 pin **12p**
18 pin **16p**
20 pin **17p**
22 pin **20p**
24 pin **21p**
28 pin **24p**
40 pin **35p**

RANGE OF HEAT SINKS AVAILABLE PHONE FOR QUOTATION

SPEAKERS
Miniature Buzzer
6V or 12V **90p**
Ultrasonic **600p**
Transducers **Pair**
Elliptical 5"x3" **198p**
6"x4" **262p**
7"x4" **314p**
7"x5" **338p**
8"x5"5W **386p**
8"x5"8W **521p**
9"x6" **431p**
Miniature 1" **90p**
1½" **90p**
1¾" **90p**
2" **90p**
2¼" **90p**
2½"8R **90p**
2½"64R **100p**
Round 5" 4W **174p**
5" 25W **409p**
5" 60W **1587p**
5¼" 10W **476p**
5½" 15W **771p**
6" 5W **297p**
6" 5W **297p**
6" 60W **1632p**
6½" 7W **423p**
8" 6W **359p**
8" 10W 423p
8" 20W **963p**
8" 60W **1346p**
10" 10W **700p**
10" 20W **1113p**
10' 30W **POA**
12" 60W **2862p**
12" 100W **4073p**
12" 150W **4336p**
15" 150W **7165p**
15" 200W **8735p**
18" 200W **£108**

MOTOROLA PIEZO TWEETERS
2" **231p**
3½" **697p**
2"x6" Horn **938p**
2"x5" **795p**
2½" **457p**
3¾" **624p**
4"x10" **1435p**
CROSSOVERS
2 Way 15W **188p**
2 Way 100W **690p**
3 Way 25W **193p**
3 Way 40W **338p**
3 Way 60W **502p**
4 Way 80W **626p**

SWITCHES
Toggle Std SPST **47p**
DPDT **62p**
Min SPST **88p**
SPDT **70p**
SPDT c/off **63p**
DPDT **85p**
DPDT c/off **117p**
4PDT **209p**
4PDT c/off **244p**
Push to make **20p**
Push to break **20p**
Key 5W SPST **259p**
Rotary IPI2W **62p**
2P6W **82p**
3P4W **62p**
4P3W **62p**
Slide Min DPDT **22p**
Std DPDT **22p**
DIP 4W **105p**
6W **128p**
8W **1158p**
10W **184p**
Microswitch **83p**

TRANSFORMERS
6-0-6 @ 100mA **167p**
6-0-6 @ 250mA **185p**
9-0-9 @ 100mA **167p**
9-0-9 @ 250mA **185p**
12-0-12 @ 50mA **155p**
12-0-12 @ 100mA **171p**
12-0-12 @ 250mA **188p**
0-12/0-12 @ 500mA **369p**
9-0-9 @ 1A **283p**
12-0-12 @ 1A **538p**
0-12-15-20-24-30 @ 1A **666p**
6-0-6 @ 2A **440p**
9-0-9 @ 2A **476p**
12-0-12 @ 2A **538p**
0-12/0-12 @ 2A **538p**
0-12-15-20-24-30 @ 2A **900p**
90-0-20 @ 2A **745p**
30-0-30 @ 2A **933p**
12-0-12 @ 3A **721p**
0-15 @ 3A **647p**
6-0-6 @ 4A **538p**
9-0-9 @ 4A **687P**
12-0-12 @ 4A **845p**
0-15 @ 6A **949p**
6-0-6 @ 8A **980p**
12-0-12 @ 8A **1615p**
TOROIDS:
30VA 6V **950p**
9V **950p**
12V **950p**
15V **950p**
18V **950p**
50VA 6V **1150p**
9V **1150p**
12V **1150p**
15V **1150p**
80VA 18V **1200p**
22V **1200p**
30V **1200p**
120VA 30V 1300p
160VA 35V **1500p**
300VA 35V **2000p**
500VA 35V **2650p**

ALL TOROIDS HAVE TWO ISOLATED SECONDARIES AT VOLTAGES SHOWN.

ORDERING INFORMATION:

P/P 50p on orders less than £20 in value otherwise post free. All components full spec & guaranteed. Discounts available on orders over £50 - phone for details. For unlisted components phone for price.

High Density 'D' Connectors

Souriau have introduced a range of sub-miniature 'D' type connectors which have a closer pin-spacing than existing sub-miniature types and offer correspondingly higher numbers of contacts. Plugs and sockets with up to 78 ways are available, and in spite of their small size the connectors offer a performance which is generally comparable with that of other sub-miniature 'D' connectors.

Designated the 8635 series, the new connectors come with either 15, 26, 44, 62 or 78 contacts and are rated at 1000 volts RMS, 5A per contact maximum. No overall current rating for a connector is specified. The contacts are size 22 crimp on 0.76mm (0.03") centres and the operating temperature range is from −55° to +150°C. The insulation material is a self-extinguishing thermosetting plastic manufactured to UL class 94 V-O and the shell is made from cadmium plated steel.

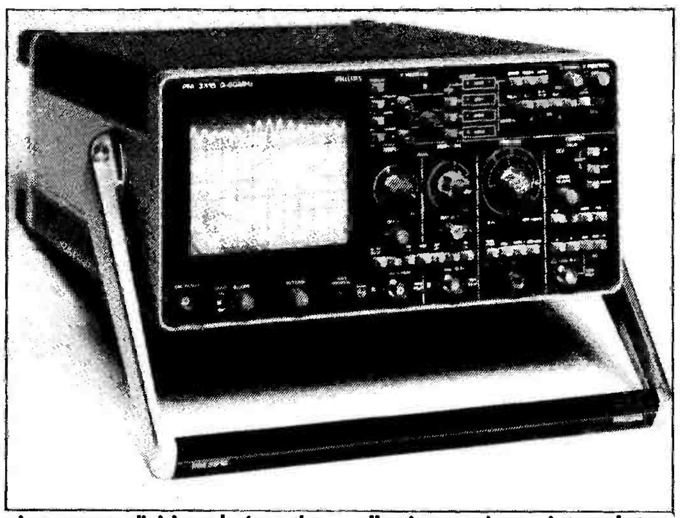
The connectors can be supplied in both rigid and float mounting versions and are also available with interfacial and back-end sealing gaskets. 8635 crimp connectors can also be ordered against equivalent MIL C-24308A (S*MA) series part numbers. For further information contact Souriau (UK) Ltd, Knaves Beech Industrial Estate, Loudwater, Nr High Wycombe, Buckinghamshire, tel 06285-24981.

Music For The Newbrain

Would the reader who sent us the above project please get in touch with the editorial office — we've lost your name and address!

●Japanese component manufacturer Alps is setting up a new plant which will create 230 jobs when it opens in Milton Keynes next year and up to 400 jobs when it reaches full production. The plant will produce parts for video recorders. In a separate statement, Cirkit have announced an increase in the range of Alps parts that they stock. The new lines will include microminiature Tactile switches, data entry switches, keytops and slide and rotary potentiometers. Cirkit Holdings PLC, Park Lane, Broxbourne, Hertfordshire EN10 7NQ, tel 0992-444111.

New Philips DSO

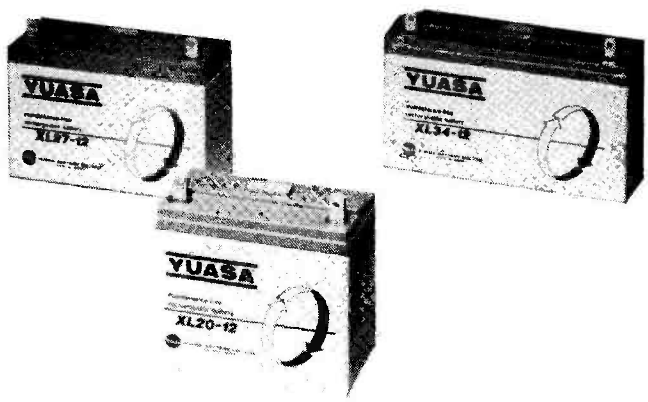


Philips have introduced a portable digital storage oscilloscope capable of sampling signals with a clock rate of up to 125 MHz. The dual-channel instrument has four memories, the contents of which can be displayed simultaneous or individually, and the user is able to program the trigger level control and all other trigger functions as well as all other switch functions.

The PM 3315's input circuitry enables analysis of repetitive signals to well over 60 MHz. Fast 125 MHz sampling allows single-shot capture up to 30 MHz with accurate reproduction. Even higher single-shot bandwidths are possible using computer data-analysis by means of the integral IEEE488/IEC625 bus interface. A digital delay facility makes possible optimal use of the available memory depth by triggering from nine screen divisions before the desired position to 9999 divisions after.

To meet the requirements of the fast growing world of TV applications, the PM 3315 also offers stable TV frame or field triggering. Other facilities include a plot-mode output for an X-Y recorder and a chart-recording mode allowing maximum internal storage of up to 40 hours. Control capability covers all front panel settings, including timebase and attenuator.

The PM 3315 costs £5195 plus VAT and is available from Philips Test and Measuring, Pye Unicam Ltd, York Street, Cambridge CB1 2PX, tel 0223 358866.



Long-Life Rechargeables

Yuasa have launched a range of lead-acid sealed rechargeable batteries which they claim have a life expectancy of ten years. The batteries have been designed with un-interruptible power supply applications firmly in mind and are said to be explosion proof and capable of retaining a high capacity under float-charge conditions.

The new range is designated the XL series and uses the same construction method as the existing NP range to make them completely leakproof. They are available in 6 and 12 volt versions with capacities of 66, 88 and 110 Ah and 33, 44 and 55 Ah respectively. They require constant-voltage charging and their nominal cell voltage is 2.23V. A low specific-gravity electrolyte has been used to reduce float voltage and self-poisoning, allowing the batteries to be used for long periods under float charge conditions without loss of capacity. A venting arrangement on the top of the batteries allows gases caused by overcharging to escape but will not allow flames to re-enter, thus removing the risk of explosion present with some vented cells.

The XL range was designed specifically for telecommunications applications and the battery sizes meet these requirements rather than being directly compatible with similar batteries used in other sections of industry. They are expected to find applications in computers, test equipment, medical equipment and un-interruptible supply applications as well as in the telecommunications field.

Yuasa Battery Sales (UK) Ltd, Hawksworth Industrial Estate, Swindon, Wiltshire SN3 1DZ, tel 0793 486818.

The Little Chill

PCA are marketing a range of equipment cooling fans which have a fixing plate size of only 80mm (3.15") square. Features claimed include low mechanical noise, zero electrical noise, low weight and long life, and the fans are expected to find wide application in domestic products as well as in office equipment, test gear and industrial equipment, etc.

The fans are available in 6, 12 and 24V DC versions and operate at a speed of 4000 RPM to achieve an air flow of 0.95m³/minute. The mechanical noise is less than 21 dBA and PCA claim that electrical noise has been entirely eliminated. The full weight is 170 grams and the anticipated life expectancy is 10,000 hours for most models.

For further details contact P. Caro & Associates Ltd, 2347 Coventry Road, Sheldon, Birmingham B26 3LS, tel 021-742 1328.

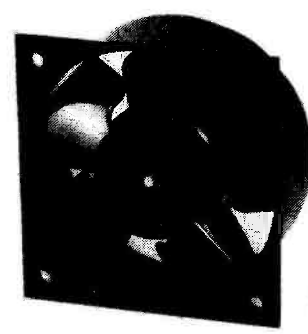


Photo-Electric Switch With Integral Amplifier

Sigma have introduced a photo-electric sensor which has a built-in amplifier. The unit can be used to detect liquid levels, passing objects, etc, requires no special cable to prevent noise problems and will operate with cable lengths of up to 50 metres.

The PM-07 is a retro-reflective sensor which will detect transparent, translucent and opaque objects at distances of up to 25mm (1") with no physical contact. It operates from a 12-24V DC supply and has a response time of less than 5ms. The case measures 7.5mm square by 38mm long and the operating temperature range is from minus 10° to plus 55° centigrade.

Further information is available from Sigma Ltd, Spring Road, Letchworth, Hertfordshire SG6 4AJ, tel 04626-3841.

Blue LEDS

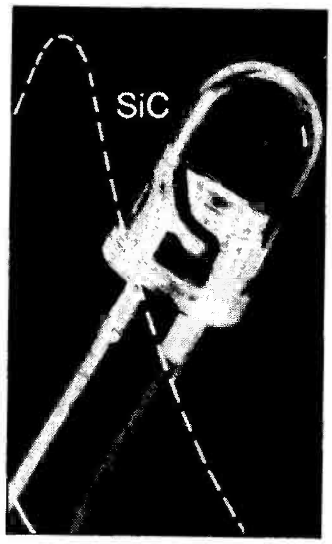
Red, yellow and green LEDs using crystalline semiconductors such as gallium phosphorus and arsenic have been available for more than a decade, but LEDs which emit blue light have been expensive and have not been generally available. Two years ago, Siemens devised a method of manufacturing 'blue-light chips' at a considerably lower price, albeit without matching the price level of LEDs in the other colours, and having sounded out the market have decided to include the fourth colour in their 1985 product range.

The new blue LED, type SLB 5410, operates at 480nm and uses silicon carbide (SiC) as the source material. SiC has emerged as the optimum semiconductor for blue light only after years of research, and although it is costly to produce, it has significant advantages over ZnSe or GaN. The SLB 5410 has a forward voltage of typically 4V at 20mA, the corresponding figures being 10V at 20mA for ZnSe or GaN types. Typical output levels are 4mcd at 20mA measured in the optical central axis at a half-angle of eight degrees, and the device is mounted in a standard 5mm plastic package.

The purity and reproductability of the blue LED's 480nm radiation are unmatched. Further characteristics are high impulse stability, a narrow spectral bandwidth and a very low ageing rate. These features make the LED suitable for use as a radiation source in spectroscopic, biophysical or medical applications, as a calibration source for TV camera and photographic equipment, and, later on, possibly even as a means for producing the blue luminous dots on flat screens.

The blue LED is less suitable for use as a mere on/off indicator than its red, yellow and green counterparts because, quite apart from higher costs, the angle of radiation and the intensity are lower than in conventional LEDs.

Siemens Limited, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex TW16 7HS, tel 09327-85691.



Safety Cap

Not being the sort of company to bottle things up, Siemens have written to tell us about their latest innovation. They have introduced a range of tantalum electrolytic capacitors which are designed to overcome the risk of fire presented by conventional electrolytics when they are fed a voltage of the wrong polarity.

If an electrolytic capacitor is operated with reverse polarity, perhaps because of a fault in a piece of equipment, it will heat up rapidly and may even explode. This effect is even more marked in tantalum capacitors which have a much higher charge density than other electrolytics. In an extreme case it is possible for the piece of equipment in which the capacitor is installed to catch fire as the result of such a fault.

Siemens have overcome this hazard by incorporating a fuse into their new B 45185 series of tantalum capacitors. The fuse takes the form of a solder wire link in the cathode lead, and if the capacitor is operated with reversed polarity this link will quickly heat up and melt and the capacitor will fail harmlessly. They are available in four types with capacities ranging from 100n to 330uF and with voltage ratings from 6.3 to 50 volts. The single-ended rectangular plastic package has climatic protection which meets the requirements of category FKE of the DIN 40040 standard and has been designed with automated assembly in mind.

For further information contact Siemens Ltd, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex TW16 7HS, tel 09327-85691.

- Semiconductor Supplies International have brought out the autumn issue of their catalogue. Its 32 A4 pages list transistors, diodes, rectifiers, microprocessors and other ICs, LEDs, capacitors and resistors. Copies are available from Semiconductor Supplies International Ltd, Dawson House, 128-130 Carshalton Road, Sutton, Surrey SM1 4RS, tel 01-643 1126.

- The new Electrovalue catalogue actually came out last month but we couldn't find room to mention it. Never mind, it's valid until the end of January 1985 so it's still worth sending off for, and its 44 A5 pages list their largest ever range of general components, computers and accessories, books and test equipment. Copies are available free of charge from Electrovalue Ltd, 28 St. Judes Road, Englefield Green, Egham, Surrey TW20 0HB, tel 0784-33603.

- Once again, the quarterly figures show an increase in the number of business failures in the electrical industry. Business information company Dun & Bradstreet Ltd tell us that there were 585 company liquidations in the industry in the first nine months of 1984, a four per cent increases over the figure for the same period of 1983. Bankruptcies among firms, partnerships and individuals in the industry totalled 88 over the same period, a 22% increase over the 1983 figure. A small glimmer of hope appears in the news that the computer manufacturing industry (micros to mainframe) has strengthened its financial position in the last five years with only 23% of firms now considered by Dun & Bradstreet to be financially vulnerable compared with 45% in 1979.

- Miller-Stephenson Chemicals have produced a spray-on conductive coating which is intended to absorb RFI and EMI over a broad frequency range. The coating is sprayed from an aerosol can, dries in fifteen minutes, is effective within minutes and provides over 78dB attenuation at 1MHz, 49dB at 10MHz and 21dB at 100MHz. For details contact the distributors, D. Fraser & Company, 129 Kylepark Drive, Uddingston G71 7DD, tel 0698-813476.

ETI

74 SERIES

7400	30p
7401	30p
7402	30p
7403	30p
7404	36p
7405	30p
7406	40p
7407	40p
7408	30p
7409	30p
7410	30p
7411	30p
7412	30p
7413	50p
7414	70p
7416	36p
7417	40p
7420	30p
7421	60p
7422	36p
7423	36p
7425	40p
7426	40p
7427	40p
7428	43p
7430	30p
7432	36p
7433	30p
7437	30p
7438	40p
7439	40p
7440	40p
7441	90p
7442A	70p
7444	110p
7445	100p
7446A	100p
7447A	100p
7448	120p
7450	36p
7451	35p
7453	38p
7454	38p
7460	55p
7470	50p
7472	55p
7473	55p
7474	50p
7475	60p
7476	45p
7480	65p
7481	180p
7483A	105p
7484A	125p
7485	110p
7486	42p
7489	210p
7490A	55p
7491	70p
7492A	70p
7493A	55p
7494	110p
7495A	60p
7496	80p
7497	210p
74100	190p
74107	50p
74109	75p
74110	75p
74111	55p
74116	170p
74118	110p
74119	170p
74120	100p
74121	55p
74122	70p
74123	80p
74125	65p
74126	55p
74128	55p
74132	75p
74136	70p
74141	90p
74142	250p
74143	270p
74144	270p
74145	110p
74147	170p
74148	140p
74150	1.75
74151A	70p
74153	80p
74154	140p
74155	80p
74156	100p
74157	80p
74159	175p
74160	110p
74161	80p
74162	110p
74163	110p
74164	120p
74165	110p
74166	140p
74167	400p
74170	200p
74172	420p
74173	140p
74174	110p
74175	105p
74176	100p
74178	150p
74179	150p
74180	100p
74181	340p
74182	140p
74184	180p
74185A	180p
74190	130p
74191	130p
74192	110p
74193	115p
74194	110p
74195	80p
74196	130p
74197	110p
74198	220p
74199	220p
74221	110p
74251	100p
74259	150p
74265	80p
74273	200p
74276	140p
74278	170p
74279	90p
74283	105p
74285	320p
74290	90p
74293	90p
74298	180p
74351	200p
74365A	80p
74366A	80p
74367A	80p
74368A	70p
74376	160p
74390	110p
74393	112p
74490	140p
7443A	100p

74LS SERIES

74LS00	28p
74LS01	28p
74LS02	28p
74LS03	28p
74LS04	28p
74LS05	28p
74LS08	28p
74LS09	28p
74LS10	28p
74LS11	28p
74LS12	28p
74LS13	34p
74LS14	52p
74LS15	28p
74LS20	28p
74LS21	28p
74LS22	28p
74LS24	50p
74LS26	28p
74LS27	28p
74LS28	28p
74LS30	28p
74LS32	28p
74LS33	28p
74LS37	28p
74LS38	28p
74LS40	28p
74LS42	55p
74LS43	150
74LS47	90p
74LS48	90p
74LS51	30p
74LS54	30p
74LS55	30p
74LS73A	30p
74LS74A	38p
74LS75	48p
74LS76A	43p
74LS83A	70p
74LS85	80p
74LS86	35p
74LS90	54p
74LS91	90p
74LS92	60p
74LS93	54p
74LS95B	75p
74LS96	90p
74LS107	43p
74LS109	43p
74LS112	45p
74LS113	45p
74LS114	45p
74LS122	70p
74LS123	90p
74LS124/	629/140p
74LS125	50p
74LS126	50p
74LS132	65p
74LS133	50p
74LS136	45p
74LS138	60p
74LS139	60p
74LS145	110p
74LS147	175p
74LS148	140p
74LS151	70p
74LS152	200p
74LS153	70p
74LS154	200p
74LS155	70p
74LS156	70p
74LS157	60p
74LS158	70p
74LS160A	75p
74LS161A	75p
74LS162A	75p
74LS163A	75p
74LS164	75p
74LS165A	110p
74LS166A	150p
74LS168	130p
74LS169	130p
74LS170	160p
74LS173A	110p
74LS174	75p
74LS175	75p
74LS181	200p
74LS183	190p
74LS190	90p
74LS191	90p
74LS192	90p
74LS193	90p
74LS194A	75p
74LS195A	75p
74LA196	90p
74LS197	90p
74LS221	100p
74LS240	90p
74LS241	90p
74LS242	90p
74LS243	90p
74LS244	90p
74LS245	160p
74LS247	110p
74LS248	110p
74LS249	110p
74LS251	70p
74LS253	75p
74LS256	90p
74LS257A	70p
74LS258A	70p
74LS259	125p
74LS260	75p
74LS261	120p
74LS266	60p
74LS273	125p
74LS279	70p
74LS280	190p
74LS283	85p
74LS290	85p
74LS292	900p
74LS293	90p
74LS295	140p
74LS297	900p
74LS298	100p
74LS299	250p
74LS321	370p
74LS323	330p
74LS324/624	350p
74LS348	200p
74LS352	120p
74LS353	120p
74LS356	210p
74LS363	180p
74LS364	180p
74LS365	52p
74LS366	52p
74LS367	52p
74LS368A	50p
74LS373	100p
74LS374	110p
74LS375	75p
74LS377	140p
74LS378	110p
74LS379	140p
74LS381	450p
74LS390	80p
74LS393	110p
74LS395A	110p
74LS399	140p
74LS445	180p
74LS465	140p
74LS467	180p
74LS490	150p
74LS540	140p
74LS541	140p
74LS608	700p
74LS610	1900p
74LS612	1900p
74LS624	1350p
74LS626	225p
74LS628	225p
74LS629	140p
74LS640	300p
74LS640-1	300p
74LS641	200p
74LS642-1	300p
74LS643	250p
74LS643-1	300p
74LS644	350p
74LS645	200p
74LS645-1	400p
74LS668	90p
74LS669	90p
74LS670	180p
74LS682	320p
74LS684	650p
74LS687	550p

74S SERIES

74S00	50p
74S02	50p
74S04	50p
74S05	50p
74S08	50p
74S10	50p
74S11	75p
74S20	50p
74S22	100p
74S30	50p
74S32	60p
74S37	60p
74S38	75p
74S40	50p
74S51	45p
74S64	45p
74S74	75p
74S85	450p
74S86	100p
74S112	150p
74S113	120p
74S114	120p
74S124	550p
74S132	100p
74S133	60p
74S138	180p
74S139	180p
74S140	100p
74S151	150p
74S153	150p
74S157	210p
74S158	200p
74S163	400p
74S169	700p
74S174	300p
74S175	320p
74S188	180p
74S189	225p
74S194	300p
74S195	300p
74S196	350p
74S200	450p
74S201	320p
74S225	520p
74S240	300p
74S241	400p
74S244	500p
74S251	250p
74S257	250p
74S258	250p
74S260	100p
74S261	300p
74S262	1100p
74S283	270p
74S287	225p
74S288	200p
74S289	225p
74S299	550p
74S373	400p
74S374	400p
74S387	225p
74S472	475p
74S473	475p
74S474	450p
74S475	450p
74S570	650p
74S571	300p
74S573	500p

4000 SERIES

4000	20p
4001	24p
4002	25p
4006	70p
4007	35p
4008	60p
4009	45p
4010	60p
4011	24p
4012	25p
4013	36p
4014	60p
4015	70p
4016	36p
4017	55p
4018	60p
4019	60p
4020	80p
4021	60p
4022	70p
4023	30p
4024	48p
4025	24p
4026	90p
4027	40p
4028	60p
4029	75p
4030	35p
4031	1125p
4032	100p
4033	1125p
4034	250p
4035	70p
4036	270p
4037	110p
4038	100p
4039	250p
4040	60p
4041	55p
4042	50p
4043	60p
4044	80p
4045	100p
4046	60p
4047	60p
4048	55p
4049	36p
4050	35p
4051	65p
4052	60p
4053	60p
4054	80p
4055	80p
4056	850p
4059	400p
4060	70p
4063	85p
4066	40p
4067	230p
4068	25p
4069	24p
4070	24p
4071	24p
4072	24p
4073	24p
4075	24p
4076	65p
4077	25p
4078	25p
4081	24p
4082	25p
4085	60p
4086	75p
4089	120p
4093	35p
4094	90p
4095	90p
4096	90p
4097	270p
4098	75p
4099	90p
4501	35p
4502	55p
4503	36p
4504	95p
4505	360p
4506	90p
4507/4030	35p
4508	120p
4510	55p
4511	55p
4512	55p
4513	150p
4514	110p
4515	110p
4516	55
4517	220p
4518	48p
4519	32p
4520	80p
4521	115p
4522	80p
4526	70p
4527	80p
4528	65p
4529	100p
4531	75p
4532	65p
4534	380p
4536	250p
4538	75p
4539	75p
4541	90p
4543	70p
4551	100p
4553	240p
4555	36p
4556	50p
4557	240p
4560	150p
4566	140p
4568	240p
4569	170p
4572	45p
4583	90p
4584	48p
4585	90p
4724	150p
14411	750p
14412	750p
14416	300p
14419	280p
14490	420p
14495	450p
14500	650p
14599	200p
22100	350p
22101	700p
22102	700p
40014/4584/40106	48p
40085	120p
40097	60p
40098	40p
40100	150p
40101	125p
40102	135p
40103	200p
40104	120p
40105	150p
40106	48p
40107	55p
40108	320p
40109	80p
40110	225p
40114	225p
40147	280p
40163	100p
40173	120p
40174	100p
40175	100p
40193	100p
40244	150p
40245	150p
40257	180p
40373	180p
40374	180p
80C95	75p
80C97	75p
80C98	75p

LINEAR ICs

AD7581	£15
ADC0808	1190p
AM7910DC	£25
AN103	200p
AY-1-5050	100p
AY-3-1270	750p
AY-3-1350	350p
AY-3-8910	400p
AY-3-8912	500p
CA3018A	100p
CA3028A	110p
CA3046	70p
CA3059	325p
CA3060	350p
CA3080E	70p
CA3086	60p
CA3089E	210p
CA3090AQ	375p
CA3130E	90p
CA3130T	100p
CA3140E	45p
CA3140T	100p
CA3160E	90p
CA3161E	160p
CA3162E	160p
CA3189E	270p
CA3240E	150p
CA3280G	270p
D7002	£10
DAC1408-8	225p
DAC0800	225p
DAC0808	225p
DG308	300p
HA1366	190p
ICL7106	675p
ICL7611	95p
ICL7650	400p
ICL7660	250p
ICL8038	300p
ICM7216B	£22
ICM7217	750p
ICM7555	100p
ICM7556	140p
LC7120	300p
LC7130	300p
LC7137	350p
LF347	50p
LF351	60p
LF353	90p
LF355	90p
LF356N	90p
LF357	100p
LF13331	350p
LM10C	450p
LM301A	30p
LM307	45p
LM308CN	75p
LM310	225p
LM311	60p
LM318	150p
LM319	180p
LM324	45p
LM334Z	115p
LM335Z	130p
LM336	160p
LM339	40p
LM348	60p
LM358P	50p
LM377	210p
LM380N-8	150p
LM380	120p
LM381AN	170p
LM382	200p
LM383	325
LM384	220
LM386N-1	100p
LM387	270p
LM389	180p
LM391	180p
LM392N	110p
LM393	85p
LM394CH	375p
LM709	35p
LM710	48p
LM711	100p
LM723	60p
LM725CN	300p
LM733	65p
LM741	18p
LM747	70p
LM748	30p
LM1011	480p
LM1014	150p
LM1801	300p
LM1830	250p
LM1871	300p
LM1872	300p
LM1886	600p
LM1889	450p
LM2917	300p
LM3302	75p
LM3900	80p
LM3909	100p
LM3911	180p
LM3914	350p
LM3915	340p
LM3916	340p
LM13600	150p
M51513L	230p
M51516L	450p
MB3712	200p
MB3730	400p
MC1310P	150p
MC1413	90p
MC1458	45p
MC1495L	250p
MC1496	70p
MC3340P	200p
MC3401	50p
MC3403	65p
MF10CN	340p
MK50240	900p
MK50398	750p
ML920	500p
ML922	400p
MM6221A	300p
NE531	120p
NE544	190p
NE555	22p
NE556	60p
NE564	400p
NE565	150p
NE566	125p
NE567	150p
NE570	400p
NE571	400p
NE592	90p
NE5532P	150p
NE5533P	180p
NE5534P	120p
NE5534AP	150p
OP07EP	500p
PLLO2A	500p
RC4136	55p
RC4151	200p
RC4558	55p
S566B	300p
SAA1900	£16
SAD1024A	1150p
SFF96364	800p
SL490	300p
SN76013N	300p
SN76023N	300p
SN76033N	300p
SN76115N	215p
SN76477	600p
SN76489	400p
SN76495	400p
SP0256AL2	700p
SP8515	750p
TA7120	120p
TA7130	140p
TA7204	150p
TA7205	90p
TA7222	150p
TA7310	150p
TBA641BX1	400p
TBA231	120p
TBA800	80p
TBA810	90p
TBA820	80p
TBA820M	75p
TBA920	200p
TBA950	225p
TC9109	500p
TCA210	350p
TCA220	350p
TCA270	350p
TCA940	175p
TDA1004A	500p
TDA1010	225p
TDA1022	450p
TDA1024	110p
TDA1170S	300p
TDA2002	325p
TDA2003	290p
TDA2004	240p
TDA2006	320p
TDA2020	320p
TDA2030	180p
TDA2541	400p
TDA2593	500p
TDA2653	700p
TDA3560	990p
TDA3810	750p
TDA7000	350p
TEA102	700p
TL061CP	40p
TL062	60p
TL064	90p
TL071	40p
TL072	70p
TL074	110p
TL081	38p
TL082	55p
TL083	75p
TL084	100p
TL094	200p
TL170	50p
TL430C	120p
UAA1003-3	935p
UA759	320p
UA2240	120p
UAA170	170p
UCN4801A	350p
ULN2001A	90p
ULN2002A	90p
ULN2003A	90p
ULN2004A	90p
ULN2068	290p
ULN2802	190p
ULN2803	180p
ULN2804	190p
UPC575	275p
UPC592H	200p
UPC1156H	300p
UPC1185H	350p
XR210	400p
XR2206	350p
XR2207	375p
XR2211	575p
XR2216	675p
XR2240	120p
ZN409	130p
ZN414	80p
ZN419P	175p
ZN423E	130p
ZN424E	130p
ZN425E8	350p
ZN426E	300p
ZN427E	600p
ZN428E	450p
ZN429E8	225p
ZN450E	750p
ZN459CP	300p
ZN1034E	200p
ZN1040E	660p
ZNA134J	£23
ZNA234E	950p

VOLTAGE REGULATORS

FIXED PLASTIC

	+ve		−ve	
1A 5V	7805	45p	7905	50p
6V	7806	50p	7906	80p
8V	7808	50p	7908	50p
12V	7812	45p	7912	50p
15V	7815	50p	7915	50p
18V	7818	50p	7918	50p
24V	7824	50p	7924	50p
5V 100mA	78L05	30p	79L05	45p
6V 100mA	78L06	30p		
8V 100mA	78L08	30p		
12V 100mA	78L12	30p	79L12	50p
15V 100mA	78L15	30p	79L15	50p

OTHER REGULATORS

Fixed Regulators		
LM309K	1A 5V	140p
LM323K	3A 5V	350p
78H05KC	5A 5V	550p
78H12	5A 12V	640p
78P05	10A 5V	900p
Variable Regulators		
LM305AH		250p
LM317T	TO-220	150p
LM317K	TO3	240p
LM337T		225p
LM350T		250p
LM338K	10A+VAR	400p
LM396K	10A+VAR	£15
LM723N		30p
78HGKC	5A+VAR	575
78GUIC	1A+VAR	225p
79HGGKC	5A−VAR	675p
79GUIC	1A−VAR	250p
Switching Regulators		
ICL7660		250p
SG3524		300p
TL494		300p
TL497		300p
78S40		250p

OPTO-ELECTRONICS

FND357	100p	MAN3640	174p
FND500/TIL730	100p	MAN4640	200p
FND507/TIL729	100p	MAN6610	200p
MAN74 DL704	100	NSB5881	570p
MAN71 DL707	100	TIL311	650p
		TIL729	100p
		TIL730	100p
		MAN8910	250p

OPTO-ISOLATORS

ILQ74	130p	TIL111	70p
MCT26	100p	TIL112	70p
MCS2400	190p	TIL113	70p
MOC3020	150p	TIL116	70p
ILQ74	220p	6N137	360p
		6N139	175p

LEDS

TIL209 Red	12p	TIL222 Green	18p
TIL211 Green	16p	TIL226 Orange	22p
TIL212 Yellow	20p	MV57164 Red Array (10	225p
CXQ95 (bi-colour)	100p	MV54164 Green Array (1)	225p
TIL220 Red	15p	Rect Leds R.G.Y	30p

COUNTERS

74C925	650p
74C926	650p
74C928	650p
72168	£22
ZN1040	670p

DISPLAYS

DL704	140p
DL707 Red	140p

COMPUTER COMPONENTS

CPU

1802CE	650p
265DA	£12
6502	350p
6502A	550p
65C02A	£15
6502B	800p
6800	250p
6802	260p
6809	650p
6809E	£12
68B09	£12
68B09E	£16
68000-LB	£36
8035	500p
8039	500p
8080A	420p
8085A	550p
8086	£22
8088	£17.50
8748	POA
TMS1601	£12
TMS9980	£12
TMS9995	£12
WD55	£14.50
Z80	280p
Z80A	375p
Z80B	800p
TMS9903	£25
TMS9911	£18
TMS9914	£14
Z80PIO	280p
Z80APIO	325p
Z80CTC	325p
Z80ACTC	325p
Z80DART	650p
Z80ADART	800p
TMS4500	£14
TMS9901	500p
TMS9902	500p
Z80DMA	900p
Z80ADMA	£10
Z80ASIO-0/1/2	900p

SUPPORT DEVICES

2651	£12
3242	800p
3245	450p
6520	300p
6522	350p
6522A	550p
6532	520p
6551	550p
6821	150p
68B21	220p
6829	£12.50
6840	375p
68B40	600p
6850	160p
68B50	250p
6852	250p
6854	650p
68B54	800p
6875	500p
8154	850p
8155	500p
8156	400p
8205	225p
8212	250p
8216	160p
8224	300p
8226	300p
8228	270p
8243	450p
8250	950p
8251A	500p
8253C-5	600p
8255AC-5	
8256	£19
8257C-5	£25
8259C-5	£11
8271	£45
8275	£29
8279	£11
8284	750p
8288D	£11
8755A	£24

REAL TIME CLOCK

MC6818P	450p
MM58174AN	850p
MSM5832RS	350p

TELETEXT DECODER

SAA5020	600p
SAA5030	700p
SAA5041	£16
SAA5050	900p

MEMORIES

2016-150	500p
2101	400p
2102	250p
2107B	500p
2111A-35	400p
2114-2L	350p
2114-3L	250p
2114 4L	200p
2147	320p
4027-3	300p
4116-15	200p
4116-20	175p
4118-3	500p
4164-15	550p
4164-20	450p
4416-20	450p
4532-20	250p
4816AP-3	200p
5101/5501	370p
5514/5114	250p
5516	650p
6116P-3	500p
6116LP-3	550p
8264-15	£24
6514-45	400p
6810	180p
74S189	225
74S201	350p
74S289	225p
93415	600p
93L422	950p
93425	600p

PROMs

28L22	475p
24S10	250p
18S030	200p
18SA030	200p
74S188	180p
74S287	225p
74S288	180p
74S387	225p
74S473	475p
74S474	400p
74S570	650p
74S571	300p
74S573	500p
82S23	150p
82S123	150p
82S129	175p

BAUD RATE GENERATORS

MC14411	750p
COMB116	650p
4702B	750p

EPROMs

2516 +5v	350p
2516-35	550p
2532	450p
2532-30	550p
2564	650p
2708	300p
2716 +5v	350p
2716-35	550p
2732	450p
2732A-2	700p
2732A-35	600p
2764-25	600p
27C64-25	£14
27128-25	£18
27128-30	£16
TMS2716	500p

CRT CONTROLLER

CRT5027	£16
CRT6545	£9
EF9364	£8
EF9365	£30
EF9366	£30
EF9367	£36
MC6845	650p
MC6845SP	750p
MC6847	650p
SFF96364	800p
TMS9918	£30
TMS9927	£14
TMS9928	£20
TMS9929	£16

INTERFACE ICs

AD558CJ	775p
AD561J	£20
AD7581	£15
ADC0808	1190p
AM25S10	350p
AM25LS2521	350p
AM25LS2538	350p
AM26LS31	120p
AM26LS32	120p
D7002	£12
DAC80-CB1-V	£28
DM8131	600p
DP8304	350p
DS3691	350p
DS8830	180p
DS8831	150p
DS8832	150p
DS8833	225p
DS8835	280p
DS8836	150p
DS8838	225p
LF13201	450p
MC1488	60p
MC1489	60p
MC3446	250p
MC3459	450p
MC3470	475p
MC3480	850p
MC3486	250p
MC3487	250p
MC4024	325p
MC4044	325p
MC14411	900p
IMC14412	750p
IML922	400p
ULN2001	90p
ULN2003A	90p
ULN2004A	90p
ULN2068	290p
ULN2802	190p
ULN2803	180p
ULN2804	190p
75107	90p
75108	90p
75109	120p
75110	90p
75112	160p
75113	120p
75114	140p
75115	140p
75121	140p
75122	140p
75150P	120p
75154	120p
75159	220p
75160	500p
75161	350p
75162	400p
75172	300p
75182	90p
75188	60p
75189	60p
7535	150p
75451	70p
75452	70p
75453	70p
75454	70p
75480	150p
75491	65p
75492	65p
8T26	120p
8T28	120p
8T95	120p
8T96	120p
8T97	120p
8T98	120p
81LS95	140p
81LS96	220p
81LS97	140p
81LS98	140p
88LS120	400p
9602	300p
9636A	180p
9637AP	180p
9638	180p
ZN425E8	350p
ZN426E8	350p
ZN427E	600p
ZN428E8	450p
ZN429E	210p
ZN447E	900p
ZN459CP	300p

DISC CONTROLLER ICs

6843	£8
8272	£26
FD1771	£20
FD1791	£22
FD1793	£20
FD1795	£28
FD1797	£22
WD2793	£36
WD2797	£32
WD1691	£15
WD2143	£8

CHARACTER GENERATORS

RO3-2513	
U.C.	750p
L.C.	700p
DM86S64	£12
MC66760	750p
SN74S262AN	£10

ENCODERS

AY5-2376	1150p
AY5-3600	750p
74C922	650p
74C923	650p

UARTs

AY-3-1015P	300p
AY-5-1013P	300p
COM8017	300p
IM6402	360p
TR1602	300p

UHF MODULATORS

6MHz UHF	375p
8MHz UHF	450p
Sound & Vision 12MHz	£12

CRYSTALS

32.768 KHz	100p
1.00MHz	270p
Freq in MHz	
1.8432	225p
2.00	2255
2.45760(L)	200p
2.45760(S)	250p
2.5	250p
2.662	250p
3.276	150p
3.5795	020p
4.00	150p
4.194	200p
4.43	100p
4.608	250p
4.9152	250p
5.000	150p
5.068	250p
6.00	140p
6.144	140p
7.00	150p
7.168	175p
8.00	150p
8.867	175p
10.00	175p
10.50	250p
10.70	150p
11.00	300p
12.00	150p
14.00	175p
14.318	160p
14.756	250p
15.00	200p
16.00	200p
17.734	200p
18.00	170p
18.432	150p
19.969	150p
20.000	175p
24.000	150p
48.00	175p
116	250p
PX01000	£12

LOW PROFILE SOCKETS BY TI

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14 pin	10p	24 pin	24p
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BC107/8	18p
BC109C	20p
BC169C	18p
BC172	18p
BC177/8	30p
BC179	30p
BC182/3	15p
BC184	16p
BC187	30p
BC212/3	16p
BC214	18p
BC237	18p
BC327	16p
BC337	16p
BC338	16p
BC461	40p
BC477/8	36p
BC516/7	50p
BC547B	20p
BC548C	16p
BC549C	18p
BC557B	18p
BC559C	24p
BCY70	30p
BCY71	36p
BD131	75p
BD132	80p
BD135/6	40p
BD139	40p
BD140	40p
BD189	60p
BD232	60p
BD233	75p
BD235	85p
BD241	60p
BD242	60p
BD379	60p
BD380	60p
BD677	40p
BF244B	40p
BF256B	50p
BF257/8	40p
BF337	36p
BFR39	32p
BFR40/1	32p
BFR79	32p
BFR80/1	32p
BFR96	160p
BFX29	45p
BFX30	45p
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BFX88	30p
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BU205	200p
BU208	200p
BU406	145p
BUX80	600p
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E310	50p
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MJ4502	400p
MJE340	50p
MJE2955	150p
MJE3055	120p
MPF102	40p
MPF103/4	40p
MPF105	40p
MPSA06	30p
MPSA12	30p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	30p
MPSA70	50p
MPSA93	40p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
TIP29A	35p
TIP29C	40p
TIP30A	35p
TIP30C	40p
TIP31A	40p
TIP31C	45p
TIP32A	45p
TIP32C	40p
TIP33A	70p
TIP33C	90p
TIP34A	90p
TIP34C	120p
TIP35A	120p
TIP35C	140p
TIP36A	140p
TIP36C	160p
TIP41A	50p
TIP41C	55p
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2N1711	36p
2N2102	70p
2N2160	350p
2N2219A	30p
2N2222A	30p
2N2369A	30p
2N2484	30p
2N2646	50p
2N2904/5	30p
2N2906A	30p
2N2907A	30p
2N2926	12p
2N3063	36p
2N3054	60p
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2N3442	140p
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2N3584	250p
2N3643/4	48p
2N3702/3	16p
2N3704/5	16p
2N3706/7	16p
2N3708	16p
2N3773	200p
2N3819	40p
2N3823	50p
2N3866	90p
2N3904	18p
2N3906	18p
2N4036	65p
2N4037	65p
2N4123/4	27p
2N4125/6	27p
2N4401/3	25p
2N4427	90p
2N4871	50p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5245	40p
2N5401	60p
2N5459	30p
2N5460	60p
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2N6247	190p
2N6254	130p
2N6290	65p
2SC1306	100p
2SC1307	150p
2SC1957	90p
2SC1969	150p
2SC2028	80p
2SC2029	200p
2SC2078	160p
2SC2335	200p
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3N140	200p
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3N204	200p
40290	250p
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OA95	9p
OA200	9p
OA202	10p
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1N916	7p
1N4148	4p
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1N4005	6p
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1N5404/7	15p
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2A 50V	30p
2A 100V	35p
2A 400V	45p
3A 200V	60p
3A 600V	72p
4A 100V	95p
4A 400V	100p
6A 50V	60p
6A 100V	65p
6A 400V	85p
10A 400V	200p
25A 400V	400p
6A 50V	80p
6A 100V	100p
6A 400V	120p
10A 400V	200p
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18 pin	35p
20 pin	40p
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16A 400V	110p
16A 400V	220p
16A 500V	130p
T2800D	130p
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TIC226D	75p
TIC246D	110p

THYRISTORS

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8A 600V	160p
12A 400V	160p
16A 100V	180p
16A 400V	180p
C106D	45p
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2N4444	180p
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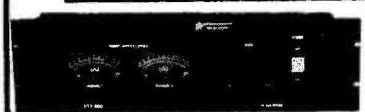

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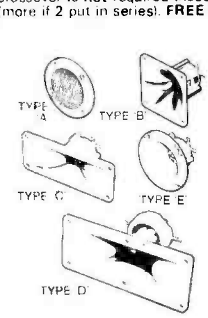

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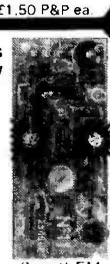

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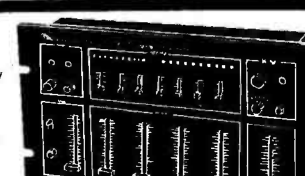

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ACTIVE BASS LOUDSPEAKER

The active loudspeaker design which appeared in the last four issues was ideal for those starting from scratch, but what about those who already have a loudspeaker system and simply want to improve it? Jeff Macaulay has been active on their behalf too.

With one or two notable (and expensive) exceptions, domestic loudspeakers are almost incapable of reproducing sounds below about 50Hz. The reasons for this are not too difficult to find. Even with the best of today's drive units a large cabinet is required to give extended bass response, and this is just not practical for modern-day lounges very few of which could be described as palatial.

True, it is possible to squeeze a few more hertz out of a small sealed box, but only at the expense of efficiency. The result is that amplifiers rated at nearly a kilowatt are required to produce anything like 'live' sound levels. Even a modest amount of bass boost will cause the midrange to go soggy, and the result in the bass register is just a boomy mess! So what is the solution?

Instead of giving your bank manager the pleasure of collecting vast amounts of interest on a loan for a new pair of speakers why not build the Neptune? It has been designed as a small add on unit which will extend the response of your existing speakers down to below 30Hz. That is a whole octave lower than 99% of the speakers on the market can manage, and for a modest outlay to boot.

Design Philosophy

Before delving deeply into the circuitry involved it will be as well to consider the design philosophy behind this project. As is well known, the deepest note that a speaker system can produce is limited by the size of the cabinet into which it is mounted. This is because any driver has a fundamental resonance due to the mass of the cone and the compliance of the speaker surround.

Imagine the cone mass as a weight suspended on a spring, which represents the surround compliance, and you can easily visualise the system. Place the driver in a sealed box and the air trapped inside effectively stiffens the compliance,making the resonant frequency higher. The smaller the volume of the box the higher the resonance and the less bass you get out of it.

To get around this difficulty some radical thought is necessary. Below the resonant frequency the response of the driver dies away at 12 dB/octave. If we were to boost the signal at that rate below the resonant frequency we would obtain a flat response.

This is the method used here. Such a speaker would be useless above the resonant frequency of the cabinet because the response with the filter added rolls of at 12dB/octave above resonance (see Fig 1). However, this response is exactly what is required for an add on bass unit as it will complement the falling response of the existing speakers.

As most of the money spent on a pair of speakers is invested in extending the response below 100Hz, it would be pointless to waste what we have already paid for. The Neptune has therefore been designed as a bass augmenter.

Having decided the form our

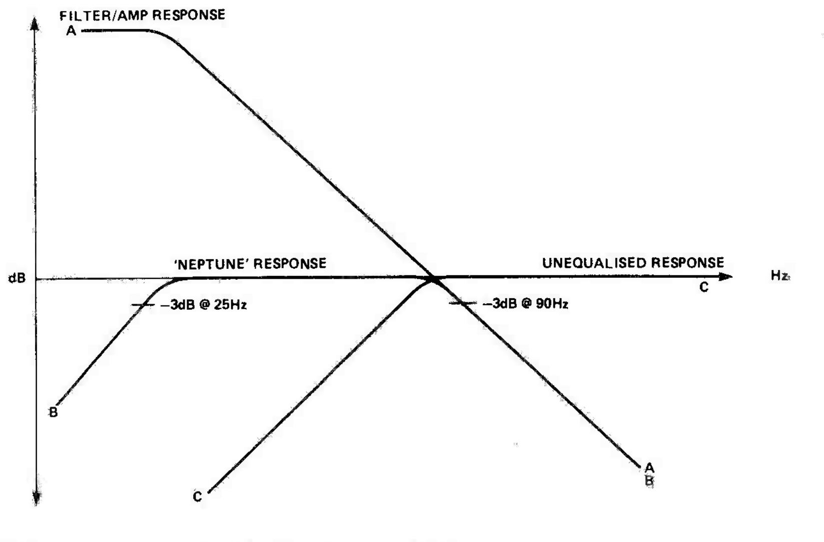


Fig. 1 Response curves for the Neptune system.

bass speaker is to take there remains to be considered the matter of quantity and quality of output.

Unlike reflex and horn enclosures the sub-resonant principle has the advantage of not using resonant effects to obtain the desired response. In a reflex cabinet, for example, the extension in bass response is obtained at the expense of 'hangover'. That is, the cabinet is still resonating after the note has stopped. This effect can be minimised by competent design but it still gives this type of enclosure a bad name.

The quantity of bass generated by a pair of 8" (200mm) speakers operating in tandem is easily quantifiable, but to appreciate the problem some understanding of the principles involved is required. If you were to look at the typical power versus frequency curve of speech and music you would find that the peak output occurs at around 200Hz, the lower midrange. Above and below this frequency the power requirement falls off rapidly, and at the lowest frequency of interest to us, 30Hz it is some 12dB down on the mean output at 200Hz.

This means that, if the speakers are required to give a mean output of 96dB SPL, the output required from the woofer would be some 84dB SPL. This the Neptune can easily give provided it is positioned on the floor and against a wall to take advantage of sound reflection from these surfaces.

The KEF B200A was chosen for this project for two reasons. First, they are blessed with a long and linear cone excursion and second the choice of a well known and respected drive unit will satisfy those who would pick holes in anything!

There is a tried and tested alternative, the Altai stocked PF81HR which has a similar performance in this application to the B200A's but is somewhat cheaper. For those on a budget these are recommended. Later upgrading simply means changing them for the B200's (see buylines).

In order to easily interface the speaker with existing stereo systems, a dedicated amplifier is required along with the active filter. These are mounted within the cabinet so that interfacing is reduced to plugging the unit into the mains and one of the speaker outlets. You might think that outputs from both channels would be required but this is not so. To ensure that bass signals are not presented out of phase from normal speakers, the bass content of stereo records is mixed down to mono below 100Hz. The signal of interest is therefore identical in both channels and can easily be obtained from one! This also has the advantage of preventing possible crosstalk between channels at higher frequencies and the woofer therefore has no deleterious effects on the stereo image.

To avoid hum loops the speaker electronics are not separately earthed. The unit is automatically earthed when connected by the amplifier earth. For this particular application nothing spectacular is required of the amplifier, especially as the bandwidth ceases at 90Hz! All that is necessary is the appropriate output power, about 30W, and

BUYLINES

A designer-approved kit of parts for this project is available from Bewbush Audio, 26 Hastings Road, Pound Hill, Crawley, Sussex RH10 4AT. The kit includes all of the electronics and two PF81HR drive units but not the woodwork. It costs £49.95 inclusive. The electronics alone can be supplied as a kit for £29.95 but note that Bewbush will not supply individual parts. B200A drive units are available from Wilmslow Audio and the Autona UL60 amplifier module is available from Bi-Pak. None of the other components should present any problems. PCBs will be included with the kits but are also available through our PCB Service.

HOW IT WORKS

The full circuit of the woofer is shown in Fig. 2. Input signals are applied to the gain control RV1 via SK1. Q1 in conjunction with R1/2/3 and R4 forms a simple virtual earth amplifier. The gain is set by the ratio of R2 to R1 whilst C1 isolates the base of Q1 from DC ground.

The amplified signal from the collector of Q1 is DC coupled into the second stage formed around Q2. This transistor is used in the emitter follower mode and provides a low impedance drive for the amplifier module.

In order to equalise the output to the woofer a Butterworth filter is used. R5/6 and C2/3 form the second order network with a -3dB point below 20Hz. The Q of the filter with the chosen component values is close to the optimum 0.7. Filters of this Q give the maximum rolloff rate consistent with low ripple in the passband.

R8 and C4 form a simple but effective decoupling network to provide the circuit with a ripple - free power line. To prevent any nasty and expensive damage to the drivers, the output is AC coupled by C5. In order to maintain a high damping factor down to low frequencies a large value electrolytic is required here.

Finally we come to the power supply proper which is thoroughly conventional. The mains voltage is both isolated and stepped down by the transformer T1. The raw secondary AC output is full wave rectified by BR1 and smoothing is provided by C6.

Notice that the drivers are wired in parallel. This means that the impedance seen by the power amplifier is some 4 ohms.

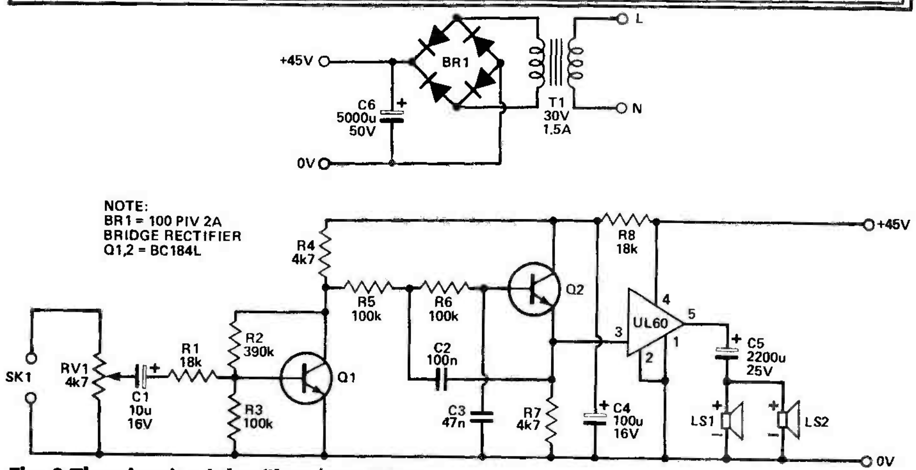


Fig. 2 The circuit of the filter/amplifier.

sufficient voltage gain. To avoid reinventing the wheel, a ready built power amp module is used.

Construction

This breaks down neatly into three parts, the electronics, the mechanics and the cabinet, and construction of the electronics should be tackled first.

The layout of the filter/amplifier PCB is shown in Fig. 3. PCB pins or veropins were used in the prototype for connections to the board, and if you plan to do likewise it is a good idea to insert them before assembling any other components. Push them well home and then solder them to ensure a good connection. If you do not wish to use pins, simply solder flying leads onto the board in the normal way, enlarging the holes if necessary to allow the wires to pass through. The rest of the PCB assembly should present no problems, the only point to watch being the polarity of the various electrolytic capacitors and semiconductors.

The next stage of the construction is to drill the heatsink and mount the PCB assembly and the amplifier module. The details are given in Fig. 4. Note that 10mm spacers have been used between the PCB and the amplifier, but if these are not available simply use nuts instead. It is important that there is good thermal contact between the amplifier heatsink and the main heatsink, so de-burr the mounting holes and make sure that no metal filings get trapped between the two surfaces when you assemble them. Finally, attach the bridge rectifier and C5 to the heatsink with 4BA nuts and bolts.

That takes care of the easy stuff - the next stage is to assemble the cabinet itself. The cutting details are given in the cabinet parts list. You can purchase a large sheet of veneered chipboard and cut it up yourself, but unless you have a good saw-bench and are resonably skilled in using it you will probably be better off purchasing the materials ready cut. Most DIY stores possess facilities to do this but you would do well to ask around and find somewhere with both the equipment and the skilled staff necessary to do a really good job. Even a smalll error will make construction much more difficult and the problems inherent in producing a neat end result and making it airtight will be multiplied considerably.

The cabinet has been designed for maximum rigidity, a fundamental requirement if rattles and buzzes are to be avoided. The rigidity is achieved by splitting the cabinet into two with an internal partition, and the panels are glued and screwed together with 1¼" self-tapping screws.

Another requirement of this design is that the cabinet should be airtight. In practise this is not a problem as long as all the joints are filled with an appropriate filler. A good seal around the drivers is also imperative but this is automatically achieved by using the gaskets provided.

PARTS LIST - ELECTRONICS

RESISTORS (all ¼W, 5%)	
R1,8	18k
R2	390k
R3,5,6,	100k
R4,7	4k7
RV1	4k7
CAPACITORS	
C1	10u, 16V electrolytic
C2	100n polyester
C3	47n polyester
C4	100u 16V electrolytic
C5	2,200u 25V electrolytic
C6	5000u 50V electrolytic
SEMICONDUCTORS	
Q1,2	BC184L
BR1	100PIV 2A bridge rectifier
MISCELLANEOUS	
LS1, 2	KEF B200A drive units (or Altai PF81HR - see text)
T1	30V, 1.5A mains transformer
SK1	two-pole input socket to choice

PCB; veropins or similar; Autona UL60 amplifier module; 6" x 4" heatsink; 10mm spacers; 'P' clip or strain relief bush; aluminium for control panel; capacitor clamps for C5 and C6; nuts, bolts, cable, etc.

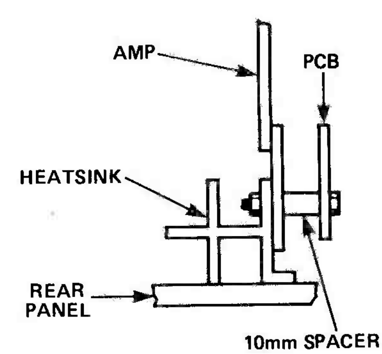


Fig. 4 Mounting arrangements for the amplifier module and PCB.

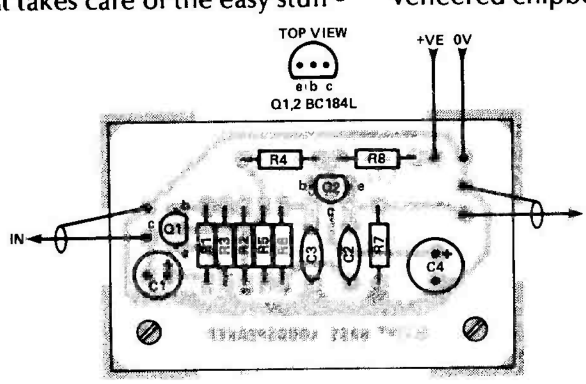
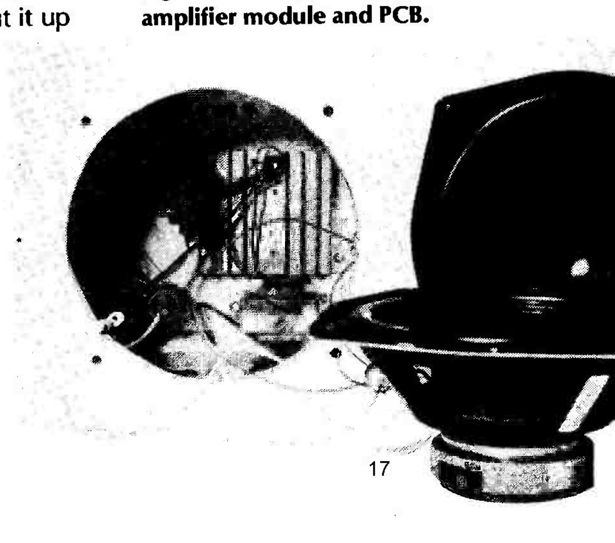


Fig. 3 The overlay diagram of the filter PCB.



PARTS LIST - CABINET

PANELS

(All ⅝" veneered chipboard)

Short sides (A)	**9" x 9" (2 off)**
Long sides (B)	**20" x 9" (2 off)**
Partition (C)	**7¾" x 9" (1 off)**
Front and back (D)	**18¾" x 9" (2 off)**

MISCELLANEOUS

Glue; woodscrews; veneer strip if desired (to cover exposed edges of panels); speaker cloth/protective grille as desired.

Assuming one has all the panels to hand construction can commence. Start by labelling each panel with the appropriate letter on its worst side, see Fig. 5. Find the partition panel (C) and drill a ¼" (6mm) hole in it to take the wires from the drive unit. The position of this hole is far from critical, and anywhere near the centre of the panel will be fine!

Mark out the position of the screw holes on the panels and drill ⅛" (3mm) pilot holes through these positions. Choosing the best face, countersink these to take the screw heads. If a countersink is not available a good job can be done with a ⅜" twist drill turned by hand against the hole. The control panel aperture in the rear panel should also be cut at this stage.

It is best to mount the heatsink, capacitors and transformer onto the back panel before assembling the cabinet. Attach them using ⅝" long No. 6. self-tapping screws and tighten down well to avoid the risk of strange buzzes etc caused by loose fittings. The interwiring of these parts is shown in Fig. 6, and 16/0.2 or a similar fairly heavy gauge wire should be used for all except the signal leads which must be single screened cable and the power leads between the PCB and amplifier which can be ordinary hook-up wire.

The cabinet itself can now be assembled. Start with the two long sides (B) and glue and screw these into position against the rear panel (D). Similarly attach the two short sides (A) and finally the partition (C). In each case the screws should

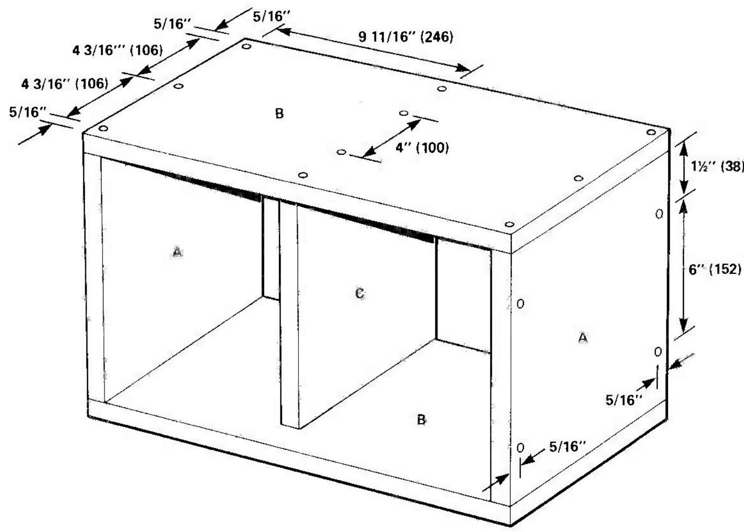


Fig. 5 Construction of the cabinet.

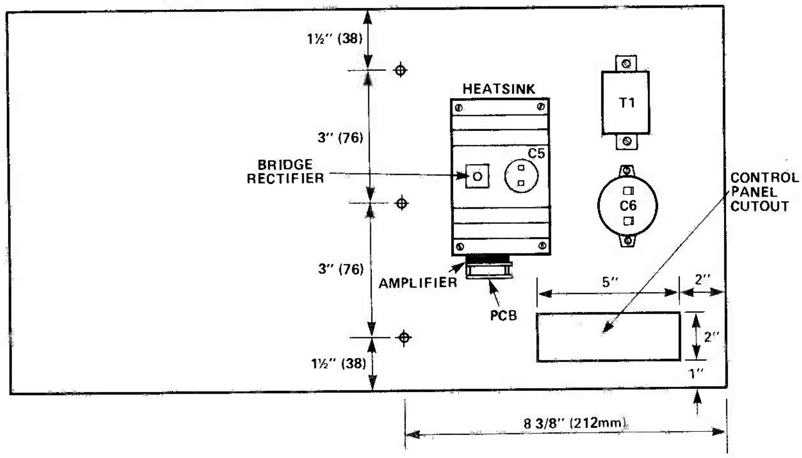


Fig. 6 The positions of the principal components on the rear panel.

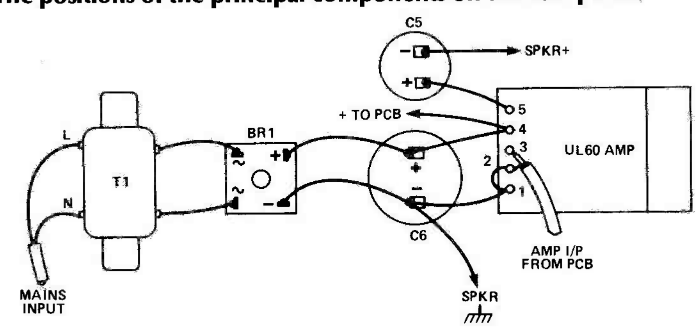


Fig. 7 Interwiring of the rear panel components.

be tightened into their countersunk holes until the heads are just below the surface of the wood.

Cut out a suitable piece of aluminium to form the control panel and drill holes to suit the potentiometer and input socket you plan to use. Wire these leaving 9" or so of free lead, drill suitable mounting holes in the rear panel of the cabinet and attach the control panel using self-tapping screws. Cut the free lead to length and solder it to the appropriate points on the PCB.

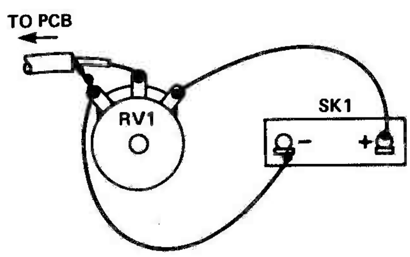


Fig. 8 Wiring of the components on the control panel.

Drill a ¼" (6.3mm) hole in the rear panel, thread the mains lead through it and use a 'P' clip or other

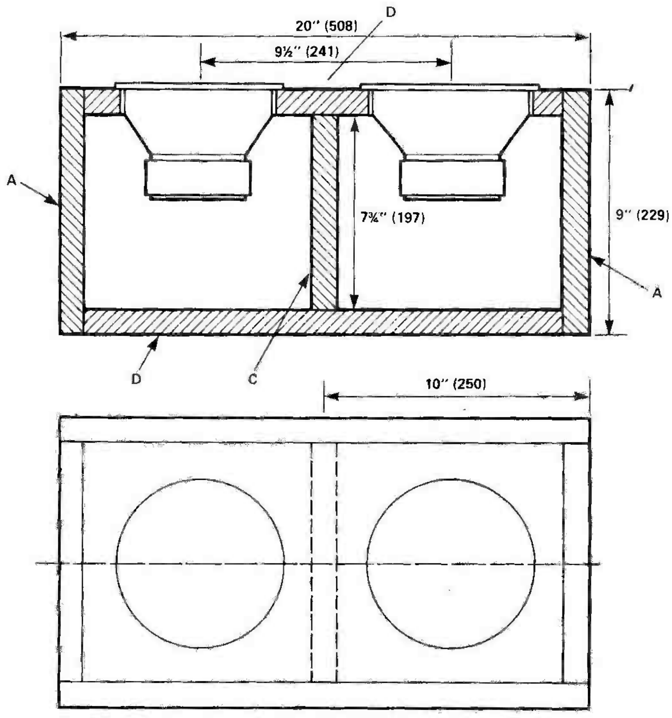


Fig. 9 Front panel and drive unit mounting details.

retaining device to provide strain relief. Don't just tie a knot in the cable! Seal the hole around the cable with a suitable glue or filler so that the finished cabinet will be air-tight. Complete the rear panel wiring by soldering leads to C5-ve and ground and leave the ends of these long ready for connection to the drive units.

Attention can now be turned to the front panel. Mark out the positions for the two drive units and use the template provided with them to mark the cut-outs and the mounting holes. The drive unit apertures can be cut by hand but it is much quicker to use a jig-saw attachment on a power drill. If the B200s are used, note that they are provided with 'T' nuts and drill the mounting holes out to ¼" to accomodate these.

Assemble the prepared front panel into the cabinet and glue and screw it into place. Draw out the loudspeaker leads through one of the drive unit apertures, solder them onto one of the drive units and solder a second pair of leads in parallel. Return this second set of leads into the cabinet, pass them throught the hole previously drilled in the central partition and draw them out through the second drive unit aperture. Solder them onto the second drive unit, taking care to observe phasing, and the internal wiring is complete. The unit should be left in this condition, with the drive units connected but not installed in the cabinet, while the initial testing is carried out.

Connect a lead to the input of the Neptune and fit a plug to the mains lead. Set the potentiometer on the control panel at minimum and switch on. Apart from the switch-on 'plop' no noise should be heard unless the ear is placed very close to one on the drive units. If there is no 'plop' or worse, if a loud hum appears, switch off immediately and check the wiring.

If all is well, advance the potentiometer towards maximum and touch the signal input terminal. This should produce a loud buzz. Again, if nothing happens, switch off and check the wiring carefully.

If this test, too, is successful, mount the two drive units in place. Don't forget to use the gaskets provided so as to ensure an air-tight seal. When this has been done, gently press one of the drive unit cones inwards using even pressure around the voice coil. The other cone should move outwards. If it doesn't, check carefully around the cabinet until you find the air leak responsible and plug it.

Installation

No mains switching has been provided on the Neptune because most modern stereo amplifiers are equipped with mains outlets and it is intended that one of these should be used. Such mains outlets are usually wired through the amplifier's on-off switch, so connecting the Neptune in this way removes the need to switch it on separately every time the stereo system is used. If your amplifier has such a socket, it is merely necessary to fit the appropriate plug to the mains lead, the most usual type being a shaver plug or an American-style twin flat-pinned plug. Leave about three metres or so of mains lead on the Neptune so that you can experiment with its positioning.

If your amplifier does not have a mains outlet, you will either have to fit an on-off switch to the Neptune or settle for plugging and unplugging the mains lead each time you use your stereo system. A mains switch could be added quite simply by enlarging the control panel slightly. Whichever approach you use, if the Neptune is switched independently of the amplifier you should always switch the amplifier on first and then the Neptune, never the other way around.

Connecting the input of the speaker to the output of your amplifier should pose no problems. With any luck you will have press-terminals on the amplifier into which the extra pair of leads can easily be inserted. If not, you will either have to make up an adaptor or add an extra socket on the back of your amplifier. Remember that you only need a connection from one channel of the amplifier and that it doesn't matter which one.

To set the unit up you will need a source of some description, preferably one offering signals containing male speech. A radio tuner set to Radio Four is probably best. Adjust the potentiometer on the control panel until there is no trace of 'boomyness' on the speech, then try the unit out with a music source. The bass response should have improved dramatically.

Experiment with the position and gain of the Neptune until you are satisfied with its performance. Remember that the best position is likely to be against the wall and floor and away from corners. **ETI**

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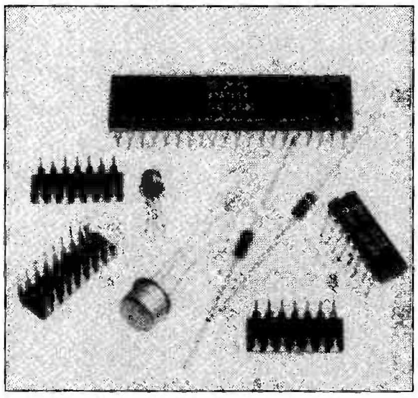

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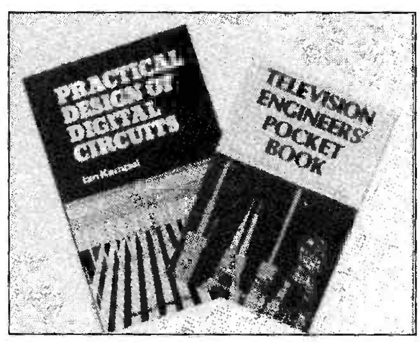

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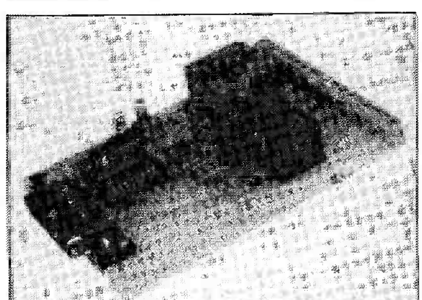

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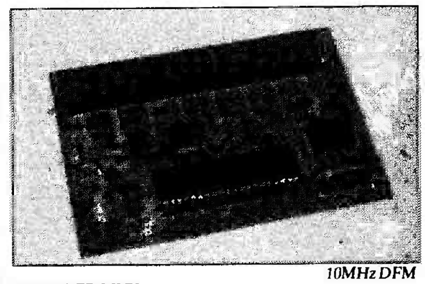

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ETI1

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IC RELIABILITY

How reliable are standard ICs? What makes them not work properly?

Conventional wisdom has it that, after early failure, ICs are by and large pretty damn reliable. However, that doesn't mean that there aren't rogue or 'problem' devices — for example, see the telex reproduced here, about a device which was successfully used by a contributor to 'Electronics Monthly', but which has subsequently been withdrawn by the manufacturer.

```
84-10-30  14:21
*
8811896ASP G
23272  GIMOST G
30 OCT 84    ATTN: H ARMSTRONG    TLX LON 3505

REF: AY-3-1270
REGRET TO INFORM U THAT I AM UNABLE TP PROVIDE U WITH A SOURCE FOR
ABOVE PRODUCT DUE TO REASONS OF DEVICE RELIABLITY.

RGDS  I MCCALL
JW
NNNN*
8811896ASP G
23272  GIMOST G
```

Elsewhere in this issue, we carry details of a 'fix' for our original 64k DRAM card. This 'fix' was made necesary because we had a number of readers telling us that they couldn't get the dratted thing to work, and we couldn't get one that we had recently built ourselves to go — even after ammending the PCB in a couple of places!

Added to this we also had informal indications (ie, nothing you could quote anyone on) that the DRAM controller IC, 74LS608, was a 'problem device'. So what makes a 'problem device'? We talked to Texas Instruments, the manufacturers of the device in question, to find out their side of the story.

Firstly, no one was aware of a specific problem with the '608, and we wouldn't identify the person who had told us that it was a 'problem device'. Although they could not locate any documentation to confirm it, there was the suggestion that there might have been some revisions to the die at a relatively early stage in the production run.

Looking at the DRAM card circuit, TI's engineers were not that happy about the delay sections formed by R1, C1, D1 and R2, C2, D2. The problem is that IC17a and b, the devices that immediately follow the delay circuits, are not Schottky devices, so the rise times from them would not be particularly fast, and this could cause problems with edge-triggered inputs. However, this was unlikely to be the cause of the problem here.

We then discussed the problems associated with the power-up of this and any other MSI device. This discussion was prompted by the section in the original article which suggested that some earlier production devices may have had problems with the power-on reset circuitry (which ties up with the suggestion that there may have been some revision of the die).

One of the problems with this and other computer add-on projects is that it is not possible to predict how power will be applied to the circuit — for instance, it may come on very quickly, there may be transients associated with ringing (although we hope that this sort of problem would be dealt with by most monolithic regulators), or the power might come on very slowly. The last of these is one possible cause of the problems with the DRAM card.

Different sections of a large or medium scale integrated device will start to function at different supply voltages. So if the supply voltage builds up very slowly after switch-on, it is possible, even likely in some cases, that fault conditions will develop that lead to a latch-up which will persist even when full power is applied to all sections.

Another problem is associated with ringing on input (or even output) lines. Readers will know how easy it is for a square-wave to acquire ringing — all it takes is a little unwanted inductance here, a little stray capacitance there, and bingo!, the square wave is ringing like Big Ben!

In a TTL (or CMOS) circuit, this can cause havoc. The problem is that the ringing excursions can take the input (or output) voltage above or below the positive or negative supply lines, respectively. This is a more manageable problem in discrete component circuits, because you always know what the real circuit is; however, with integrated circuits, there are always parasitic devices; eg transistors or thyristors, that have

The TI Scare

Readers will remember that a little while back, it was alleged that possibly faulty chips had been sold on defence contracts. Quite a stir was created, with the story making the evening TV news and front pages of several papers.

The truth is a little more mundane, but in its own way equally alarming. According to a letter in the trade press (Electronics Times, 25 Oct) from Peter Van Cuylenburg, TI's MD, the ICs were properly tested. However, the tests did not conform to those laid down in the specifications for the devices, but, according to Mr Cuylenburg and to the Pentagon, the tests carried were actually *more* appropriate to the way the devices were to be used than the tests laid down in the specification.

However, no-one has yet explained how the wrong tests came to carried out and how it came to be that this was not picked up at a much earlier stage. This failure is, if anything, considerably more worrying than a few rogue devices finding their way into the system.

been produced inadvertently while making the wanted devices. This is as a direct consequence of all the devices on an IC being made on the same piece of silicon, and much of the design effort in laying out an IC is devoted to avoiding problems from parasitic devices.

The objective will be to ensure that, under normal operating conditions, the parasitic devices will all be biassed off. However, input and output conditions which exceed the supply lines — such as occur with ringing — can cause a parasitic device to come on, leading to the generation of a false logic state, or even to complete latch-up.

For example, some MOS DRAMs are very sensitive to over-shoot and under-shoot, and will latch up completely due to the presence of parasitic thyristors. However, so long as the signal lines do not exceed the supply lines, these devices will be perfectly reliable.

Whilst we're on the topic of supply lines, another problem is that they tend to be rather noisy, particularly in TTL circuits where fairly high currents are being switched. For this reason it is not good practice to tie any IC inputs to the positive supply line — although we all do it. The safest option is to design around this in the first place, where this is possible, but otherwise tie inputs to the output of a spare gate, or use a pull-up resistor. Again, this is a particular problem with edge-triggered inputs, where noise on the supply line can lead to false triggering.

So do problem devices exist after all? TI are confident that all their devices meet the published specifications. That said, there will inevitably be some devices that will be rather more sensitive to circumstances of their use than one would like. Obviously, when introducing a new device, a semiconductor manufacturer cannot imagine — let alone test — all possible applications or circuit lay-outs. Basically, it is all too easy to inadvertently exceed the specification of an IC without realising it, and it will be only after extensive testing that you will find out what is going wrong. Fortunately, most devices are reasonably tolerant of minor violations on most of the specs.

Meanwhile, TI and ourselves will be investigating the 64k DRAM card further, to see what has been causing the problem. We'll let you know of the outcome when we have something to report.

ETI

IC Testing

The testing that a standard IC goes through lasts all the way through its production process, and begins even before the wafer on which it is made is fabricated. The selection of materials, the growing of the crystal, the slicing of the crystal up into wafers and the growing of an epitaxial layer on the wafer are all closely monitored.

At every stage of the diffusion of dopants into the wafer checks are carried out on the resistivity of the silicon — obviously, this is influenced by the amount of impurity which has been absorbed.

Next, checks are performed on the test geometries that are placed on each wafer for no other reason. If you see a wafer before it is sliced up, you will notice that four or so dies are actually different from the rest — these are the test geometries, and simple go/no-go measurements can be carried out on these to detect gross faults.

The finished wafer then passes to a test bed where each die is tested as follows:
1. Basic electrical test;
2. Truth table check (does it do what it is supposed to do?);
3. Functional test (does it work in a circuit?)
4. Parametric test (does it live up to the fine print in the data sheet?).

Any dies that fail this test get a red dot of ink, and are discarded at the next stage, where the wafer is sliced up into dies and packaged. After packaging, every single IC goes through the same test programme again. Only after this do the ICs get 'symbolised' (ie, labelled).

The next stage is only carried out on military equipment or on larger dies, eg microprocessors; this is testing at an elevated temperature, and temperature cycling. This tests for two things: firstly, it will check to see that the die is properly mounted, otherwise the expansion and contraction will detach it; and it also accelerates early failures.

In fact operating at an elevated termperature greatly decreases the life of all devices, and one of the quality control tests that a competent manufacturer will be doing is testing samples of all devices at an elevated temperature to see how long they last. This can then be extrapolated back to devices used at normal temperatures to see if there is any sort of longevity problem with them.

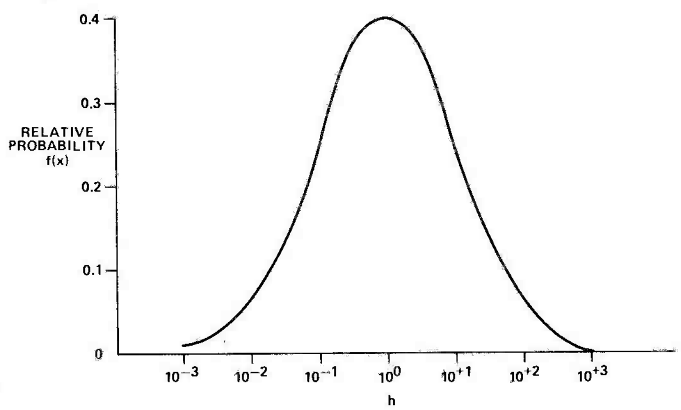

Fig. 1 Typical IC failure rate against time — the actual time-scale will vary, though.

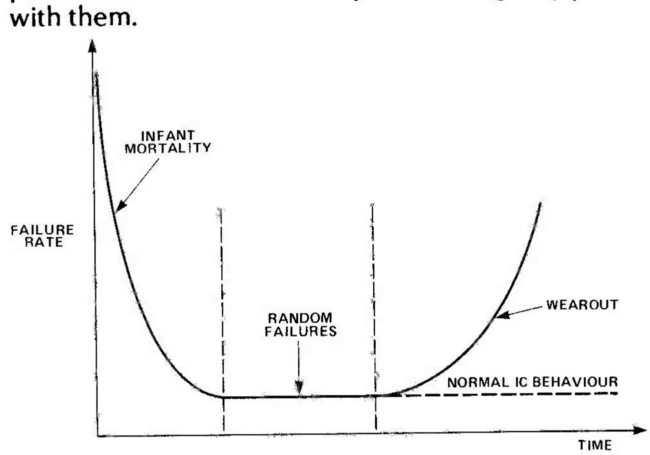

Fig. 2. Long-term failure rate — electronic components should not wear out unless there are problems.

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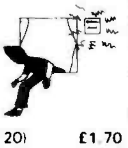

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IR GARAGE DOOR CONTROLLER KIT

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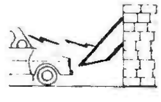

Lots of applications like controlling lights and TVs, etc. in the home. Ideal for aged or disabled persons, this coded kit comprises of a mains-powered infra-red receiver with a normally open relay output plus two latched transistor outputs, battery-powered transmitter and opto-isolated solid state mains switch.

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XK105	Extra transmitters	£10.50

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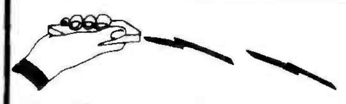
INFRA-RED REMOTE CONTROL KITS



These kits are designed to enable infra-red remote control to be incorporated into virtually any application from switching car locks or alarms to controlling Hi-Fi or TV. The application will determine the interface circuitry between the receiver and the controlled device. General instructions and applications are supplied. The kits are coded and provide a high degree of security and noise immunity.

MK 18 Transmitter Kit — for use with MK11/MK12 receivers. Requires PP3 battery. Size: 8 × 2 × 13cms. Range approx. 60 ft. £6.80

Keyboards for MK18

MK9	4-way for use with MK12	£1.90
MK10	16-way for use with MK12	£5.40
MK13	11-way for use with MK11	£4.35

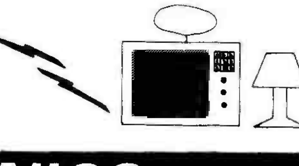
MK11 Receiver Kit — mains powered. Provides 10 latched plus 3 analogue outputs ideal for controlling audio amplifiers, TV or lighting where control of light brightness is required. £13.50

MK14 AC Power Controller Kit — for (phase) controlling AC loads from MK11 analogue outputs, eg lamp dimming. £5.20

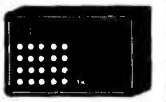
MK19 Stereo Amplifier Controller Kit — for remote control of bass, treble and volume (or balance) by MKII. Includes a one of 10 decoder remote channel or input selection. May be connected between the pre-amp and power amp of almost any audio system. £10.70

MK12 Receiver Kit — mains powered with 16 latched or momentary outputs. Latched version is for applications requiring one output on at a time, eg TV channel selection. Momentary type gives an output only during transmission. Lines may be latched as required. Size: 9 × 4 × 2cms. £13.50

MK15 Dual Latched Solid State Relay — for switching mains loads such as lamps, TVs, etc, from the outputs of the MK12 (momentary). 15 items may be switched independently using 8 MK15s. Triacs (not supplied) switch at mains zero to reduce interference. £4.50



MICROPROCESSOR TIMER KIT



Designed to control 4 outputs independently switching on and off at preset times over a 7-day cycle. LED display of time and day, easily programmed via 20-way keyboard. Ideal for central heating control (including different switching times for weekends). Battery back-up circuit. Includes box. 18 time settings

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Complete kit (except front panel)
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TS300K	Touch Switch	£7.75
TDE/K	2-way extension for above kits	£2.50
LD300K	Rotary controlled Light Dimmer	£3.95

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DL1000K — This value-for-money 4-way chaser features bi-directional sequence and dimming. 1kW per channel. **£15.95**
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Optional opto input allowing audio 'beat'/light response (DLA/1) **70p**
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MK5	Mains Timer	£6.50
MK6	Infra Red Transmitter	£4.50
MK7	Infra Red Receiver	£10.50

All kits include PCBs, components and assembly instructions.
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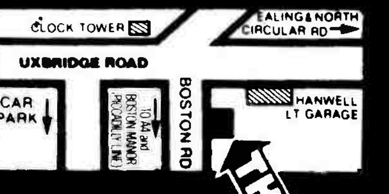

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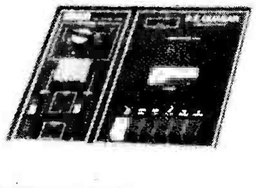

Noise Reduction System
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Kit includes tape transport mechanism, ready punched and back printed quality circuit board and all electronic parts i.e. semiconductors, resistors capacitors, hardware top cover, printed scale and mains transformer. You only supply solder and hook-up wire.
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SPECIFICATIONS:
Max. output power (RMS): 125 W. Operating voltage (DC): 50 - 80 max. Loads: 4 - 16 ohm. Frequency response measured @ 100 watts: 25Hz - 20KHz. Sensitivity for 100w: 400mV @ 47K. Typical T.H.D. @ 50 watts, 4 ohms: 0.1%. Dimensions: 205x90 and 190x36mm.

KIT **£12.00** +£1.15 p&p. BUILT **£17.50** +£1.15 p&p.

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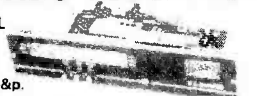

This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with PE (July 81) For ease of construction and alignment it incorporates three Mullard modules and an I.C. IF System. Front scale size 10½"x 2½" approx. With diagram and instructions.

MONO MIXER AMP

Ideal for halls and clubs.
£45.00
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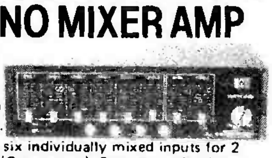

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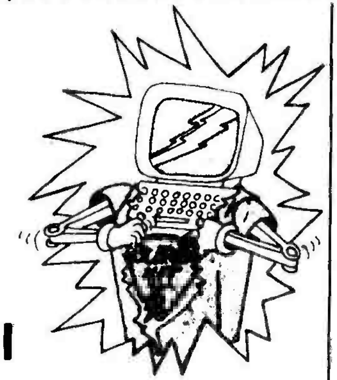

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DRAM BOARD UPDATE

Ahh! Doesn't it take you back to the balmy days of September 1983 when ETI first published its 64K DRAM board? The sheer technical excellence of the design, the excitement as you completed your very own memory card, the horror when you found it didn't work. Never mind, says Phil Walker, memories are re-made like this....

In September 1983 we ran a design for a 64K DRAM board to connect to the Microtan 65 system or indeed any 6502 processor system. Although the original worked satisfactorily we received a number of letters from readers who could not get theirs to work. At first it looked as though there was a faulty batch of the 74LS608 controller chip around which the design was based but after a while it became apparent that it was "a problem device".

To overcome the shortcomings of the original design and to simultaneously incorporate some new features, last month's Experimenter's DRAM Card was designed. This removed the need for special ICs by using standard components. The only unusual items were the 4416 16K x 4 bit dynamic RAMs which were used because they allowed the PCB to be only partially populated when a significant proportion of the address space was not required.

Once this board was working on the author's 6502 system — which runs at 1.25MHz, a little faster than the tangerine — it seemed reasonable that we should go back and do something for all those people who had built the 1983 project. To this end we have designed a small PCB which contains all the necessary control logic to replace both the 74LS608 and two other devices on the original board.

This PCB is mounted 'piggy-back' fashion on the PCB once all the original control ICs and timing components have been removed.

All the original features relating to address space allocation are retained and the same PROM can be used. One thing which may be of interest to non-Tangerine users is that there is no longer any need for the φ1 signal to be provided as all timing is taken from the edges of the φ2 signal.

The Circuit

This is identical in most respects to the control logic in last month's project. One significant difference is that the incoming select signal from the PROM is high to enable rather than low. However, since

HOW IT WORKS

This is very much the same as for last month's Experimenter's DRAM Card project but we shall go through it briefly in relation to the original design.

All timing is performed relative to the rising and falling edges of the φ2 signal from the 6502 processor. φ2 is buffered by IC22a and by means of the delays in IC22b, C21 and 22. IC23 is triggered on both edges of 02 to produce the RAS pulse. The width of this pulse is controlled by RV21 in conjunction with C23 and R23.

A delayed version of the RAS signal is used as the MUX signal to operate the row/column address multiplexers. Shortly after this IC24a is clocked, and if φ2 is currently high and the inverted SEL line is low, the CAS output will go low and stay low until φ2 goes low at the end of the processor access period. This keeps the data at the outputs available for longer when a read cycle is required. If φ2 was low then the CAS output will stay high and a refresh operation will occur.

If all other conditions for a processor access cycle have been satisfied, to write data to memory the R/W line will be low. This condition is gated with the state of the inverted φ2 signal in IC22c and with the MUX signal in IC22d. This ensures that the WE low condition is only asserted at the requisite time.

At the end of each RAS pulse IC24b is clocked to sample the state of the φ2 signal. The outputs of IC24b are used to enable and disable the address buffers and allow the processor or refresh addresses onto the memory chip address pins at the appropriate times. Doing it this way rather than with the φ1 and φ2 clock signals allows more settling time for the buffers and the refresh address counter before the RAS strobe occurs to start the next operation.

The last piece of circuitry to describe is the power-on-reset. This is produced by IC1b and c together with C25 and R21. D21 allows C25 to discharge rapidly when the power is turned off. By means of this circuit, IC23 and 24b are held in a defined state for a short while after power is applied. This allows the internal circuitry of the memories to become operational. This operation is required when power is applied, not when the processor is reset. Note also that eight RAS only cycles should by performed after the power-on-reset before the memories are fully operational. However this will usually be taken up by the system initialisation routines reading from ROM.

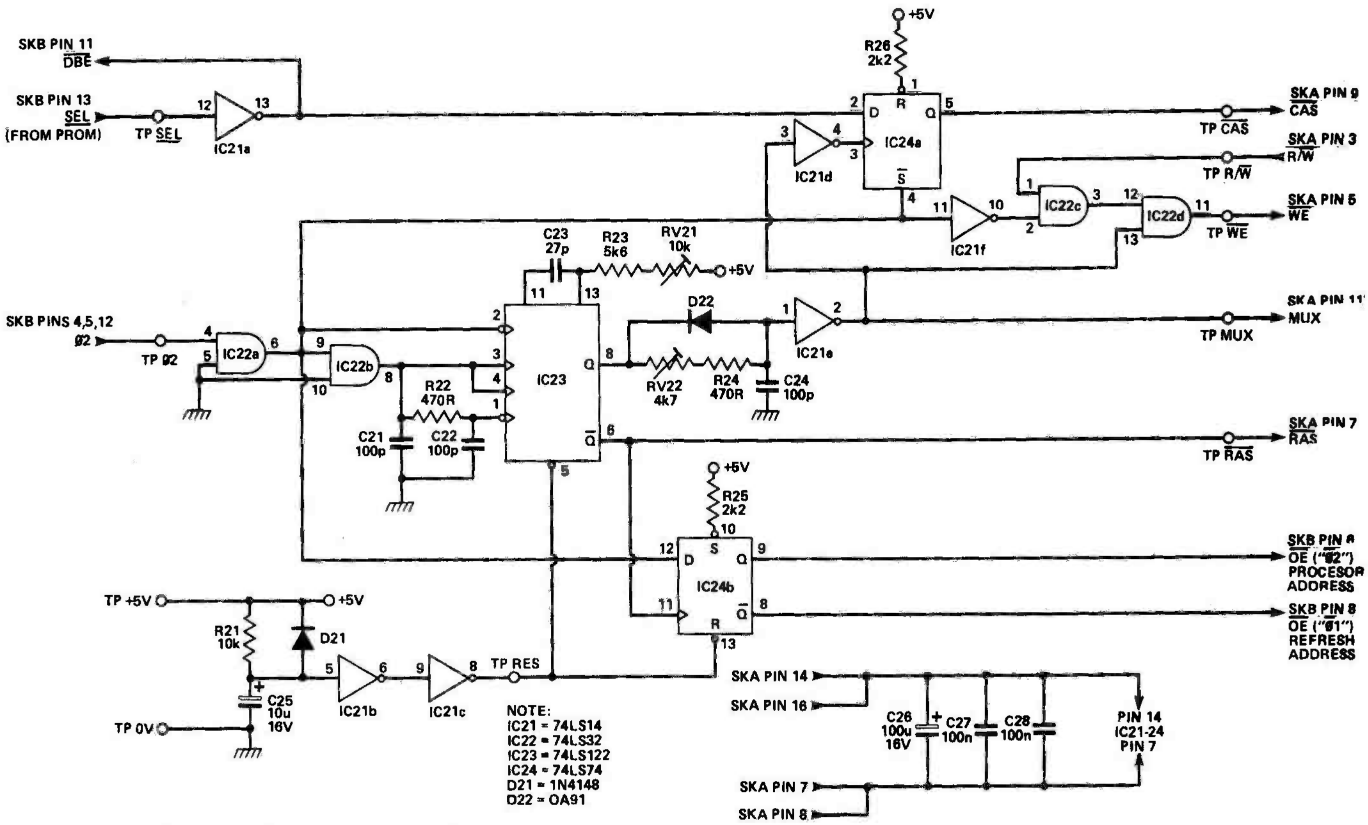


Fig. 1 Circuit diagram of the new control logic.

there is no G pin on the 4164 devices, the inverter which previously provided this signal can now be used to invert the SEL line and enable the data buffer at the appropriate time.

The other difference is in the WE circuitry. The lack of the G pin on the 4164 means that, if we want to connect the data - in and data - out pins of the memory chips to the same data bus as in the original design, the write cycle must be the so-called 'early write' detailed in the data sheet. This requires that the WE signal go low before the CAS signal goes low. If this is not done the data outputs of the memory chips will become active and may try to drive the data bus into a state opposite to that of the bus buffer.

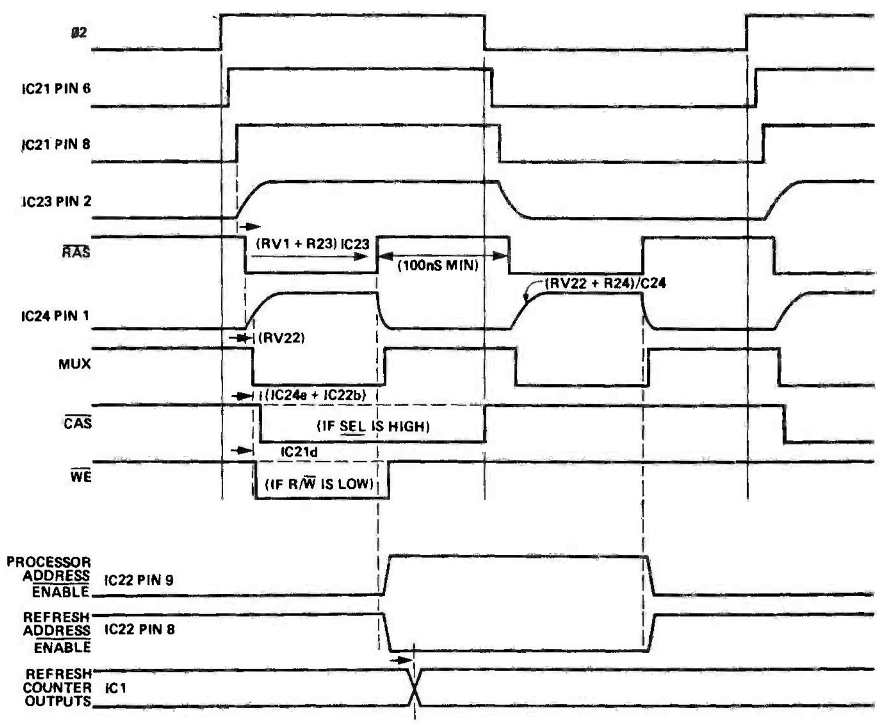


Fig. 2 Timing diagram for the control logic showing how all of the signals are derived from $\varphi 2$.

Construction

Construction of the PCB itself is quite straightforward. Remember that there are four wire links to be inserted as this is a single sided board. If height is likely to be a problem then solder the ICs directly into the PCB but otherwise use sockets. The other components are simple to install but the usual care should be taken to get polarities correct.

Assembly onto the main board should be postponed until the add-on board has been tested. You will need access to a signal generator giving a 1MHz TTL compatible square wave signal and an oscilloscope with which to see the results.

Connect a suitable +5V supply to the board and check that the current drawn is not more than

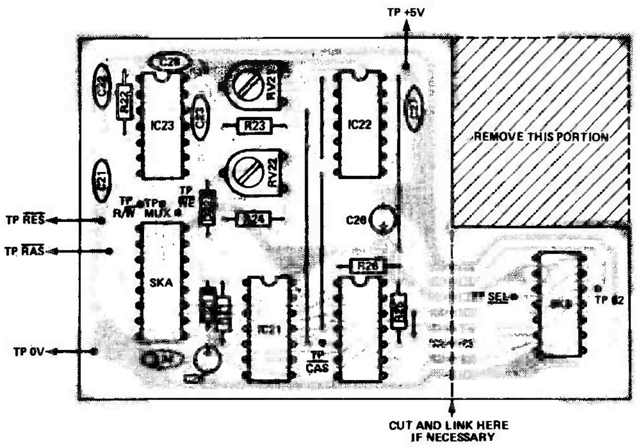


Fig. 3 Component overlay of the PCB.

100mA or so. Connect the SEL testpoint to 0V and a 1MHz square wave TTL compatible signal to the φ2 test point and monitor the signals on the RAS, CAS and WE test points. Only RAS should show any activity at this stage and its low time should be set to about 300ns by means of RV21 (one half to three-quarters clockwise rotation). Both the CAS and WE signals should be high. A worthwhile check at this stage is to see that SKB pins 6 and 9 are switching at the same rate as the φ2 signal but phase shifted from it. Also check that the MUX signal at SKA pin 11 is similar to the RAS signal but slightly delayed from it (RV22 should be set to approximately one quarter of its clockwise rotation). Note that the RAS and MUX signals are at twice the φ2 frequency.

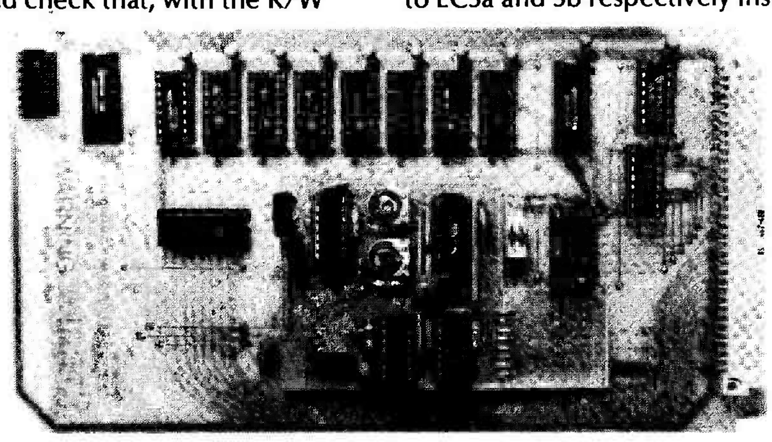
So far we have checked that IC21e, 22a & b, 23 and 24b are working. Now set the SEL test point to +5V, or just open circuit the link you previously inserted, and check that the CAS test point shows low pulses but only while φ2 is high. The RAS to CAS delay time can be adjusted by means of RV22 if required but will only be critical if you have a slow processor.

There are only two other sections to check. Monitor the WE output and check that, with the R/W input open circuit or logic high, this output is also permanently high. Applying a logic low or 0V signal to the input should cause the WE output to produce a series of low pulses, at the same rate as φ2 but with the same width as the MUX low signal. The WE pulses should only occur when φ2 is high.

The last thing to check is the power-on-reset. If possible, monitor the RES test point and the voltage across C25. Temporarily short circuit C25 and check that the test point stays high for a few milliseconds after the short is removed.

By now you should have a fully tested board and will be ready to connect it to the original DRAM. First disconnect all the wires you used in the testing phase and connect 22 SWG tinned copper wires to the SKA and B positions. Cut these off flush with the top side of the board but leave them about 25mm (1 inch) long on the wiring side.

Next remove IC16, 17 and 18 from the original PCB together with their sockets and R1 to 6, C1 to 6 and D1 to 3. If you have not corrected the original PCBs you should now connect IC1 pins 2 and 12 to 0V, IC3 pin 9 to IC4 pin 9 and the tracks going to EC2a and 2b to EC3a and 3b respectively instead.



PARTS LIST

RESISTORS (¼ watt 5% carbon film)

R21	10k
R22, 24	470R
R23	5k6
R25, 26	2k2
RV21	10k miniature horizontal preset
RV22	4k7 miniature horizontal preset

CAPACITORS

C21,22,24	100p silver mica or polyestyrene
C23	27p silver mica or polystyrene
C25	10u 16V tantalum bead
C26	100u 6V tantalum bead
C27, 28	100n ceramic disc

SEMICONDUCTORS

IC21	74LS14
IC22	74LS32
IC23	74LS122
IC24	74LS74
D21	1N4148
D22	OA91

MISCELLANEOUS

PCB; 4 off 14 pin DIL Sockets if required; thin sheet of insulating material.

In order to fit the PCB into the Microtan rack we found it necessary to remove C7 and trim the through-board link near IC1 pin 14.

Having done all necessary corrections, the time has come to put the two PCBs together. First remove all of the ICs from both boards and put some thin insulating sheet under the new PCB to prevent shorts to tracks on the top of the old board. Now carefully feed the wires from SKA through the holes vacated by IC16 and the wires from SKB through those left by IC18. Make sure that none of the wires are misplaced or strained and carefully ease the two PCBs as close as possible to each other. Solder the wires on the underside of the old PCB and clip off excess length.

Insert all ICs (except 16, 17 and 18) and the assembly should be ready for use. If necessary, some adjustment may be made to RV21 and RV22 but this will usually not be necessary if the other stages have been carried out.

ETI

BUYLINES

Absolutely everything here is readily available from any number of different suppliers and the PCB is available from our PCB service.

THE OTHER END OF THE SCALE

Single-bit microcomputers are alive and well - and will soon be living in your washing machine or TV. James McGuigan, System Engineer at Motorola Semiconductor Products Sector, East Kilbride, introduces the MC6804P2 single - chip microcomputer.

Single-chip microcomputers are set to invade our homes! Like Greek warriors, they'll be hiding inside Trojan horses, although these horses will look more like washing machines and TV sets.

Actually, it's all very logical and nothing to worry about. Mechanical controls are unreliable and expensive to make, and for some time electronic controls have been replacing them in a large range of applications. What could be more logical than using a single-chip microprocessor to replace a board-full of TTL or CMOS, and, at the same time, upgrading the 'intelligence' of the control unit.

This invasion will be self-reinforcing: the more devices use the single-chip microcomputers, the cheaper and better known they will become, and so more devices will use them. Prime targets will be TVs and videos, games, toys, cameras, motor vehicles, power tools and domestic appliances. For example, the device here could be used to control a TV set, tuning in the channel selected via a phase-locked loop, controlling the sound level by a voltage-controlled potentiometer, and accepting instructions from a remote control unit.

Motorola's involvement in single-chip microcomputers started with them second-sourcing MOSTEK's MC3870. Motorola's first 'home-grown' single-chip device was the MC6801, which was on the market in 1978.

As you might expect, the MC6801 had quite a lot of the same circuitry the MC6800 microprocessor - why re-invent the wheel when you can use something that you know works? Additional circuitry included program memory (ROM) and data memory (RAM), besides input/output ports, a serial communications interface and a multi-function timer.

In 1979, the availability of improved chip fabrication techniques allowed the size of the chip die — the actual piece of silicon on which all the clever stuff is mounted — to be reduced. The technology used is refferred to as HMOS (High density n-MOS) and involved the use of interconnections on the silicon of 3.9 um width (by comparison, Motorola are presently preparing themselves to use tracks of 1 um or smaller). The size of the die makes quite a difference to the price of the final IC, so this change allowed the price to fall.

Also in 1979, Motorola introduced the MC6805P2. This was essentially a development from the 6801; it had been found that most applications did not require as sophisticated a register set as the 6801 provided, and so these were reduced. The RAM and ROM were reduced in size, and the timer was simplified, and the serial interface was dropped.

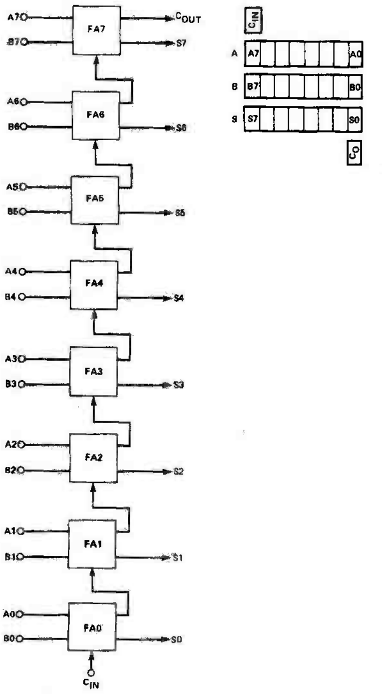


Fig. 1 Eight-bit parallel adder with ripple-through carry.

There are now a series of devices in the 6805 family, all with different bells and whistles added to make them more appropriate to particular control or other applications.

All Change

The MC6804P2 represents a major change in direction for Motorola's single-chip computers. Not only has any resemblance to the 6800 been abandoned, but the whole basis for the architecture has been changed. The major difference is that the 6804 uses serial rather than parallel architecture. However, Motorola have managed to work the trick of making the 6804 appear to be an eight-bit device to the user. The whole purpose of this is to reduce the die size, which, as we've already observed, reduces the cost of the finished IC. Let's take a closer look at what having serial architecture actually means.

Conventional microprocessors manipulate data in lots of eight bits, ie bytes. For example, the central processing unit (CPU) and data bus are eight bits wide. An address bus and program counter (PC) of 12 bits wide can access up to

4096 bytes (4K) of data.

With the 6804 family all the hardware is actually only one bit wide. All data transfers, arithmetic and address operations are carried out serially one bit at a time. This means that the CPU, data bus, address bus, program counter, timer and prescaler are all only one bit wide.

Consider, for example, an eight-bit arithmetic and logic unit (ALU). Within this ALU we have an eight-bit adder to add two eight-bit numbers A and B (and possibly a carry-in bit as well). The adder will have eight sum bits and a carry-out bit as its output.

The eight-bit adder will be made up of eight separate single-bit full adders as shown in Fig. 1, which shows a 'ripple-through' adder configuration. First of all the least significant bits A0 and B0 are added to Cin. The sum appears at SO and any carry 'ripples' through to be added to the sum of A1 and B1. This carries on until the eight-bit sum of A and B is calculated.

The eight-bit adder described above uses eight single-bit full adders plus three registers to hold A, B and their sum — this is a lot of hardware and consequently expensive. However, it is possible to make do with just one single-bit full adder as shown in Fig. 2. This serial adder is made up of one single-bit full adder, three shift registers and a D-type flip-flop.

When two eight-bit numbers are to be added, they are loaded into shift registers A and B. The least significant bit is to the right and the most significant bit is to the left. On each clock pulse, registers A and B are shifted one bit to the right. The bits which 'fall out' of the registers provide the inputs to the adder along with Cin. The adder's sum output is shifted into the SUM shift register. Any carry from this single-bit addition is latched by the D-type flip-flop.

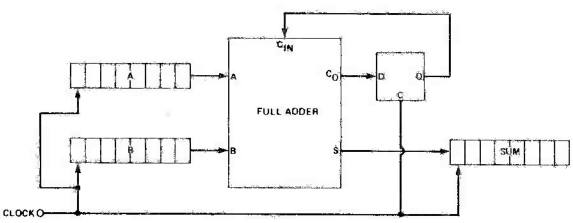


Fig. 2 Eight-bit serial adder using only one full adder.

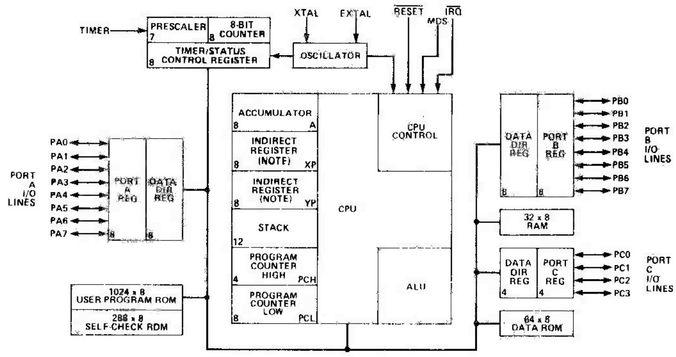
Obviously, the serial method is somewhat slower but there is an enormous saving in hardware and, consequently, space. Consider now the above principles applied to microprocessors. If we can reduce the amount of on-chip hardware then considerable savings can be made in chip size. A smaller chip size means that more can be fabricated on to a silicon wafer. In turn, this means increased productivity and cheaper processors.

Of course, the serial approach is always going to be slower than parallel design but there are many applications in which speed is not critical. In any case, with the 6804 provision has been made to permit the use of very high clock speeds: the maximum external oscillator frequency for the 6804P2 is 11MHz.

The following description applies mainly to the MC6804P2 version with mask-programmed program ROM; however, the soon to be released MC68705P3 EPROM version is similar to the point of pin-compatibility. Also, a wide range CMOS (as opposed to NMOS) devices are planned and these will also be very similar.

In More Detail

Figure 3 shows the MC6804P2 block diagram. The CPU contains the ALU, control, stack and registers. Memory consists of three areas: program ROM (1K), data memory (64 bytes ROM and 32 bytes RAM) and the stack. The timer circuitry is made up of prescaler, counter and control



NOTE. 8-BIT INDIRECT REGISTERS XP AND YP, ALTHOUGH SHOWN AS PART OF THE CPU, ARE ACTUALLY LOCATED IN THE 32 x 8 RAM AT LOCATIONS S80 and S81

Fig. 3 MC6804P2 block diagram.

registers and oscillator circuitry. The 6804P2 also has 20 versatile I/O lines.

The CPU is similar to that of the 68705P3. However, there are some differences. The eight-bit accumulator is memory-mapped at address $FF and has indirect registers which replace the index register on the 68705P3. The indirect registers are memory-mapped at locations $80 and $81.

There are only two condition code flags on the 6804P2, C and Z, and there is no condition code register. The flags used for normal processing and interrupts are different. With interrupts, the processor automatically uses the interrupt-mode flags and, on return from interrupt, the normal-mode flags are used. Previous flag states will be used when switching from one set to another.

The stack is used to store subroutine and interrupt return addresses. It is a hardware stack, 12 bits wide and four levels deep (ie equivalent to a 48-bit shift register). Its last-in, first-out (LIFO) configuration eliminates the need for a stack pointer.

A crystal, R-C network or external signal can be used to generate the system clock. A mask option selects either the crystal or R-C network oscillator circuit.

The oscillator frequency is divided (internally) by four to produce the internal clock. This in turn is divided by twelve to produce a machine cycle. A machine cycle is the smallest unit needed to execute any operation and an instruction may need two, four or five machine cycles to execute.

To facilitate testing, a signature analysis circuit has been included on the chip. The circuit consists of two eight-bit shift registers (memory-mapped at addresses $OA and $OB) configured to perform a Cyclic Redundancy Check on the ROM. The CRC registers can also be utilised as a pseudo random number generator as a result of continuous CRC calculations being performed.

Memory

The 6804P2 has 1K of program memory which contains all instructions to be executed, immediate data and interrupt vectors. Figure 4 shows the 6804P2 memory map. Data space comprises 64 bytes of ROM for constants and tables, all 32 bytes of RAM and the I/O, timer and CRC registers. This configuration is different from the 68705P3 where program and data memory are combined in a von Neuman architecture (ie there is no distinction between program and data storage except that some areas — the EPROM sections — cannot normally be written to).

Note that only the PC is stored on the stack. Any other registers have to be saved in RAM by means of software and reloaded at the end of the subroutine or interrupt routine. On a stack push the bottom register always 'falls out' of the bottom of the stack. The stack should not be pulled more than four times in succession without any pushes.

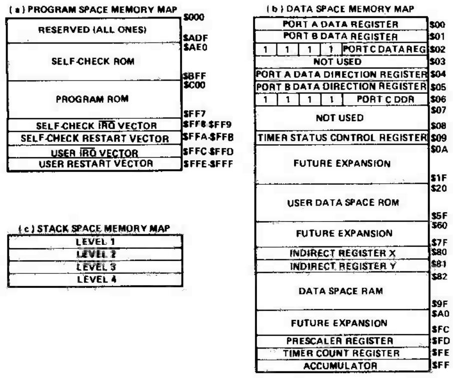


Fig. 4 MC6804P2 address map.

Timer

Timer circuitry for the MC6804P2 is shown in Fig. 5. The timer comprises an eight-bit timer counter register (TCR) with a seven-bit prescaler and a timer status control register (TSCR). These registers are all memory-mapped and are readable and writeable.

The TCR is clocked towards zero by the prescaler output. The prescaler is used to provide longer or shorter timer intervals by dividing the input clock. The prescaler tap is selected by bits 0-2 of the TSCR — giving a range of divide-by-1 to divide-by-128.

PSI, bit 3 of the TSCR, is used to initialise the prescaler (to $FF) and inhibit counting when logic zero. The TCR is also inhibited but its contents are unchanged. When PSI = 1 the prescaler begins to count.

Unlike the 68705P3, the 6804P2's timer can operate in both input and output modes. Bit 5 of the TSCR, TOUT, selects output when high and input when low.

As an input, the TIMER pin is connected directly to the prescaler input. Therefore the prescaler is clocked by the signal on the TIMER pin. The prescaler then clocks the TCR which sets bit 7 of the TSCR (TMZ) when it reaches zero. TMZ can be tested by software to perform a timer function whenever it goes high.

Operation in the output mode is somewhat similar to that for input mode. With TOUT = 1, the TIMER pin is connected to the DOUT latch and the prescaler is clocked by the internal sync pulse. The positive-going TMZ transition latches the DOUT bit and provides it as an output for the TIMER pin. Note that TMZ can be set by writing zero to the TCR or by setting TMZ directly.

Interrupt And Reset

Processing can be interrupted by applying a logic low signal to the IRQ pin. Whether the negative-going edge or the actual low level is sensed is determined by a mask option. With the 68705P3, however, we have a choice of three interrupts, external, timer and software. The flowchart in Fig. 6 gives a detailed description of 6804P2 interrupt handling.

On power-up the interrupt mask is set. This blocks any

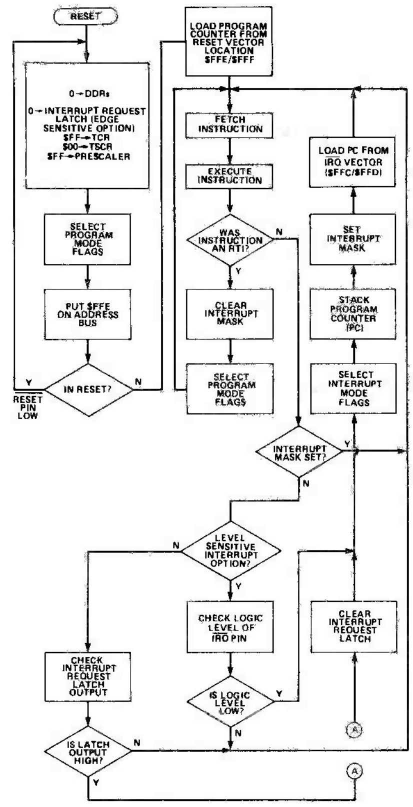


Fig. 6 Reset and interrupt processing flowchart.

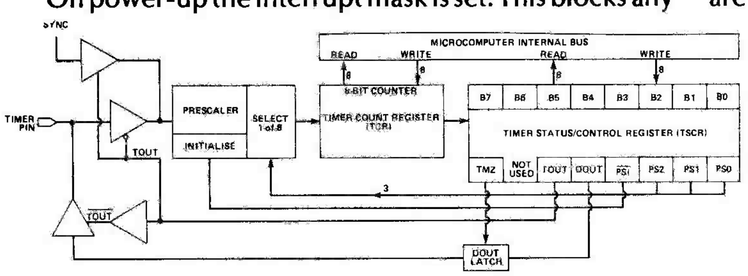
'ghost' interrupts from occurring. To clear the interrupt mask the programmer should jump-to-subroutine (JSR) to an initialisation routine as the first instruction in a program. This initialisation routine should be terminated with an RTI instruction instead of TRS since RTI will not only restore the PC, but will also clear the interrupt mask.

During power-up a short delay — to allow the internal oscillator to stabilise — is needed before allowing the RESET line to go high. The configuration in Fig. 7 provides sufficient delay.

Interrupt and reset vectors on the 6804P2 are actually JMP instructions to the interrupt or reset routine which are placed at fixed addresses in the Program ROM. With the 6804P2, a vector fetch forces an address value into the PC, whereas with the 68705P3 a vector fetch forces an address value directly onto the address bus. Figure 8 shows the manner in which resets should be programmed.

Input / Output Ports

All 20 I/O lines are programmable as inputs or outputs by setting the corresponding bit in the appropriate data direction register (DDR) low or high respectively. On reset the port data registers are not initialised but all ports are configured as inputs. To avoid undefined levels it is a



TIMER PIN STATUS

TOUT	PRESCALER CLOCK	TIMER PIN
0	TIMER PIN	INPUT MODE
1	SYNC	OUTPUT MODE

Fig. 5 Timer block diag

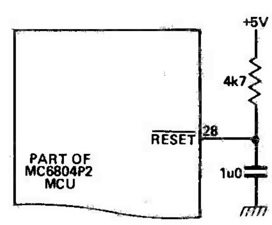


Fig. 7 Power-up reset delay.

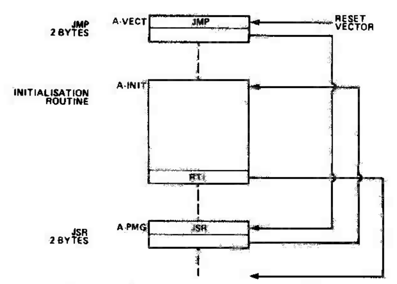
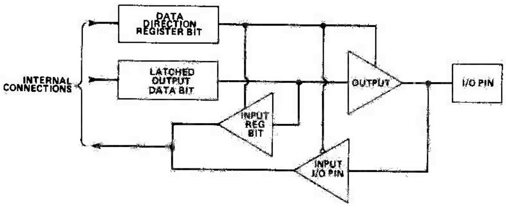


Fig. 8 Program flow after reset vector fetch.

good idea to write to the data registers before writing to the DDRs.

When programmed as outputs, the latched output data is readable as input data regardless of the logic levels at the output pin due to output loading. Figure 9 shows typical port circuitry.



DATA DIRECTION REGISTER BIT	OUTPUT DATA BIT	OUTPUT STATE	INPUT TO MCU
1	0	0	0
1	1	1	1
0	X	HI-Z	PIN

Fig. 9 Typical I/O port circuitry.

All ports are LSTTL compatible as inputs and outputs. Port B outputs can also drive LEDs, with suitable current-limiting resistors. The user can select one of two mask options (for all ports) as either pullup resistors for CMOS output compatibility or open-drain output; see Fig. 10 for typical port connections.

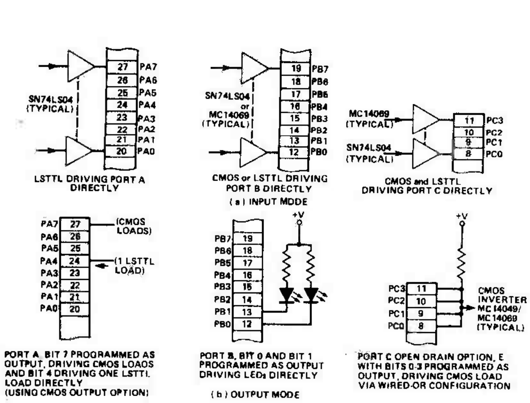
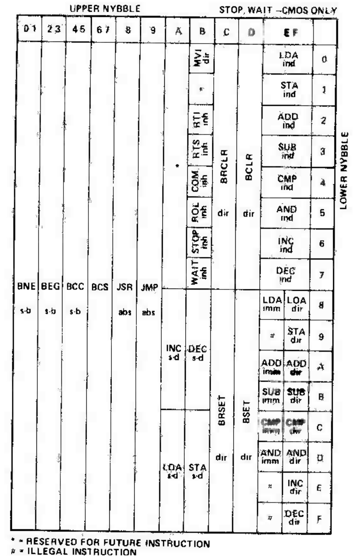


Fig. 10 Typical port connections.

Software And Instruction Set

The MC6804P2 has a rather unique, byte-efficient, instruction set. There are 41 instructions with opcode and 17 assembler-recognised instructions. Figure 11 shows the 6804P2 opcode map. The instruction set is similar to the 68705P3 including true bit manipulation plus a 'move immediate data' instruction.

BSET/BCLR can set or clear any register or RAM bit. BRSET/BRCLR can be used to test any bit in data space (including ROM) and branch or not as a result of the bit's state. The C-flag is set to the value of the bit referenced by BRSET/BRCLR. Bit manipulation allows the user to have individual flags and to handle the I/O bits individually with ease.



* - RESERVED FOR FUTURE INSTRUCTION
≠ - ILLEGAL INSTRUCTION

Fig. 11 6804P2 op-code.

The 'move immediate data' instruction transfers immediate data into data RAM and has the format 'MVI ADDRESS DATA'. Previously, on the 68705P3, data had to be loaded and stored through the accumulator. This takes up 4 bytes of ROM but only 3 on the 6804P2 when the MVI instruction is used.

The implied instructions shown in Fig. 12, exist because the accumulator and indirect registers are in RAM. For example, bit manipulation of bit 7 of the accumulator and indirect registers can give pseudo-ops such as BRSET 7,$80 for 'branch if X minus' (BXMI), BCLR 7, $FF for 'ensure accumulator positive' and ADD $FF for ASLA.

The 6804P2 has nine addressing modes. In summary these are immediate, direct, short-direct, extended, relative, bit set/clear, bit test and branch, register-indirect and inherent. Most of these modes are similar to those used on the 68705P3. However, short-direct, relative (-short), register-indirect and inherent addressing modes use only one byte.

There is no indexed addressing as on the 68705P3 but register-indirect addressing is the same except that an offset cannot be used. This addressing mode works on

ASSEMBLER RECOGNISED INSTRUCTIONS (DERIVED)
NO OPCODES FOR THESE INSTRUCTIONS

ASSEMBLER	INSTRUCTION	
ASLA	ADDSFF	Adds contents of the ACC to itself
CLRA	SUBSFF	Substr. contents of the ACC from itself
DECA	DECSGG	Subtract ONE from ACC
INCA	INCSFF	Add ONE to the ACC
CLRX	MVI#S0, XREG	Move 0 to X
CLRY	MVI#S0, YREG	Move 0 to Y
DEC X	DECS80	
DEC Y	DECS81	
INCX	INCS80	
INCY	INCS81	
LDXI	MVI DATA, S80	Move constant into X
LDYI	MVI DATA, S81	Move constant into Y
TAX	STA X	
TAY	STA Y	
TXA	LDA X	
TYA	LDA Y	

Fig. 12 Implied instruction set.

RAM location $80 and $83, ie the X and Y indirect registers and two others. A typical register-indirect instruction is CMP (X) which compares the contents of the accumulator with the contents of the address pointed to by the indirect X-register.

Summary

The Mc6804P2 is the first of a new family of Motorola single-chip microcomputers. Its unique architecture means that it can offer eight-bit power at a four-bit price.

As mentioned earlier, EPROM versions will soon be available and are ideally suited for use by hobbyists for a wide range of applications. Anyone used to working with Motorola's M6805 family will find the new 6804 range surprisingly simple to use.

(For further details of other single-chip microcomputers, we suggest 'Single Chip Microcomputers', Edited by Paul F. Lister, published by Granada publishing Ltd, ISBN 0-246-12106-8).

ETI

THE ETI READERS' SURVEY

Survey time is here again, and this time there's the chance to win ten free subscriptions for one year. The draw will take place on the 1st of February, so don't delay getting your form to us.

Here is the ETI survey! We'd be most grateful if you could answer our questions as best you can.

We'll be using the information in two ways. Firstly, to see what you think of the magazine and the ways you think that it could be improved. Secondly, we want to persuade more advertisers that ETI is the place to sell their goods.

On this second point, we have had to ask some personal questions. Please be reassured that any personal information you give us will be treated as confidential, and not stored in any data retreival system or communicated in any way. All that we need are some (suitably impressive!) statistics on our readers.

That said, we know that some people like to keep the details of their salary private between them and their employer, so we've included a 'mind your own business option' on this question. If any other questions offend, please don't feel obliged to answer them — we'd prefer that you returned the survey form with some bits left out rather than not at all. However, all the information you can give us will be of use.

Finally, one piece of information we will need is your name and address, because otherwise we won't know where to send the free subscription if you win one. If you do leave off your name and address, we'll just draw another name out of the hat.

Name ....

Address ....

....

....

Post-code ....

1. Sex: are you?
- male ☐
- female ☐

2. What age range are you in?
- Under 15 ☐
- 15-19 ☐
- 20-24 ☐
- 25-29 ☐
- 30-39 ☐
- 40-49 ☐
- 50-64 ☐
- 65+ ☐

3. Marital Status: are you?
- Married ☐
- Single ☐

4. Do you own:
- (a) Your home Yes ☐
- (b) A car Yes ☐

5. In which independent TV station area do you live? (This information is used to code the area.)
- LWT/Thames ☐
- TVS ☐
- TSW ☐
- Scottish ☐
- Granada ☐
- Yorkshire ☐
- Central ☐
- Harlech/HTV ☐
- Anglia ☐
- Tyne Tees ☐
- UTV ☐
- Channel ☐

6. Occupation — please bear with us, this is a little complicated!

(a) Are you studying full-time?

Yes ☐

If 'No', please go to part (b)

Are you at:
- School ☐
- FE College ☐
- University/Poly/TT/CHE/etc ☐

Are you sponsored in your studies?

Yes ☐

Please go to part (d)

(b) Are you employed, either full or part-time?

Yes ☐

If 'No', please go to part (c).

Is your work:
- Teaching ☐
- Electronics industry ☐
- Other electronics ☐
- Other ☐

Are you self employed?

Yes ☐

Please go to part (d).

(c) Are you not employed?
- Yes, I am not employed ☐

Are you:
- Unemployed ☐
- Retired ☐
- Invalid ☐
- Housewife/Husband ☐

(d) What is your approximate income, per year?
- Under 3000 ☐
- £3000 to £5000 ☐
- £5000 to £7000 ☐
- £7000 to £9000 ☐
- £9000 to £12000 ☐
- More than £12000 ☐
- No income — just pocket money ☐
- Mind your own business! ☐

What level of education have you reached?
- No formal qualifications ☐
- CSE ☐
- 'O' Level/SCE ☐
- 'A' Level/Scottish Higher ☐
- ONC ☐
- HNC ☐
- Degree or above ☐

Are you still studying, full or part time?

Yes ☐

Did or does your course of study involve electronics?

Yes ☐

Was or is your main subject electronics?

Yes ☐

7. How did you obtain your copy of 'Electronics Today International'? Was it:
- Subscription ☐
- Through a regular order at a newsagent ☐
- Bought from newsagent's shelves ☐
- From an electronics shop ☐
- From a friend ☐

8. Do you have any difficulty in finding 'Electronics Today International'?
- Yes, some difficulty ☐

9. How many people read your copy?
- Just you ☐
- You and one or two others ☐
- You and three or more others ☐

10. How many projects do you build a year?
- None — only just got interested ☐
- 1 to 3 ☐
- 4 to 12 ☐
- 13 or more ☐

11. Do you have problems in finding the components for your projects?
- Yes, some problems ☐

12. Do your projects work first time (or nearly first time)?
- Yes ☐
- No, but can usually get them going quickly ☐
- No, rarely work at all ☐

13. (a) Do you usually build projects?:
- Exactly as printed ☐
- With a few mods ☐
- With a large number of mods ☐
- Designed from scratch (with a few sections 'borrowed') ☐

(b) Do you usually use?
- PCBs ☐
- Veroboard or similar ☐
- Other form of construction ☐

(c) Do you make your own PCBs?

Yes ☐

If 'No', would you like to eventually make your own?

Yes ☐

(d) Is your audio system home-made?
- No ☐
- Yes, some bits ☐
- Yes, nearly everything ☐

14. How much do you spend on your hobbies per year?
- £20 or less ☐

£20 to £50 ☐
£50 to £100 ☐
£100 to £200 ☐
£200 to £500 ☐
More than £500 ☐

15. Do you own a home computer?
Yes ☐

If 'No', please go to part (b).

(a) Please tick the computer(s) you own:
Spectrum/ZX81 ☐
Vic 20/Com 64 ☐
BBC/Electron ☐
Oric/Atmos ☐
TRS 80 ☐
Other ☐
(b) Do you intend to buy a home computer in the near future?
Yes ☐

16. What sort of subjects would you particularly like to see articles on in future issues of 'Electronics Today International'? Please tick all those that apply (but don't tick every box, we haven't got room for everything!)
Electronics theory ☐
Constructional tips ☐
Household projects ☐
Computer hardware ☐
Computer programming ☐
Interfacing ☐
Robots ☐
Audio ☐
Music projects ☐
Car electronics ☐
Experimentation ☐
Security ☐
News and views from the world of electronics ☐

17. Please tick any of the following you intend to buy in the next year or so:
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Component storage ☐
PCBs ☐
Cases ☐
Other electronic hardware ☐
Soldering iron ☐
Pliers/wire cutters ☐
Other electronic tools ☐
Multimeter ☐
Power supply ☐
Oscilloscope ☐
Other test gear ☐
Computer hardware ☐
Computer peripherals (eg printer, etc) ☐
Computer software ☐
Books on electronics ☐

18. (a) Do you read the advertisements in ETI?
Yes ☐
(b) Do you buy items mail order from ETI advertisers?
Yes ☐
(c) Do you buy items mail order through advertisements in other electronics magazines?
Yes ☐
(d) Do you buy items from the same supplier(s)?
No, but I shop around for the best prices ☐
Yes, I use the same few suppliers most of the time ☐
Yes, I use the same suppliers all the time when I can ☐

19. (a) Are you involved in electronics professionally?
Yes ☐
(b) If 'No', please go to the next question.
Are you involved in the buying of electronic equipment or components?
No ☐
Yes — equipment only ☐
Yes — components only ☐
Yes — both components and equipment ☐
(c) Approximately what total value of components or equipment have you been involved in the purchasing of during the last year?
£1,000 or less ☐
£1,000 to £10,000 ☐
£10,000 to £100,000 ☐
More than £100,000 ☐

20. Which other magazines do you read, how often, and what do you think of them?

	How often do you read?			Your rating:		
	Every issue	Some issues	Rarely never	Good	Average	Poor
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Elektor	☐	☐	☐	☐	☐	☐
Practical Electronics	☐	☐	☐	☐	☐	☐
Everyday Electronics	☐	☐	☐	☐	☐	☐
Digital & Micro Electronics	☐	☐	☐	☐	☐	☐
Electronics Digest	☐	☐	☐	☐	☐	☐
Electronics And Computing	☐	☐	☐	☐	☐	☐
Electronics - The Maplin Magazine	☐	☐	☐	☐	☐	☐
Wireless World	☐	☐	☐	☐	☐	☐

How do you think 'Electronics Today International, rates on these scales? ☐ ☐ ☐

21.

Finally, please use the space here to write in any comments you may have, eg, suggestions for articles you'd like to see, etc.

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74F151	1.26
74F153	1.26
74F157	1.30
74F158	1.17
74F161	2.34
74F164	1.68
74F175	1.82
74F181	3.90
74F189	5.10
74F190	3.20
74F191	3.20
74F194	1.68
74F20PC	0.52
74F240	3.16
74F241	2.42
74F243	2.80
74F244	2.96
74F245	6.08
74F251	1.26
74F253	1.26
74F257	1.26
74F258	1.34
74F280	1.74
74F283	1.74
74F32PC	0.52
74F352	1.26
74F353	1.26
74F373	3.16
74F374	3.16
74F379	1.83
74F381	6.62
74F382	4.22
74F398	3.16
74F399	2.70
74F521	2.76
74F533	3.16
74F534	3.16
74F537	6.02
74F538	4.38
74F539	4.38
74F64PC	0.52
74F74PC	0.58
74F86PC	0.77

HIGH SPEED CMOS

74HC00N	0.42
74HC02N	0.42
74HC03N	0.64
74HC04N	0.44
74HC08N	0.42
74HC107N	0.78
74HC109N	0.50
74HC10N	0.64
74HC112N	0.86
74HC113N	0.86
74HC132N	1.28
74HC137N	1.81
74HC138N	1.20
74HC139N	0.78
74HC151N	1.16
74HC153N	0.90
74HC157N	1.02
74HC158N	1.02
74HC160N	0.90
74HC161N	0.90
74HC162N	1.51
74HC163N	1.51
74HC164N	0.95
74HC165N	2.24
74HC173N	1.35
74HC174N	0.80
74HC175N	0.78
74HC194N	1.28
74HC195N	1.28
74HC20N	0.40
74HC237N	1.80
74HC240N	1.38
74HC241N	1.34
74HC242N	2.24
74HC243N	2.24
74HC244N	1.32
74HC251N	1.03
74HC253N	1.03
74HC257N	1.03
74HC266N	0.92
74HC273N	2.24
74HC27N	0.80
74HC280N	3.26
74HC32	0.40
74HC373N	2.40
74HC374N	2.40
74HC393N	1.78
74HC4002	0.64
74HC4017	1.16
74HC4020	1.46
74HC4024	1.20
74HC4040	1.46
74HC4060	1.46
74HC4075	0.64
74HC42N	0.90
74HC4511	2.51
74HC4514	3.76
74HC4538	2.36
74HC4543	3.04
74HC51N	0.64
74HC533N	2.40
74HC534N	2.40
74HC589N	1.72
74HC58N	0.64
74HC595N	1.84
74HC597N	1.72
74HC73N	0.84
74HC74N	0.84
74HC75N	0.92
74HC76N	0.64
74HC85N	2.02
74HC86N	0.80
74HCU04N	0.80

TTL

74LS00	0.25
74LS01	0.25
74LS02	0.25
74LS03	0.25
74LS04	0.25
74LS05	0.25
74LS08	0.25
74LS09	0.25
74LS10	0.25
74LS109	0.54
74LS11	0.25
74LS112	0.54
74LS113	0.42
74LS114	0.44
74LS12	0.25
74LS122	0.75
74LS123	0.95
74LS124	2.30
74LS125	0.49
74LS126	0.49
74LS13	0.46
74LS132	0.73
74LS136	0.46
74LS138	0.77
74LS139	0.77
74LS14	0.80
74LS145	1.23
74LS148	1.50
74LS15	0.25
74LS151	1.10
74LS153	1.10
74LS155	0.77
74LS156	0.77
74LS157	0.62
74LS158	0.62
74LS160	0.80
74LS161	0.80
74LS162	0.80
74LS163	0.80
74LS164	1.10
74LS165	1.30
74LS166	1.95
74LS173	1.13
74LS174	1.30
74LS175	0.96
74LS181	2.09
74LS190	0.98
74LS191	0.75
74LS192	1.10
74LS193	1.10
74LS194	0.78
74LS195	0.78
74LS196	1.10
74LS197	1.10
74LS20	0.25
74LS21	0.25
74LS22	0.25
74LS221	1.08
74LS240	1.40
74LS241	1.40
74LS242	1.36
74LS243	1.36
74LS244	1.40
74LS245	1.95
74LS248	1.16
74LS249	1.16
74LS251	0.78
74LS253	0.78
74LS257	0.78
74LS258	0.78
74LS259	1.77
74LS26	0.30
74LS261	2.60
74LS266	0.35
74LS27	0.25
74LS273	1.35
74LS279	0.77
74LS28	0.25
74LS283	1.00
74LS290	0.86
74LS293	0.86
74LS30	0.25
74LS32	0.25
74LS33	0.30
74LS365	0.55
74LS366	0.55
74LS367	0.55
74LS368	0.55
74LS37	0.25
74LS373	1.50
74LS374	1.50
74LS375	0.75
74LS377	1.50
74LS378	1.22
74LS379	1.50
74LS38	0.25
74LS386	0.50
74LS390	1.10
74LS393	1.10
74LS40	0.25
74LS42	0.85
74LS47	1.00
74LS48	1.00
74LS49	1.00
74LS51	0.25
74LS54	0.25
74LS55	0.25
74LS670	2.30
74LS73	0.30
74LS74	0.35
74LS75	0.50
74LS76	0.35
74LS78	0.35
74LS83	0.90
74LS85	1.16
74LS86	0.42
74LS90	0.66
74LS91	1.30
74LS92	0.66
74LS93	0.66
74LS95	0.77

CMOS 4000 Series

4000	0.25
4001	0.52
4002	0.25
4006	0.90
4007	0.25
4008	0.92
4009	0.25
4010	0.25
4011	0.30
4012	0.25
4013	0.45
4014	0.50
4015	0.65
4016	0.46
4017	0.63
4018	0.46
4019	0.39
4020	0.45
4021	0.56
4022	0.42
4023	0.34
4024	0.66
4025	0.22
4026	0.74
4027	0.52
4028	0.34
4031	0.93
4033	2.40
4034	1.00
4035	0.54
4040	0.65
4041	0.36
4042	0.76
4043	0.64
4044	0.62
4045	2.00
4046	0.77
4047	0.50
4048	0.40
4049	0.50
4050	0.49
4051	0.52
4052	0.48
4053	0.66
4054	1.30
4055	0.72
4060	0.68
4063	0.60
4066	0.50
4068	0.25
4069	0.40
4070	0.40
4071	0.40
4072	0.40
4073	0.40
4075	0.46
4076	0.48
4077	0.40
4078	0.25
4081	0.40
4082	0.25
4085	0.66
4086	0.40
4093	0.32
4099	0.50
4502	0.86
4507	0.47
4508	0.96
4510	0.68
4511	0.69
4512	0.40
4514	1.76
4515	1.84
4516	0.68
4518	0.40
4519	0.25
4520	0.96
4521	1.32
4522	0.84
4526	0.52
4527	0.52
4528	0.48
4532	0.68
4541	0.82
4543	0.60
4553	2.40
4555	0.48
4556	0.44
4585	0.48

CRYSTALS

A111B	1MHz	4.50
A112A	1.008MHz	4.00
A113A	1.8432MHz	3.50
A116A	2.4576MHz	2.00
A120B	4MHz	1.25
A132A	6MHz	1.70
A140A	8MHz	1.25
A169A	3.6864MHz	2.00
A173A	9.8304MHz	2.75
A182A	19.6608MHz	2.50

DIL SKTS TIN

		1+	100+
07070802	8 PIN	0.07	0.05
07071402	14 PIN	0.09	0.07
07071602	16 PIN	0.09	0.07
07071802	18 PIN	0.15	0.10
07072002	20 PIN	0.19	0.14
07072202	22 PIN	0.21	0.15
07072402	24 PIN	0.24	0.16
07072802	28 PIN	0.26	0.17
07074002	40 PIN	0.29	0.18

DIL SKTS GOLD

06060802	8 PIN	0.16
06061402	14 PIN	0.20
06061602	16 PIN	0.21
06061802	18 PIN	0.22
06062002	20 PIN	0.28
06062202	22 PIN	0.32
06062402	24 PIN	0.42
06062802	28 PIN	0.46
06064002	40 PIN	0.66

DIL SKTS W/WRAP TURNED PIN

9090802	8 PIN	0.36
9091402	14 PIN	0.75
9091602	16 PIN	0.86
9091802	18 PIN	0.96
9092002	20 PIN	1.08
9092202	22 PIN	1.18
9092402	24 PIN	1.28
9092802	28 PIN	1.50
9094002	40 PIN	1.70

ZIF SOCKETS

08082402	24 PIN	5.70
08082802	28 PIN	6.90
08084002	40 PIN	8.25

components

GILRAY ROAD, DISS, NORFOLK. TEL: 0379 4131

INSULATION DISPLACEMENT CONNECTOR SYSTEM

HEADERS

	SHROUDED 90°	OPEN 90°	OPEN — STRAIGHT PINS
10 way	0.86	0.65	0.47
14 way	1.22	0.83	0.59
16 way	1.34	0.92	0.65
20 way	1.36	1.13	0.77
26 way	1.70	1.40	0.95
34 way	2.04	1.78	1.19
40 way	2.28	2.07	1.37
50 way	2.70	2.54	1.67
60 way	3.20	3.02	1.96

SOCKETS

10 way	0.88
14 way	1.06
16 way	1.16
20 way	1.38
26 way	1.66
34 way	1.94
40 way	2.08
50 way	2.78
60 way	3.34

CARD EDGE

10 way	1.84
20 way	3.14
26 way	3.80
34 way	4.90
40 way	5.52
50 way	6.68
60 way	8.06

DIP PLUGS

14 way	0.92
16 way	1.06
24 way	1.60
40 way	2.40

TRANS. CONNS.

10 way	0.86
16 way	1.17
20 way	1.37
26 way	1.67
34 way	1.87
40 way	2.23

D-TYPE SOCKETS

9 way	1.47
15 way	2.02
25 way	2.90
37 way	3.97

D-TYPE PLUGS

9 way	1.38
15 way	1.85
25 way	2.52
37 way	3.34

CABLE ASSEMBLIES

IDC JUMPERS SINGLE ENDED

36" cable	IDC socket
10 way	1.72
14 way	2.07
16 way	2.22
20 way	3.14
26 way	3.75
34 way	3.98
40 way	4.23
50 way	5.36
60 way	6.36

DIP JUMPERS

Single Ended

	— 24" cable
14 pin	1.73
16 pin	1.90
24 pin	2.73
40 pin	3.96

Double Ended

	6" cable	12" cable	18" cable
14	2.74	2.84	2.94
16	3.03	3.14	3.25
24	4.18	4.36	4.55
40	5.89	6.18	6.47

DISC DRIVE CONNECTING CABLES

34 way card edge to 34 way card edge 1M	11.30
34 way card edge to 2 × 34 way card edge 1.5M	18.00
34 way card edge to 34 way IDC SKT (BBC) 1M	8.50
34 way card edge to 2 × 34 way IDC KT (BBC) 1.5M	14.50
BBC Power Cable — Single Drive	3.50
BBC Power Cable — Dual Drive	4.75

RIBBON CABLE (PRICED PER FOOT)

	GREY	RAINBOW
9	0.16	0.25
10	0.16	0.25
14	0.21	0.35
15	0.22	0.37
16	0.23	0.39
20	0.28	0.48
25	0.34	0.60
26	0.35	0.62
34	0.45	0.80
40	0.52	0.92
50	0.64	1.14
60	0.76	1.35

BBC MICRO CONNECTORS

DIN PLUG 7 PIN	0.40
DIN PLUG 6 PIN	0.40
DIN PLUG 5 PIN 180°	0.40
DIN PLUG 5 PIN DOMINOE	0.40
POWER PLUG (36" CABLE)	3.00
ANALOGUE INPUT PLUG	2.25
5 WAY DIN SKT 180°	0.90
5 WAY DIN SKT DOMINOE	0.90
6 WAY DIN SKT	0.90
7 WAY DIN SKT	0.90
15 WAY DIN SKT	2.15

Connecting cables for personal computers

A comprehensive range of high quality interconnecting cables for popular micro computers. All cables utilise high quality connectors and are individually tested to ensure trouble free use.

Part number	Description	Computer	
Video cables			
CON100	Phono plug to phono plug (2M)		1.20
CON101	Phono plug to BNC plug (2M)		2.95
CON102	BNC plug to BNC plug (2M)		3.95
CON107	6 pin DIN to open end (1M)	BBC	1.05
CON108	6 pin DIN to 6 pin DIN (1M)	BBC	1.50
CON119	Phono plug to coax plug		1.35
CON160	DIN plug to 2 phono plugs	Dragon	1.20
Cassette recorder cables			
CON109	7 pin DIN to open end	BBC	1.25
CON110	7 pin DIN to 2 × 3.5mm + 1 × 2.5mm J/plug	BBC	2.50
CON111	7 pin DIN to 5 pin DIN + 2.5mm J/plug	BBC	2.50
CON118	5 pin DIN to 2 × 3.5mm J/plugs	Spectrum/ZX	2.50
CON117	5 pin DIN to 2 × 3.5mm + 1 × 2.5mm J/plug	Dragon	2.50
Parallel printer cables			
CON130	36 way plug to 36 way plug (2M)	Sirius/Apricot	18.00
CON131	36 way plug to 36 way plug (5M)	Sirius/Apricot	26.50
CON132	36 way plug to 36 way socket (2M)		18.00
CON133	36 way plug to 36 way socket (5M)		26.50
CON144	36 way plug to 25 way male D type (2M)	IBM/TI PC	19.00
CON145	36 way plug to 25 way male D type (5M)	IBM/TI PC	27.50
CON134	36 way plug to 25 way male D type (2M)	RML/Apple	19.00
CON135	36 way plug to 25 way Male D type (5M)	RML/Apple	27.50
CON142	36 way plug to 20 way IDC socket (2M)	Dragon	13.95
CON139	36 way plug to 26 way IDC socket (2M)	BBC	9.95
CON140	36 way plug to 26 way IDC socket (5M)	BBC	22.95
CON141	36 way plug to 34 way card edge (2M)	TR580 Lev 1	18.50
CON143	36 way plug to 34 way IDC socket (2M)	TR580 Lev 2/ Memotech	10.95
RS232 Cables			
CON106	25 way male D type to 5 pin DIN	BBC	5.85
CON128	'Universal' RS232 cable (pins 1-8, 20 connected and 20 jumpered as required) 2M		15.95
CON164	'Universal' RS232 cable as above but 5M		20.95
CON120	25 way male to male 1-25 connected (2M)		16.95
CON121	25 way male to male 1-25 connected (5M)		22.50
CON122	25 way male to male 1-25 connected (10M)		32.50
CON123	25 way male to male 1-25 connected (30M)		68.00
CON124	25 way male to female 1-25 connected (2M)		15.45
CON125	25 way male to female 1-25 connected (5M)		21.00
CON126	25 way male to female 1-25 connected (10M)		31.00
CON127	25 way male to female 1-25 connected (30M)		66.50
CON129	25 way male to 9 way male	Spectrum	15.95
CON162	25 way male to 9 way male	Mackintosh	15.95
CON163	25 way male to 5 pin DIN	RML 480Z	14.95

PART NO.	DESCRIPTION	MAIL ORDER PRICE
BBC MICROS AND ACCESSORIES		
ANB01	BBC Model B Micro	£325.00
ANB02	BBC Model B Micro with Econet I/F	£385.00
ANB03	BBC Model B Micro with Disc I/F	£406.00
ANB04	BBC Model B Micro with Disc & Econet	£445.00
ALA01	Acorn Electron	£139.00
ANB21	DNFS ROM	£17.91
ANB23	Disc Interface Kit	£71.65
ANB14	Speech Interface	£40.00
ANK01	IEEE488 Interface Adaptor	£277.75
ANB22	Econet I/F Kits	£35.00
BBC 45	Joysticks	£8.00
STAND	Monitor Stand	£7.50
SRE1	Sideways ROM Expansion Board	£25.95
DISC DRIVES WITHOUT POWER SUPPLY		
BBC30	Single 100k TEC 40 track single sided	£99.95
BBC31S	Single 100k TEC (expandable to dual) 40 track	£115.00
BBC31D	Dual (2 × 100k) TEC 40 track single sided	£225.00
BBC34	Single 400k TEC 80 track double sided	£174.00
BBC34S	Single 400k TEC (expandable to dual) 40/80 track switchable double sided	£194.00
BBC34SW	Single 400k TEC 40/80 track switchable double sided	£184.00
BBC34D	Dual (2 × 400k) TEC 40/80 track switchable double sided	£310.00
BBC34S/80	Single 400k TEC (expandable to dual) 80 track double sided	£184.00
BBC34D/80	Dual (2 × 400k) TEC 80 track double sided	£300.00
DISC DRIVES WITH POWER SUPPLY		
BBC30P	Single 100k TEC 40 track single sided with P.S.U	£130.00
BBC31SP	Single 100k TEC (expandable to dual) 40 track with P.S.U	£150.00
BBC31DP	Dual (2 × 100k) TEC 40 track single side with P.S.U	£250.00
BBC34P	Single 400k TEC 80 track double sided with P.S.U	£209.00
BBC34SP	Single 400k TEC (expandable to dual) 80 track with P.S.U	£229.00
BBC34DP	Dual (2 × 400k) TEC 40/80 track switchable with P.S.U	£345.00
MECHANISMS		
F8501	TEC 100k single sided	£91.00
FB504	TEC 400k double sided	£150.00
FLOPPY DISCS		
MD-1C/B	Nashua single sided, single density 40 track (10 discs)	£12.00
MD-1DC/B	Nashua single sided, double density 40 track (10 discs)	£13.00
MD-2DC/B	Nashua double sided, double density 40 track (10 discs)	£15.50
MD-2FC/B	Nashua double sided, quad density 80 track (10 discs)	£17.85
SPECIAL OFFER		
BBC40TD	BASF double sided, double density 40 track (10 discs)	£14.00
DISC STORAGE BOXES		
MDT25/3	3½" Flip 'N' file Micro disc box (cap. 25)	£7.75
DT25/5	5¼" Flip 'N' file lockable disc box (cap. 25)	£18.77
DT60/5	5¼" Standard lockable disc box (cap. 60)	£10.65
MONITORS		
9MON	9 inch green screen high resolution NEC high quality monitor	£125.00
12MON	12 inch green screen high resolution NEC high quality monitor	£135.00
1431	Microvitec 14" RGB colour monitor	£175.00
1441	Microvitec 14" RGB colour monitor high resolution	£410.00
1451	Microvitec 14" RGB colour monitor medium resolution	£295.00
1431/AP/MS	Microvitec 1431 PAL & RGB inputs and sound facility	£225.00
BBC COMPATIBLE SOFTWARE		
SBB03	View Rom	£45.00
SBB04	View Printer Driver	£7.50
AES20	Fileserver Level 1-40 track	£80.50
AE521	Fileserver Level 2-80 track	£202.00
SNB08	Acornsoft Invoicing program	£16.00
SNB09	Acornsoft Mailing System program	£16.00
SNB10	Acornsoft Accounts Receivable program	£16.00
SN811	Acornsoft Stock Control program	£16.00
SNB12	Acornsoft Order Processing program	£16.00
SNB13	Acornsoft Acounts Payable program	£16.00
SNB14	Acornsoft Purchasing program	£16.00
SNL01	Forth — 40 track	£15.00
SNL02	Lisp — 40 track	£15.00
SNL04	Microtext — 40 track	£47.50
MATRIX PRINTERS		
RX80	Epson RX80 100cps matrix printer	£204.00
RX80F/T	Epson RX80F/T 100 cps matrix printer friction or tractor feed	£231.00
FX80	Epson FX80 150cps matrix printer	£328.50
MT80SP	Mannesmann Tally MT80 matrix printer friction or tractor feed with film ribbon and tear off facility	£209.00
LETTER QUALITY PRINTERS		
HR5	Brother HR5 Thermal printer A/C mains or battery	£115.00
HR15	Brother HR15 Daisy wheel printer (13cps)	£326.00
HR25	Brother HR25 Daisy wheel printer (23cps)	£550.00
UCHIDA	Uchida DWX305 Daisy wheel printer (20cps)	£227.00
PRINTER SUPPLIES		
11241P160	11×9½ 1 part plain listing paper (2,000)	£11.25
11241P2CI	11×9½ 2 part (otc) plain listing paper (1,000)	£14.00
11241P3CI	11×9½ 3 part (otc) plain listing paper (700)	£16.25
11370R160	11×14½ 1 part ruled listing paper (2,000)	£13.50
11370R2NC	11×14½ 2 part (ncr) ruled listing paper (1,000)	£22.50
11370R2CI	11×14½ 2 part (otc) ruled listing paper (1,000)	£15.00
12235P160S	12×9½ 1 part plain listing paper with side perfs (2,000)	£12.00
HR1R	Brother HR1 ribbon	£2.20
RIB119	Diablo Hytype II Multistrike film ribbon	£1.75
GP205	Diablo Hytype II fabric ribbon	£2.50
MX80	Epson MX80, RX80, FX80, fabric ribbon	£3.00
MT80	Mannesmann Tally MT80 film ribbon	£6.50
RIB117	Uchida DWX305 multistrike film ribbon	£2.75
HR5R	Brother HR5 ribbon	£2.20
HR15R	Brother HR15 multistrike ribbon	£4.00
HR25R	Brother HR25 multistrike ribbon	£4.00
	Brother daisy wheels	£14.00
	Uchida/Oume daisywheels	£4.00
LAB089361C	3½×1 7/16 Labels — 1 wide (12,000)	£20.00
LAB089361S	3½ 1.7/16 Labels — 1 wide (2,000)	£13.00
LAB070363F	2¾ 1 7/16 Labels — 3 wide (1/10") (2,000)	£8.00

DIGITAL FRAMESTORE

Now we come to the two nitty-gritty bits of the circuitry - the conversion to and from digits, and the storage and retrieval of the digits in a hurry. Daniel Ogilvie shows how its done.

With a clock rate of 13MHz we have 1/13MHz = 78 ns to convert the data and store it in memory. Of the readily available ADCs, the National Semiconductor ADC0800 takes 10 µs; obviously, we will have to look for something rather more exotic for the ADC here.

Most common ADCs work by the successive approximation technique, which requires a number of clock cycles to obtain a digital representation of the incoming analogue signal. Even at high frequencies, the number of clock cycles would take an unacceptable length of time; for instance, if we were able to clock the ADC0800 at 10MHz, it would still require 40 clock cycles to complete a conversion, which would mean that we would have to allow 4µs for each conversion — still far too slow.

Successive approximation ADCs contain just one comparator, see Fig. 4, and what they do is to try the different bits in the latch, starting with the most significant and working down to the least significant, to see which should be on in the final result.

An alternative technique is used by flash (or parallel) converters; here, there are lots of comparators all tied to the input and to different points in the resistance ladder. The encoder logic has to decide which is the highest comparator which is on. The time taken for conversion is just the propagation delay of the comparators and the encoder. However, the big disadvantage of these ADCs is the complexity, as there has to be a comparator for every possible output word. So, for an n-bit converter, there have to be 2^n comparators, and this also means that there have to be more resistors in the chain, and that the encoding logic has, necessarily, to be that much larger.

There are a number of flash converters on the market, the Ferranti ZN440 and the RCA CA3300 for example. The type we are going to use is the TRW TDC1014, which is a six-bit converter. Both eight-bit and four-bit versions are available and could be used instead; however, the four-bit version will not offer sufficient resolution for any serious application and the eight-bit version is very expensive, in effect containing four times the logic and comparators of the six-bit version. The six-bit version is a compromise.

The ADC is the single most expensive item in the framestore. It does contain a lot of very fast logic, including 64 latched comparators, for example. Its cost is about £100, and as we have seen there is no way round this. The framestore can, of course, be built without the ADC and used only to display images loaded by computer — not exactly a framestore then though is it?

The Dynamic Ram

The DRAM is a significantly cheaper memory cell per byte than static RAM. It would be possible to design the framestore using fast (better than 70ns) access time static RAM, which would consume over 100 16K × 1, for example. These would require a second mortgage to acquire (£10/chip). So if only for financial reasons the DRAM would appear to be the right choice and the 64K × 1 variant is the cheapest and most convenient available for us. However they do require more thought and circuitry to drive them. The problem of their slow access time is discussed below. We will consider briefly here how to get data in and out of them.

You have probably noticed that the 64K × 1 DRAM comes in a 16-

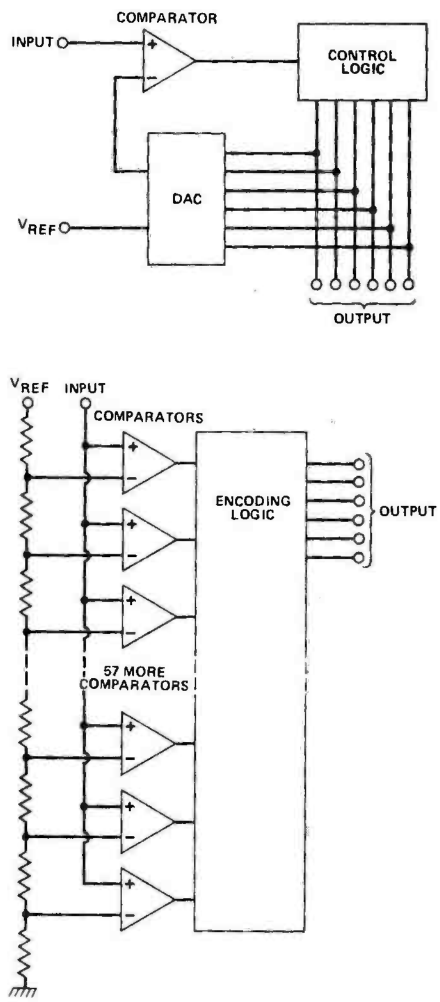

Fig. 4 Two ways of converting analogue to digital: (a) sucessive approximation ADC; (b) 'flash' converter ADC.

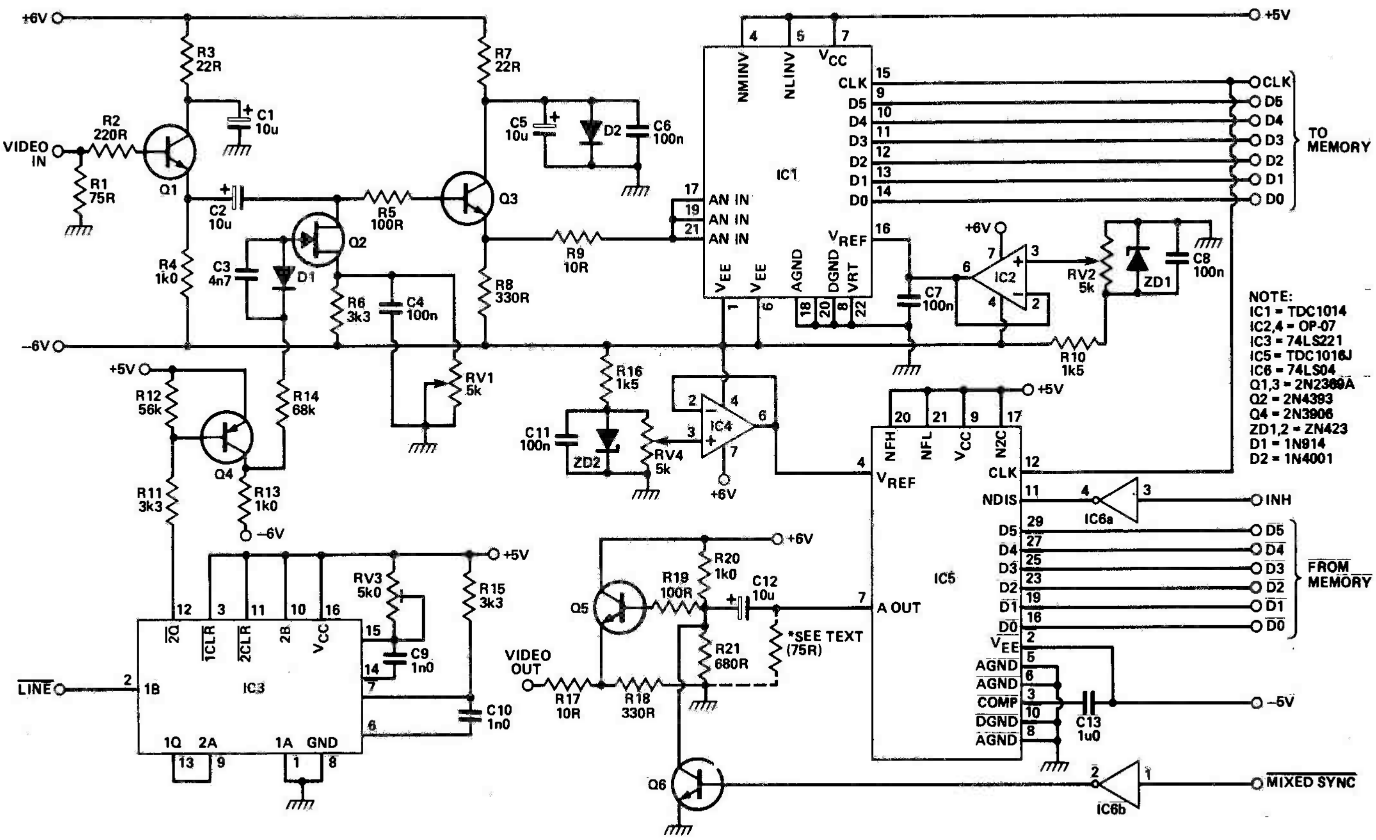

Fig. 5 Circuit diagram of the converter section.

HOW IT WORKS - ADC/DAC

R1 terminates the video signal at the appropriate 75 ohms. Q1 buffers the video, and the signal is then AC coupled to driver transistor Q3 via C2 and R5. Q3 is needed because the input to IC1, the ADC, is quite capacitive (100p).

The DC level of the signal is determined by the clamping action of Q2, as follows. IC3 is a dual monostable, and it generates a 2 µs pulse 3 µs after the LINE signal goes low, which is every 64µs. This pulse is fed via Q4 to the gate of Q2, which turns this transistor on, shorting the negative end of C2 to the voltage set up by R6 and RV1.

The portion of the video waveform when this is happening is known as the 'back porch', and, by definition, it is reference black. So R6 and RV1 set the reference black level for the video signal. Clamping the waveform every 64µs ensures that the tone of the image remains consistent across the screen.

The ADC is IC1, a TDC1014J, which converts continuously at 13MHz. 10ns after the rising edge of the clock input, the video input is latched into its comparators and compared with the voltage fed to the reference input. This latching operation means that the input does not have to be held steady while the conversion is taking place.

On the falling edge of the clock signal, the comparator outputs are fed to a 63-to-6 decoder. The outputs from the comparators essentially form a bar-graph representing the video signal size: for example, if the video input is half the reference voltage, then half the comparators will be on and half will be off. The conversion logic takes the bar-graph output and converts it into a six-bit binary word.

The binary word is latched into the ADC output on the next rising edge of the clock and the data becomes available 30ns later. There is what is known as a one pipeline delay in the output, and the ADC takes in new data whilst converting the previous data.

The reference voltage is provided by ZD1 and this is buffered by IC2. RV2 allows the reference voltage to be changed which gives some control over the gain of the ADC; the lower the reference voltage, the lower the threshold between adjacent comparators in the ADC, so the smaller the change in the input signal that is required to change from one output binary word to the next.

IC5 is the DAC, TDC1016. It acquires data from the memory on the rising edge of the clock input provided that the data has been set up 20ns beforehand. The reference input, provided by ZD2 and buffered by IC4, is used, with the digital data, to decide the size of the output voltage. The output of the DAC can be forced to 0V (black) by the NDIS input and this is done outside the stored picture area to prevent rubbish being displayed.

The output of the DAC can drive the standard 75R line, but will provide only 500mV output swing, which will give disappointing contrast on a monitor, which would be improved by amplifying the output. On the other hand, without termination, the output voltage swing can be 1 V but fast edges of the video could cause some slight overshoot, although it is unlikely that such edges would be generated by anything other than a computer-generated image.

In the circuit shown, we leave the choice of whether or not to terminate the output from the DAC with 75R up to you; the resistor required to do this is shown dotted. The black level of the output is set by the ratio of R20 to R21 and when a MIXED SYNC pulse is present, this point is shorted to 0V by Q6 to provide a composite output.

Q5 provides a 75R drive capability for the video. No low-pass filtering has been used to reconstitute the video output, as this will almost certainly be performed by the monitor.

pin package and yet would require 16 address lines to select all of its bits (2^{16} = 64K). This is because the address is sent in two eight-bit bytes and strobed into latches by two lines (row address select,RAS, and column select,CAS). You can consider the memory as a grid with two latches selecting the vertical and horizontal rows to access the bit we require. On the falling edge of RAS the row address is latched and a little later we take CAS low which latches the other address. The CAS line also turns on the output drivers and therefore some time (the access time) after CAS the data will appear on the Q output.

If we wish to write data in we must ensure the data is valid and generate a write pulse; the data is written in on the rising edge of the pulse. It will be noticed that there is a dead time between successive accesses. This is required by the DRAM to restore the memory cell to its steady state after an access, and is referred to as the precharge time. This has to be allowed for when driving DRAMS and so the total cycle time (read or write) is the RAS access time + the precharge time.

DRAM uses a capacitor to store the data bit which loses its charge over a period of time (2ms or sometimes 4ms) and to prevent us losing data, it has to be read and written over a period of time, which is called refreshing. Refresh is performed by strobing RAS low and providing a sequential address (0 - 128 or sometimes 256) on the address bus. However when DRAM is read it destroys the data in the cell which must be automatically written again at the end of the read cycle. We are continually accessing the DRAM to display the stored picture and therefore by ensuring the RAS addresses are the low-order address lines, refresh is automatically performed.

HOW IT WORKS - MEMORY CARD

The memory chips used cannot possibly work at the speed at which the frame-store converts analogue to digital or vice versa; so the design here uses shift registers to convert eight serial bits from each of the six data bits into a parallel data word, which is then stored in parallel in memory. Thus the memory can read or write at one eighth of the speed that the ADC or DAC are working at; however, this does have the disadvantage that effectively six memory cards are required.

Fig. 8 shows the circuit for just one storage card; all the connections to this are paralleled with the other memory cards, except SI, the serial data input bit from the ADC, SO, the serial data out to the same bit on the DAC, and MPUD, which is connected to one bit of the processor data bus.

The dynamic RAM is usually being read. RAS is strobed low when the lower address bits (A0-A7) have settled. After the RAS hold time of the dynamic RAM the upper address lines are enabled and CAS is strobed low. The 16-bit address bus is multiplexed to eight bits by the two 'LS257 two-to-one multiplexers. The select line is the LO output of the control card. After the CAS access time of the RAM has elapsed the Q outputs of the DRAM become valid. These are synchronously loaded into the eight-bit data shift register formed by two 'LS195s. This eight-bit data is then clocked out of the shift register whilst the RAM is accessing the next bit.

The address inputs to the RAM have 33R resistors in series with them to damp possible destructive negative voltage excursions on the address lines due to the high capacitance of the DRAM inputs and the PCB tracks.

Should we wish to load data into the RAM we need to pull down the write line to the RAM at the appropriate time; this is handled by the control card. Data from the ADC is clocked into the shift registers. When eight bits have been loaded, the Q outputs of the shift register are loaded into an eight-bit latch on the rising edge of the transfer pulse. The data is then valid and held for the next write cycle of the DRAM.

Any additional I/O on the board is for MPU access and will be discussed in a future article.

The type of RAM shown is Motorola MCM6664. This has an on-chip refresh counter which can make interfacing to an MPU a little easier. However any 64K 200ns DRAM should work quite satisfactorily as there are no critical timings.

Speedy Shifting

To store a picture to our required resolution we need a six-bit word to be converted by the ADC and stored in the RAM in 78ns. We have (I hope) justified our choice of DRAM instead of fast static RAM, but the fastest DRAM that we can procure is 100ns and comes expensive (there are some DRAMs that allow us to access four-bit data in 50ns but that does not satisfy our requirement either).

Some way must be found to overcome this deficiency and the answer comes in the form of the humble shift register. We can use the shift register to temporarily store the fast data from the ADC and parallel load this into the dynamic RAM.

The access time of the DRAM is reduced by the number of bytes in the shift register. This is illustrated in Fig. 6. The data from the ADC is clocked into the shift register which is configured in a shift right mode. When eight bits of data have been received, after eight clock pulses, the eight Q outputs of the shift registers are loaded into a latch. We now have eight clock cycles (8 × 78ns) of stable data to load into the DRAM. The shift register in the meantime is loading the next 8 bits of data.

We can arrange a similar system to retrieve data from the DRAMs. If we strobe the DRAMs such that the data is available at their Q outputs, we can parallel load this into the shift register and clock it out at 13MHz. The dynamic RAM then has 8 × 78ns = 624ns to provide the next data byte. This is illustrated in Fig. 7. The full dynamic RAM timing diagram was published last month when the control card was discussed.

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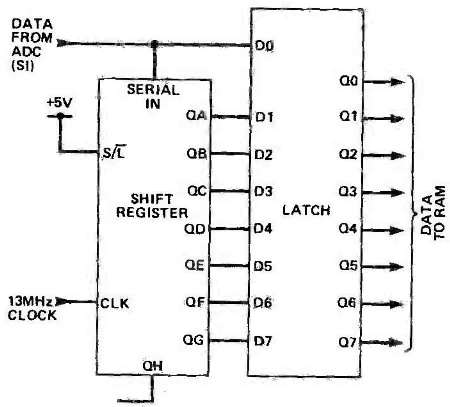

Fig. 6 Assembling eight successive bits into a parallel data word.

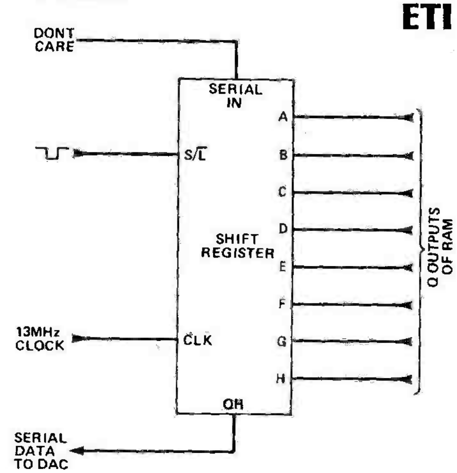

Fig. 7 Re-converting the parallel data word into a stream of eight bits.

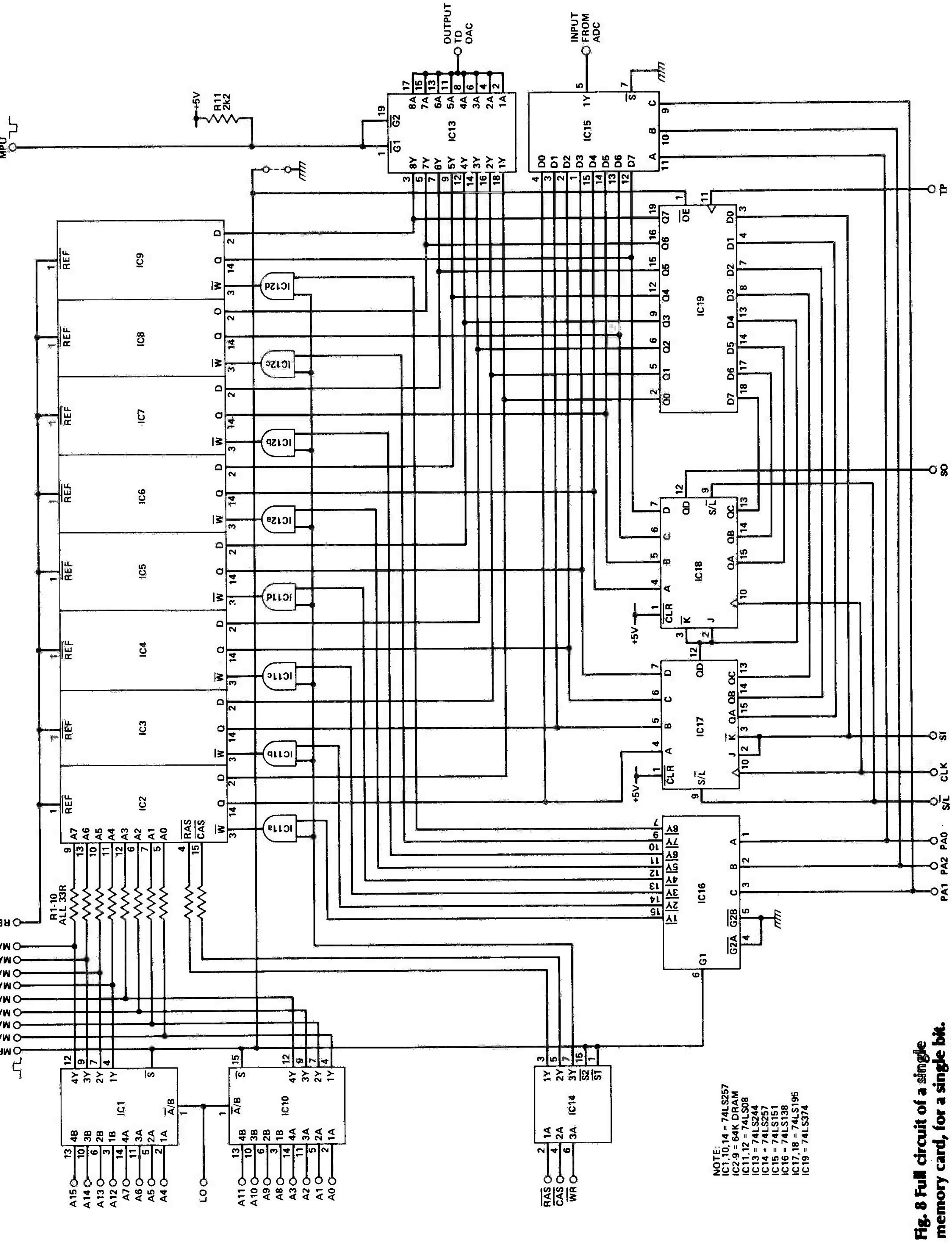

Fig. 8 Full circuit of a single memory card, for a single bit.

SYSTEM FAILURE

The UK's defence industry isn't delivering - either in terms of reliability, which is this report's main concern, or in commercial and export terms. Dave Bradshaw has been talking to a very experienced engineer, working in defence, to find out why.

Like it or not, each adult in the UK contributes several hundred pounds a year to the defence industry (the exact figure is not easy to calculate). A large proportion of our electronics engineers are employed in this industry, either directly or indirectly, and much the largest share of all research is conducted for military purposes.

With all this effort going on, it is important to ask whether we are getting value for money, because it would represent a huge waste of resources if we were not. To give value for money, a military system must work, ie it must be reliable. But there are are very serious question marks against the reliability of some systems. For example, when the Belgrano was sunk during the South Atlantic conflict, conventional torpedoes were used even though the submarine which did the sinking was believed to have 'Stingray' torpedoes aboard. Why? Could it be that the sub's captain didn't trust the high-tech torpedoes to do the job?

The problem with torpedoes is that if the first one misses, it gives the enemy warning that an attack is being mounted, which in turn gives time for preventative action to be taken. So a very high degree of reliability is necessary for torpedoes. On the other hand, another high-tech weapon, the Exocet, was used with devastating effect. Here, the circumstances are different, because if the weapon fails, it might not alert the enemy, but just crash into the sea. Even if the attacker is unlucky enough to alert the attacked, there is still ample time to launch another missile, because the target is slow-moving and the attacker is much faster.

So 'reliable' can mean different things in different circumstances. When there was a scare over some chips manufactured by TI not having been correctly tested, BAe publically stated that they had used the chips in question in the Rapier missile, and that the missile had an 80% success rate which was considered to be very good. In weapons terms, Rapier is a low-complexity, high-reliability weapon.

An example of about the most complex weapons system in service at the moment is the Tornado multi-role combat aircraft. Each major 'service' on a Tornado takes about three months, and that will involve the stripping down of all the systems and sub-systems, and the thorough testing of them all, both individually and in an assembled state. However, by the time the Tornado has landed after its first flight, it has several systems that are not fully functional, and it has to go for further repairs. The F1-11 has similar problems.

It requires a major maintenance effort to keep aircraft like this functional. By contrast, the Harrier is very robust and simple, despite having a particularly highly stressed engine. And we've *given* Harrier technology away to the USA, because we preferred to concentrate on Tornado.

The remainder of this report will look at the factors that affect the reliability of military hardware. One of the problems we have encountered, though, is that while there are countless examples of blunders committed in defence contracts, the actual examples we might be able to give are all covered by the Official Secrets act. In the vast majority of these cases, the details of the mistakes have very few if any defence implications. They do have very large implications for the companies involved in defence. It would be in the long term public interest if details were known - but they cannot be released. Perhaps this is one of the reasons why the British defence industry is losing ground in competing for orders against the Israeli and French industries?

Specification

The specification is basically the document in which the customer says what is required. It is one of the most critical stages in the procurement of a piece of military equipment, and mistakes made here can be difficult if not impossible to rectify. There are a number of 'golden rules' — many of them little more than common sense — which should be followed, but which are all breached to a greater or lesser extent for much of the time. Let us take a look at the rules. They are:

1. The specification must say exactly what the customer wants. There is no room for vagueness, as this will inevitably by exploited in one way or another by one or more parties to the deal.

2. The buyer must understand the specification and all the implications of what is being asked for. This may seem obvious, but contracts are usually drawn up by non-technical staff, at least in part.

3. The contractor, designer, developer and producer must all understand the specification; again, there is a problem of the contract being negotiated by non-technical staff, with the result that it may be inconsistent or open to several different interperetations in key areas.

4. The specification must be complete and must not leave anything out. Here there is the problem of the wrong priorities being emphasised in the drawing up of the spec, but there are additional problems. Military contracts generally run for around ten years from start to completion, but in 1984 it is impossible to predict what circumstances equipment will find on the (hopefully theoretical) battlefields of 1994. Also the sheer complexity of military items can make it virtually impossible to describe them fully — imagine trying to write a full description of a multi-role combat aircraft.

5. Another problem associated with the contracts running for so long is that you cannot be sure that the device will be used as it is designed to be used. If the design work is done ten years before deployment, the actual way it will be used cannot be predicted.

6. The device must be testable, and this must be built into it from the start. Inevitably, there will be aspects that cannot be tested, and it must be understood how

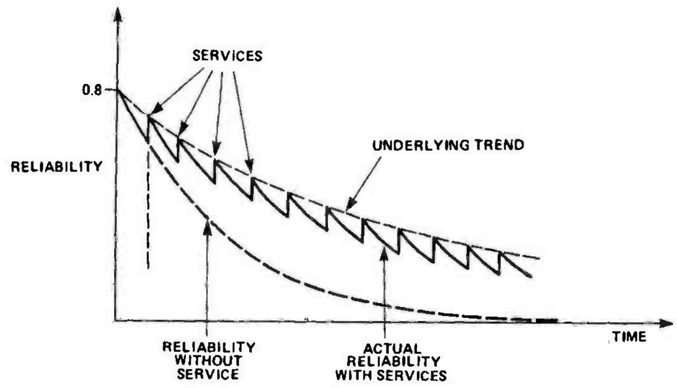

Fig. 1 Reliability declines with servicing.

much cannot be tested and how important that is to the system.

7. It must be possible to test the device without degrading it too much. One of the ironies with large-scale systems is that testing them actually makes them less reliable in the long run, see Fig. 1.

Let us pursue this question of testing a bit further. Large-scale weapons systems have some sort of self-test capability (ie BITE, built-in test equipment). Others, like missiles, will have an associated test box, so that you can plug the missile into a box of tricks that will then put the missile through its paces, testing the main routines that the missile's equipment will have to perform in actual use. This test might be a daily, weekly or monthly ritual, depending on the device in question.

Such a test can only give a partial check on the system, so periodically the whole missile will be taken apart, all the sub-systems in it tested, then it will be reassembled and given a full system test which will, so far as is possible without actually firing the missile off at a target, test the full system under simulated systems conditions.

There are several problems here. Firstly, without firing the missile, you can't fully test it - and there are major aspects of the operating environment you just cannot simulate. For example, you cannot simulate the launch satisfactorily. There are so many combinations of conditions that the missile may encounter that you cannot test them all.

There is a whole range of one-shot devices in any system that cannot be tested; these range from the warhead itself to explosive bolts. Testing these destroys them and they can only be replaced with similar items which, again, you can't test without destroying.

A further problem with mechanical parts of the system is that even after testing you cannot be sure that they will work. An example would be the wings and engine air-intake on a cruise missile. There are so many variables involved here that can prevent these from working, for example dirt or debris that entered the mechanisms during testing, or small mechanical deformations accidentally introduced in re-mounting the missile. All that you can say is that the mechanical bits worked when tested, but you cannot be sure that they will work the next time they're called upon.

There are particular problems with integrated circuits. After each step of building an IC — and this includes the different diffusion stages of the wafer — the IC is tested and inspected, to see that everything has been done properly. Once the IC is capped (encapsulated) you cannot go back to check on earlier stages, so you're confined to just checking to see that it behaves, so far as you can test, in line with its specifications.

Burnt Out?

One of the principles behind the reliability verification of systems is that of burn-in. The idea is to make sure that the large numbers of early-life failures that occur with any device - be this individual ICs or a large-scale system - occur on the test bench rather than the battle-field. Failure early in the lifespan is somewhat tastelessly referred to as 'infant mortality'. These are usually caused by gross failure mechanisms due to manufacturing shortcomings (eg, dry joints, unsecured components, poor insulation , etc).

The idea is to create the worst possible operating conditions in which the device must operate, and subject it to these conditions for a period of time — typically 168 hours (one week) for high reliability ICs — and see if it fails. Individual devices, eg ICs, are burnt in, then they're assembled into boards and burn-in repeated, then the boards are assembled in sub-systems and the burn-in repeated, and finally the whole system is assembled and burnt in.

If the burn-in procedures are not adhered to fully, faults will get through and end up appearing in the finished items of equipment. Combined with the effects of long-term degradation, such infant mortality faults can appear to be random failures - except that these 'random' failures would be occuring rather more often than would be expected. However, it is difficult to distinguish between random failures and a quality control problem due to inadequate burn-in.

Manufacturers are under quite a lot of commercial pressure to curtail burn-in where possible. It costs a great deal of money and ties down resources. For example, assembling even the smallest system could take four weeks and tie up environmental testing facilities for that length of time as one week will be required for each stage — burning-in the components, the boards, the sub-systems and the system as a whole, albeit in different sections of the factory, or in different factories.

Even with an apparently adequate 'burn-in' programmme, we still come back to the problem that you cannot adequately reproduce the full operating conditions. For example, the way components are mounted can count for a lot. If they are mounted in such a way that they can vibrate, it is not unknown for them to go into a very destructive mechanical resonance during, say, the launch of a missile.

Contracting

The commercial arrangements surrounding military contracts have strong repercussions on the reliabilities of the eventual products. Until recently, all contracts used to be on a *cost-plus* basis - the contractor would be paid as much as was spent on a particular project **plus** an agreed profit margin. As you might imagine, this was a licence to print money for the contractor, but it also encouraged very bad habits on the part of the customer.

The main problem was that the military would continue to change the specification of the equipment required right the way through the contract's life. These changes would be called 'enhancements', although they would frequently be incompatible with the original specification. These 'enhancements' might be trivial - for example, the moving of a bracket - but they might also be quite large. An accumulation of apparently trivial changes can amount to a major design change.

During the typical contract life of ten years, the military would be going back to the contractor with 'enhancements' for virtually the full life of the contract, almost as a matter of course. Over ten years there will be a considerable change in the technology available, and the military wants to see the latest in technology incorporated into their toys. 'Enhancements' have the result that the system at the end of the project could be completely different from the concept at the start. Obviously, it has considerable repercussions for the reliability of the system if there are a number of 'bolt-on' extras added at different stages of the design and development.

Fixed Cost?

To overcome some of these problems, the present minister of defence, Michael Heseltine, has introduced what at first seems like a step in the right direction (no pun intended). The *fixed - price contract* is, in theory, exactly what it says — the contractor will get a fixed amount of money for doing a fixed job. This was introduced mainly to prevent the sort of price escalation that has been so common in defence contracts, but as a side-effect it should have got rid of the continuously varying spec. It hasn't.

The problem is that the eventual users of the equipment are still treating these contracts as cost-plus, and are demanding 'enhancements' from the contractors. Contractors are all too pleased to provide the enhancements requested — and even to make a few suggestions of their own —because, not unexpectedly, it will mean an increased price for the work. The customer can hardly object to this, and in any case, there could be no question of taking away the contract from one company and moving it to another, because that would extend the wait before the equipment comes into service.

Even if the military do not want 'enhancements', the contractor can easily find ways to increase the price because the specification and contractual terms are generally very loose, as is the monitoring of contracts. Just how loosely military contracts are monitored here can be judged in comparison to the way that NASA and ESA monitor their contractors' behaviour.

For example, if you are a sub-contractor to NASA, periodically you will recieve a visit at very short notice from a technical expert. The warning you get could be 24 hours or less. The expert will want to see all the work you are doing, how it is progressing, and will want to know the reasoning behind all the procedures you have adopted. Engineers who have been through this process describe it as 'very testing'. However, it would be unthinkable for the MoD to adopt a similar process here.

Splitting It Up

Fixed price contracts are not the end of the changes the Government are introducing. The next stage is the putting out of every major stage of the contract to tender. So different companies would have the opportunity to bid at each of the stages; in a typical case, these are: feasibility study; project definition; development; initial production; and quantity production.

The new system has only just been introduced, so it is not yet possible to see how it will work out in practice. The idea is to make contractors competitive in price at every stage of the process, but the major fear is that it might result in significantly less reliable end-products.

The problem is that if different contractors do different stages in the process, there is a lack of the engineering continuity which is essential for high reliability through feasibility, definition, development and production. As has already been mentioned, contracts are not normally drawn up by technical staff, although there is technical involvement. The more separate contracts are placed, the more contracts have to be written and the more the problems associated with this come to matter. However, on top of this there are always many things that even competent engineers do not write down - these range from apparently insignificant details to underlying assumptions; indeed, it is more likely to be the latter, rather than the former, that don't get written down.

Even if everything of importance does get written down, the experience and enthusiasm of the engineers involved in the project cannot be transferred from one contractor to another. In particular, if an engineer gets involved in a job which is then taken away, it is unlikely that the next engineer will, at least initially, have the same experience and motivation.

One effect that may not be all that bad is that the switch to part-contracts may lead companies to develop — or buy-in — ranges of off-the-shelf components instead of developing new ones. For example, to produce a generator, the fastest solution is to use off-the-shelf components of engine, dynamo and voltage regulator, whereas at the moment a contractor would automatically design a special-purpose unit from scratch. The reason for this change is that contractors will have to bid for a large number of jobs at any one time — all of them of shorter duration than at present — and it will not be known what the next contract will require. So the flexibility of off-the-shelf units will be necessary.

Finally, an inevitable consequence of part-contracts will be that contractors will spend more on making proposals. Each proposal costs time and money, and the customer will end up paying for this in the long run. At present, it is not uncommon for the cost of making a proposal to be buried in the costs of existing contracts — the system is so slack that contractors can allocate engineers' time to virtually anything they like. Whether fixed price contracts will eventually make it more difficult for costs to be hidden remains to be seen, but it is thought unlikely that it will make much difference.

Design Discipline

A good example of the importance of design discipline has been documented for the cruise missile programme. The sub-contractor doing the software ran into problems, but instead of properly analysing the trouble, the approach adopted was to throw more money at it by bringing in more software engineers. This just compounded the problems. Prof. C. Brooks of the University of N. Carolina's computing department describes the nature of working on software with the following analogy: "The bearing of a child takes nine months, no matter how many women are assigned.

Many software tasks have this characteristic because of the sequential nature of debugging." In other words, you can't rush writing software, but that doesn't stop defence contractors trying.

In general, contractors start their FMECA study far too late in the life of contracts. FMECA stands for Failure Mode, Effects and Criticality Analysis, and it is concerned with looking at the likely shortcomings of the design in a very critical and analytical way. Starting this process any later than the early stages of design and development can greatly reduce its effectiveness. However, contractors will often not start this procedure until they've already realised that there is a problem — ie, they're already in trouble and they're clutching at remedial straws. They throw money at the problem as a substitute for proper planning in the early stages.

Ideally, it should be written into any contract that the FMECA programme should start at some short interval — say 30 days — after the development contract has been awarded. This would then have to be very closely monitored to make sure that it really did happen. Very often an inquiry as to the progress on FMECA will result in the contractor hurriedly starting it up — but at too late a stage to have any real impact. The contractor will then pretend to the customer that the FMECA programme had been in hand all the time and they can get away with it because the MOD(PE) does not monitor effectively.

Short Term Contracts

It should be possible to carry through most military contracts in a much shorter time than they presently occupy. We would suggest that a target of two years — not ten — should be aimed for. A number of advantages would be incurred by going for much shorter time scales.

Firstly, the contractor and the customer would have to stick to the original specification. This would have the effect of 'freezing' the technology used at the time of design — but with only a two-year time lapse, this technology would still be in-date and not nearly obsolete, as would be the case with a ten-year contract.

Secondly, there would be a general reduction in price. Besides fixed price actually meaning that, the massive overheads incurred by having a job going on for so long would be reduced, as would the expenses involved in meetings. The main losers would be hoteliers, restaurants, travel agents and air-lines.

Finally, there would be the real opportunity to learn by mistakes. You can actually have an item of equipment out and in use at the time that you are looking at either the Mk.2 version, or at the next generation of equipment.

As far as we can see, it is sheer inertia that is stopping this sort of development, not technical complexity. If compact disc players can be designed and developed, using entirely new technology, in the space of a couple of years or so, then why not a new command, control, communication system for the army? Yet the Ptarmigan system has been under development by Plessey for the last 12 years and is still not fully deployed.

Conclusion

The way that the defence industry is organised at the moment, the products work despite the system, and mainly because of the dedication of individuals. A major reorganisation would result in a much less costly more effective industry, which would, in the long term, be better for all concerned. **ETI**

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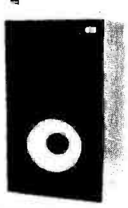

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DISTORTION METER

Writing in his Audio Design article in the August issue of ETI, John Linsley Hood offered to describe a simple yet sensitive distortion meter, assuming, that is, the editor didn't mind! Needless to say, the editor didn't mind at all.

The ideal audio power amplifier, along with other pieces of audio signal handling gear which are not intended to modify the frequency response of a system, is well described by the old adage 'a straight piece of wire with gain'. This implies that such equipment does not modify or impair the nature of the signal being handled, except to amplify or add muscle power.

However, if this is the specification, how do we check to see how well or badly this requirement is being met? This is, alas, something on which there is very little agreement between audio engineers or circuit designers. So, before we consider the hardware, we need to examine the job we want it to do.

In simple terms, what we want is that the output from an amplifier should be identical to the input, except that it might be bigger or smaller or perhaps with one part of the frequency spectrum enlarged or diminished with regard to another. This is an awkward bit, so let us leave that on one side for the moment and look just at the simple flat-frequency-response area.

When people first considered this problem, their thoughts turned to the examination of a continuous, fixed frequency sine waveform somewhere in the middle of the audible band, say at 1000Hz. The logic of this was that any distortion of this waveform would lead, as could be shown by mathematical analysis, to the generation of harmonics of the input signal, and these could be isolated and measured.

The problem with this approach is that it is highly artificial. We simply do not listen for instruction or enjoyment to steady single tones. Nevertheless, the technique is a useful one, especially if the output from the distortion meter can be examined on an oscilloscope. Quite a lot of information about its defects — yes, there are always some, if one looks hard enough — can then be gained, which allows the effects of changes to be assessed.

The most common of this kind of distortion meter is the simple 'notch filter', which will remove the incoming sine-wave signal and leave only the waveform impurities which have been added by the hardware we are testing.

The sort of result we would get from this kind of test on an amplifier with cross-over distortion, or one driven into clipping, is shown in Fig. 1, a and b. What the distortion meter is showing us, in both cases, is what kind of a waveform would have to be added to the distorted output in order to get back to the waveform with which we started. Clearly, there is a difference between these, which can point the experienced worker in the right direction to remedy the defect, especially if the input signal and distortion meter output waveforms can be displayed at the same time on a double-beam oscilloscope.

The most conspicuous audible effect of the presence of large amounts of 'low order' harmonic distortion, (ie. mainly 2nd and 3rd) is that, as its name suggests, harmonic tones are added, which make the system sound rather shrill. Those of us with long

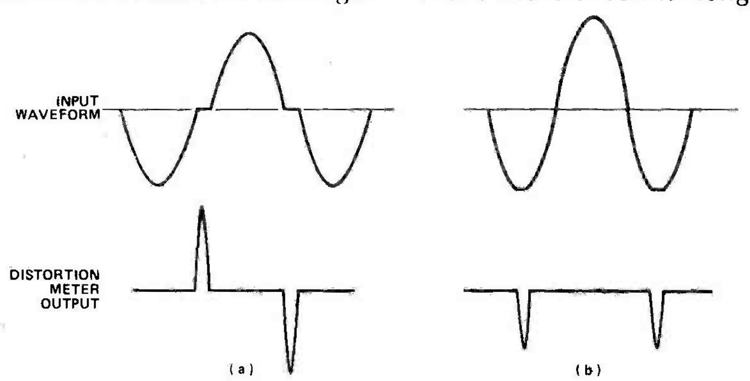


Fig. 1 Examples of the waveforms obtained by using a notch filter on distorted sine-waves.

memories will recall the sound of output pentode valves, which generated generous quantities of 3rd harmonic distortion, and for which the palliative was to stick a 10n capacitor across the primary of the output transformer. Triodes were much preferred, since they mainly generated only 2nd harmonic distortion, and this was lower down in the frequency spectrum and therefore much less squawky.

Also, as one might guess, these 'low order' harmonics generate spurious waveforms which do, in fact, harmonise with the input signal; once one gets beyond the 3rd harmonic in the 'odd' series, or beyond the 6th in the 'even' one, the tones become increasingly dissonant and objectionable to the listener.

This was one of the reasons why the first transistor amplifiers (whose residual crossover distortion produced 7th, 9th, 11th, and other audibly dissonant odd harmonics) were so much worse, even at a 0.1% distortion figure, than the valve units they replaced.

However, back to valves. When, in the early post-war years, designers began to consider seriously the requirements for high quality audio systems — at that time largely based on triode valve output stages, operated in push-pull to cancel as much of the even order harmonics as possible — attention was drawn to the other defect, shown in Fig. 2. This was associated with non-linearity in the handling of the signal, and was the so-called intermodulation distortion, which led to a muddling of the tonal quality.

If we take two separate and distinct audio signals as shown in Fig. 2a, and add them together as shown in Fig. 2b, and if we pass them through an amplifying stage having the sort of non-linear input-output characteristic shown in Fig. 2c, the result will be similar to that shown in Fig. 2d, in which the gain of the amplifier is reduced as it swings into its upper voltage region.

The worse the non-linearity, the more the intermodulation effects between initially separate and distinct input signals. Also, as you can see from Figs. 2e and 2f, a different kind of non-linearity will produce a different kind of intermodulated output. Once again, the effects due to high order defects such as crossover distortion are worse, audibly, than those due to smooth bends in the transfer characteristics of the system — which provides yet one more reason why designers try to minimise the generation of the higher order harmonics.

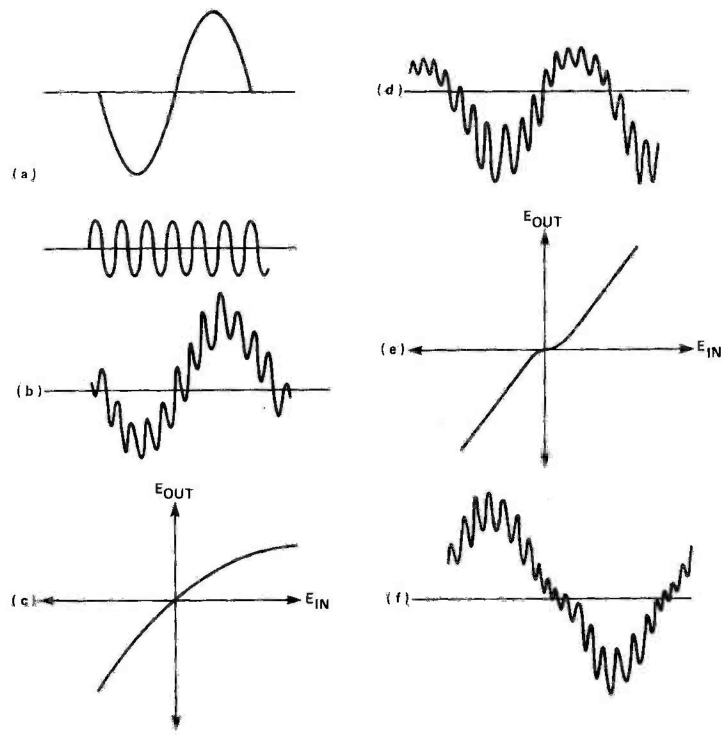


Fig. 2 The introduction of intermodulation distortion as a result of passing two signals through a stage having non-linear characteristics.

The way in which intermodulation distortion is measured is by passing a pair of signals through the system, and then measuring the sum and difference products caused by the non-linearity of the system. For example, if two sine-wave input signals are introduced, one, say, at 70 Hz and one at 3000 Hz, the result of the non-linearity in the amplifier would be to generate additional spurious signals at 2930 Hz and 3070 Hz. If these are filtered out and measured, the amount of distortion in the amplifier can be assessed.

Looking at this in practical terms, if the transfer curve of the amplifier is as shown in Fig. 2c where the gain of the system decreases as it swings more positive, and if we assume that the 3000 Hz signal is a small one riding piggy-back on the much larger 70 Hz one, then, as the 70 Hz signal moves the operating point of the system from lower left to upper right, so the 3000 Hz signal will get bigger or smaller as shown in Fig. 2d.

This is helpful as a yardstick in assessing amplifier quality in that it simulates the effect of typical audio signals which are composed of many different parts, all happening at once, and, in a poor amplifier, with lots of intermodulation distortion, all getting jumbled up together into a kind of audio porridge.

The snags are two. The first of these is that it takes quite good audio filtering in the test instrument to separate out the 2930 Hz and 3070 Hz signals from the 3000 Hz one, which makes such meters expensive. The second snag is that, having got the answer in terms of the amount of intermodulation distortion, the designer isn't given much assistance in finding just where the problem lies. The simple THD meter, with a display on an oscilloscope, is much better in this respect.

A more recent technique, adopted by the French CCIR committee, employs two high frequency signals, such as 19,950 Hz and 20,050 Hz. These give a frequency product appearing at 100 Hz, and it is easy to filter this out from the 20 kHz equal-amplitude carriers.

The argument offered in favour of this approach is that amplifiers, even nowadays, are much less good at 20 kHz in terms of their linearity than they are at, say, 1000 Hz. The counter argument is, of course, that we don't have ears like bats, so we are more interested in how the system behaves at 1000 Hz than what it does at 20 kHz.

Another very up-market technique is to put in a high-purity sinewave signal, or indeed as many of these as one feels inclined to use, and then display the output of the amplifier as a sweep of the frequency spectrum on a spectrum analyser. This is a development of the earlier 'Frequency Analyser' technique, in which the magnitudes of the outputs at various harmonic frequencies related to the input sinewave frequency could be displayed on a meter for individual analysis.

While spectrum analysis gives a very effective display of the amplifier output — 50 Hz warts and all — and the better modern ones are usable down to a noise threshold of –90 or –100dB (0.003—0.001%), in all fairness, it is a bit difficult to see what one has got on the display or print-out if it is much below –80dB (0.01%).

All this kind of kit is very nice, and mouth-watering to contemplate if one is setting up a 'cost no object' test laboratory, but it is a bit remote from the more frugally financed DIY enthusiast. So what can one do for oneself?.

The THD Meter

The most useful piece of gear which one can organise simply, and which will give amplifiers a clean bill of health — or otherwise as the case may be — is a simple Total Harmonic Distortion measuring instrument or THD meter for short.

This operates by 'notching out' the fundamental frequency of the input sinewave and leaving the distortion products, together with any hum and noise there may be in the amplifier output, to be measured on a millivoltmeter. The main snags with this approach are that it will show these hum and noise components as harmonic distortion in the final output to the meter, yet they are nothing to do with the linearity of the system as a whole and are likely to be completely innocuous, audibly, if one can't hear them from the normal sitting position when listening to the system.

Fortunately, it is a simple enough matter to identify which is which, even without access to the oscilloscope, by merely disconnecting the signal source from the amplifier, looking at what remains in numerical terms, and subtracting this from the original result. In order to get a result which is not over-generous to the unit on test, this must be done as an RMS subtraction — I will come to that later.

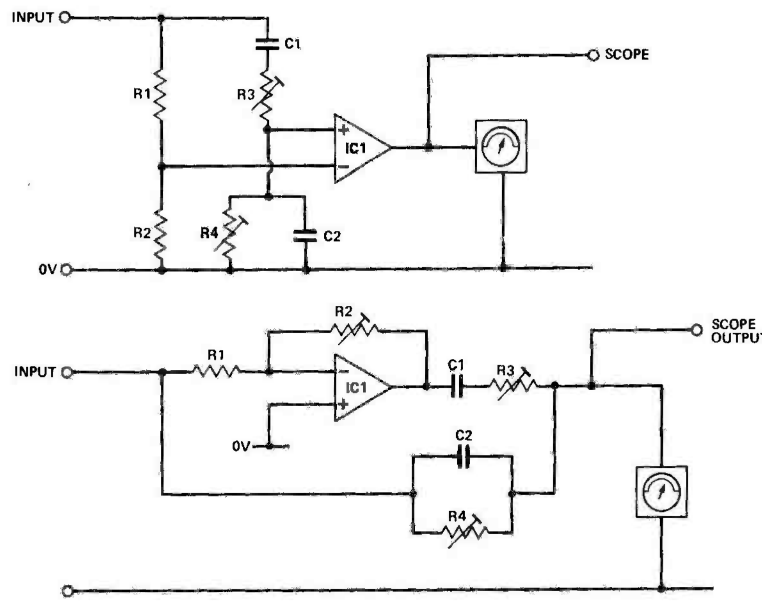


Fig. 3 a and b — Two possible arrangements of the Wien network.

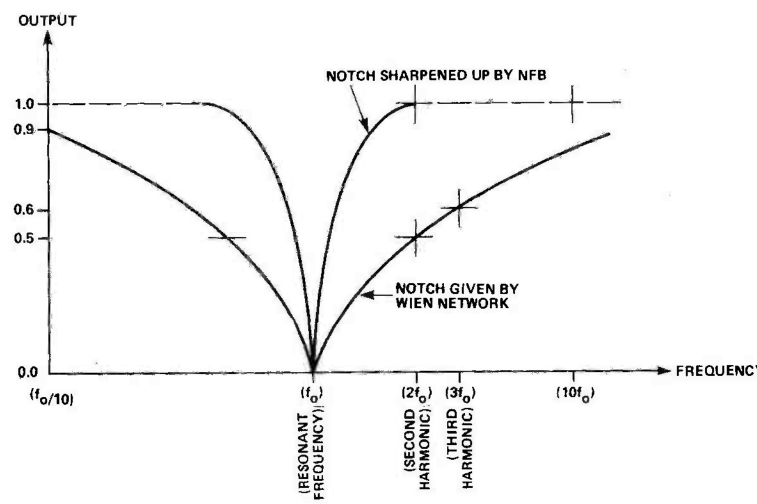


Fig. 4 The notch produced using the arrangement of Fig. 3b.

It is not a difficult matter to generate quite a good notch in a frequency response and tune it precisely to coincide with the frequency of one's test waveform, and there are several circuit choices available for doing this. Of these, the two most convenient and therefore the most commonly used are the RC 'parallel T' and the various arrangements of the Wien network, which I have shown in Fig. 3.

The interesting thing about the Wien network, C1,C2,R3 and R4 in Fig. 3a, is that it has zero phase shift and an attenuation of just 3 times at one specific frequency. If one makes R3 and R4 adjustable, this frequency can be altered. If C1 and C2 are not quite the same — in theory C1=C2 and R3=R4 — the attenuation will not be exactly 3x, but this could be compensated for by an adjustment to R1 or R2.

The differential amplifier I have shown as IC1 would need to be a very good one for this kind of circuit to work well, so the alternative arrangement I have shown in Fig. 3b is preferable.

In this, the amplifier IC1 is used simply to invert the phase of the signal and amplify it by 2x. This utilises the feature of the Wien network that the impedance of C1,R3 is twice that of C2,R4 at the frequency where the phase shift produced by each part of the network is equal. So, if IC1 applies a signal to the upper half of the network which is exactly twice the size of that applied to the lower and of opposite phase, the output will come to a null at some frequency dependent on the values of C and R chosen, as I have shown in Fig. 4.

If we want just to remove the input signal frequency, without attenuating the harmonics, the skirts of the notch must be steeper than those produced by the simple arrangement shown in Fig. 3. However, we can do this by applying a bit of negative feedback around the loop, as I have shown in schematic form in Fig. 5.

To tune the notch frequency so that it exactly coincides with the input signal frequency, we need to be able to adjust the value of either the Cs or the Rs in the network. Since the operating frequency is given by the equation

$$F_0 = \frac{1}{2\pi}\sqrt{C1\ C2\ R3\ R4}$$

the values of C are too large, unless a very high impedance circuit is employed, to allow the use of a twin gang variable capacitor. In fact, if we want the value of R3 and R4 to be 10k, C1 and C2 will need to be 16n for a notch frequency of 1 kHz. Lower frequencies would require proportionally larger values of capacitors.

It is possible to make such a system with an air-spaced twin-gang capacitor, but the necessarily high values of R make the whole unit very sensitive to 'hum' pick-up. Overall, I think it is easier to use variable resistors, which are easier to get and a lot more compact.

The necessary slow-motion adjustment can be obtained by the use of two resistors in series, one ten times the value of the other, when the high value resistors (as ganged pairs adjusted together) can be used as the coarse frequency adjustment, and the lower ones for fine trimming. This principal could be extended, of course, to employ three such twin gangs in series, to allow a very fine adjustment indeed.

Since the resistor which adjusts the gain of IC1 in Fig. 3, (R2), is a single potentiometer, a ten-turn variable resistor can be used in this position to adjust the gain of this limb so that a complete notch is obtained, with no residues of the input frequency remaining.

The final part of the system is a wide bandwidth millivoltmeter, to display the value of the distortion and noise residues remaining when the input sine-wave is removed.

Since we live in the real world, and there will inevitably be some hum pick-up somewhere in the system we are testing, it is useful to incorporate a 50 Hz filter which can be switched in. Also, while we are doing that, we may as well include some HF filtering options, so that we don't measure the THD over too wide a frequency 'window', with its associated noise components.

Finally, it is very helpful, in tests where one is taking the measuring instrument to the gear being tested, to have a built-in signal source of adequate quality.

I am going to describe a relatively simple and low cost THD meter which incorporates the general ideas described above, and I propose to show this circuit in two forms, one a laboratory standard quality instrument operated from a mains input supply, and one a somewhat simpler unit operated from a single 9V battery, which will be rather easier to make if the demands made upon it are less stringent.

I like battery operated instruments myself because they are highly portable and don't cause problems with earth loops. However, if one wants high performance, it is impractical to demand very lower power consumption at the same time. If one then accepts a higher battery drain — say 10–25mA — it is expensive if one forgets to switch the instrument off after use, while any 'auto off' function may well switch it off right in the middle of a measurement, which is infuriating.

Hence the two versions of the unit. I have deliberately tried to make the battery operated system as economical in current consumption as possible without resorting to exotic ICs, and in both cases I have organised things so that the millivoltmeter is available as a separate input, so that it and the oscillator can be used on their own as a means, for example, of measuring frequency response.

To be completed next month.

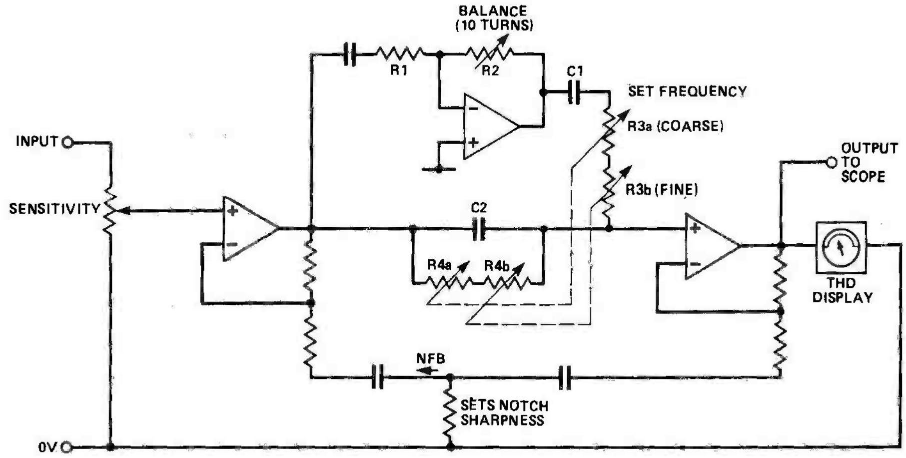
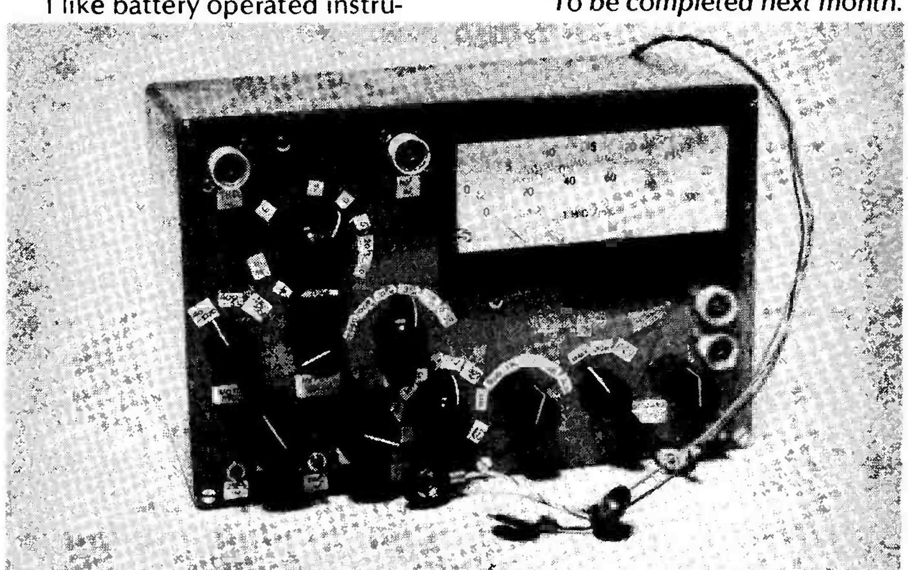


Fig. 5 Wien network with negative feedback to produce a sharper notch.



The prototype, looking much the way most prototypes do at this stage in their development!

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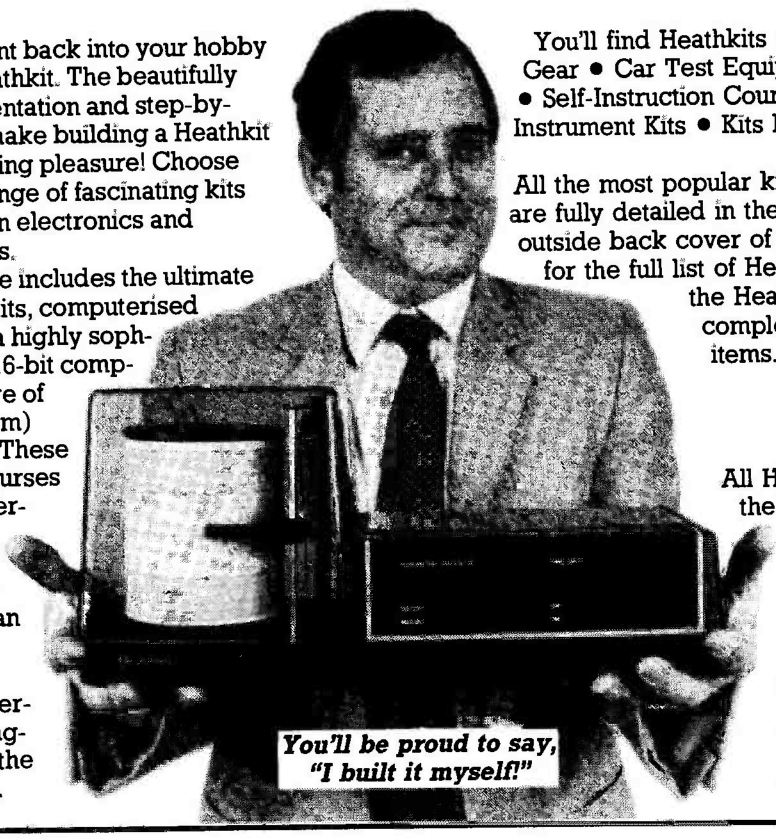

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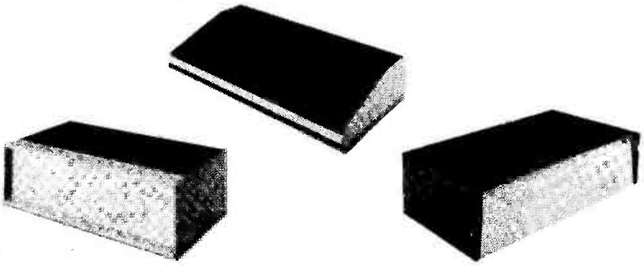

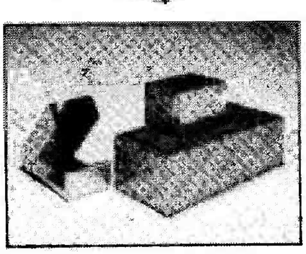

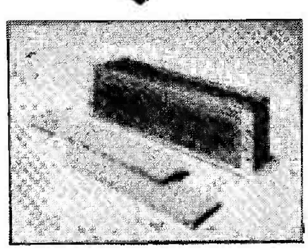

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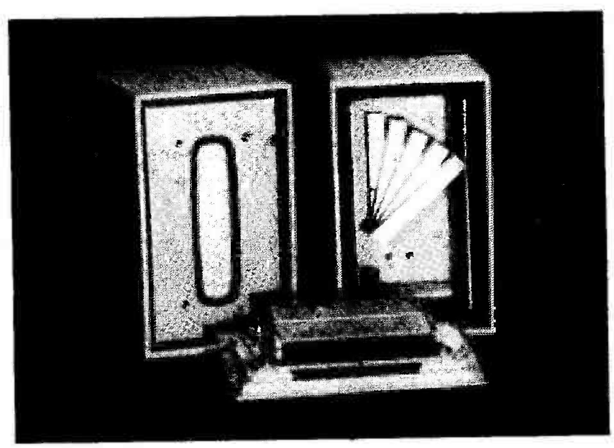

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DIGITAL DELAY LINE

Without further ado, we pass into the constructional stage of the project. Design and development by Ray Lowe.

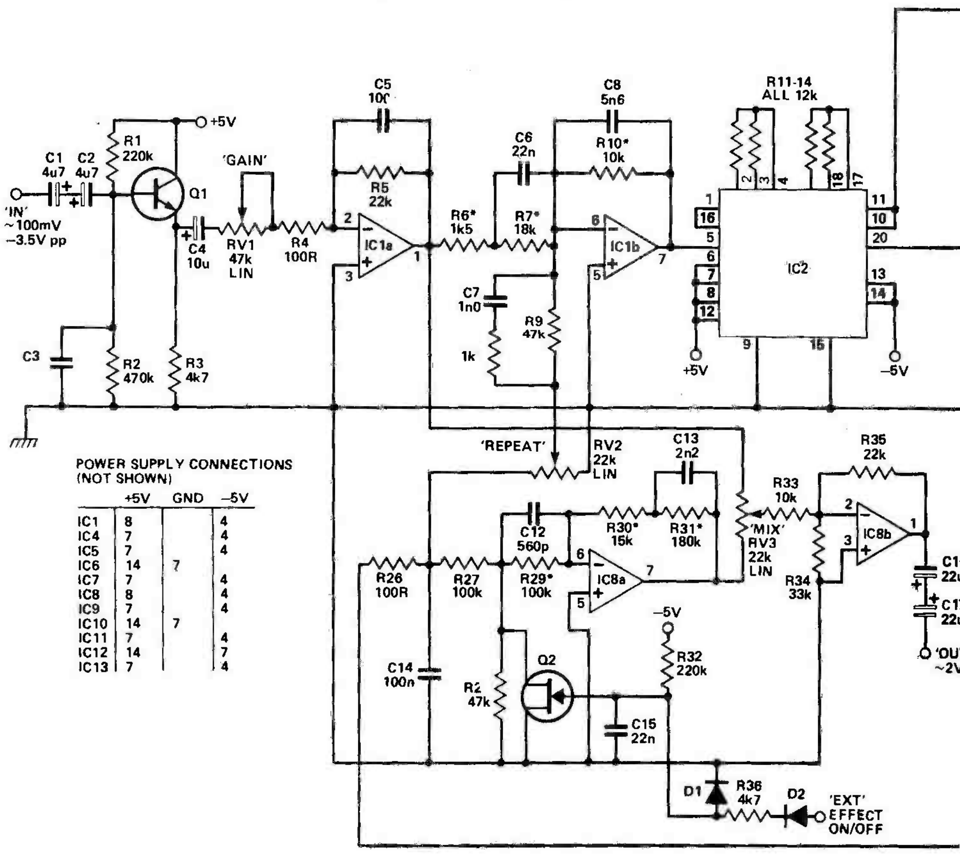
First of all, before commencing construction, read *all* the article (including last month's part) thoroughly and don't rush at the construction when you do begin!

To keep costs down, we haven't used through-plated holes on the PCBs (these would add around 50% to the price of the PCBs); however, this does mean that rather a large number of through-links have to be made. We would suggest spending an hour or so inserting and soldering all the linking pins, then all those components which have their leads used for through-connections, afterwards carefully checking that you've got all the connections right.

A tip here is to support the board above the work surface and insert lengths of tinned wire through the hole positions before soldering them in a batch. Check very carefully for solder bridges between tracks at every opportunity — a fine-tipped iron and fine solder are strongly recommended as parts of the boards are a bit crowded! Making your own PCBs is not recommended for this reason, unless you have access to

OOPS!

We suffered a loss of sync between the component numbering on the circuit diagram and the 'How It Works' text for the digital section, published last month. In the text:
IC24 becomes IC26
IC26 becomes IC25
IC27 becomes IC36
IC29a becomes IC33a
IC29b becomes IC33d
IC29c becomes IC33c
IC29d becomes IC33b
IC30 becomes IC24c
IC30d becomes IC24a
IC32, 33 becomes IC28, 29
IC35 becomes IC32
IC37 becomes IC30
SW11-SW8 should read SW1-SW8
SW9 becomes SW11
SW11 becomes SW9
D7 becomes ZD1
D8 becomes D6
R65 becomes R61
R69 becomes R62
On the circuit diagram, the junctions of R51-54 and R55-58 should be tied to +5V, not 0V, the line from the 0_0 output of IC31 should be labelled CK, and this line also has a spurious unlabelled junction with IC32 that shouldn't be there. We are sorry for any confusion this may have caused!



	+5V	GND	–5V
IC1	8		4
IC4	7		4
IC5	7		4
IC6	14	7	
IC7	7		4
IC8	8		4
IC9	7		4
IC10	14	7	
IC11	7		4
IC12	14		7
IC13	7		4

Fig. 8 Circuit diagram of the analogue section.

HOW IT WORKS — ANALOGUE SECTION

C1, C2 provide non-polarised AC-coupling to emitter follower Q1's base, which is biased by R1, R2. C3 provides HF filtering; Q1 is a low noise device. IC1a is connected as an inverting amplifier. Since the emitter follower has low output impedance, the stage gain is set by RV1 as R5/RV1 approx. DC blocking is provided by C4 so that IC1a's output swings about 0V plus offset voltage. C5 limits the HF response; strict bandwidth limiting is desirable to minimise aliasing and overal system noise.

The amplified original signal is passed to RV3 and to the inverting pre-emphasis stage around IC1b. R6, R7, C6 provide roll-on starting at about 400 Hz whilst R10, C8 start roll-off at around 3.2 kHz, thus mid range lift is produced.

The pre-emphasised signal is (low pass) anti-alias filtered by three MF10 second-order switched capacitor filter stages connected in series, giving -36dB/Octave cut off in total. The corner frequency of the filter is 1/50th of the square wave clock frequency applied to pins 10, 11. In this way, the Nyquist sampling criteria is always satisfied since the sampling frequency is synchronised to the cut off frequency via the system clock.

Some clock breakthrough occurs in the filters and this is removed by R19 and C9; subsonics are removed by R20 and C10. The fully filtered signal is buffered by IC4 such that it swings about 0V. IC4 and IC5 are chosen to have a low input offset voltage of about 1mV for a reason which will become apparent when you read on!

The buffered signal is fed to a 'signal polarity' comparator with hysteresis to elminate noise-induced switching in the absence of a signal. IC9 is the comparator, comprising a high-performance op-amp with a high slew rate — so high that its output can swing between power rails within a microsecond, and respond very quickly indeed to the polarity of the signal on its inverting input. No frequency compensation is required in this application. R37 and R38 give approx 6.5 mV of hysteresis, which is sufficient if you consider that the polarity assigned to a 0 V signal is irrelevant.

D3 and R39 stop IC10b's data input from going −ve; IC10 is a dual positive-edge triggered D-type flip-flop. IC10b latches the comparator output state on receipt of every SC (start conversion) pulse. Q and $\overline{Q}$ control CMOS switches IC6 a,b such that either the inverted or uninverted signal, respectively, is selected at any sample time, so that the signal reaching IC6c is wholly positive (rectified).

The Q values of IC10b form bit nine of the data word for a sample A/D conversion. The bit nine 'bus' direction is controlled by the OE control line. IC6c and C11 form a sample-and-hold, updated on every SC pulse, and in conjunction they also perform low-pass filtering.

IC7 is a FET input op-amp with low offset voltage and low offset vs. temperature coefficient (FET inputs generally have higher offsets than bipolar). It also has very high input impedance so as not to load C11; however when switch IC6c is open this means that the non-inverting input/C11 node is at a very high impedance with respect to ground and is therefore susceptible to electromagnetic interference. Including R23 reduces this impedance from something like 100 Mohm to 680 kohm and interference is much reduced. R23 shorts the switch instead of going straight to ground in order that the discharge of C11 is minimised. IC7 acts as a voltage follower with gain of three, and the offset is nulled by adjustment of PR1. This output is A/D converted into data bits '1' to '8'.

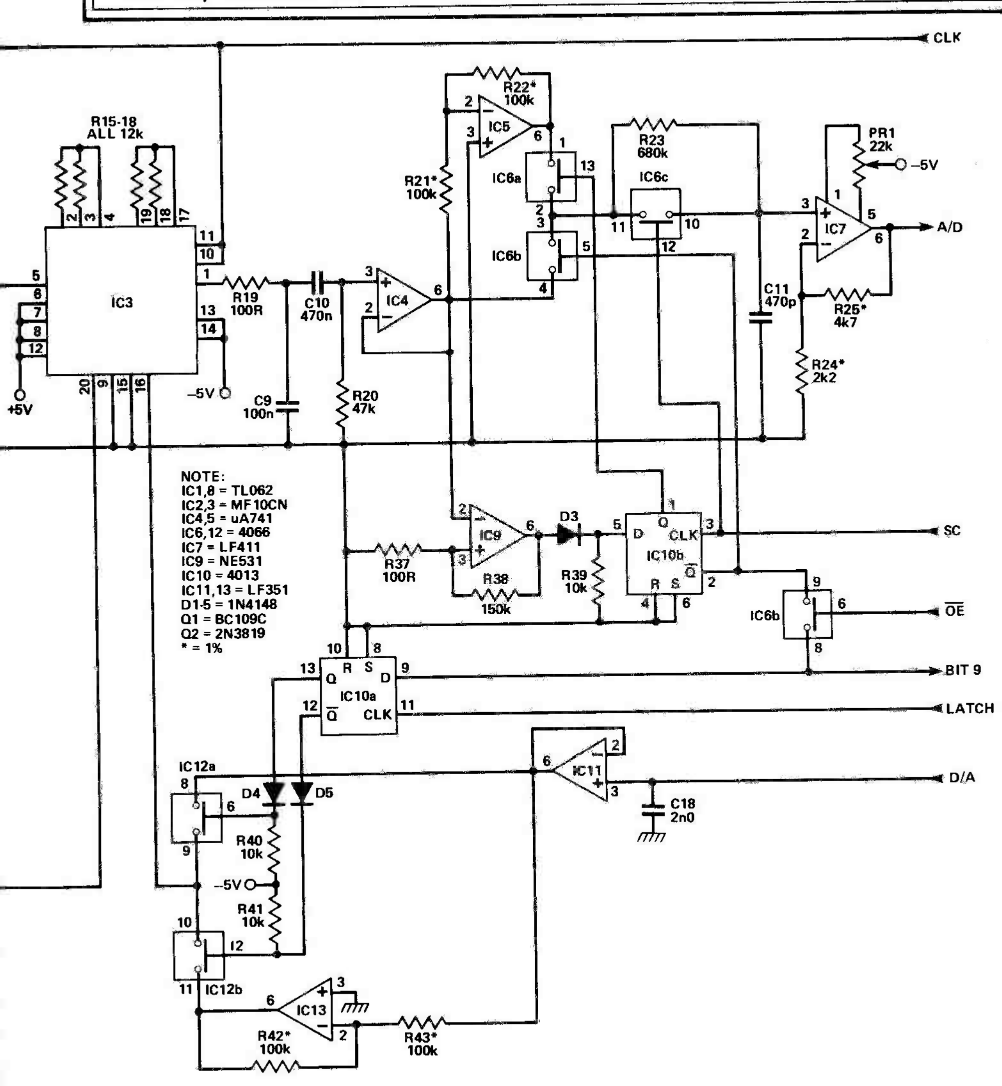
The delayed signal from the D/A is low pass filtered by C18 in conjunction with the D/A's 4k output impedance, to remove HF breakthrough, and the signal is then buffered by IC11. It is then accurately inverted by IC13, R42, R43. Analogue switches IC12 a,b select either the erect or inverted signal dependant upon the sign of 'bit nine' latched into IC10a by the D/A latch pulse. The sign of 'bit nine' is used in a way such that any signal, irrespective of original polarity, is only inverted once throughout the entire A/D & D/A conversion process, thus minimising signal degradation.

The signal entering the second-order low pass filter stage of IC4b at pin 16 has been reconstructed to be bipolar about 0V with 5V P-P amplitude. IC3b 'rounds off' the step-like waveform. The delayed but still pre-emphasised signal appears together with clock breakthrough at pin 20. Breakthrough is removed by R26 and C14.

A fraction of the signal is fed back to be delayed again by applying it to the summing point of IC1b. The feedback fraction, which determines the echo decay rate, is governed by RV2. R8, R9 and C7 counter the effect of roll-off on each extra traversal through this stage, however a slight treble cut remains, but this is useful because it tends to mask the quantisation distortion which builds up with each conversion process. R8 also prevents IC1b from going into HF oscillation, as might happen if C7 were slightly inductive (it would be across the inputs when RV7 is fully off).

The delayed signal is also fed to the output mix control RV3 via de-emphasis amplifier/buffer IC8a. Normally, Q2 has a −ve gate potential which holds its channel resistance very high. When −ve bias is removed, by shorting EXT to 0V, the resistance falls to several hundred ohms which in conjunction with R27, severely attenuates the signal ie, shuts off the echo channel.

The desired blend between original and delayed signals is set by RV3 and the output is buffered by IC8b. Non-polarised DC blocking for the output is done by C16 and C17. The output can drive low impedance headphones directly.



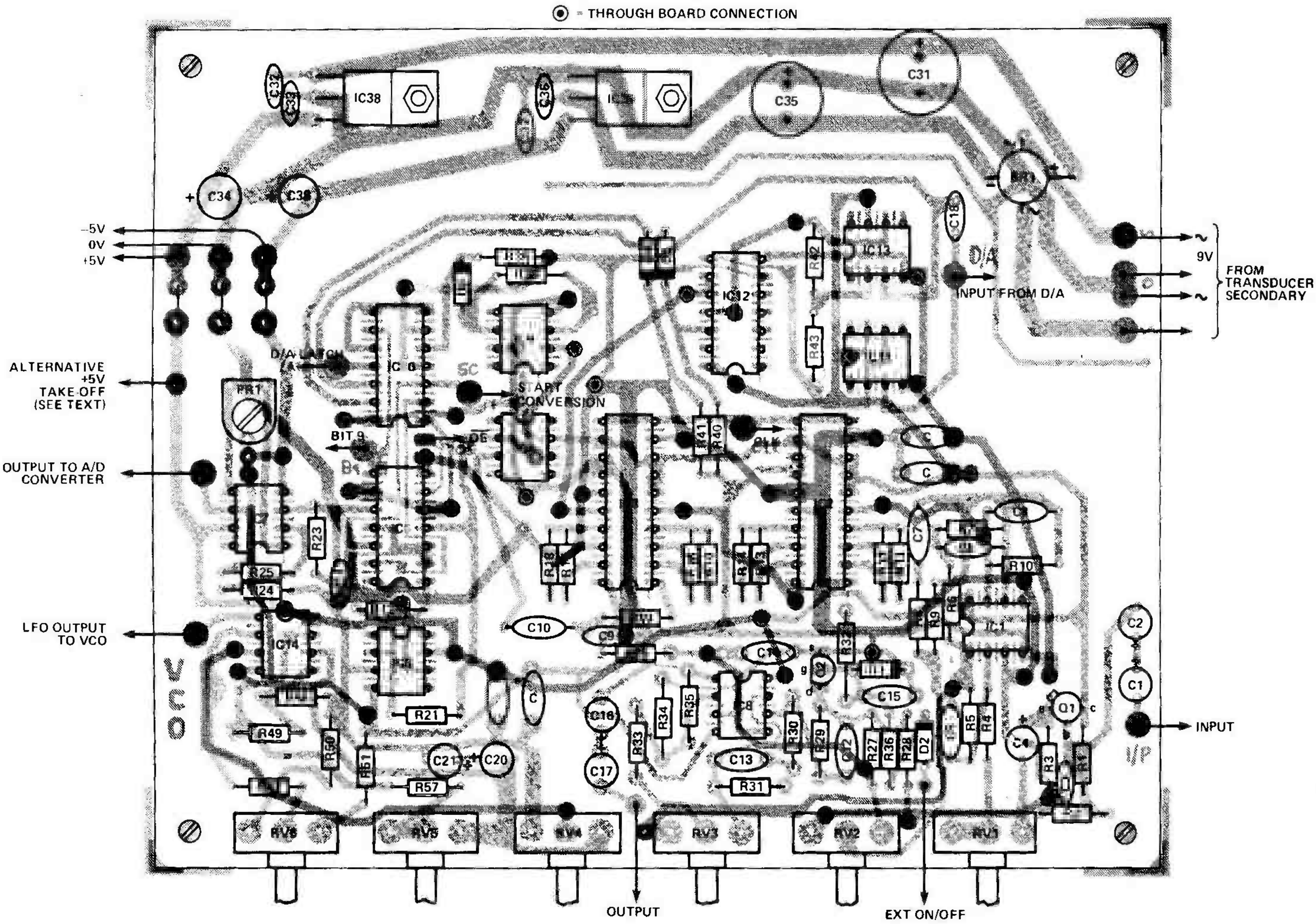


Fig. 9 Overlay for the analogue PCB.

PARTS LIST

RESISTORS (¼W 5%)

R1, 32	220k
R2	470k
R3, 25*, 36	4k7
R4, 19, 26, 37	100R
R5	22k
R6*	1k5
R7*	18k
R8*	1k0
R9, 20, 28	47k
R10*, 33, 39-41	10k
R11-18	12k
R21*, 22*, 27, 29*, 42*, 43*	100k
R23	680k
R24*	2k2
R30*	15k
R31*	180k
R34	33k
R35	22k
R38	150k
R44	680R
R45	4k7
R46	3k9
R47	15k
R48	18k
R49, 50	100k
R51-58, 61, 64	10k
R59, 60, 62	100k
R63	15k
R65	82k
R66	390R
R67	470R
RV1	47k lin
RV2, 3, 6	22k lin
RV4	1M0 lin
RV5	220k lin
PR1	22k horiz preset

* = 1%

CAPACITORS (metalised plate ceramic or 5% polystrene unless stated)

C1, 2	4u7 10V elec
C3	33p
C4	10u 10V elec
C5	100p
C6	22n
C7	1n0
C8	5n6
C9, 14	100n mylar
C10	470n
C11	470p cer
C12	560p poly
C13	2n2
C15	22n mylar
C16, 17	22u 10V elec
C18	2n0 cer (or 2 x 1n0)
C19, 20	100u 10V elec
C21-28	100p
C29	1u0 5V elec
C31, 35	2200u 16V elec
C32, 33, 36, 37	50n (or 47n) ceramic
C34, 38	10u 10V elec

Unmarked capacitors — all 100n ceramic

SEMICONDUCTORS

IC1, 8	TL062
IC2, 3	MF10CN
IC4, 5	uA741
IC6, 12	4066
IC7	LF411
IC9	NE531
IC10	4013
IC11, 13	LF351
IC14	TL062
IC15-23	6116 (any speed)
IC24	4001
IC25	4068
IC26, 27	4051
IC28, 29	4040
IC30	4046
IC31, 32	4017
IC33	4011
IC34	4002
IC35	ZN427E
IC36	uA741
IC37	ZN428E
IC38	7805
IC39	7905
Q1	BC109C
Q2	2N3819
D1-6	1N4148
ZD1	5V6 400mW zener
LED1	min red LED
BR1	35V/1A bridge rectifier

MISCELLANEOUS

SW1-11	DPDT push switches, latching, PCB mtg
SW12	Mains switch
T1	9-0-9V 3VA (min) mains tranformer

Case to suit; mains fuse and holder; input, output and ext sockets to choice; heatsink for +5V regulator; mains cable gland.

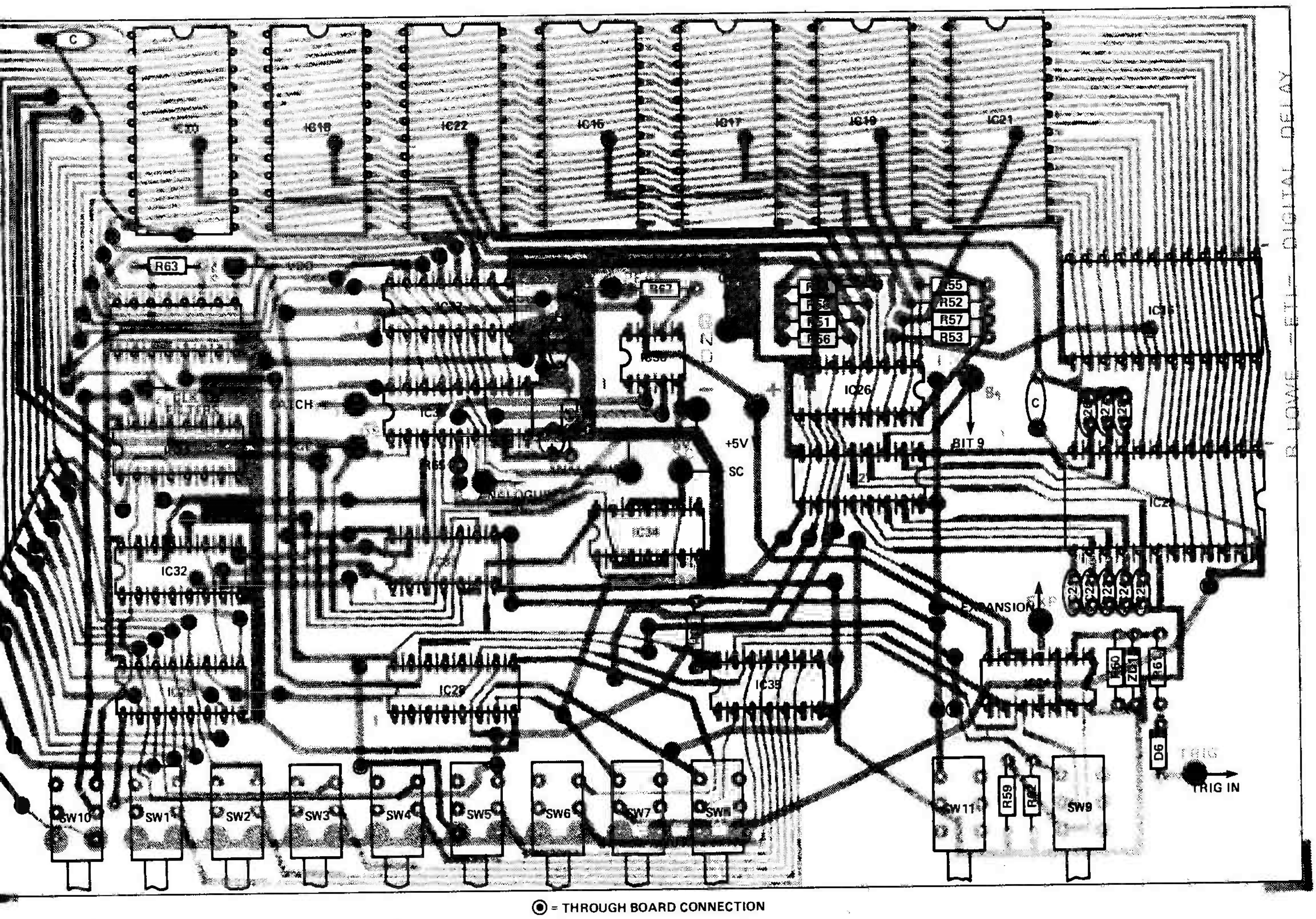


Fig. 10 Overlay for the digital section.

photo-etching gear.

Construct the PSU section first. What we would suggest doing is mounting the mains switch, the mains fuse and the transformer all in the case to start off with. As you'll be fiddling round with the boards, doing the assembly and setting up, it will probably be best not to mount the boards in the case until you have got the unit going properly, so initially link the transformer secondaries to the analogue board using longish lengths of wire. In any case, whatever you do, you must exercise suitable precautions for the mains side of the circuit. Clamp the mains cable firmly, so that it cannot pull free even with a strong pull. Use a suitable mains fuse, in a substantial panel-mounting fuse holder. Use the mains earth to earth the case and all other metalwork (except the regulator heatsinks, if you haven't used an insulating kit on them). There must be adequate clearances and/or insulation around the mains sections and associated components. On this last point, you will almost certainly find yourself operating the unit without the lid on at some stage, so use heathshrink wrap, etc, to make sure that you can't accidentally touch live parts.

After the PSU section is constructed, connect it up to the mains and check that it does deliver + and −5V. Then commence construction of the other sections of the circuits by inserting all the IC sockets (after, of course, disconnecting the unit from the mains!). Then re-connect the mains and check that + or −5V appears across the correct pins. Insert resistors, capacitors, transistors and switches, checking all the time for secure joints and for solder-bridges. With the mains re-connected, check that the current drain is negligible and that the supply rails are at the correct voltage.

With the supply off, plug in the chips one at a time, starting with the least expensive, then reconnect the supply and check that the current drain is sensible and nothing gets too hot (although, with all the ICs inserted, the positive regulator will run warm). Unplug the unit between tests, and remember to discharge your fingertips before handling the CMOS — you can do this by touching an earthed metal case in your work area.

The last items to insert are the A-to-D, the D-to-A, the switched capacitor filters and the memory chips. To check operation of the unit, only two memory ICs are needed, IC15 and IC23, and as S-RAMs are not cheap, it might be prudent to check that the unit is fully functional before you insert any more memory.

The final job before testing is to do all the inter-wiring between the PCBs and any controls, etc, not mounted directly on the PCBs, and to secure the boards firmly in the case.

Setting Up

If all goes well, the unit should be operational as soon as it is switched on, however there is no harm in looking over one final time to see if there's anything you've missed. Do make certain that all is safe on the mains side — not just for your own sake, but for the sake of the equipment you'll be connecting the unit to.

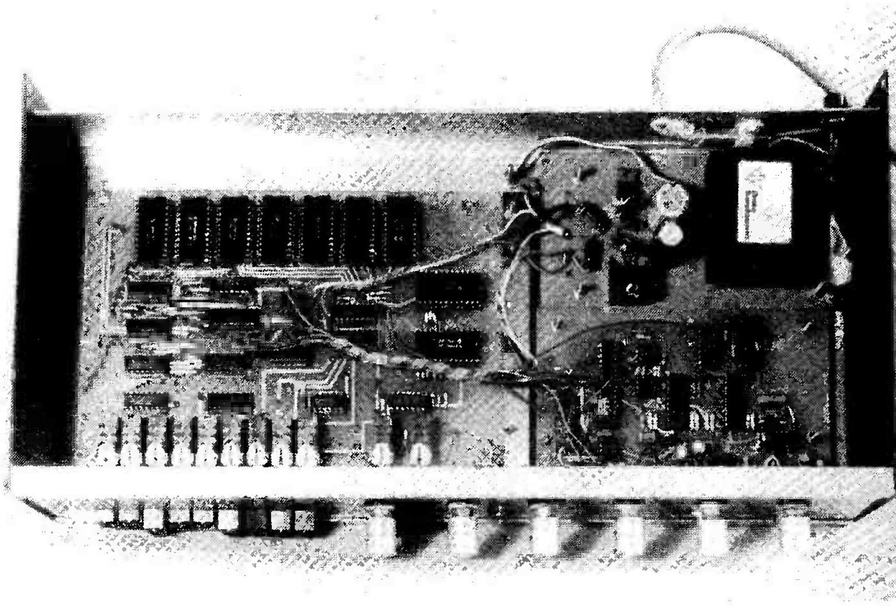
Circuit operation is quite easily checked using an oscilloscope — see the timing diagram, Fig, 4 (given last month). However, the following is a suggested procedure for those constructors without access to a scope.

Connect the output from the unit to an amplifier and speaker, and apply an input signal. The first check is to see if the peak indicator glows with the gain and bandwidth set to maximum (although, this does depend on your input signal being above 200mV or so) — if this doesn't work, the first point to check is the LED polarity. Next, check that with the mix control fully anti-clockwise, the original signal is heard; this will show whether or not there is signal continuity through the analogue board. If no signal is heard, go back and check your construction.

With the shortest delay setting, the mix control fully clockwise, repeat control fully anti-clockwise, freeze and percussion switches out, and the LFO depth control off, check that a delayed signal is heard. It may be distorted, but at the moment this is nothing to worry about.

Remove the input signal and adjust PR1 so that the unit's output is now silent for all bandwidth settings; check that distortion is at a minimum on low-level signals.

The unit should now be ready for mounting in the case. Any case should do, more or less, provided it is big enough to take the boards; however, you might wish to have details of the expansion board before choosing the case, and these will be given next month.



The insides of the prototype: a general-purpose PSU PCB was originally used, with a few mods here and there, so please don't look too closely! Also not recommended is duplicating the author's mains cable relief arrangements!

The one critical area is the cut-out to take the PCB-mouted components; a suggested panel layout-out is shown in the photograph.

Once completed, and with the full memory complement that you've decided to use, the unit should be ready for use. So don't delay further . . .

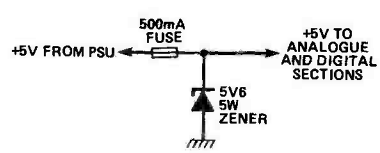


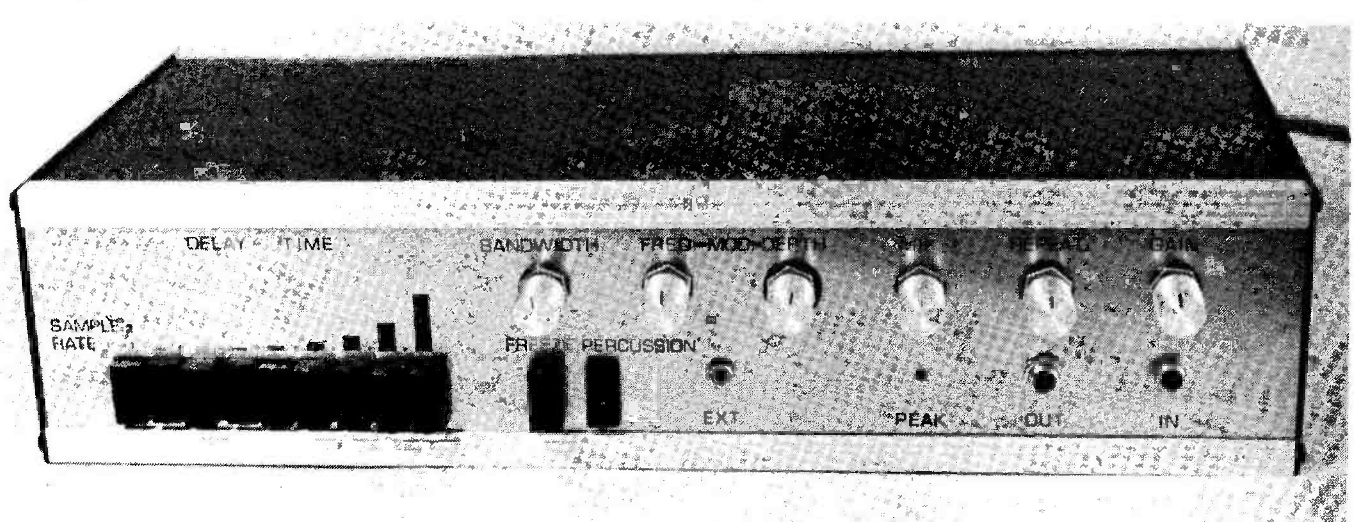
Fig. 11 A suggested modification to make sure that a PSU over-voltage doesn't do too much damage.

BUYLINES

Rather surprisingly with the esoteric devices used in this project, the one semiconductor which might cause a few problems is a humble op-amp — the LF411 (IC7), which was eventually traced to Maplin. A substitute type could be used here, but at the risk of increased cross over type distortion (a very low offset device is required). All the other semiconductors are available from Watford, Cricklewood, Technomatic and Rapid to name but a few, as well as Maplin.

The switches SW1-9 must have the correct lead spacing (0.15" between pins, 0.2" between rows) to fit on the PCB, but this should not create too many problems (for once, RS types are not suitable, as these fit a 0.1" matrix). The ones in the prototype were from Cirkit.

ETI



The finished unit — all ready to go.

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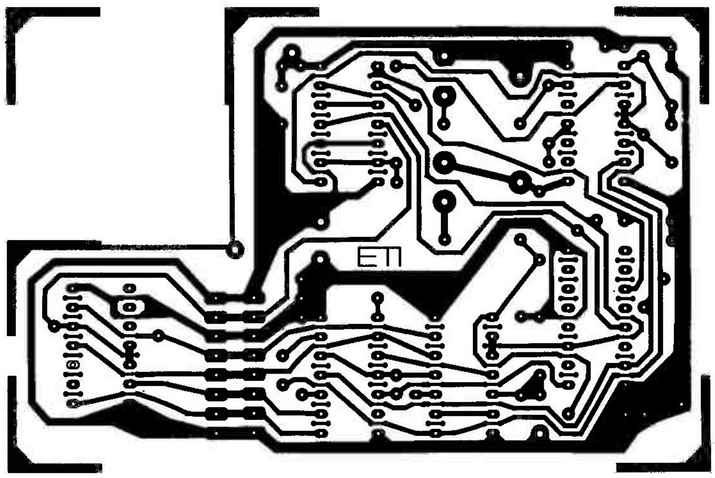
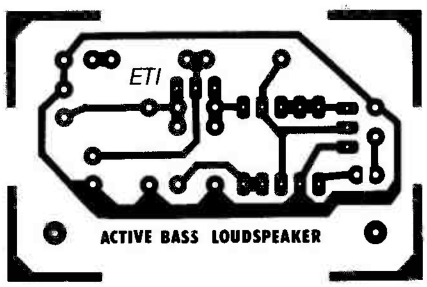


The PCB layout for the DRAM board modification.



The Active Bass Loudspeaker PCB.

Please note that due to lack of space we have been unable to reproduce the Digital Delay Line foil patterns here. We hope to include them next month.

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ETI ADVERTISERS INDEX JANUARY 1985

INDEX 1984

Only a few months have passed since the publication of our complete project index and already it's time for our annual features and projects index. Listed below are all the projects we have published in the last twelve months and all the features other than Digest and Read/Write. Note that, where a series of articles has been carried over from the previous year or continues into this year, we have listed only those parts which actually appeared in 1984. We have also, following the practice adopted in the project index, listed corrections to projects.

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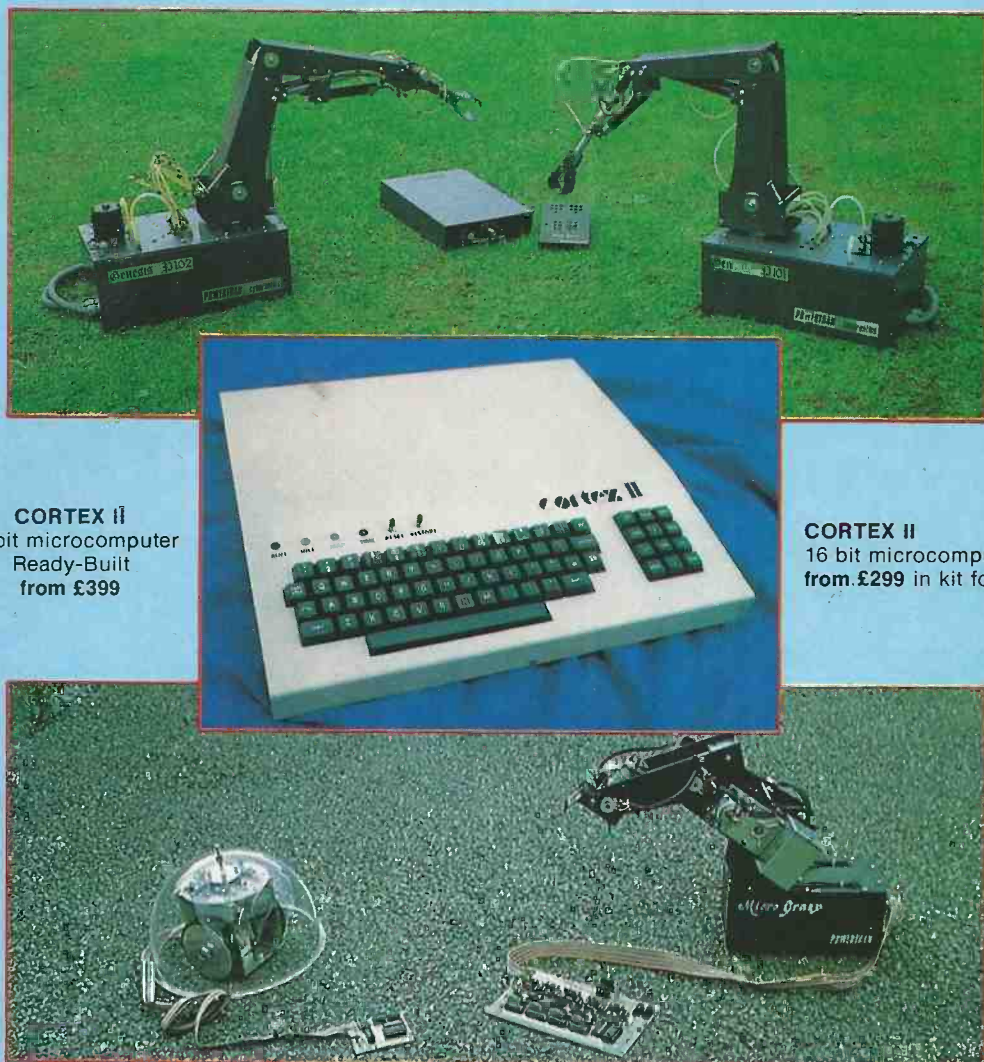

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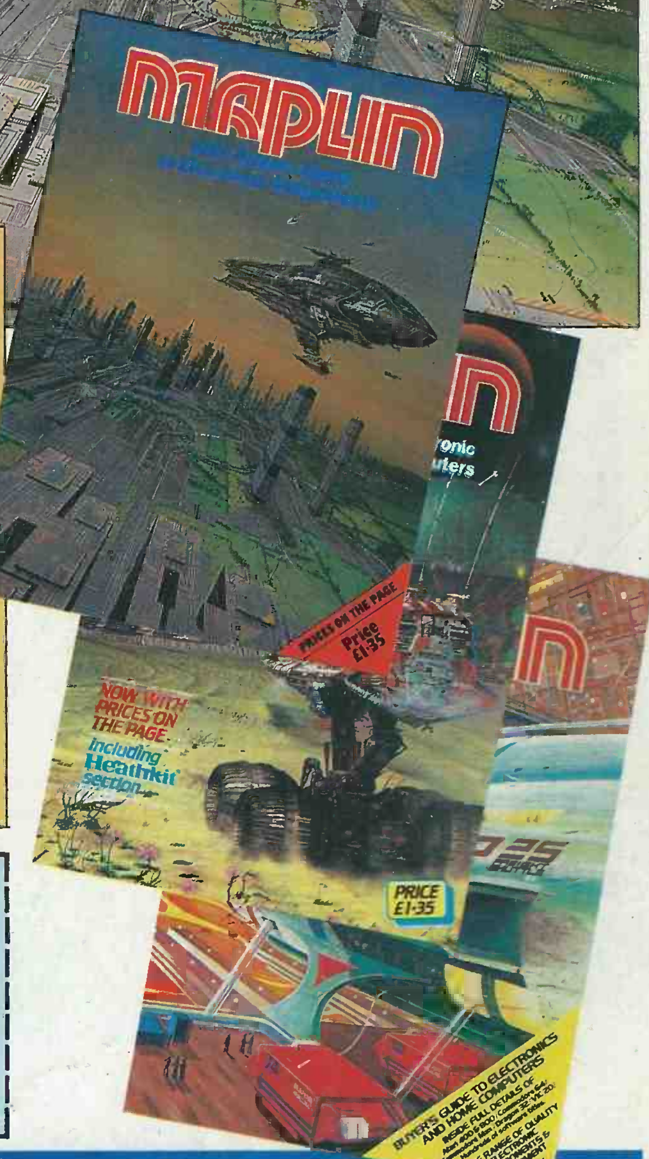

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