AN ARGUS SPECIALIST PUBLICATION

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OCTOBER 1985 £1.10

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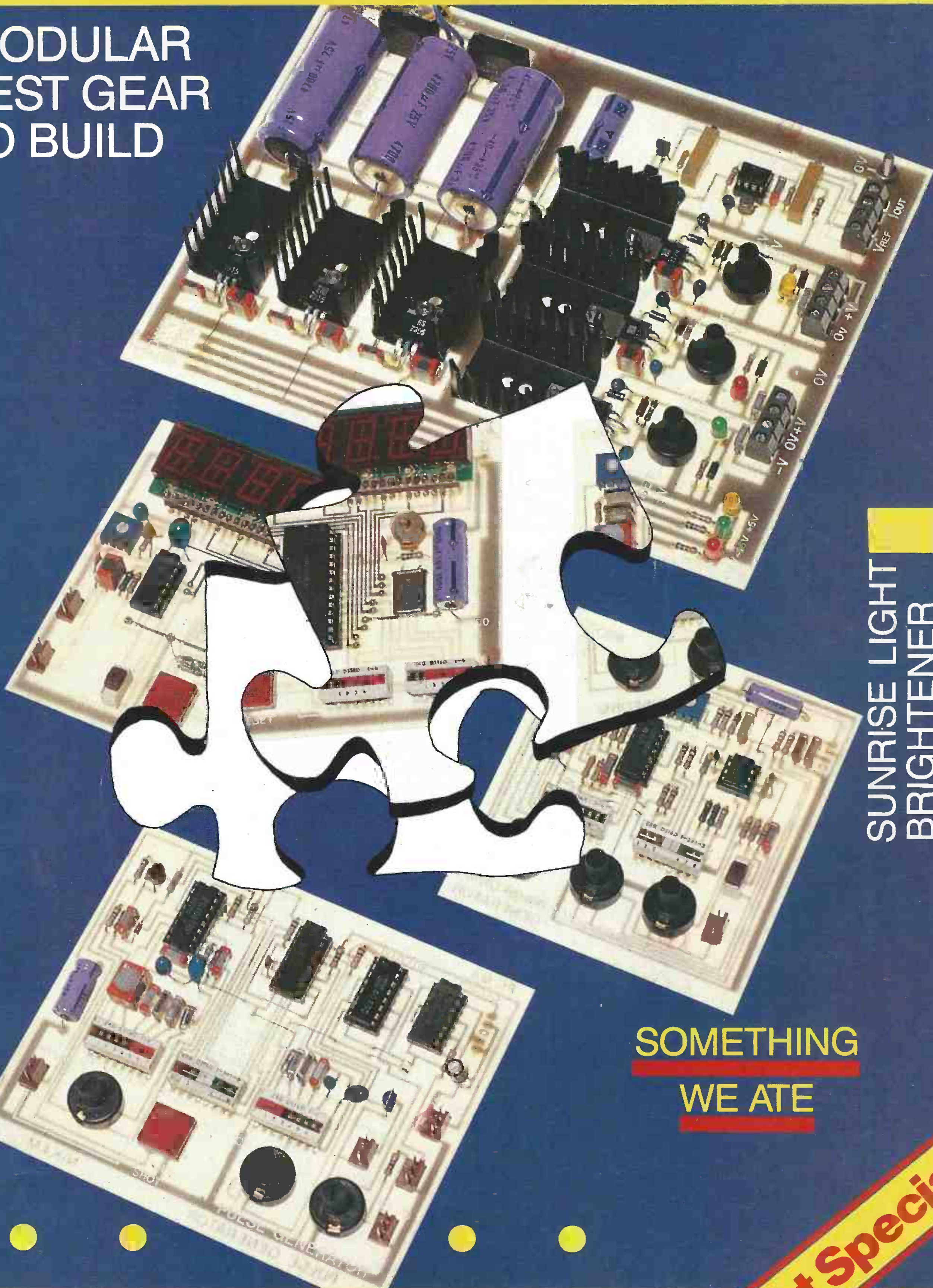
PULSE GENERATOR
WAVEFORM GENERATOR

MODULAR TEST GEAR TO BUILD



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INTERNATIONAL OCTOBER 1985 VOL 14 NO 10

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FEATURES

PROJECTS

ETCETERA

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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 **120p**; 3300 **145p**; 4700 **245p**; **50V**: 2200 **95p**; 3300 **155p**; **40V**: 4700 **160p**; **25V**: 2200 **70p**, 3300 **85p**; 4000, 4700 **75p**; 10,000 **250p**; 15,000 **270p**; **16V**: 22,000 **200p**.

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**.

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**

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**

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/20V **7p** 100nF/20V **7p**

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**.

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 **18p**
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K & 100K **20p.**

DIODES

AA119	8
AA129	10
AAY30	8
BA100	10
BY100	15
BY126	12
BY127	10
CR033	198
OA9	10
OA47	10
OA70	9
OA79	10
OA81	10
OA85	10
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	12
1N5404	16
1N5406	1
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	60

BRIDGE RECTIFIERS

1A/50V	16
1A/100V	20
1A/400V	25
1A/600V	30
2A/50V	26
2A/200V	40
2A/400V	42
2A/600V	50
6A/100V	83
6A/400V	96
10A/200V	215
10A/600V	296
25A/200V	240
25A/600V	396
BY164	56

75 SERIES

75107/8	95
75110	90
75114	150
75121/2	130
75150	125
75154	125
75158	150
75159	195
75160	350
75162	650
75182	99
75188/9	100
75322	140
75324	360
75325	165
75361/3	150
75365	185
75450	85
75451/2	50
75454	70
75491/2	65

ZENERS

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

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

TRIACS

3A200V	54
3A400V	56
8A100V	60
8A400V	69
8A800V	115
12A100V	78
12A400V	90
12A600V	136
16A100V	103
16A400V	106
16A800V	220
25V500V	220
25A800V	296
T2800	125

VARICAPS

BB105B	40
BB106	40
BB109B	45

DIAC

ST2	25

TRANSISTORS

AC126/7	35	BC547/8	12	BFX81	45	OC75/76	55	ZTX501.2	15	2N4286	25	40315	90
AC141/2	35	BC549C	15	BFX84	35	OC81/82	50	ZTX503	18	2N4289	25	40316	95
AC176	35	BC556/7	15	BFX85/6	35	OC83/84	70	ZTX504	25	2N4314	78	40324	100
AC187	35	BC558/9	15	BFY50/51	30	OC170/71	75	ZTX531	125	2N4400	25	40326	70
AC188	35	BCY39/40	85	BFY52	30	OC70	40	ZTX550	25	2N4427	80	40347	90
ACY19/21	75	BCY41/42	30	BFY53	35	OC200	75	2N697	23	2N4871	55	40348	120
ACY22/41	75	BCY45	50	BFY55/56	56	TIP29A	32	2N698	40	2N5135/6	30	40360	60
AD142	120	BCY58/59	36	BFY64	40	TIP29C	38	2N699	48	2N5138	25	40361 2	70
AD149	79	BCY70/71	18	BFY81	120	TIP30A	35	2N706A	25	2N5172	25	40407 8	75
AD161	42	BCY72	25	BFY90	80	TIP30C	37	2N708	25	2N5179	45	40411	285
AD162	42	BCY78	30	BRY39	50	TIP31A	38	2N918	40	2N5180	45	40412	90
AF115/6	80	BD114	190	BSX20	30	TIP31B	39	2N1131 2	40	2N5190.1	75	40467A	130
AF188	80	BD121	95	BSX26/29	45	TIP31C	45	2N1302	45	2N5194	80	40468	85
AF124/26	70	BD124	115	BSY26	35	TIP32A	43	2N1307	70	2N5305/8	30	40594	105
AF139	40	BD131/32	65	BSY95	35	TIP32C	45	2N1671B	180	2N5457/8	30	40603	110
AF178	75	BD133	70	BU105	180	TIP33A	70	2N2160	325	2N5459	30	40673	75
AF186	70	BD135	45	BU205	180	TIP33C	75	2N2219A	28	2N5485	36	40871 2	90
AF239	55	BD136/37	40	BU206	200	TIP34A	85	2N2220A	28	2N5777	45		
BC107	12	BD138/39	40	BU208	200	TIP34C	105	2N2221A	25	2N5879	180		
BC107B	14	BD140	40	BUY69C	225	TIP35A	120	2N2222A	25	2N6027	32		
BC108	12	BD144/45	198	MD8001	250	TIP35C	130	2N2368	25	2SA671	250		
BC108B	14	BD158	68	MJ2955	90	TIP36A	130	2N2369A	18	2SA715	75		
BC108C	14	BD205/6	110	MJE170	150	TIP36C	140	2N2483/4	27	2SC495	85		
BC109	12	BD245	65	MJE180	150	TIP41A	50	2N2646	46	2SC496	85		
BC109B	14	BD378	70	MJE340	54	TIP41B	52	2N2904/5	28	2SC1061	250		
BC109C	14	BD434	70	MJE370	100	TIP42A	55	2N2906/7	28	2SC1096	85		
BC114/5	30	BD517	75	MJE371	100	TIP42B	58	2N2907A	28	2SC1162	45		
BC117/8	25	BD645	80	MJE520	85	TIP120	70	2N2926G	10	2SC1173	125		
BC137/9	40	BD695A	150	MJE521	96	TIP121 2	73	2N3053	25	2SC1306	100		
BC140	38	BD696A	150	MJE2955	98	TIP141/2	120	2N3054	55	2SC1307	150		
BC142/3	38	BF115	45	MJE3055	70	TIP147	120	2N3055	50	2SC1449	95		
BC147	12	BF154/8	30	MPF102	40	TIP2955	70	2N3252	46	2SC1678	140		
BC147B	15	BF167	35	MPF103	30	TIP3055	70	2N3441/2	140	2SC1679	180		
BC148	12	BF173	35	MPF104	30	TIS43	50	2N3614/5	180	2SC1923	85		
BC148B	15	BF177	35	MPF105	30	TIS44/5	45	2N3663	20	2SC1945	225		
BC149	12	BF178	35	MPF106	40	TIS88A	50	2N3702/3	10	2SC1963	80		
BC149C	15	BF179	40	MPSA05	30	TIS90/91	30	2N3704/5	10	2SC1957	80		
BC182L	10	BF184/5	38	MPSA08	30	UC734	99	2N3706/7	10	2SC1969	160		
BC183L	10	BF194/5	12	MPSA12	32	VK1010	99	2N3708/9	10	2SC2028	85		
BC184	10	BF198/9	18	MPSA55	30	VN10KM	70	2N3713	140	2SC2029	200		
BC184L	10	BF200	80	MPSA56	30	VN46AF	95	2N3771	179	2SC2078	170		
BC186/7	28	BF224A	40	MPSA70	40	VN66AF	110	2N3772	195	2SC2091	85		
BC188 6/7	25	BF224B	40	MPSU02	58	VN88AF	120	2N3773	210	2SC2314	86		
BC12	10	BF245	50	MPSU05	60	VN89AF	120	2N3819	35	2SC2166	105		
BC212L	12	BF256A	45	MPSU06	60	ZTX107/8	12	2N3820	60	2SC2335	200		
BC213	10	BF256B	50	MPSU52	65	ZTX109	12	2N3822/3	60	2SC2547	40		
BC213L	12	BF257/8	32	MPSU55	60	ZTX212	28	2N3866	90	2SC2612	200		
BC214	10	BF259	40	MPSU56	60	ZTX300	13	2N3903/4	18	2SD234	74		
BC214L	12	BF275	55	OC26	170	ZTX302	16	2N3905/6	15	2SK45	80		
BC237/8	15	BF336/7	35	OC28	220	ZTX303	25	2N3906	17	2SK288	225		
BC256B	35	BF394	40	OC35	50	ZTX304	17	2N4037	60	2SJ84	225		
BC307B	15	BF451	40	OC36/41	75	ZTX326	30	2N4058	15	2SJ85	225		
BC308	16	BF494/5	40	OC42/75	75	ZTX451	23	2N4061 2	15	3N128	115		
BC318	80	BF594/5	30	OC71/72	50	ZTX500	14	2N4264	30	3N140	115		
BC327	15	BFR39/40	30										
BC337/8	15	BFR41/79	25										
BC441/61	34	BFR80/81	25										
BC477	40	BFR98	105										
BC516/7	40	BFX29	35										

F CHOKES Miniature PCB type
1uH, 2u2, 4u7, 10uF, 22u, 33u, 47u, 100u, 220u, 330u, 470u **35p**
1mH, 1m5, 2m2, 4m7, 10mH **40p**
22mH, 33mH, 43mH, 47mH **60p**
100mH, 220mH **75p**

74HC

HC00	55
HC02	55
HC08	55
HC10	55
HC20	55
HC32	55
HC42	135
HC51	55
HC74	70
HC86	60
HC107	70
HC109	75
HC139	120
HC153	35
HC160	35
HC161	135
HC164	135
HC165	270
HC173	120
HC174	120
HC175	120
HC240	195
HC249	195
HC241	195
HC242	135
HC244	195
HC245	195
HC259	270
HC373	225
HC374	225
HC393	225
HC640	240
HC645	240

COMPUTER ICs

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2114	275	8154	750	MK3886-2M	£7
2147	300	8155	400	MM5280D	696
2516	300	8156	400	MM5303	636
2532	300	8TLS95	175	MM5307	1275
25L32	450	8TLS96	175	MM5387A	865
2564	600	8TLS97	175	MM58174	875
256 K Dram	495	8TLS98	175	MM74C922	420
26501	75	8202	£25	RO-3-2513L	700
2716-5V	300	8205	225	RO-3-2513U	650
2732A	585	8212	220	SAA5050	875
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2764-250	295	8216	150	SPO256AL2	475
27C64	800	8224	300	TJ3101J	£13
27128-250	695	8226	300	TMS2716-3V	725
27256-2	1055	8228	300	TMS4047	100
3242	675	8236	300	TMS4164	200
4027	95	8243	290	TMS4416-2	355
4116-200n	100	8250	£11	TMS4500	£12
4164-150n	200	8251A	350	TMS4532-3	350
4416-2	299	8253	1370	TMS6011	500
4532-3	250	8255	350	TMS9914	895
4816-100ns	100	8256AC	£15	TMS9927	£14
4864-15	200	8257-5	400	TMS9928	£16
6116-150	200	8259	400	TMS9929	£16
6116L-120	220	8271	£46	ULN2003	75
6117-100n	575	8272	£15	UPD7002	440
6167-6	795	8279	750	WD1691	£14
6264L-15	580	8282	450	WD1770	£14
63A03	£14	8283	450	WD2143	850
6464L-15	£11	8284	550	Z80CPU 2.5	295
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6502A	545	8T26A	99	Z80A CTC	310
6503	350	8T27	150	Z80BCPU	£11
6503	550	8T31	350	Z80 DART	650
6504 250	550	8T95	90	Z80A DART	800
6505	650	8T97N	90	Z80B	£8
6520PIA	175	88LS120	395	Z80 DMA	795
6522A	545	9602	220	Z80ADMA	925
6522VIA	340	9637A	250	Z80 PIO	250
6530	610	AM26LS31C	125	Z80A PIO	315
6532RRIOT	650	AM26LS32A	125	Z80 SIO-1	850
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6551ACIA	850	AY-5-1013	300		
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68A02	345	DM8131	275		
6803	560	DP8303	450		
6805	670	DP8304	350		
6808	520	DS3647	600		
6809E	560	DS3691N	350		
6810	150	DS88LS120	300		
6820	150	DS8820	110		
6821	150	DS8830	140		
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		MC3487	225		
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		MC6845	625		

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555Cmos	80
702	50
709C 8 pin	35
710	50
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747C 14 pin	60
748C 8 pin	35
735 8 pin	185
810	160
9400CJ	375
ADC0808	1000
AY-1-1320	225
AY-1-5050	99
AY-1-5051	160
AY-1-6720	210
AY-3-1270	720
AY-3-1458	350
AY-3-8910	390
Booklet for AY-3-8910	150
AY-3-8912	450
AY-5-1317A	630
AY-5-1350	450
AY-5-8100	850
AY-5-3500	650
CA3011	130
CA3012	175
CA3014	275
CA3018	85
CA3019	90
CA3020	210
CA3023	210
CA3028A	110
CA3035	255
CA3036	270

CA3043	275	M51515L	430	TDA2003	190
CA3045	385	M51516L	475	TDA2004	230
CA3046	65	MB3712	200	TDA2006	320
CA3059	325	MB3756	440	TDA2020	320
CA3075	215	MC1204	250	TDA2030	190
CA3080E	65	MC1301	90	TDB0791	420
CA3081	180	MC1310P	110	TL 170	50
CA3085	160	MC145106	695	TL497A	185
CA3086	60	MC1455	50	TL509	110
CA3090	250	MC1458	35	TL061CP	40
CA3123E	165	MC1469	300	TL062CP	60
CA3130	85	MC1494	695	TL064CN	95
CA3140	45	MC1495	300	TL071CP	40
CA3160	95	MC1496L	70	TL072CP	60
CA3161	180	MC1596	225	TL074CN	110
CA3162	540	MC1709G	90	TL081CP	30
CA3189	270	MC3302	75	TL082CP	60
CA3240E	135	MC3401	60	TL083CP	75
HA1336W	175	MC3403	65	TL084CN	100
HA1388	235	MC3404	85	TL091CP	60
ICL7106	675	MC3405	150	UA2240	120
ICL7107	975	MC3423	80	UA78S40	225
ICL7611	95	MC3487	00	ULN2003	75
ICL7660	250	MC4016	295	ULN2004	75
ICL8038CC	300	MF10	300	ULN2283	150
ICL8211	225	MFC	75	ULN2803	190
ICM7216C	950	ML924	275	UPC575	275
ICM7217A	750	NE515	275	UPC1025H	375
ICM7224	785	NE529	225	UPC1156H	295
ICM7240	300	NE531	120	UPC1182	425
ICM7555	80	NE543K	225	UPC1366	195
ICM7556	140	NE544	170	XR2206	365
LA3350	250	NE555	25	XR2207	400
LA4031P	340	NE556	45	XR2211	575
LA4032	295	NE558	170	XR2216	675
LA4400	350	NE560	350	XR2266	360
LA4422	320	NE564	420	ZN409	160
LC7120	300	NE565A	115	ZN414	80
LC7130	300	NE566	140	ZN423E	130
LC7137	350	NE567V	130	ZN424E	130
LF347	120	NE570	370	ZN425E	350
LF351	40	NE571	370	ZN426E	300
LF353	75	NE5532	150	ZN427E	600
LF355	90	NE5534	100	ZN428E	450
LF356	90	OM335	650	ZN429E	240
LF357	100	RC4136D	55	ZN459	615
LF398	495	RC4558	40	ZN1034E	200
LM10	325	SAB3209	425	ZN1040E	665
LM301A	30	SAB3271	485	ZNA234E	925
LM307	45	SA84209	295		
LM308T	75	SG3402	295		
LM311	45	SL490	300		
LM318	135	SL827OCD	150		
LM319	180	SN76003	350		
LM24A	45	SN76018	150		
LM334Z	85	SN76131	135		
LM335Z	130	SN76226N	95		
LM337	250	SN76477	470		
LM339	40	SN76488	525		
LM348	60	SN76489	400		
LM349	125	SP8629	150		
LM358	50	SPO256AL	475		
LM377	210	TA1002	485		
LM379	495	TA7120	120		
LM380	95	TA7204	150		
LM381N	150	TA7205	90		
LM382	130	TA7222	150		
LM384	140	TA7310	120		
LM386	90	TAA700	275		
LM387	120	TAA900	395		
LM389	160	TAB1042	110		
LM393	60	TAD100	159		
LM394CH	380	TBA120S	70		
LM558	170	TBA920	200		
LM725CN	300	TBA990	350		
LM733	65	TBA641BX1	300		
LM1458	35	TBA800	70		
LM1871	300	TBA810	90		
LM1889	400	TBA820	65		
LM2907	395	TCA220	350		
LM2917	300	TCA270	350		
LM3900	70	TCA280A	220		
LM3909	95	TCA940	175		
LM3911	175	TCA965	180		
LM3914	300	TDA1008	310		
LM3915	345	TDA1010	200		
LM3916	300	TDA1022	400		
LM13600	150	TDA1024	110		
LS7220	295	TDA034	350		
M706B1	150	TDA1490	350		
M51513L	230	TDA2002	325		

TTL74

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

74C

74C244	150
74C245	150
74C373	180
74C374	425
74C922	550
74C923	600
74C925	650

74S

S00	45
S02	40
S03	40
S04	40
S05	40
S08	40
S09	40
S10	40
S11	50
S15	60
S20	40
S22	60
S30	50
S32	50
S37	50
S38	70
S40	40
S51	40
S64	40
S65	40
S74	70
S85	295
S86	100
S112	60
S113	120
S114	120
S124	300
S133	90
S134	60
S135	110
S139	170
S140	75
S151	140
S153	140
S157	200
S158	190
S162	300
S174	250
S175	300
S188	180
S189	225
S194	280
S197	300
S201	250
S225	500
S226	350
S240	375
S241	375
S244	475
S251	225
S257	225
S258	225
S260	70
S262	£10
S287	200
S288	180
S289	200
S301	350
S365	250
S373	375
S374	375
S412	380
S470	325
S472	600
S474	400
S475	425
S571	600
S573	450

74LS

LS00	25	LS193	80
LS01	25	LS194	75
LS02	25	LS195	75
LS03	25	LS196	85
LS04	25	LS197	85
LS05	25	LS221	85
LS08	25	LS240	80
LS09	25	LS241	80
LS10	25	LS242	95
LS11	25	LS243	95
LS12	25	LS244	80
LS13	35	LS245	100
LS14	50	LS247	105
LS15	25	LS248	105
LS19	45	LS249	105
LS20	25	LS251	75
LS21	25	LS253	75
LS22	25	LS256	90
LS24	50	LS257	75
LS26	25	LS258	75
LS27	25	LS259	125
LS28	25	LS260	70
LS30	25	LS261	100
LS32	25	LS266	60
LS33	25	LS273	120
LS37	25	LS275	350
LS38	25	LS279	70
LS40	25	LS280	180
LS42	50	LS283	80
LS47	80	LS290	80
LS48	80	LS293	80
LS49	100	LS294	999
LS51	25	LS295	140
LS54	25	LS297	850
LS55	25	LS298	100
LS63	55	LS299	225
LS73	30	LS320	210
LS74	35	LS322	360
LS75	45	LS323	400
LS76	40	LS324	150
LS78	40	LS325	150
LS83	70	LS326	290
LS85	70	LS327	290
LS86	35	LS347	120
LS90	35	LS348	140
LS91	90	LS352	110
LS92	55	LS353	110
LS93	55	LS355	220
LS96	80	LS356	200
LS107	40	LS363	150
LS109	45	LS364	150
LS112	45	LS365	50
LS113	40	LS366	50
LS114	40	LS367	50
LS122	70	LS368	50
LS123	80	LS373	100
LS124	125	LS374	100
LS125	50	LS375	70
LS126	50	LS377	130
LS132	60	LS378	95
LS133	50	LS379	130
LS135	28	LS380	310
LS136	45	LS382	310
LS138	60	LS384	460
LS139	50	LS385	330
LS145	95	LS386	50
LS147	165	LS390	60
LS148	130	LS393	100
LS151	70	LS395	110
LS153	70	LS396	300
LS154	155	LS398	195
LS155	70	LS399	135
LS156	70	LS445	125
LS157	60	LS447	80
LS158	60	LS465	140
LS160	70	LS490	150
LS161	70	LS540	100
LS162	70	LS541	100
LS163	70	LS624	155
LS164	75	LS629	130
LS165	110	LS640	200
LS166	150	LS641	150
LS168	100	LS645	195
LS169	100	LS668	90
LS170	140	LS669	90
LS173	100	LS670	170
LS174	75	LS673	890
LS175	70	LS674	800
LS181	190	LS678	275
LS183	190	LS684	350
LS190	85	LS687	350
LS191	85		
LS192	80		

SWITCHES

TOGGLE 2A, 250V
SPST 35p DPDT 48p

SUB-MIN TOGGLE

SPST on off	58p
SPDT c over	64p
SPDT centre off	85p
SPDT biased both ways	105p
DPDT 6 tags	80p
DPDT centre off	88p
DPDT biased both ways	145p
DPDT 3 positions on on on	185p
4-pole 2 way	220p

SLIDE 250V:

DPDT 1A	14p
DPDT 1A c off	15p
DPDT ½A	13p

PUSHBUTTON 6A with 10mm Button

SPOT latching	150p
DPDT latching	200p
DPDT moment	200p

Mini Non Locking

Push to Make	15p
Push to Break	25p

DIGITAST Switch Assorted Colours 75p each

GAS/SMOKE DETECTORS

TGS812 or TGS813 **£6 each**
Holders for above **40p**

DIP SWITCHES

(SPST) 4 way **65p**; 6 way **80p**; 8 way **85p**; 10 way **125p** (SPDT) 4 way **190p**

ROTARY SWITCHES

(Adjustable Stop type)
1 pole/2 to 12 way; 2 pole/2 to 6 way; 3 pole/2 to 4 way; 4 pole/2 to 3 way **48p**

ROTARY: Mains DP 250V 4 Amp on/off **68p**

ROTARY: (Make-a-switch) Make a multiway switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers (max. 6 pole/12 way + DP switch). Mechanism only **90p**

WAFERS: (make before break) to fit the above switch mechanism. 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6p/2 Way **65p**
Mains DP 4A Switch to fit **45p**
Spacers **4p**. Screen **6p**.

ROCKER SWITCHES

ROCKER: 5A/250V SPST	28p
ROCKER: 10A/250V SPDT	36p
ROCKER: 10A/250V DPDT c/off	95p
ROCKER: 10A/250V DPST with neon	85p

THUMBWHEEL Mini front mounting switches

Decade Switch Module	275p
B.C.D. Switch Module	298p
Mounting Cheeks (per pair)	75p

JUMPER LEADS (Ribbon Cable Assembly)

Length	14 pin	16 pin	24 pin	40 pin
Single ended DIP (Header Plug) Jumper				
24 inches	145p	185p	240p	380p
Double ended DIP (Header Plug) Jumper				
12 inches	198p	215p	315p	480p
24 inches	210p	235p	345p	540p
36 inches	290p	370p	480p	525p

IDC Female Header Socket Jumper Leads 36

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

TRANSFORMERS

3-0-3V, 6-0-6V, 9-0-9V; 12-0-12V, 15-0-15V @ 100mA **130p**
PCB mounting. Miniature. Split bobbin
3VA: 2x6V/0.25A; 2x9V/0.15A, 2x12V/0.12A, 2x15V/0.2A **235p**
6VA: 2x6V/0.5A, 2x9V/0.3A, 2x12V/0.25A; 2x15V/0.2A **280p**
Standard Split Bobbin type
6VA: 2x6V/0.5A, 2x9V/0.4A, 2x12V/0.3A, 2x15V/0.25A **250p**
12VA: 2x4.5V/1A3; 2x5V-1A; 2x9V/0.6A, 2x12V/0.5A; 2x15V-0.4A, 2x20V/0.3A **345p** (35p p&p)
24VA: 2x6V/1.5A, 2x9V/1.2A; 2x12V/1A; 2x15V/0.8A; 2x20V/0.6A **385p** (60p p&p)
50VA: 2x6V/4A, 2x9V/2.5A, 2x12V/2A, 2x15V/1.5A; 2x20V/1.2A; 2x25V/1A, 2x30V/0.8A **520p** (60p p&p)
50VA: Outputs +5V/5A; +12V, +25V, −5V, −12V at 1A **620p** (60p p&p)
100VA: 2x12V/4A, 2x15V/3A, 2x20V/2.5A; 2x25V/2A, 2x30V/1.5A, 2x50V/1A **955p** (75p)
P&P charge to be added over and above our normal postal charge

VEROBOARD 0.1"

2½ × 1	30p
2½ × 3¾	95p
2½ × 5	110p
3¾ × 3¾	110p
3¾ × 5	125p
3¾ × 17	420p
4¾ × 17	590p
VQ Board	195p
DIP Board	395p
Vero Strip	95p

VERO WIRING PEN

+ Spool	380p
Spare spool	75p
Combs	8p
Pen + Spool + Combs	599p

PROTO DECs

Veroblock	480p
S-Dec	350p
Eurobreadboard	590p
Bimboard	575p
Superstrip SS2	1350p

VERO PINS per 100

Single Ended	55p
Double Ended	60p
Wire Wraps S/E	155p
Wire Wraps D/E	255p

Vero Tools

Spot face cutters	150p
Pin insertion tool	185p

FERRIC CHLORIDE
1lb bag Anhydrous
125p + 50p p&p

DALO ETCH RESIST PEN
Plus spare tip **100p**

COPPER CLAD BOARDS

Fibre glass	Single-sided	Double sided
6" x 6"	100p	125p
6" x 12"	175p	225p

DIL SOCKETS

	Low Prof	Wire Wrap
8 pin	8p	25p
14 pin	10p	35p
16 pin	10p	42p
18 pin	16p	52p
20 pin	20p	60p
22 pin	22p	65p
24 pin	25p	70p
28 pin	28p	80p
40 pin	30p	90p

EDGE CONNECTORS

	.1"	.156"
2x6 way	—	75p
2x12 way	—	160p
2x15 way	—	165p
2x18 way	175p	160p
2x22 way	200p	170p
2x23 way	150p	—
2x25 way	250p	245p
2x28 way	180p	—
2x30 way	280p	—
2x36 way	300p	—
2x40 way	320p	—
2x43 way	400p	—
2x75 way	600p	—

SIL SOCKET 0.1" Pitch 20 way **65p**

ANTEX SOLDERING IRONS

C15W	525p	CS17W	545p
C18W	550p	XS25W	570p
Spare Bits	85p	Elements	230p
Iron Stand	175p	Heat Shunt	30p

VOLTAGE REGULATORS

1A TO220 Plastic Casing

	+ve		-ve	
5V	7805	45p	7905	50p
12V	7812	45p	7908	50p
15V	7815	45p	7912	50p
18V	7818	45p	7915	50p
24V	7824	45p	7918	50p
			7924	50p

100mA TO92 Plastic package

5V	78L05	30p	79L05	45p
6V	78L06	30p	-	-
8V	78L08	30p	-	-
12V	78L12	30p	79L12	45p
15V	78L15	50p	79L15	45p

ICL7660	245p	TAA550 .... 50p
RC4194	375p	TDA1412 .... 50p
RC4195	160p	TL497 .... 185p
LM309K	135p	78H05×5V/5V 550p
LM317K	250p	78H12×12V/5A .. 695p
LM317KP	450p	78HG×5V to × 25V
LM323K	450p	5A 585p
LM337	175p	79HG-2.25V to
LM723 Var	30p	-24V 5A 785p
78S40	225p	

SOLDERCON PINS

Ideal for making SIL or DIL Sockets

100 pins	45p
500 pins	195p

ALUM BOXES

3 x 2 x 1"	85p
4 x 2½ x 2"	100p
4 x 2½ x 2½"	103p
4 x 4 x 2"	105p
4 x 4 x 2½"	120p
5 x 4 x 1½"	99p
5 x 4 x 2½"	120p
5 x 2½ x 1½"	90p
5 x 2½ x 2½"	130p
6 x 4 x 2"	120p
6 x 4 x 3"	150p
7 x 5 x 3"	180p
8 x 6 x 3"	210p
10 x 4 x 3"	240p
10 x 7 x 3"	275p
12 x 5 x 3"	280p
12 x 8 x 3"	295p

IDC CONNECTORS

	PCB with Pins Strt	Plugs latch Pins Angle	Female Header Plug	Female Card Edge Conct
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	—
20 way	145p	166p	125p	195p
26 way	175p	200p	150p	240p
34 way	200p	236p	160p	320p
40 way	220p	250p	180p	340p
50 way	235p	270p	200p	350p
60 way	—	—	230p	495p

EURO CONNECTORS

Gold Flashed Contacts	Female Strt Pins	Socket Angle Pins	Male Strt Pins	Plug Angle Pins
DIN41617 31 way	125p	—	—	175p
DIN41612 2 x 32 A + B	200p	·	175p	220p
DIN41612 2 x 32 A + C	225p	·	185p	230p
DIN41612 3 x 32 A + B + C	280p	290p	295p	300p

DIL PLUG (Header)

	Solder	IDC
14 pin	40p	95p
16 pin	45p	100p
24 pin	85p	135p
28 pin	150p	200p
40 pin	200p	255p

RIBBON CABLE

price per foot

	Grey	Color
10 way	15p	28p
16 way	25p	40p
20 way	30p	50p
24 way	40p	65p
28 way	55p	80p
34 way	60p	85p
40 way	70p	90p
50 way	100p	135p
64 way	120p	160p

ZIF TEXTOOL DIL SOCKETS

24 pin	575p
28 pin	695p
40 pin	845p

'D' CONNECTORS

	9 way	15 way	25 way	37 way
Male				
Solder lugs	55p	80p	120p	150p
Angle pins	110p	175p	225p	300p
PCB pins	100p	100p	180p	250p
Female				
Solder lugs	90p	125p	180p	275p
Angle pins	150p	200p	260p	390p
PCB pins	100p	125p	195p	355p
Covers	75p	70p	70p	85p

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

25 way 'D' CONNECTOR (RS232)

Jumper Lead Cable Assembly

18" long, Single end, Male	475p
18" long, Single end, Female	510p
36" long, Double Ended, M/M	995p
36" long, Double Ended, F/F	£10
36" long, Double Ended, M/F	995p

AMPHENOL PLUGS

	IDC	SOLDER
24 way IEEE plugs	465p	460p
24 way IEEE skt	485p	480p
36 way Centronics plug	375p	390p
36 way Centronics skt	480p	450p

PANEL METERS

FSD
60 × 46 × 35mm
0-50uA
0-100uA
0-500uA
0-1mA
0-5mA
0-10mA
0-50mA
0-100mA
0-500mA
0-1A
0-2A
0-25V
0-50V
0-300V **465p each**

CRYSTALS

32.768KHz	100
100KHz	400
200KHz	370
455KH	370
1MHz	265
1.008M	275
1.28MHz	450
1.6MHz	200
1.8MHz	545
1.8432M	220
2.0MHz	225
2.4576M	200
3.12MHz	240
3.278M	150
3.5794M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.19430M	200
4.433619M	100
4.608MHZ	200
4.80MHz	200
5.0MHz	150
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	140
6.5536MHz	225
7.0MHz	150
7.168MHz	175
7.7328MHz	250
7.68MHz	200
8.0MHx	150
8.089333M	395
8.86723M	175
9.00MHz	200
10.0MHz	175
10.24MHz	200
10.5MHz	250
10.7MHz	150
12.0MHz	150
12.528M	300
14.31814M	170
15.0MHz	155
16.0MHz	200
18.0MHz	150
18.432M	150
19.968MHz	150
20.0MHz	150
24.0MHz	150
24.930MHz	325
26.69M	150
27.648M	170
27.145M	180
38.6667M	240
48.0MHz	240
100.0MHz	295

RELAYS

Miniature, enclosed, PCB mount.

SINGLE POLE Changeover
RL-91 205R Coil; 12V DC, (10V5 to 19.5V), 10A at 30V DC or 250V AC **195p**

DOUBLE POLE Changeover, 6A 30V DC or 250V AC
RL-113 53R Coil, 6V DC (5V4 to 9V9) **190p**
RL6-111 205R Coil, 12V DC (10V7 to 19V5) **195p**
RL6-114 740R Coil, 24V DC (22V to 37V) **200p**

ASTEC UHF MODULATORS

Standard 6MHz	375p
Wideband 8MHz	450p

BUZZERS

miniature, solid-state 6V, 9V & 12V	70p
PIEZO TRANSDUCERS PB2720	70p
ULTRASONIC TRANSDUCERS 40KHz	475pr

LOUDSPEAKERS

Miniature, 0.3W· 8

2in, 3¼in, 2½in, 3in	80p
2½in 40Ω 64Ω or 80Ω	80p
6" x 4" 8Ω	200p
7" x 5" 8Ω	225p
8" x 5" 8Ω	250p

MONITORS

- ZENITH — 12" Green, Hi-Resolution Popular **£66**
- MICROVITEC 1431. Standard Res, Colour RGB input 14" incl cable **£195**
- MICROVITEC 1451. 14" Medium resolution **£237**
- KAGA 12". Med-res. RGB Colour. Has flicker-free characters. Ideal for BBC, Apple, VIC, etc **£225** (car £7)
- KAGA 12". As above but Hi-Resolution **£310** (car £7)
- Connecting Lead for KAGA **£5**

Carriage £7 Securicor

SPECIAL OFFER

	1×	10×
2764-250nS	250p	195p
27128-250nS	400p	385p
6116LP-120nS	200p	195p
6264LP-150nS	580p	550p

CMOS

4000	20
4001	20
4002	20
4006	70
4007	20
4008	60
4009	40
4010	40
4011	20
4012	20
4013	30
4014	50
4015	40
4016	25
4017	45
4018	55
4019	35
4020	50
4021	55
4022	60
4023	20
4024	35
4025	20
4026	90
4027	30
4028	40
4029	45
4030	20
4031	125
4032	65
4033	130
4034	145
4035	70
4036	250
4037	115
4038	75
4039	270
4040	45
4041	55
4042	45
4043	45
4044	50
4045	110
4046	60
4047	50
4048	50
4049	25
4050	25
4051	50
4052	50
4053	60
4054	70
4055	70
4056	85
4057	1000
4059	400
4060	70
4061	500
4062	986
4063	80
4066	25
4067	230
4068	20
4069	20
4070	25
4071	20
4072	20
4073	20

4075	25
4076	60
4077	25
4078	25
4081	20
4082	20
4085	60
4086	60
4089	120
4093	25
4094	70
4095	70
4096	100
4097	260
4098	70
4099	110
4160	95
4161	96
4162	96
4163	96
4174	96
4175	105
4194	105
4408	850
4409	850
4410	725
4411	750
4412	805
4415	590
4419	280
4422	770
4435	850
4440	900
4450	360
4451	350
4490	450
4500	395
4501	40
4502	50
4503	45
4504	100
4505	350
4506	100
4507	45
4508	115
4510	50
4511	50
4512	50
4513	150
4514	115
4515	115
4516	50
4517	275
4518	50
4519	35
4520	50
4521	110
4522	125
4526	70
4527	60
4528	45
4529	80
4530	90
4531	120
4532	65
4534	365
4536	250
4538	70
4539	80

4541	95
4543	65
4548	40
4549	390
4553	210
4554	180
4555	50
4556	50
4557	250
4558	120
4559	340
4560	110
4561	104
4562	350
4566	160
4568	250
4569	175
4572	45
4580	255
4581	125
4582	99
4583	100
4584	40
4585	65
4597	330
4599	155
40085	90
40097	45
40098	42
40100	215
40101	130
40102	140
40103	412
40104	120
40105	220
40106	40
40107	55
40108	325
40109	100
40110	235
40114	240
40161	194
40163	75
40173	100
40174	75
40175	75
40181	220
40182	80
40192	75
40193	90
40194	70
40195	75
40244	196
40245	196
40257	196
40373	220
40374	220
45106	586

OPTO

OCP71	120
ORP12	85
ORP61	86
BPX25	250
BPW21	320
TIL139	225

OPTO ELECTRONICS

LEDs with clips

TIL 209	10
TIL211 GRN	14
TIL212 Yel.	14
TIL220 2" Red	12
2" Green, Yellow or Amber	14
0.2" Bi colour	
Red/Green	100p
Green/Yellow	115p
0.2" Tri colour	
Red/Green/Yellow	85
Hi-Brightness Red	58
High-Bri Green or Yel	68
Flashing red	
0.2" red	55
Square LEDs, Red, Green, Yellow	30
Rectangle Stackable LEDs	
Red, Green or Yellow	18
Triangular LEDs	
Red	18
Green or yellow	22
LD271 Infra Red	48
SFH205 Detector	118
TIL32 Infra Red	52
TIL78 Detector	55
TIL38	50
TIL100	75
BARGRAPH Red 10 segments	275

ISOLATORS

IL74	145
ILD74	145
ILQ74	275
TIL111/2/4	70
ILCT6 Darlington	135
TIL117	125
4N33 Photo Darlington	136

7 Segment Displays

TIL312 .3" CA	120
TIL313 .3" CC	120
TIL321 .5" CA	140
TIL322 .5" CC	140
TIL729/730	140
DL704 .3" CC	125
DL707 .3" CA	125
FND357 Red	120
FND500	130
3" Green CA	150
6" Green CA	215
3" ± 1 Red CA	150
.3" ± 1 Green CA	150
LCD 3½ Digits	496
LCD 6 Digits	625
Reflective Switch	225
SLOTTED Optical Switch similar to RS Comp's	295

TURNED PIN Low Profile

Professional DIL SOCKETS

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

BT TELEPHONE CONNECTOR

LJU 1/4A	Mini Line Master	430p
LJU 1/6A	Mini Line Slave	295p
LJU 2/4A	Line Master	370p
LJU 2/6A	Line Slave	250p
LJU 3/4A	Flush Master	370p
LJU 3/6A	Flush Slave	240p
LJU 10/3A	Dual Splitter	550p
4 WAY	BT Plug	65p

COMPUTER CORNER

- EPSON RX80 F/T Printer £219
- EPSON FX80 Printer £316
- EPSON FX100 Printer £429
- KAGA/TAXAN KP810 Printer £239
- KAGA/TAXAN KP910 Printer £339
- BROTHER HR15 Daisywheel £329

Cable for above printers to interface with BBC Micro £7

- TEX EPROM ERASER — Erases up to 25 Eproms. Has a built in safety switch £30
- SPARE 'UV' Lamp Bulb £8
- C12 Computer CASSETTES in Library cases 35p
- 8½" & 9½" Fan Fold paper (1000 sheets) .... £7 (Carr. 150p)

(Securicor Carriage charge on printers is £7)

CALL IN AT OUR SHOP FOR A DEMONSTRATION ON ANY OF THE ABOVE ITEMS. BE SATISFIED BEFORE YOU BUY OR WRITE IN FOR OUR DESCRIPTIVE MICRO PERIPHERALS LEAFLET.

5¼" DISC DRIVES for the BBC Micro

(All Drives are supplied cased with Power Supply and Utilities Disc)

- **CS200** – Epson Single 200K, 40 track Double sided £110
- **CS400S** – Mitsubishi Single 400K, 80T, Double sided 40 track switchable £135
- **CD400** – Epson Twin 400K, 40 track, Double sided drive £185
- **CD800S** – Mitsubishi Twin 800K, 80T, 40/80 track switchable Drive £259
- **TWIN Disc drive case** with Power supply and Cables to house ones own drives £35
- All Single Drives with Power supply are supplied in a twin case for later inclusion of a second drive.

(Securicor Carriage on Drives £7)

- **DISC INTERFACE KIT** complete £65
- **DFS Manual** (comprehensive) (NO VAT) £7

SPECTRUM 32K UPGRADE

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

£20

BBC MICRO WORDPROCESSING PACKAGE

A complete wordprocessing package (which can be heavily modified to your requirements, maintaining large discount). We supply everything you need to get a BBC Micro running as a word-processor. Please call in for a demonstration.
Example Package:
BBC Micro, with DFS Interface, Wordwise, Twin 400K TEC Disc Drives, 12" High-res green monitor, Brother HR15 Daisywheel printer, Beebcalc & Database software on Disc, 10 3M Discs, 500 sheets of paper, 4 way mains trailing socket, manuals and all cables.

Only: £999

BBC MICROCOMPUTER & ACCESSORIES

BBC Model B **Only £289**

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

DIGEST

British Computer Uses The 68020

Durham-Based Integrated Micro Products Ltd have launched a 32-bit multi-user microcomputer which is said to be considerably faster than many minicomputers costing ten times as much.

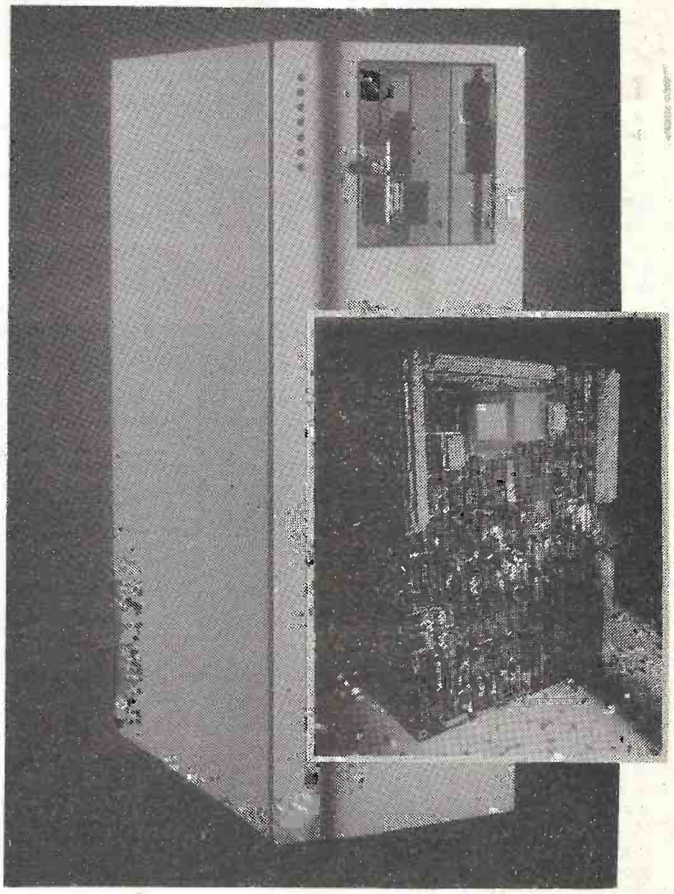
It owes much of its high performance to the use of Motorola's new 68020 microprocessor(described in ETI October 1984) and is the first British designed and built computer to use the chip.

The IMP-Mentor is available either as a complete super-micro computer or as a series of VME-Bus boards which can be used in other systems. It runs several versions of the Unix operating system and IMP say that it can support thirty-two users simultaneously with virtually no degradation of processing speed.

The main board carries the 68020 and 2M bytes of RAM, expandable up to 8M bytes. There is also provision for a 68881 floating-point co-processor. Two more boards carry the disk controller and the communications controller and each has its own 68000 microprocessor. This leaves the main microprocessor free to operate at the limits of its performance, which can be as high as eight million instructions per second.

To illustrate the speed of the Mentor, IMP quote its performance on the Sieve of Eratosthenes, a test that involves calculating about 2,000 prime numbers. The Mentor takes a mere 0.6 seconds, while a DEC VAX 78 minicomputer takes 1.8 seconds and an IBM-PC XT takes 9.0 seconds.

IMP say the Mentor is ready for immediate shipment. For more details contact Integrated Micro Products Ltd, Number One Industrial Estate, Medomsley Road, Consett, County Durham DH8 6TJ, tel 0207-503481.



ETI Printed Circuit Board Service

We must again apologise to our readers for the suspension of this service.

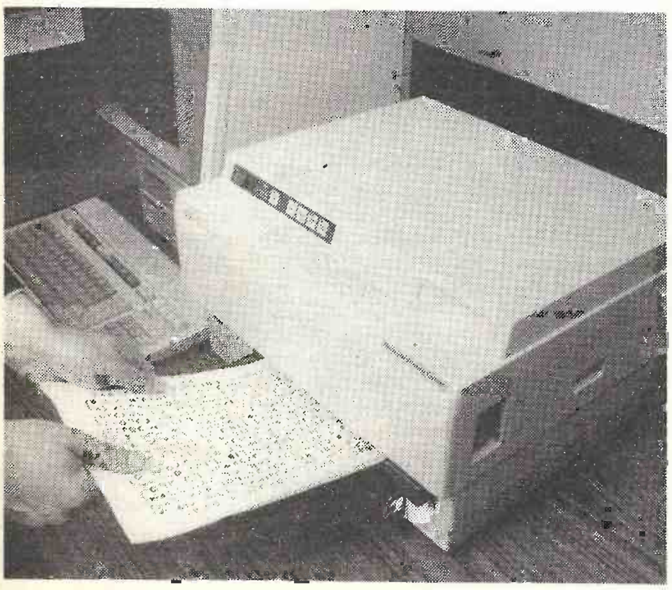
As we explained in our last issue, the company who used to supply our PCBs have decided that they no longer wish to continue doing so. Until we find another supplier we cannot send out any boards.

At the time of going to press we are close to reaching an agreement with a new supplier but nothing has yet been signed. We would hope to be able to start sending out boards again within a few weeks of signing such an agreement.

In the meantime, we will happily refund money to those who have paid but not received boards. However, if readers prefer they can leave their orders with us and we will deal with them as soon as we are able.

We would like to thank our readers for the forebearance many have shown in this matter and once again offer our apologies for the inconvenience.

● Hitachi have published a sixteen page brochure which describes their HD6305 CMOS microprocessor family. It covers types under development as well as those now available and includes information on support devices, software, etc. Hitachi Electronic Components (UK) Ltd, Hitec House, 221-225 Station Road, Harrow, Middlesex HA1 2XL, tel 01-861 1414.



Bumble Gives Us The Moon — By Laser

A research unit at Brunel University has developed a word processing system which can convert the written word into forms better suited to the needs of blind and partially-sighted people.

The system is called BUMBLE (Brunel University Moon, Braille and Large-print Equipment) and was developed by a team led by Dr. John Gill. It consists of a sixteen-bit microcomputer, specially developed software, and a laser printer.

Because the laser printer uses a non-impact printing system it is able to cope with a wide range of type styles and sizes. The paper can then be heat-treated to produce enbossed Braille characters.

The system can also print the less well known Moon language. Developed before Braille, Moon has the advantage that it is very easy to learn, but the difficulty of printing it using traditional typesetting methods has prevented its widespread adoption. The Brunel team hope that their work will lead to a revival of interest in Moon.

Bumble was originally developed for use by social service departments and voluntary associations, but the simplicity of the system should enable it to be used by a wide variety of agencies who currently make no provision for the blind and partially-sighted when preparing information. For further details contact Dr. Gill on 0895-71206.

COMPUTER WAREHOUSE

1000's OF BARGAINS FOR CALLERS

THE "ALLADINS" CAVE OF COMPUTER AND ELECTRONIC EQUIPMENT

EX-STOCK INTEGRATED CIRCUITS

4164 200ns D RAMS 8 for **£14.95** **4116** 300 ns **£1.50** **2112** **£10.00** **2114** **£2.50** **2102** **£2.00** **6116** **£2.50** **EPROMS** 2716 £4.50 **2732** £3.00 **2764** £4.95 **27128** £5.50 **6800** £2.50 **6821** £1.00 **66A09** £8.00 **6B09** £10.00 **8085** £5.50 **8086** £15.00 **8251** £7.00 **8748** £15.00.

Thousands of IC's EX STOCK send SAE for list.

RECHARGEABLE BATTERIES

Dry Fit **MAINTENANCE FREE** by Sonnenschein & Yuasa
A300 07191315 12v 3ah as RS 591-770 **NEW £13.95**
A300 07191312 6v 3ah as RS 591-360 **NEW £9.95**
A300 07191202 6-0-5v 1.8ah as RS 591-382 Ex Equip **£5.99** 3.6v 100 mah PCB mount as RS 591-477 **NEW** £1.00

HOT LINE DATA BASE

DISTEL©

The **ORIGINAL FREE OF CHARGE** dial up data base. Buy, browse or place **YOUR OWN AD** for goods or services to sell. 1000's of stock items, spares and one off bargains. Updated daily. **ON LINE NOW.** CCITT, 8 bit word, no parity. For **300** baud modems call 01-679 1888. For **1200**-75 baud modems call 01-679 6183

PRINTER / TERMINAL SCOOP

A **MASSIVE** purchase of these attractive stand alone terminal units enables a **SUPER BARGAIN** offer. Made by the **US GENERAL ELECTRIC CORPORATION** the **GE MODEL 30** features a standard **QWERTY** 80 key electronic keyboard coupled to a quality built matrix printer with variable 3" to 9.5" forms tractor. The printer is capable of continuous duty printing, with up to 120 characters per line. Standard **RS232** interface accepts **ASCII** data at 110, 150 or 300 baud. Ideal for Terminals, Data loggers, local label printing, or just as a printer!! Sold **TESTED** with data **ONLY £95.00**. Also available with **TWIN MAGTAPE CASSETTE** unit for data capture, data preparation etc **£150.00** Carriage £10.00.

DISK DRIVES

Japanese Half height, 80 track double sided disk drives by **TEAC, TOSHIBA** etc. Sold as **NEW** with 90 day guarantee **ONLY £125.00.**
SUGART SA400 SS FH 35 TRK **£55.00**
SIEMANS FDD100 SS FH 40 TRK **£75.00**
carriage on 5¼" drives **£5.50**
Brand **NEW** metal cases with internal PSU etc for above drives, below cost!!
DSKC 1 for 2 HH or 1 FH 5¼" drive **£39.95** + pp £4.50 **DSKC 2** for 1 HH or 1 FH 5¼" drive **£29.95** + pp £4.50
8" Refurbished standard units.
SUGART 801 SS £175.00 + pp £8.50
SUGART 851 DS £250.00 + pp £8.50
DRE 7100 SS as seen £125.00
TWIN SUGART 851's in smart case, complete with PSU etc, £595.00
8" DRIVE PSU for 2 drive units £45.00
Hard Disk Drives.
DRE/DIABLO Series 30 2.5 Mb front load, **£525.00**, Exchangeable version £295.00
ME3029 PSU for above £95.00
DIABLO 44/DRE4000A, B 5+5 Mb from £750.00
CDC HAWK 5+5 Mb £795.00
CDC 9762 80 Mb RM03 etc £2500.00
PERTEC D3422 5+5 Mb £495.00
RODIME 10MB ST506 Winchester NEW £299.00
BASF 6172 23Mb Winchesters, as seen £199.00
Carriage on other drives £10.00.
Unless stated all drives are refurbished with 90 day guarantee. Many other drives and spares in stock – call sales office for details.

MODEMS

Join the communications revolution with our super range of **DATA MODEMS**, prices and specifications to suit all applications and budgets...
BRAND NEW State of the art products.
DACOM DSL2123 Multi standard 300-300, 1200-75 Auto answer etc **£268.00**
DACOM DSL2123AD Auto dial, smart modem with multi standard **AUTO SPEED** detect, and data buffer with flow control etc **£365.00**
DACOM DSL2123GT The **CREAM** of the intelligent modems, auto dial, auto call, index, buffer etc etc **£498.00**
STEEBECK SB1212 V22 1200 baud **FULL DUPLEX**, sync or async, optional auto dial, **£465.00**
TRANSDATA 307A Acoustic coupler **300** baud full duplex, originate only, **RS232** **£49.00**

Ex **BRITISH TELECOM** full spec, CCITT, ruggedised, bargain offers. Sold **TESTED** with data. Will work on any **MICRO** or system with **RS232** interface.
DATEL 2B 300 Baud Modem see **SPECIAL OFFER.**
MODEM 13A 300 baud unit, only 2" high fits under phone. **CALL** mode only £45.00
MODEM 20-1. 75-1200 baud. Compact unit for use as subscriber end to PRESTEL, TELECOM GOLD, **MICRONET** etc **£39.95** + pp £6.50
MODEM 20-2 1200-75 baud. Same as 20-1 but for computer end. **£65.00** + pp £6.50
DATEL 2412 Made by SE labs for BT this two part unit is for **synchronious** data links at 1200 or 2400 baud using **2780/3780** protocol etc. Many features include 2 or 4 wire working, self test, auto answer etc.
COST OVER £800 Our price **ONLY £199** + pp £8.00
DATEL 4800, RACAL MPS4800 baud modem, EX BT good working order, **ONLY £295.00** + pp £8.00
SUMMER OFFER
MODEM TG2393. Ex BT, Up to 1200 baud, full duplex over 4 wire or half duplex over 2 wire line. **ONLY £85.00 PER PAIR** + pp £10.00

For more information CONTACT OUR SALES OFFICE

COOLING FANS

Keep your hot parts **COOL** and **RELIABLE** with our range of **COOLING FANS**
ETRI 126LF21 240v 5 blade equipment fan Dim. 80 x 80 x 38mm **£9.95**
ETRI 88XUOI Dim. 92 x 92 x 25mm 240v equipment fan, complete with finger guard **NEW £9.95**
GOULD JB-3AR Dim. 3" x 3" x 2.5" compact very quiet running 240v operation. **NEW £6.95.**
BUHLER 69.11.22 8-16v DC micro miniature reversible fan. Uses a brushless servo motor for extremely high air flow, also silent running and guaranteed 10,000 hr life. Measures only 62 x 62 x 22mm. Current cost £32.00. OUR PRICE **ONLY £12.95** complete with data.
MUFFIN-CENTAUR standard 4" x 4" x 1.25" fans 110v OR 240v **NEW** at **£10.50** or tested EX EQUIPMENT 240v £6.25 or 110v £4.95.
1000's of other fans **Ex Stock.**
Call for Details. Post & Packing on all fans £2.00.

QWERTY KEYBOARDS

Manufacturer's **BRAND NEW** surplus.
ALPHAMERIC 7204/60 Full travel **ASCII**, 60 key with parallel output and strobe. £39.95
DEC LA34 Uncoded keyboard with 67 quality gold plated switches on X-Y matrix – ideal micro conversions etc. **£24.95**
AMKEY MPNK-114 Superb word processor chassis keyboard on single **PCB** with 116 keys. Many features such as On board Micro, Single 5v rail, full **ASCII** coded character set with 31 function keys, Numeric keypad, cursor pad and **9600** baud **SERIAL TTL ASCII OUTPUT!! ONLY £69.00** with data.

Carriage on all Keyboards £3.50

PLESSEY VUTEL

Manufactured by **PLESSEY** Ltd this compact unit, only slightly larger than a telephone, features an all in one **TELEPHONE**, 24 x 40 character CRT screen, **VIEWDATA – PRESTEL** modem, Keypad and electronics to run as a fully fledged **PRESTEL** terminal or telephone. Ready to plug direct into a BT 600 type jack socket and instantly connect you to **PRESTEL**, etc. Many other features include Memory dialling, Recall button. Off line screen data storage, Picture expand, Standard Mullard **LUCY** chip set, Integral 5" JVC crt monitor, etc etc. Designed to sell to the **EXECUTIVE** at over **£600!!** But from **DISPLAY, BRAND NEW AND BOXED** at only £99.00 for **DTMF** tone dial or **£140.00** for standard **DIAL PULSE** version. Carr. £8.00.

COLOUR AND MONOCHROME MONITOR SPECIALS

'SYSTEM ALPHA' 14" COLOUR MULTI INPUT MONITOR

made in the UK by the famous **REDIFFUSION Co.** for their own professional computer system this monitor has all the features to suit your immediate and future monitor requirements. Two video inputs: **RGB** and **PAL** Composite Video, allow direct connection to the **BBC** and most other makes of micro computers and **VCR's**. An internal speaker and audio amplifier may be connected to your systems output or direct to a VCR machine, giving superior sound quality. Many other features included PIL tube, Matching **BBC** case colour, Major controls on front panel, Separate Contrast and Brightness – even in **RGB** mode, Two types of audio input, Separate Colour and audio controls for Composite Video input, **BNC** plug for composite input, 15 way 'D' plug for **RGB** input, modular construction etc etc.

This Must be **ONE OF THE YEAR'S BEST BUYS**

Supplied **BRAND NEW** and **BOXED**, complete with DATA and 90 day guarantee. **SUPPLIED BELOW ACTUAL COST – ONLY £149.00**

DECCA 80 16" COLOUR monitor. **RGB** input.

Little or hardly used manufacturer's surplus enables us to offer this special converted **DECCA RGB** Colour Video TV Monitor at a super low price of only **£99.00**, a price for a colour monitor as yet unheard of!! Our own interface, safety modification and special 16" high definition **PIL** tube, coupled with the tried and tested **DECCA 80** series TV chassis gives 80 column definition and picture quality found only on monitors costing **3 TIMES OUR PRICE**. In fact, **WE GUARANTEE** you will be delighted with this product, the quality for the price, has to be seen to be believed. Supplied complete and ready to plug direct to a **BBC MICRO** computer or any other system with a **TTL RGB** output. Other features are: internal speaker, Modular construction, auto degaussing circuit, Attractive **TEAK CASE**, compact dimensions only 52cm W x 34 H x 24 D, 90 day guarantee. Although used, units are supplied in **EXCELLENT** condition, **ONLY £99.00** + Carr.

DECCA 80, 16" COLOUR monitor. Compositve video input. Same as above model but fitted with Composite Video input and audio amp for **COMPUTER**, VCR or **AUDIO VISUAL** use. **ONLY £99.00** + Carr.

REDIFFUSION MARK 3, 20" Colour monitor. Fitted with standard 75 ohm composite video input and sound amp. This large screen colour display is ideal for shops, schools, clubs and other **AUDIO VISUAL** applications. Supplied in AS NEW or little used condition **ONLY £145.00** + Carr.

BUDGET RANGE EX EQUIPMENT MONOCHROME video monitors.

All units are fully cased and set for 240v standard working with composite video inputs. Units are pre tested and set up for **80** column use on **BBC** micro etc. Even when MINOR screen burns exist – normal data displays are unaffected.
12" KGM 320-1 B/W high bandwidth input, will display up to 132 x 25 lines. **£32.95**
12" GREEN SCREEN version of **KGM 320-1** Only **£39.95**
9" KGM 324 GREEN SCREEN fully cased very compact unit Only **£55.00**
9" HITACHI VM-906E/K Black and White screen **£49.95**

Carriage and insurance on all monitors **£10.00**

D.C. POWER SUPPLY SPECIALS

GOULD OF443 enclosed, compact switch mode supply with DC regulated outputs of +5v @ 5.5a, +12v @ 0.5a, -12v @ 0.1a and -23v @ 0.02a. Dim 18 x 11 x 6 cm. 110 or 240v input. **BRAND NEW** only **£14.95**
GOULD G6-40A 5v 40 amp switch mode supply NEW £130.00
GREENDALE 19A-BOE Switch mode 60 watt open PCB with a fully regulated DC output of 5v @ 6 amps, and three semi regulated outputs of +12V, -12V +15V @ upto 1 amp. Dim only 11 cm x 20 cm x 5.5 cm. Similar to RS 591-994. 110 or 240v AC input. **TESTED** ex equipment. **Only £24.95**
AC-DC Linear **PSU** for **DISK** drive and **SYSTEM** applications. Constructed on a rugged ALLOY chassis to continuously supply fully regulated DC outputs of +5V @ 3 amps, -5V @ 0.6 amps and +24v @ 5 amps. Short circuit and overvoltage protected. 110 or 240 V AC input. Dim 28 x 12.5 x 7 cm **NEW £49.95.**

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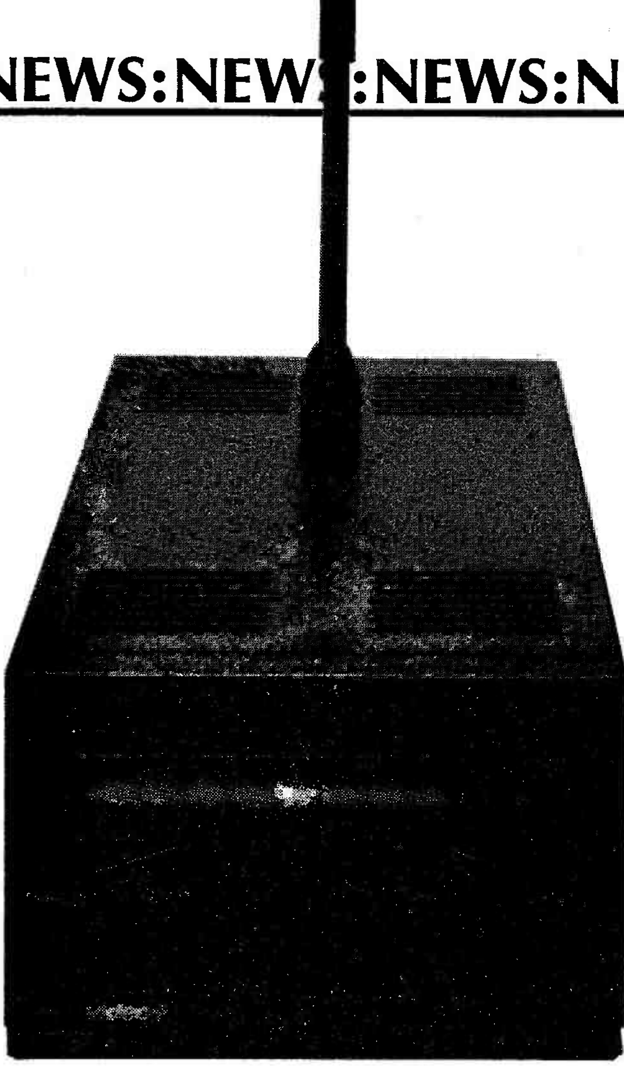


Short-Range Transmitter For VCRs

Mastertronic have developed a UHF amplifier and aerial unit which will broadcast pictures from a video cassette recorder so that they can be picked up by nearby television sets.

The system has a range of about 45 feet and could be used, for example, to transmit the signal from a centrally placed VCR to a portable TV elsewhere in the house or to enable one VCR to be used with several TV sets simultaneously.

The Video+ takes the UHF signal from the output of the VCR, amplifies it and feeds the output to a short, detachable aerial. Because the final output is only an amplified version of the VCR signal, the transmission frequency will be that to which the VCR is tuned and the programmes can be picked up on the TV channel normally used when the VCR is plugged in directly.

The nominal bandwidth of the amplifier covers UHF channels 32 to 40 with a maximum usable bandwidth extending from channel 21 to channel 60. Two touch panels on the front of the unit increase or reduce the gain, the result being shown on a bargraph type LED display. This makes it possible to select the minimum output power necessary to achieve good reception.

It may come as a surprise to some readers to learn that retransmission in this way is not illegal, but Mastertronic assure us that they have had a team of lawyers working on the case and that even after contacting eighteen Home Office departments they have not been able to find any legal impediment.

Mastertronic are marketing the Video+ with the domestic user very much in mind, but also expect it to be of use in schools, colleges, conference centres, hotels, etc. It will be sold through leading high street electrical shops at a recommended price of £149.95 including VAT, complete with mains lead, aerial and VCR connecting lead.

Mastertronic, Park Lorne, 111 Park Road, London NW8 7JL, tel 01-732 9242.

● MS Components have published a new electronic components equipment catalogue. Its 300 or so pages contain details of around 10,000 products and the company say they can despatch all orders on the day of receipt. Copies are available free-of-charge from MS Components Ltd, Zephyr House, Waring Street, West Norwood, London SE27 9LH, tel 01-670 4466.

● *Honeywell have issued the latest edition of their quarterly journal, Scientific Honeyweller. It includes an article on secure computer systems which explains how sensitive data can be protected against 'hackers', and also has an article describing an intelligent computer program which can be used in the design of large computer systems tailored to suit particular applications. Copies of the magazine are available free-of-charge from the Information Desk, Honeywell Information Systems Ltd, Honeywell House, Brentford, Middlesex TW8 9DH, tel 01-568 9191.*

● There are still areas in which valves reign supreme, some of them very specialised. Among the companies supplying some of the more exotic types are Westinghouse, who have just published a new, sixteen page catalogue. It covers high-vacuum (triode) amplifiers, high-vacuum (triode) pulse amplifiers and high-vacuum diodes for use in industrial, broadcasting, radar and similar applications, and the guide includes specifications and detailed scale drawings. Copies are available from Peter Collings, Westinghouse Electric SA, Industrial and Government Tube Division, 43 High Street, Marlow, Buckinghamshire SL7 1BD, tel 06284-75876.

● **Semiconductor Supplies are distributing an eight-page brochure which describes their range of Kaise and Eagle power supplies and test meters. The power supplies include fixed and variable voltage regulated types and also steplessly variable regulated units. Both analogue and digital meters are available, the analogue types having input sensitivities up to 100,000 ohms-per-volt, and there is also a range of AC and DC clamp meters, insulation testers, earth testers and an analogue light meter. Copies are available from Peter Cresswell, Semiconductor Supplies International Ltd, Dawson House, 128-130 Carshalton Road, Sutton, Surrey, SM1 4RS, tel 01-643 1126.**

Key Note

Next time you fancy a little innocent amusement on a crowded bus or train just try clapping three times.

You may be unlucky and elicit nothing more than a few odd looks. On the other hand, you may be rewarded with a cacophony of high-pitched bleeps and a frenzied rustling noise as dozens of embarassed faces disappear behind their daily papers.

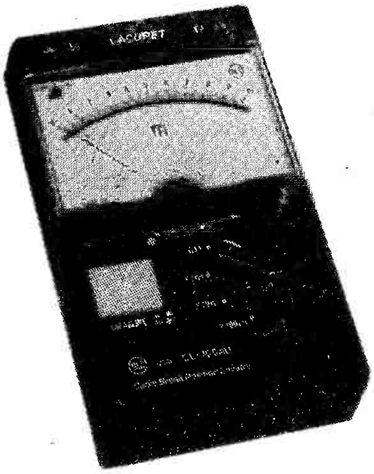
For Dudley Langmead Enterprises have introduced the Key Tracer, an electronic keyring which looks well set to replace the electronic alarm watch as the principal cause of unintended beeping in public places.

The Key Tracer is designed to help those who habitually mislay their keys and behaves like any other keyring until activated by the sound of three claps. It then emits the aforementiond high-pitched tone, alerting the owner to its presence and passers-by to its owner's carelessness.

The social impact of such an invention may well be out of all proportion to its size. We will probably get used to seeing our public spaces filled with people who wear anxious looks and stride around clapping rhythmically, and unpopular orators will no doubt come to accept the high-tech accompaniement which starts up shortly after the first few rounds of slow hand-clapping. However, we can only be thankful that Dudley Langmead did not go for voice pattern recognition and that we are spared the sight of distracted owners calling "Here, Keyring, Keyring" as they wander.

The cost of this miraculous device is surprisingly modest at £6.95 and the manufacturers are surely to be congratulated on their achievement. But please, no applause. You never know what might result.

Dudley Langmead Enterprises Ltd, 16 Bedford Street, Hitchin, Hertfordshire, tel 0462-35928.



Cable Length Meter

TMK are marketing a portable meter which will measure electronically the length of a piece of cable or the distance to a break or short circuit.

The Lacopet CL-100AU can measure cablem lengths from 1 metre to 1000 metres and will work with both two-core and coaxial cables. It works by injecting a 1kHz signal into the line and then measuring the response.

In use, the meter is first calibrated using a 1m piece of cable identical to the length under test. It can then be connected to the unknown cable and a direct reading of length obtained. It could be used, for example, to measure the amount of cable on a drum without uncoiling it or the distance to a break or short circuit in a buried cable.

The CL-100AU is battery operated and has a basic accruacy of ±5% of FSD. A phono output is provided so that the 1kHz tone can also be injected into cables or equipment for signal tracing purposes.

The meter measures 163 x 100 x 47mm and weights 300gm. It comes complete with all test leads, batteries, a carrying case and an instruction manual and has a neck harness which allows it to be supported at a comfortable viewing angle in front of the user whilst leaving the hands free. Optional extras include a signal tracer which can be used to detect the 1kHz output tone.

The CL-100AU costs £199.75 plus VAT and the optional signal tracer costs £125.00 plus VAT complete with case, batteries and earphone. Also available is the CL-100AUK which is generally similar to the CL-100AU but has a measuring range of up to 5000m. It costs £445.00 plus VAT.

TMK Test Instruments, 138 Grays Inn Road, London WC1X 8AX, tel 01-837 7937.

Careers Advice Centre

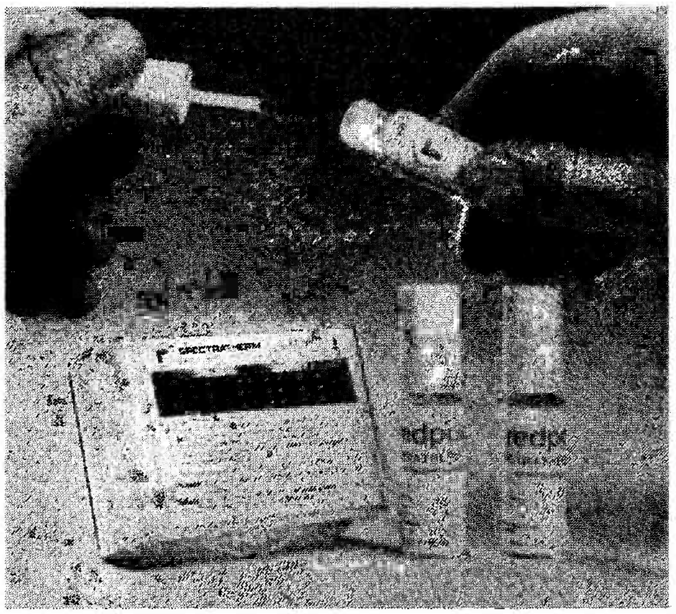
A Careers In Engineering centre will be one of the features at the Technology Engineering Fair, to be held at the NEC, Birmingham from 8-11th October.

The centre will be staffed by representatives from leading engineering employers and technical institutes and will offer advice on career opportunities to students and engineers who are currently unemployed. Advice will also be available for engineers who are in employment but feel that their skills are not being fully used.

The centre will be opened by Sir Monty Finniston. For details contact Juliet Northage, Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham, Middlesex TW1 3SZ, tel 01-891 5051.

● The British Standards Institution have issued their BS 6600 entitled Outline Dimensions of Transformers and Inductors for use in Telecommunications and Electronic Equipment. The first section to be issued is part 10 which covers the Q range of C-core transformers and inductors. BSI hope that it will encourage manufacturers to avoid needless variety in producing these parts. BS 6600 part 10 costs £16.20 (£8.10 to members) from BSI, Linfold Wood, Milton Keynes MK14 6LE.

● The Plessey radio payphone described in News Digest in July has found a customer, but instead of being taken up by poor Third World countries as Plessey expected the first purchasers are the wealthy Swiss. The systems will be installed at fashionable ski resorts in the Alps where a cabled system would be too expensive.



Temperature Indicating Paint

Redpoint have introduced an improved version of their Spectratherm paint, a substance which changes colour to indicate the temperature of the surface onto which it is coated. The new formula measures temperatures over the range 58-117°C and can be used to check the temperature of semiconductors, heatsinks and other electronic devices.

Spectratherm is available as a kit of three bottles, each of which has a brush built into the cap. It can be applied to any dark surface and the temperature can then be assessed by comparing the paint colour with a printed spectrum chart provided. Redpoint claim that under laboratory conditions the paint can be used to indicated temperature to within 0.5°C. Spectratherm works best on non-reflective surfaces but shiny semiconductor packages and similar finishes will give reliable readings if they are rubbed over with a black felt pen first.

Redpoint expect the new paint to be of interest to most electronic engineers and especially to test and quality assurance engineers. They plan to introduce an airbrush so that Spectratherm can be used for temperature mapping on large surfaces.

The three bottle kit costs £25.30 including VAT and postage and packing, and further details can be obtained from Redpoint Limited, Cheney Manor, Swindon, Wiltshire SN2 2PS, tel 0793-37861.

● *NEC claim to be both a world leader in relay technology and a pioneer in fibre optic communications. To prove it they have published a 122-page guide to their relay products and a 344-page book on fibre optics, both of which are said to contain technical data, reference guides and a glossary of terms and definitions. Copies are available free-of-charge from NEC Electronics (UK) Ltd, Carfin Industrial Estate, Motherwell, Scotland ML1 4UL, tel 0698-732221.*

● **ECW have an easy-to-build stereo VU meter kit which uses rows of 16 LEDs to give a bar-graph-type display. It operates from a 12V DC supply, has an input impedance of 10k and a sensitivity of from 100mV to 10V full scale. The kits costs £20.85 including postage, packing and VAT from Electronics & Computer Workshop Ltd, 171 Broomfield Road, Chelmsford, Essex CM1 1RY, tel 0245-262149.**

● Axiom Electronics have signed an agreement with ITT Cannon under the terms of which they will distribute a wide range of Cannon connectors. They can also provide free copies of technical literature and specifications on the new product lines which include D subminiature connectors, the DIN 41612 range, Solda-D, D*U and low cost plastic connectors, turned-pin IC sockets, chip carrier and pin grid array sockets, and IDC connectors. Axiom Electronics Ltd, Turnpike Road, Cressex Estate, High Wycombe, Buckinghamshire HP12 3NR, tel 0494-442181.

● The autumn issue of Cirkit's component catalogue should be out by the time you read this and will be available from high street newsagents for £1.15. Its 128 pages will carry details of an expanded range of parts and will include a special offer on modems and interfaces for the Amstrad computer at a price which Cirkit say is amazingly low.

● *STC have published the 1985 edition of The Tool Book, an 80-page catalogue of tools, assembly aids, service aids, storage equipment and cells and batteries. Over 400 products are listed, from screwdrivers to complete soldering/desoldering stations. Also available is The Electronics Book, a catalogue of electronic components which runs to nearly 700 pages and contains information on almost 40,000 products. Included are details of Estelle, their on-line ordering and information system which is available to anyone with a computer and modem. Both books are available free-of-charge from STC Electronic Services, Edinburgh Way, Harlow, Essex CM20 2DE, tel 0279-26777.*

● **The Institute of Electrical Engineers are planning to produce a Guide for Industry on the Design and Achievement of Testability in engineering products. They say that it is debatable whether some of today's sophisticated microelectronics designs can be tested completely (see our article in this issue for more on this) and hope the Guide will help designers to incorporate test procedures to help overcome the problem. Anyone who feels they have anything to contribute should contact the IEE, Savoy Place, London WC2R 0BL, tel 01-240 1871.**

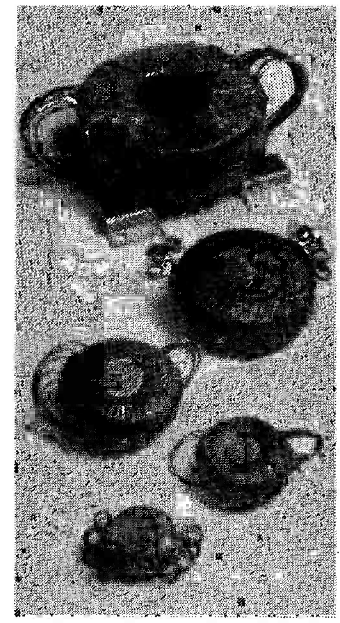
● *PSP have updated their free-form literature which contains photographs and information on their range of connectors. They are distributors for ITT Cannon, Thomas & Betts, Transradio, ITT Pomona, Panduit and Souriau and their range covers just about every conceivable application. PSP Electronics Ltd, Unit 2, 2 Bilton Road, Perivale, Greenford, Middlesex UB6 7DX, tel 01-998 9061.*

Transformer Design Service

Avel-Lindberg have set up a new department which can produce small quantities of toroidal transformers designed to the requirements of individual customers.

The Small Quantities and Prototype Department can produce transformers in batches of from one to twenty units. They say they can tackle anything within the limits imposed by winding machine and wire technology and offer ratings from 10VA to 3kVA. Finishing options range from Melinex tape winding through to full impregnation and resin filling and they can cope with most special requirements regarding insulation and magnetic shielding. Transformers can be constructed to meet all specifications, including Defence Standard 05-24.

Avel-Lindberg use a computer to speed up the design process and can execute the simpler jobs in a few hours. In practice, they feel that most such requirements will be catered for in their standard range and expect the new service to be used mainly for more complex jobs, some of which may need to be passed back and forth between them and the customer before the design is perfected.



Avel Lindberg Ltd, South Ockenden, Essex RM15 5TD, tel 07080-853444.

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DIARY

Electronics for Peace: London Group Meeting — September 5th
London New Technology Network, Camden, London, 7.30 pm. For details see September '85 ETI or 'phone 01-541 1825.

Vacation School On Cable Television — September 9-13th
Leeds Polytechnic. For details see September '85 ETI or 'phone 01 - 240 1871 extension 270.

RAE Course Enrolment - September 10th
Bradford & Ilkley Community College, Bradford. For details see September 1985 ETI or contact P. Nurse, Bradford & Ilkley Community College, Great Horton Road, Bradford, West Yorkshire BD7 1AY.

Interconnection Europe — September 10-12th
Cumberland Hotel, Marble Arch, London. For details see February '85 ETI or 'phone 0582 - 417438.

Alarm Training Seminars — September 24-27th
Castle Alarms, Windsor. Four one-day training seminars covering the basic technology, avoiding false alarms, system design and specification and business study. Aimed at engineers, security staff, management and surveyors, the cost is £85 plus VAT per day including lunch and refreshments. Castle Alarms and Electronics, North Street, Winkfield, Near Windsor, Berkshire SL4 4SY, tel 0344-886446.

Programming in C: A Hands-On Workshop — September 24-27th
London: venue to be announced. For details see July '85 ETI or contact ICS at the address below.

Computer Graphics Course — September 24-27th
Venue to be announced. For details see July '85 ETI or contact ICS at the address below.

Semiconductor International — October 1-3rd
NEC, Birmingham. For details see August '85 ETI or contact Cahners at the address below.

System Security Conference — October 2/3rd
Tara Hotel, London. For details see August '85 ETI or contact Online at the address below.

Offshore Computers Conference & Exhbition — October 8-10th
Aberdeen Exhibition & Conference Centre. Conference devoted to the use of computers in petroleum exploration. Thirty-seven papers from seven countries will be presented and the costs range from £160.00 + VAT for one day to £390 + VAT for the full event. Entry to the associated exhibition is free. Contact Offshore Exhibitions and Conferences Ltd, Rowe House, 55-59 Fife Road, Kingston upon Thames, Surrey KT1 1TA, tel 01-549 5831.

Technology Engineering Fair — October 8-11th
NEC, Birmingham. For details see August '85 ETI or contact Cahners at the address below.

Internepcon UK — October 10/11th
Metropole Hotel and Brighton Centre, Brighton. For details see August '85 ETI or contact Cahners at the address below.

Computer Graphics '85 — October 15-18th
Wembley Conference Centre, London. For details see August '85 ETI or contact Online at the address below.

Electronic Displays '85 — October 29-31st
Kensington Exhibition Centre, London. For details see September '85 ETI or contact Network Events at the address below.

Addresses:
Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham, Middlesex TW1 3SZ, tel 01-891 5051.
ICS Publishing Co (UK) Ltd, 3 Swan Court, Leatherhead, Surrey KT22 8AD, tel 0372-379211.
Network Events Ltd, Printers Mews, Market Hill, Buckingham MK18 1JX, tel 0280-815226.
Online Conferences Ltd, Pinner Green House, Ash Hill Drive, Pinner, Middlesex HA5 2AE, tel 01-868 4466.

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74S189	180p
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74S195	300p
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74S241	400p
74S244	500p
74S251	250p
74S257	250p
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74S260	100p
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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	125p
4032	100p
4033	125p
4034	250p
4035	70p
4036	70p
4037	110p
4038	100p
4039	250p
4040	60p
4041	55p
4042	50p
4043	60p
4044	60p
4045	100p
4046	60p
4047	60p
4048	55p
4049	30p
4050	35p
4051	65p
4052	60p
4053	60p
4504	80p
4055	80p
4056	85p
4059	400p
4060	70p
4063	65p
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	36p
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	55p
4517	220p
4518	48p
4519	32p
4520	60p
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	60p
4557	240p
4560	140p
4566	140p
4568	240p
4569	170p
4572	45p
4583	90p
4584	48p
4585	60p
4724	150p
14411	750p
14412	750p
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40104	120p
40105	150p
40106	48p
40107	55p
40108	320p
40109	20p
40110	225p
40114	225p
40147	280p
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LM319	150p
LM324	40p
LM334Z	115p
LM335Z	130p
LM336	180p
LM339	40p
LM348	60p
LM358P	50p
LM377	300p
LM380N-8	150p
LM380	150p
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LM382	200p
LM383	325
LM384	220
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LM393	100p
LM394CH	300p
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LM733	95p
LM741	22p
LM747	70p
LM748	30p
LM1011	450p
LM1014	180p
LM1801	300p
LM1830	280p
LM1871	300p
LM1872	300p
LM1886	550p
LM1889	550p
LM2917	300p
LM3302	90p
LM3900	60p
LM3909	100p
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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

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LM396K	10A+VAR	£15
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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
75365	150p
75450	50p
75451	50p
75452	50p
75453	70p
75454	70p
75480	150p
75491	65p
75492	65p
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4.43	100p
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7.00	150p
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READ/WRITE

Holey Filing System

Dear Sir,

It is now over a year since I submitted an item for your Tech Tips feature. I can only presume it is among the lost. I shall not moan on about not hearing from you, etc — let him with the perfect filing system cast the first stone. But please, please, let me hear from you soon. I can even take a rejection letter. Of course, I would much rather take a cheque for I am only a poor preacher (as you would realise if you had heard me).

Yours sincerely,
Alan Sharp (Rev.)
Aberdeen

Fear not, Reverend Alan, for that which was lost has been found and is even now among the chosen, in that heavenly place which men doth call the ETI Tech Tips feature. And great shall be your reward (well, almost) for your name is written in the book (in our accounts department) and a small slice of mammon will shortly be winging its way to you.

Thinking Along The Right Lines

Dear Sir,

Further to the article Trains of Thought in the September issue, I find Roger Amos' dual controller intriguing.

I would like to experiment along these lines and would appreciate a sight of his circuit. Perhaps we could have a further article on the subject?.

Yours faithfully
C.W. Davies
Cardiff

I'm sure a lot of readers would like to experiment along these lines, so as soon as we track down Roger we'll pass on your comments.

Some Cases For John Linsley Hood

Dear Sir,

I read Dr P.A. Joiners letter in the August edition of ETI with great interest, because I have been trying since February to get a copy of Newrad's well advertised catalogue.

I have written on three seperate occasions sending a large stamped addressed envelope as instructed. I have also made countless phone calls only to be answered by a phone answering system. I left my name and address and a message. On one occasion the phone was actually answered by a human being and I was told "our catalogues are being printed and you will receive one in two weeks" that was two months ago. Do these people want any customers?

Yours faithfully
M.B. Blight
Basingstoke

Dear Sir.

I greatly enjoyed reading John Linsley Hood's constructional series on his 80W amplifier design. However, for those of us who can't afford to build this design (or who do not require the power output), would it not be possible to persuade him to resurrect and up-date his simple Class-A design?

If the design could be uprated to 15 or 20 watts and the high sensitivity input of the 80W design retained, life would be wonderful.

Yours faithfully
Colin Shelbourn
Windermere

The Class A amplifier (a design which was not originally published in this magazine, incidentally) would require significant modification before it could offer the sort of power levels you are talking about and even then the increase in volume level would be negligible. We will pass your comments on to JLLH, of course, but he may not have much time to consider them since he is busy working on his next ETI design!

Dear Sir,

I have recently built the Linsley Hood 80 watt amplifier, not from a kit but by etching my own boards and buying in components from suitable suppliers. I am generally pleased with the results and can confirm the claims for the quality of the sound. The treble is more open and free from the 'tinselly' sound of my previous amplifier, and the overall sound is more detailed.

I do feel that I must take issue with Mr Linsley Hood on his choice of input sensitivity. The amplifier seems to be too sensitive and I have found it impossible to get rid of the hum induced from the input leads. I feel certain that this problem could be overcome by reducing the sensitivity to 774mV into 600R for full output.

I have tried to do this using a potential divider at the input in place of the volume control (I have a volume control in my pre-amplifier) but the hum problem remains. The most obvious solution would be to increase the negative feedback but I do not have the experience to do this. Would it be possible to prevail upon the designer to produce an alternative input arrangement, with a sensitivity tailored to 774mV at 600R?

I think that, if you consider the sources available today, this is a more realistic input requirement. Compact disc players have a standard output of about 2 volts, and I am sure that anybody who has one will agree that they are the highest quality source available. Radio sources can quite easily be amplified up to the level, and with the passage of time we may well see tuners produced which match the output of CD. The poor old vinyl disc section won't suffer from a bit of extra amplification, the quality being so obviously inferior anyway!

Yours faithfully
D.I. Field
Bath

It seems unlikely that hum problems should arise from JLLH's choice of input sensitivity and impedance. After all, if the input is too sensitive, simply turn the volume control down. If you still suffer from hum problems when the system is used at normal listening levels, the problem is not one of excessive sensitivity.

Too high an impedance can lead to hum pick-up, but the Audio Design amplifier has input impedances of approximately 47k into the disc stage and 100k into the main buffer stage, and both of these figures are perfectly standard. The 600R professional standard does have distinct advantages in the electronically noisy environment of a stage or recording studio (particularly when, as is usual,

the lines are also balanced to ground), but its advantages in a domestic environment are minimal and changing to the system is most unlikely to cure your hum problem. And even were a change of input impedance and reduced sensitivity likely to produce a solution, increasing the negative feedback would not be the best way of going about it. Changing the level of negative feedback in a carefully designed amplifier is guaranteed to have far-reaching and almost certainly unpleasant effects.

It seems more probable that your problem is caused by a hum loop or some similar wiring problem. If in doubt, why not send our Auntie Static a few more details of the problem with a diagram of the present wiring arrangements?

International Electronics

Dear Sir,

Greetings to all Electronics Today magazine staff. Please allow me to say something about myself. My name is Rodney Dulce and I'm 16 years old. I'm studying to be an electronics technician here in the Philippines.

I really like to read Electronics Today because it helps me with the school work. I have used the magazine as a reference for my school assignments and I consider it to be the best of its kind. It's very educational.

Unfortunately, most of the copies of ETI that I see are long out of date and are only borrowed. I would really like to have my own copy each month but I just cannot afford to buy it. My country has been facing an economic crisis for more than a year now and we are greatly affected by it. I don't even have enough to spend on basic needs and am just hoping that I can continue to attend the school.

The reason I am writing to you is that I would like to ask a favour. If possible I would like to have some back numbers of your magazine because I believe they would really help me. Even better would be to have a free subscription. I'm really ashamed at having to ask this but I do believe your magazine could help me a lot. I ask for your kindness and understanding.

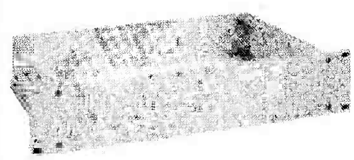
Thank you so much and all power to the magazine.

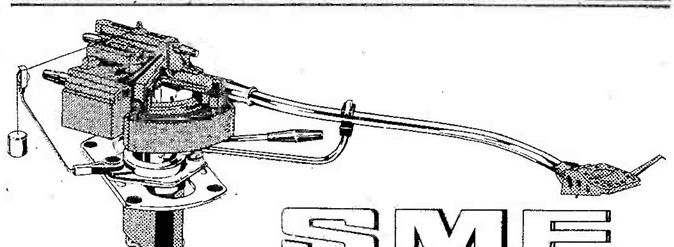
Very respectfully yours,
Rodney Dulce
Cebu City
Philippines

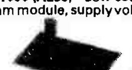
We have sent a parcel of back issues off to Rodney, but we are unable to help him with a free subscription. As you might imagine, we get a lot of requests for such favours and we cannot afford to help all of them, nor have we the time or the ability to determine which are deserving cases and which are not.

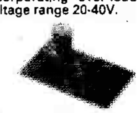
Instead, it occurred to us that some of our readers might like to help. If anyone is interested in writing to Rodney and sending him their old copies on a regular basis, we would like to hear from them. It might be best if a group of individuals got together, or perhaps an electronics class in a school or college, and shared the postage costs.

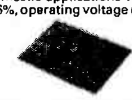
Rather than risk having Rodney buried under a mountain of letters which he might then feel obliged to reply to, we have not printed his address but ask readers to write to us in the first instance. We will then sort through the responses and pass on his address to those who seem best placed to help him. — Ed.

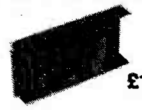


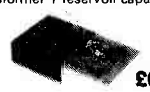












AUNTIE STATIC'S PROBLEM CORNER

Dear Auntie,

I am at present building a hi-fi pre-amplifier which I hope to make remote-controllable, using the Plessey ML920 remote control receiver. Since I would like the amplifier to be the hi-est of fi I would appreciate your advice on the following:

1) What would be the best means of input selection? I had thought of using a pair of LM1037 audio switches, but the specified THD of 0.04% seems rather high. Would using individual FETs or DIL relays be more advantageous?

2) Can you suggest an appropriate IC to decode the 5-bit binary program selection output of the ML920?

3) Is the Mullard TDA1074 of high enough quality to be used as a volume and balance control?

Yours sincerely,
David Tilch,
Sandton,
South Africa

Your letter raises all kinds of interesting questions. On your first point, I can't tell you whether or not a THD figure of 0.04% will be suitable for your purposes — that is for you to decide — but a few general comments may help you to make up your mind.

If you look at the data sheet for the LM107 you will find that 0.04% is a 'typical' distortion figure measured with a 1kHz 1V RMS input signal. Now, we all know that audio components tend to perform better towards the middle of the audio frequency range than at either end — distortion at 10Hz or 10kHz could well be much higher — but something even more misleading has crept in. What on earth is a typical distortion? If you buy an LM1037, can you be sure that the distortion will be 0.004% even at 1kHz? No, of course you can't

Look again at the data and you'll find a maximum distortion figure of 0.1% quoted (again at 1kHz, 1V RMS). This is a better figure to work with. If you design an amplifier expecting results based on this figure, the chances are you'll do better than you expected, but if you use the typical figure you could well be disappointed. It is just a meaningless number which helps the manufacturer to sell ICs. There is not even a standard way of calculating 'typical' performance figures. Is it the mean of a batch of measurements? The median? Or just a figure chosen at random? I know where I'd place my bets.

You may think I'm rather labouring the point, but 'typical' performance figures are creeping in all over the place, so be on your guard! Engineers will always work with worst case figures — if they can achieve their aims on that basis, any additional performance is a bonus. Taking 'typical' figures is just taking a gamble on whether or not the equipment will perform adequately.

Having got that off my chest I will return to the best means of input switching. As it happens, the distortion figures for the LM1037 are fairly constant from 20Hz to around 100kHz, and for inputs from 100mV RMS to 5V RMS. For good signal-to-noise figures, very small signals from record cartridges and such like should, of course, be amplified before being applied to this switch.

The LM1037 is a bipolar switch, if the circuit schematic is to be believed. It consists of a long-tailed pair for each input, the switching being achieved by turning the tail current sources on or off. You may well be able to achieve better distortion figures by the use of FETs, or the type of analogue switch consisting of FETs and switching logic all in one package. The results you will achieve with this type of device will depend as much on your design skills as on the device itself as the performance depends to a great extent on how it will interact with other components in the circuit.

As for relays, it is generally frowned upon to introduce unnecessary mechanical switching into the path of an audio signal. As hi-fi is an area where designers seem to support their own pet theories much as people of different inclinations might support a football team, I thought it best to attempt to ascertain whether this is a genuine engineering problem or just another piece of esoteric nonsense that surrounds hi-fi in general. After speaking to a number of relay manufacturers and audio engineers, the picture seams to be like this. First of all, new relays don't cause problems. If you use cheap 'n' cheerful relays, however, odd things can happen as they age. Silver contacts can end up with a coating of silver sulphide and unsealed types will gather dust and all kinds of grolly from the atmosphere on their contacts. The result is that if very small signals are applied, the contacts can rectify to some extent, appear to have a high resistance, or even fail to conduct at all.

Remembering that today's bog standard is yesterday's state of the art, engineers ten years ago would have found relays very troublesome. One answer that seems to have been used was to apply a DC 'wetting' current to the contacts and to superimpose the audio signal on top of this. You can imagine the thumps and other noises that would be heard from the speakers any time the relay contacts opened or closed. Naturally enough, relays were generally avoided when possible. Sad to say, instead of keeping up with technology, the idea that relays are no good for audio systems has entered hi-fi mythology as a rule to be followed come what may.

I am assured that a modern sealed relay with precious metal contacts that has been designed for signal switching is as good as, and often better than, solid state switches. There are even relays for very demanding applications such as thermocouple switching where the signal is likely to be a few mV at fractions of a μA and no thermal offset from the relay's own contact materials can be tolerated. In a nutshell, if you buy any old relay the chances are you'll have problems. If you buy one designed for signal switching, you won't.

Now to your second question. The ML920 is one of a series of remote control ICs from Plessey. The transmitter, SL490, responds to a switch matrix by generating one of 32 possible output codes according to the switch pressed. These codes are transmitted via an infra-red or ultrasonic link.

At the receiving end, the ML920 is one of a number of possible decoders. 'Program selection' refers to TV programs, by the way, as these ICs are inteded for use in TV remote control. The outputs you can get from the various receiver ICs include a 5-bit binary code corresponding to the switch pressed at the transmitter, a 4-bit code, three analogue outputs and some control signals (from the ML922), and various other combinations of analogue and digital outputs.

Any further decoding you do will depend on the details of your circuit. The digital outputs are CMOS compatible (but not TTL), so any CMOS ICs can be used. You may find a BCD to ten line decoder useful with the ML922, for instance. I can't really be more specific than that.

Now for the TDA1074. Not having any data on the IC, I did the obvious thing and phoned Mullard. They claimed that it is indeed suitable for hi-fi, and since they were honest enough to say that some of their other ICs were not up to the mark, you may choose to believe them. Otherwise, I suggest you get hold of a data sheet and judge for yourself — Auntie.

ETI

THE REAL COMPONENTS

John Linsley Hood brings his series to a close with a look at digital logic ICs.

The world of electronics is becoming dominated, increasingly, by digital devices and techniques. I suspect that some of my fellow electronics engineers, brought up in a far off time when all things were — more or less — linear, feel a little like medieval knights, beleaguered in their castles and surrounded by a sea of advancing black plastic caterpillars.

For myself, I do not complain. There seems nowadays to be a certain scarcity value in understanding how to handle signals that change gradually and irregularly from one voltage to another. However, I think that it is essential to understand the competition, if only so that it may be made to work for oneself as well. One can, even, make digital ICs function in a linear mode — not marvellously, perhaps, but they are certainly inexpensive. Such are the economies of scale for devices made in very large numbers.

However, to begin at the beginning.

Evolution

From their earliest days — and I can remember when a logic gate was a flip-flop made up from a 6SN7 valve — the desirable qualities of logic gates have been the same. A good gate should operate at high speed, have low current consumption and power dissipation, a good speed/power product, the ability to source and sink a reasonable amount of current, equality of output rise and fall times, good fan-out (the ability to drive many other similar gates), low noise susceptibility, and low noise generation. They should also be cheap!

Resistor-transistor logic (RTL) was one of the earliest forms of IC logic element and derived from the days when such devices were hard wired from discrete components. RTL ICs were created by the simple process of transferring the whole circuit on to the surface of a silicon slice. I have shown a typical circuit block which will operate as a 3-input NOR gate in Fig. 1.

The snags are that it is slow, has poor input noise immunity in the sense of being able to decide when the input signal is a 0 and when it is a 1, and the on-chip resistors are of such a value that they occupy a large chip area. This is now an obsolete system.

Diode-transistor logic (DTL) represents an improvement over RTL in that the number of resistors has been reduced and the input signal selection is performed by diodes, which don't occupy nearly as much space on the chip.

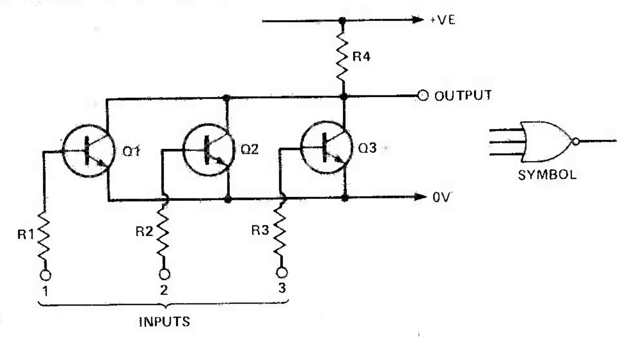


Fig. 1 A three input NOR gate using RTL (resistor-transistor logic) circuitry.

A typical 3-input NOR gate circuit of this type is shown in Fig. 2.

This style of logic gate is still pretty slow and inefficient in terms of power consumed. This is because the maximum pull-up speed at the output, referred to in the data books as T_{off}, is limited by the presence of inevitable output stray (PCB) capacitances, usually in the range 15-50pF. Their effect can be minimised by making R3 very small, but this uses a lot of current in the 'on' condition. They do have a reasonable noise

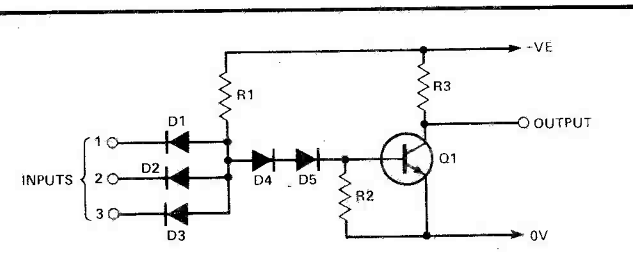


Fig. 2 A three input NOR gate using DTL (diode-transistor logic) circuitry.

immunity, however, and although obsolescent are still available for direct replacement purposes.

High noise immunity logic (HNIL) is also known as high threshold logic (or HTL), and is of the form shown in Fig. 3. This is a version of DTL in which the input 'on' threshold has been lifted by the inclusion of the zener diode, ZD1. Since there are better ways of achieving the threshold requirement, this type of circuit is also obsolete.

Transistor-transistor logic (TTL) in its 54 (military

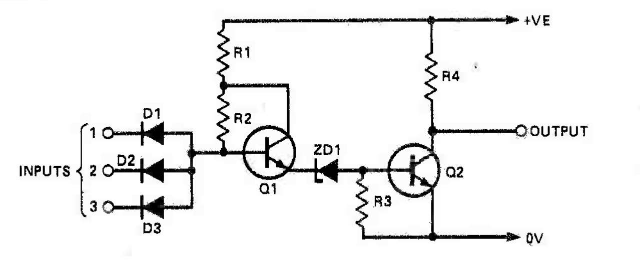


Fig. 3 A three input NOR gate using HNIL (high noise immunity logic) circuitry.

temperature range) and 74 (commercial temperature range) versions, is, or was, the mainstay of low complexity logic ICs. I have shown a typical circuit, again for a 3-input NOR gate, in Fig. 4.

This is quite fast, and avoids the use of an output transistor collector load resistor (R4 in Fig. 1 or R3 in Fig. 2) by replacing it with another transistor (Q3). The output stage has what is described as a totem pole layout, in which, when Q2 is on, Q4 is on and Q3 is off. The only reason R4 is there at all is because the output has to charge stray capacitance in the load and also because, for hole storage reasons, Q4 can be

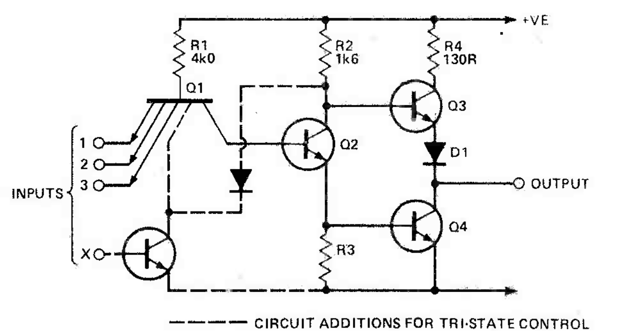


Fig. 4 A three input NOR gate using contemporary TTL (transistor-transistor logic) circuitry.

turned on very much faster than Q3 can be turned off.

Therefore, in the absence of R4, the peak current on switching transitions could be very high, which would lead to very high dissipations. This brings one immediately up against the fact that there has to be a trade-off between speed and dissipation, and leads to the manufacturers offering several alternative logic forms for different applications. For example, the 74H00 series offers higher speed than the standard 7400 series but has higher current consumption.

Schottky TTL

This is a modification to the standard TTL circuit which includes a Schottky diode, based on a metal-silicon junction of the type shown in Fig. 5, connected

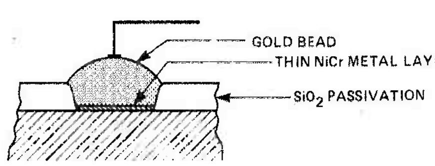


Fig. 5 Cross-section through a Schottky (metal semiconductor) diode.

between the case and collector junctions of each of the TTL transistors. This has the effect of greatly speeding up the switching times by eliminating hole storage in the transistors. The process is illustrated in Fig. 6.

When a bipolar junction transistor is driven very hard into conduction, the collector voltage will fall to a very low forward value which is normally much below the voltage actually applied to the base junction. In this condition, the transistor is said to be driven into saturation. Its recovery time, the amount of

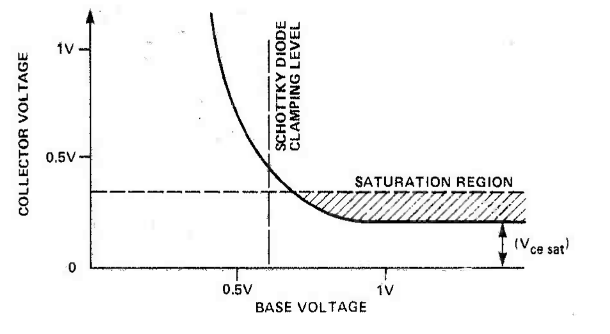


Fig. 6 The relationship between base-emitter voltage and collector-emitter voltage in a switching transistor.

time it will take to turn off again, is limited by the need for the electron-hole pairs generated in the depletion region to recombine or be swept out of the junction zone.

This process is greatly assisted by the inclusion of the Schottky diode, as shown in Fig. 7. The diode is very fast in operation, and has a forward voltage in the 'on' state which can be as low as 0.2V. This means that if the transistor of Fig. 7 is turned on by a positive input signal and if the collector voltage seeks to fall 0.2V lower than the applied base potential, the Schottky diode will conduct and feed the base drive current straight through to the collector which prevents the transistor from saturating. Also, while the

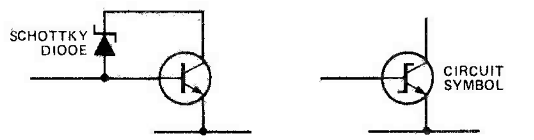


Fig. 7 A Schottky diode clamped transistor and its circuit symbol.

diode is conducting in the brief period after turn-off, it provides a low impedance return path for the stored charge.

Emitter Coupled Logic

ECL takes the form shown in Fig. 8, and is the fastest commercially available logic system. The output signals are taken from the emitters of transistors and developed across relatively low value emitter resistors.

Because the transistors act as emitter followers they are, by definition, non-saturating. In addition, because the output impedance of an emitter follower is very low as a result of the internal negative feedback, the switching transition times are very fast.

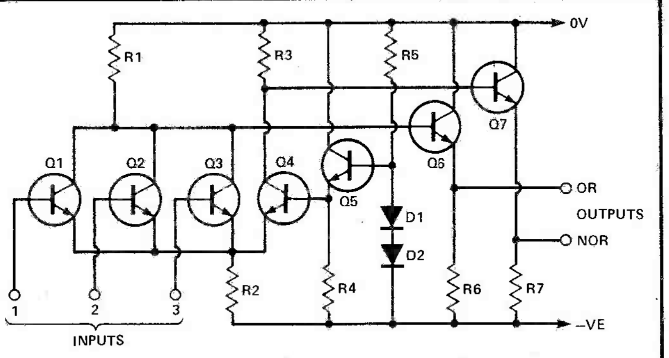


Fig. 8 A three input OR/NOR gate using ECL (emitter-coupled logic) circuitry.

In the particular circuit shown, a 3-input OR/NOR, the input transistors Q1–3 act with Q4 as an input long-tailed pair, in which, if the input goes positive, Q1–3 collectors will fall in potential and that of Q4 will rise. Q5 and diodes D1–2 just act to hold the base of Q4 at a fixed potential. It is fairly typical of ECL that both inverting and non-inverting outputs are provided.

ECL also has the distinction of being the logic system which uses the largest amount of power per gate of all the normal types, and also requires a negative power supply line. The symbol for this type of logic is distinguished by the arrows on input and output, as shown in Fig. 9. The commonly used logic units have the symbols shown in Fig. 10.

Complementary MOS

CMOS is one of the most useful and versatile of all the logic types, and is as much liked by the manufacturers as it is by me. One of its advantages is a very high input impedance, which means that there are no

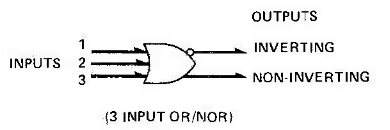


Fig. 9 The circuit symbol for an ECL three input OR/NOR gate.

problems over input drive capability from other logic elements or from outside signal sources. It requires very little operating power — static values of the order of 0.01µW/gate are quoted — and it is also quite tolerant about the supply line voltage. It will accept a supply anywhere in the range +3V to +15V, and I have occasionally had circuits survive careless application of 20–25V!

As with any other logic IC, it is prudent to lessen the possibility of unwanted gate triggering from spurious voltage spikes on the DC supply lines. This is done by liberally strewing small, non-inductive capacitors (ceramic disc or similar) along the +ve rail to decouple this to the ground plane, as close as possible to the supply input to the IC.

Its popularity with the manufacturers is due to the fact that CMOS gates are very easy to fabricate, and use nothing other than P-channel and N-channel MOS transistors. No diodes, no zeners, no resistors! As an example I have shown a simple inverter stage in Fig. 11, and a 2-input NOR in Fig. 12.

Its disadvantages are its relatively slow switching speed and its susceptibility to unwanted signal pick-up due to its high input impedance gate characteristics. However, unless you are in the world of main-frame computers, its relatively slow propagation speed is unlikely to be a major problem. The CMOS gate inputs are, however, a little static sensitive, though often the makers protect them by the incorporation of the diodes D1–4 shown in Fig. 12.

In the 18 or so years since these devices became available, I do not know that I have ever damaged one by careless handling — though I wouldn't go so far as to say that none have ever given up the struggle because I inadvertently wired them up in some particularly idiotic fashion.

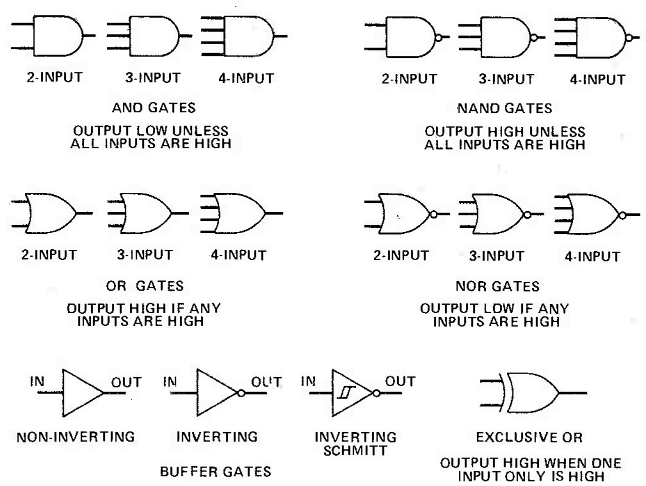


Fig. 10 Standard symbols for logic gates. More complex digital devices such as flip-flops, counters, registers, etc are shown as rectangular boxes.

Construction Methods

To illustrate the advantage of the CMOS structure, I have shown in Fig. 13a some cross sections of a bipolar IC (eg. TTL), showing three of the various circuit elements. At least nine of these would probably be needed to make a functioning gate. In Fig. 13b, for comparison, I have shown the cross section of a complete CMOS inverting buffer.

The more elements there are in an IC, the larger the chip area and the more costly it will be. Also, the more complex the IC is, the greater will be the failure rate for that IC type. Because of this it is understandable that a lot of effort has been put into developing further the simple and compact CMOS structure, which gives good yields and high profits.

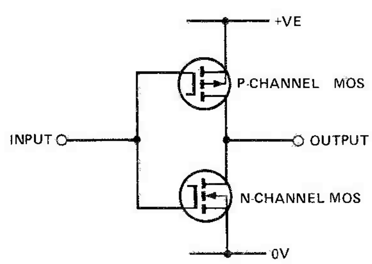
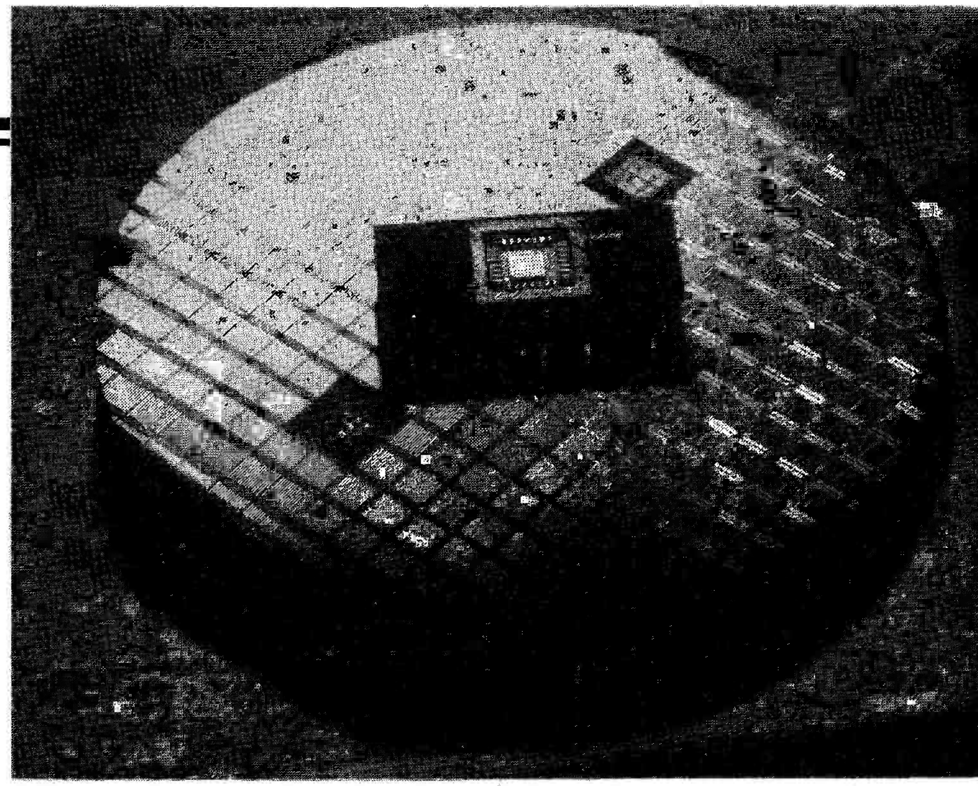


Fig. 11 An inverting buffer using CMOS (complementary metal oxide silicon) circuitry.



Both Schottky TTL and CMOS types have benefitted from a lot of recent development work. In the case of Schottky, the first stage was to reduce the power consumption to something nearer the 1mW/gate figure of low power TTL (74L00), but without the slow response of the 74L00 types (33ns/gate transition). In the event the 74LS00 (Low-power Schottky) types achieve some 9-13ns/gate with a 1mW power outlay.

A further development along these lines has been the Advanced Low Power Schottky types (known as ALS or Fast), which achieve 3-4ns transition speeds and yet only consume 1-2mW/gate. Meanwhile, the Advanced Schottky (AS) types have attained an operating speed approaching that of ECL (1.5ns/gate or 200MHz clock speed) without the associated problem of awkwardness in use. They have a gate dissipation of 20mW, as compared with a 25-60mW/gate dissipation for ECL.

On the CMOS front, development has involved replacing the aluminium metallising of the gate electrode with polycrystalline silicon. This can be more precisely deposited, in narrower regions, which allows a considerable reduction in the parasitic gate capacitances. The resulting gate propagation delay is of the order of 7-10ns, which is very similar to low power Schottky and faster than the standard 7400 TTL. The poly gate CMOS (74HC00) is specified for operation in the 4.75-5.25V TTL supply range.

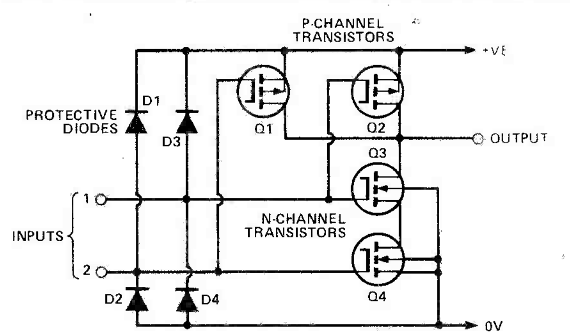


Fig. 12 A two input NOR gate using CMOS circuitry.

Performance Data

I have summarised the performance characteristics in terms of speed and current consumption in Tables 1 and 2, and I have provided a pecking order list for the various types in Table 3. However, there are some things which must be borne in mind when reading such data, mainly related to the gentle art of specification writing.

I think the statistics quoted for digital ICs are pretty honest (well, relatively so!). This may have something to do with the fact that the digital circuit fraternity tend to be young, and the writers are, perhaps, not yet steeped in guile. Certainly in the field of linear ICs I

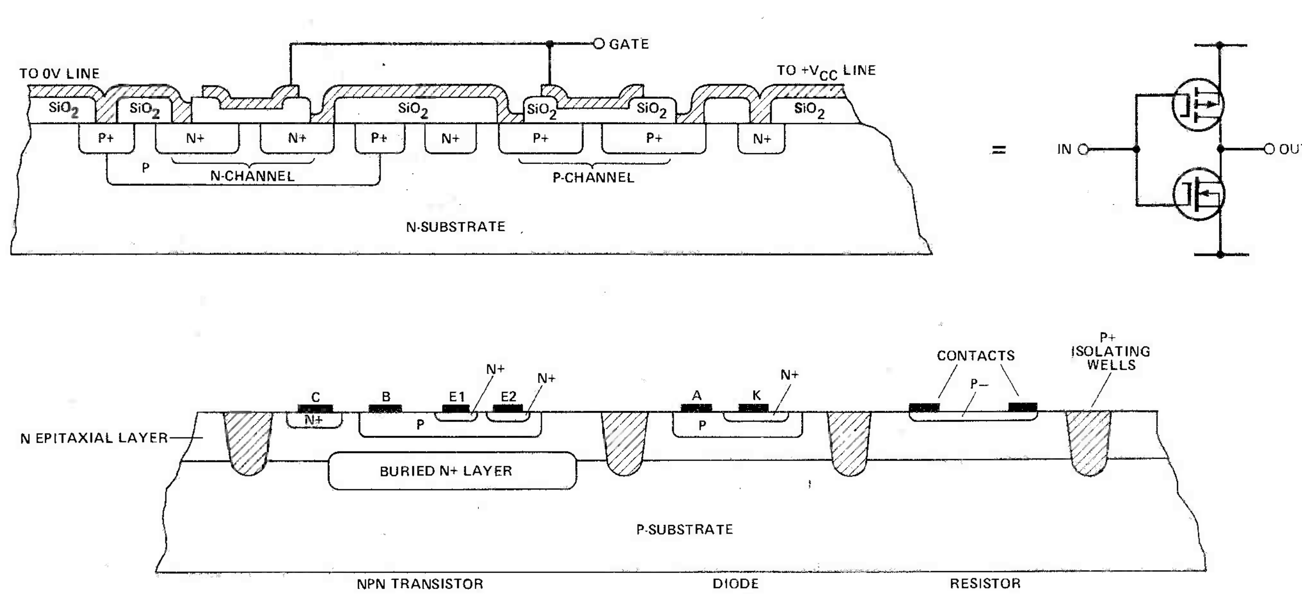


Fig. 13 Cross-sections through a), a CMOS chip and b), a TTL chip.

sometimes get the feeling that the specifications are written by temporarily unemployed science fiction authors.

With regard to the CMOS ICs, the main thing to remember is that the gate propagation delay will be worse at the lower voltages, so the specifications will usually quote the gate delay at 10 or 15V where it is better. There are two types of CMOS IC, the 7400 pin compatible 74C (and now 74HC) varieties, and the generally non-compatible 4000 series. The 4000 series devices will usually be specifed for an output (stray capacitance) load value of 15pF, whereas, in practice, 20-40pF is probably nearer the truth. The

Device Type	Series Code	Maximum Frequency
Low power TTL	74L00	3MHz
Standard CMOS (5V)	4000	5MHz
Standard CMOS (15V)	74C00	15MHz
Standard TTL	7400	35MHz
Low power Schottky	74LS00	45MHz
High speed TTL	74H00	50MHz
High speed CMOS (5V)	74HC00	50MHz
Standard Schottky	74S00	125MHz
Advanced low power Schottky	74ALS00	60MHz
Advanced Schottky	74AS00	200MHz
Emitter coupled logic	MC10100	500MHz

Table 1 Contemporary logic IC types ranked according to maximum operating frequency.

Device Type	Gate Propagation Delay	(per gate)	Power Consumption (per gate)
Low power TTL	33ns 26ns	50pF 15pF	1mW
Low power Schottky	13ns 9ns	50pF 15pF	2 mW
Advanced Low power Schottky	3-4ns	50pF	1-2 mW
Standard TTL	15ns 10ns	50pF 15pF	10 mW
Standard Schottky	4.5ns 3ns	50pF 15pF	20mW
Advanced Schottky	1.5ns	50pF	20 mW
Standard CMOS (10V)	20ns 15ns	50pF 15pF	Negligible at LF
High speed CMOS (5V)	10ns 7.5ns	50pF 15pF	Negligible at LF

Table 2. Comparison of the speed and power consumption of contemporary logic IC types. Note that buffered devices will always have greater propagation delays.

Logic Family	Speed	Power Dissipation	Fan Out	Noise Immunity	Noise Generation
DTL	6	4	3	4	2
TTL	5	4	3	3	3
S	3	5	3	3	3
LS	4	2	3	3	3
ALS	4	2	3	3	3
AS	2	5	3	3	3
ECL	1	6	2	3	1
NMOS	5	2	2	2	2
CMOS	6	1	1	1	2
HCMOS	4	1	1	1	2

Table 3 A league table of logic IC performance. A '1' indicates the best performance and a '6' the poorest.

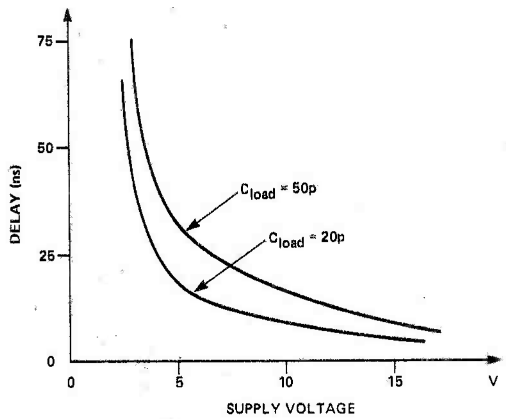


Fig. 14 The propagation delay through a CMOS gate for differing values of load capacitance and supply voltage.

74C types are a bit faster, and are specified for a 50pF output load, but usually at 10V supply voltage.

Another factor which must be remembered is that one gate does not make a logic IC (with the exception perhaps of an inverting buffer). So, IC types quoted at 15ns/gate, such as the 4000 series, may still introduce a considerable delay. For example, the delay from data to output in a CD4013 dual D-type flip-flop operated from 5V is 200ns. The 74C74 is marginally faster at 180ns. The 10V figures are better, at 80ns and 70ns respectively.

The way in which CMOS propagation delay varies with output capacitance and supply voltage is shown in Fig. 14. There will be no significant effects inside the device because the internal circuit capacitances will only be 1-2pF. I have also shown the input/output voltage transfer characteristics of a typical CMOS

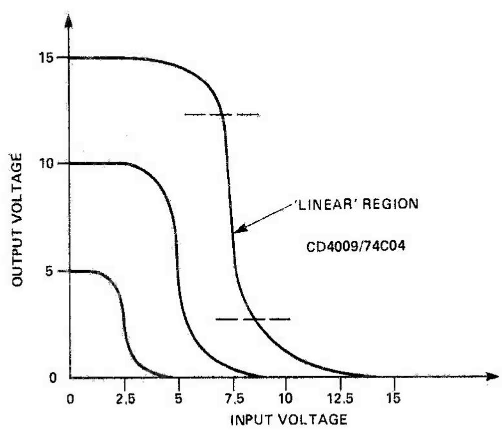


Fig. 15 Transfer characteristics for a CMOS inverting buffer.

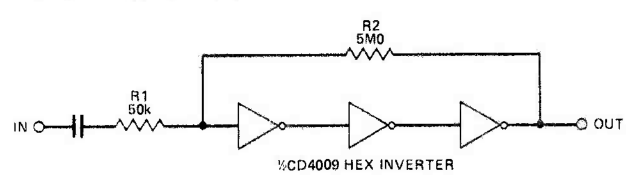


Fig. 16 Using a CMOS inverting buffer as a linear amplifier with a gain of 100. If R1 is removed, the circuit will function as a squarer.

inverter, such as the CD4009 or 74C04, in Fig. 15. As these characteristics suggest, it is possible to use the device in a linear amplifier mode, as shown in Fig. 16. This particular kind of circuit is useful in amplifying and squaring-off input AC signals of up to 10MHz or so, although the output waveform won't be very square above a few hundred kilohertz due to the absence of the higher harmonics.

A point which must be watched in all CMOS logic ICs is that unused gate inputs must not be left to float. All unwanted inputs should be tied either to the 0V or the +Vcc line. Unless this point is remembered, endless problems can arise.

Also, while CMOS dissipates very little power when used in static or low frequency switching applications, as the clock frequency rises more and more power will be required to charge and discharge the output load (stray) capacitance, so the gate dissipation will also increase. I have shown a graph of dissipation versus clock frequency for a CMOS gate in Fig. 17. Other logic systems will follow a similar pattern at the higher frequency end of the curve.

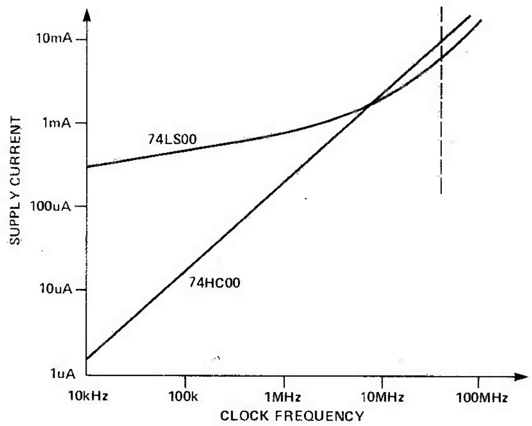


Fig. 17 Supply current demand per CMOS gate as a function of operating frequency.

Cost

This is a major factor in the use and choice of ICs and is influenced, to a dramatic extent, by the popularity of the IC in question.

This means that if an IC has been overtaken in performance by a competitive type, not only will the cost of the competitive IC decrease as more are made or as a promotional ploy by the makers, but the price of the IC which it replaces will now increase as the numbers sold decline. So, although I have listed the relative costs of various forms of the same logic IC (a quad 2-input NAND gate) in Table 4, these relative costs are changing as time passes. In a year's time, the dearest may no longer be available and the cheapest may no longer be the cheapest.

Device Type	Series	Cost (1 off) 1985
CMOS	CD 4011	34-88p
LS	74LS00	40-80p
HCMOS	74HC00 74HCT00	40-123p
ALS	74ALS00 74F00	49-70p
TTL	7400	57-111p
CMOS	74C00	60-110p
AS	74AS00	71p
ECL	MC10104	160p
S	74S00	176p

Table 4 Comparative cost of different types of quad two input NAND gate.

Large Scale Integration

LSI is the great success story in the digital IC field, allowing very complex functions to be achieved on a single IC chip by joining together very large numbers of relatively simple logic gates.

LSI derives largely from developments in MOS technology, although bipolar Integrated Injection Logic which uses simplified transistor circuitry of the type shown in Fig. 18 has had some success in computer work. However, the main need was for simple, low chip area circuitry with very low power dissipation per gate, and this was provided most effectively by MOS technology, either as NMOS with further NMOS devices acting as load resistors, or, more recently, with CMOS.

Many small personal computers, such as the one on which I am typing this article, are based on NMOS LSI single chip microprocessor ICs, like the Z80 and the 8080A. However, advanced poly silicon gate CMOS offers higher operating speeds and reduced power consumption, often as little as 5% of that for the equivalent NMOS circuitry.

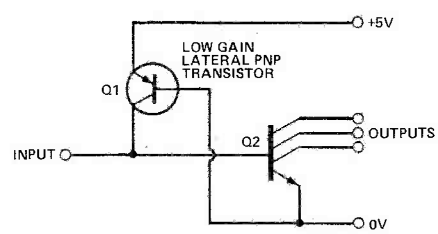


Fig. 18 An integrated injection logic (I^2L) gate.

I have listed some of the current applications of LSI ICs of the CPU/RAM/ROM types in Table 5, in increasing order of chip complexity.

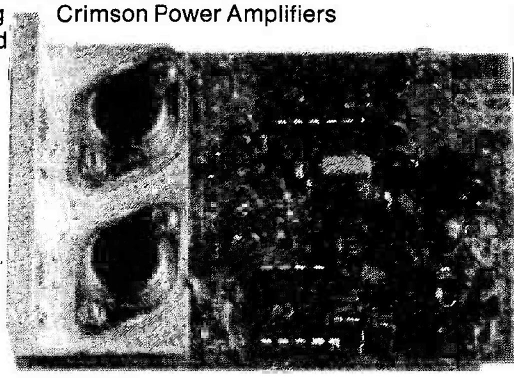
ETI

	Calculators Controllers Printers Sequence timers	Process controllers Automatic instruments Data loggers Games Automotive	Smart terminals Billing/Accounting Point of sale hardware Personal Computers	Minicomputers Advanced instruments Intelligent terminals
ROM	1-2K	1-4K	2-16K	8K+
RAM	32-128	64-256	128-64K	4K++
I/O Lines	10-32	20-64	32-200	128+
Peripherals	0-1	0-3	1-8	5+

Table 5 Typical applications for single-chip LSI (large scale integration) devices ranked according to degree of complexity.

POWER AMPLIFIER MODULES

After years of extensive tests and empirical research, Crimson have developed the ultimate in Bipolar Power Amplifier Modules, making Crimson Power Amplifiers the most sophisticated and highly protected modules available today.



All of these modules now incorporate the following:
- HP Protection — Automatic shutdown to prevent damage from unstable signal source.
- Thermal Protection — A Thermal Sensor which again causes the amplifier to enter the Shutdown Mode before any danger is reached.
- Power Supply Protection — Diodes have been added to the P.C.B. to prevent reverse polarity damage.

MODULE	POWER/LOAD		PRICE INC. V.A.T. P&P
CE608	60	8Ω	£21.00
CE1004	100	4Ω	£24.50
CE1008	100	8Ω	£27.50
CE1704	170	4Ω	£35.00
CE1708	170	8Ω	£35.00

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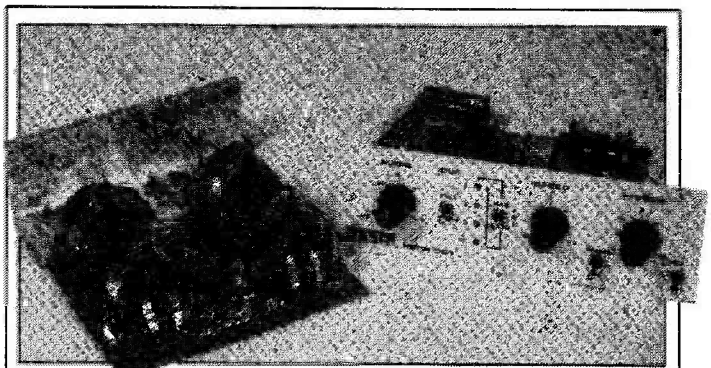

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THE SAMPLE LIFE

Paul Chappell tests the water and gives some samples of the problems and solutions facing the designer of a low-cost digital sound sampler.

Several years ago I remember seeing a *Tomorrow's World* which featured a new kind of musical instrument. It looked like an ordinary electronic organ, but instead of generating its own sounds it borrowed them from the outside world. The sound of a violin, say, would be recorded into the instrument's memory through a microphone. Pressing a note on the keyboard would then give the sound of a violin at the appropriate pitch, by varying the speed at which the sampled sound was played back.

Commercial Sound Samplers

Leaving aside instruments such as the Fairlight, which will set you back more than £20,000, and the Emulator at around £7,000, you can now buy a self contained sampler and keyboard, the Ensoniq Mirage, for a mere £1700. To get anything cheaper, you'll have to supply some odds and ends yourself. For instance, the Akai S612 polyphonic sampler at £800 or so has no keyboard, you'll have to provide one, and if you want to store the sounds you've sampled you'll also need a disc drive. Powertran's MCS1 costs around £600 as a kit, but is only monophonic. The MCS1 and S612 can be controlled by a BBC micro, or any computer with a MIDI interface.

At the budget end of the market there are some very low cost devices. The sound quality and features you can expect from these bear very little relation to the price tag, so it's worth taking a good look at the spec sheets to see just what you'll be getting before breaking open your piggy bank. One possibility is the Logitech sampler at £200, a low budget sampler with a low budget sound if the reviews are to be believed. Then there is the Greengate DS3, an add-on for the Apple computer. The sampler box and software will cost you £280 and the music keyboard (as opposed to the computer keyboard) is another £280 on top of this.

The main differences, apart from how many extras you will have to buy, are in sound quality, sound manipulation and editing facilities, and the number of notes you can play at once. The simplest devices, such as the Logitech, use 8-bit linear sampling which implies poor dynamic range and high quantisation noise. They can only play one note at a time. The DS3 also uses linear sampling, but has good editing facilities and is 4-note polyphonic. If 'dynamic range' and 'quantisation noise' are mysterious concepts to you, hold your breath a moment.

Build Your Own

These days it is not particularly difficult to build your own sampler as an add-on for a home computer. A very basic design for the Spectrum appeared in a music magaxine not so long ago. It consisted of four ICs for A-D and D-A conversion and address decoding. The Spectrum RAM was used to store the sample. There was no filtering of any kind and the sound would hardly have been super-fi, but no doubt it was fun to experiment with, which was all it was really intended for.

So what is the ETI design to be? A single chip add-on for the ZX81 or a Fairlight look alike that will still leave you with some change from a second hand Ford Cortina? After much debate ('What do you think we should do, Alf?' 'Search me!') we eventually decided on a Spectrum add-on. At the moment you can pick up a brand new Spectrum for the price of a cup of coffee, so there's no excuse for saying you haven't got one. As for the circuit itself, our efforts have been directed towards getting the sound right rather than adding extra gadgets. Constructional details will begin next month, all being well, so have your soldering irons warmed up and ready for action.

The Greengate sound sampler (bottom right) and all the other necessary bits and pieces,

General Principles

The hardware used to translate analogue signals to digital form and back again has recently been described in the pages of ETI (August, 1985), so I won't go over the same ground again. What this feature on A-to-D and D-to-A conversion didn't mention, however, were the practical consequences of performing the translation. The waveform that is recovered from a digital sampling process is never quite the same as the waveform that went in. Sampling, by its very nature, breaks continuous waveforms into discontinuous elements. The trick is to get it as close as possible to the original. Without taking any special precautions, you will certainly end up with a sound that is recognisable, but it will be noisy and distorted. Why does it happen, and what can be done about it?

First of all, we have the problem that a fixed number of 'quantisation levels' are available according to the number of bits that will represent the sample digitally. We would like each sample to equal the exact value of the analogue signal at the time. Instead, we must round it up or down to the nearest level for which a digital code is available. A 2V signal, for example, would be okay for an 8-bit sampler, but 2.005V would not.

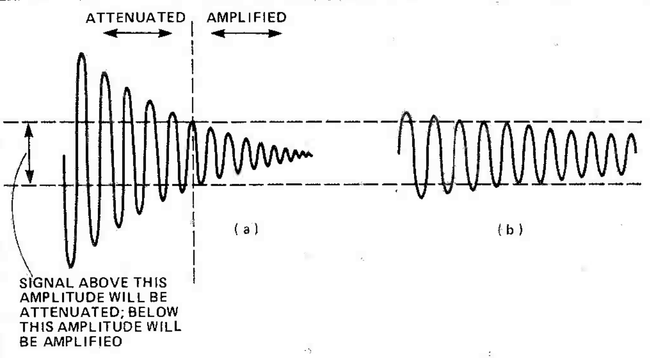


Fig. 1 (a) Input to compressor, (b) Output from compressor

The result of the rounding process is known as quantisation noise and sounds very much like the kind of thermal noise hiss that any audio equipment will make to a greater or lesser extent. Intuitively, you can see why it sounds like noise by thinking of the difference between the true value of the audio signal and its quantised value as an extra and unwanted signal that is superimposed on the input.

For an arbitrary input, the value of this extra signal at each sampling will be random, in the sense that it will not be related in any obvious way to the harmonic structure of the input, will not repeat, and so on. There are certain inputs for which this will not be the case, but for general audio signals it's a reasonable way to look at the situation. The main difference between quantisation noise and thermal noise is that quantisation noise is only present when the sound is being reproduced, while thermal noise is there in the background all the time.

For an 8-bit word length, which we are more or less stuck with if we want to make use of Spectrum's memory for storing the samples, the signal-to-noise ratio will be 48dB for a signal which is large enough to make use of all 256 available quantisation levels. This is certainly not hi-fi, but could be tolerated; a cheap domestic tape recorder will give similar results.

Unfortunately, the signal-to-noise ratio degrades very quickly as the amplitude of the input signal drops. For an input 20dB below the overload point (the point at which ithe A-D converter runs out of codes) the S/N ratio is a mere 28dB. Not too good. The reason fo the degradation is fairly obvious; in the extreme case the input may be so small that it only alters the least significant bit in the binary code. The resulting variation between two possible output levels would not track all the nuances of the input with any degree of precision.

Companding

The simplest solution to this problem is to ask the user to adjust the input so that the ADC is operated as close as possible to its overload level without actually exceeding it. Not very practical, you think? Just take a look at the Greengate sampler, which does exactly this.

Assuming that the sound to be sampled can be repeated a few times to allow the input level to be adjusted, we are still left with the problem that as the sound decays the noise will increase. A piano note, for example, will begin with a high amplitude as the hammer strikes the string. The amplitude will then drop away quickly to a much lower sustain level. A sampler adjusted to accept the initial level would not give very good results during the sustain period.

Another possibility is to adjust the sound level electronically. Devices which do this are called companders (compressor/expanders) and are available ready made in the form of ICs. In essence, the compressor section will reduce the amplitude of signals that are above a certain pre-defined level and increase the amplitude of small signals, so that the range of amplitudes is close to a constant level (Fig. 1). Thus output will have a substantially reduced, or compressed, dynamic range and the signal can be kept close to the overload point of the sampler at all times. The expander secton returns the dynamic range to normal after the signal has been translated back into the analogue form.

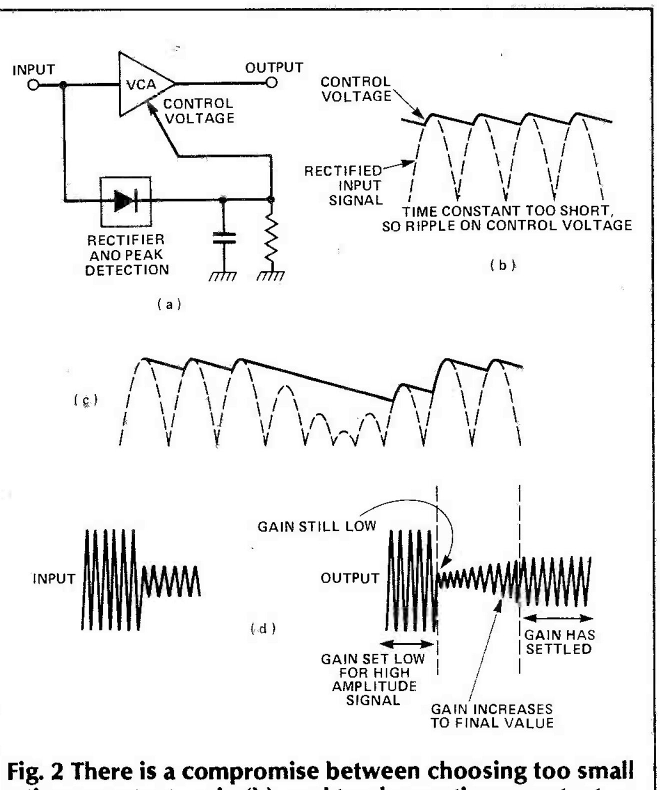


Fig. 2 There is a compromise between choosing too small a time constant, as in (b), and too long a time constant, as in (c) and (d).

This is all very well in theory, but companders work by taking an average of the signal level and using this average to control a VCA which modifies the output level. The averaging process involves rectifying the input and integrating the result. A short time constant on the integrator will give an accurate average but will result in a good deal of ripple on the VCA control signal, while a long time constant gets rid of the ripple but will make the circuit slow to respond to amplitude changes (Fig. 2).

As rapid changes of gain in the VCA cause considerable distortion, compander circuits tend to err on the side of a slightly longer time constant. The resulting amplitude changes cause an effect often described as 'breathing'.

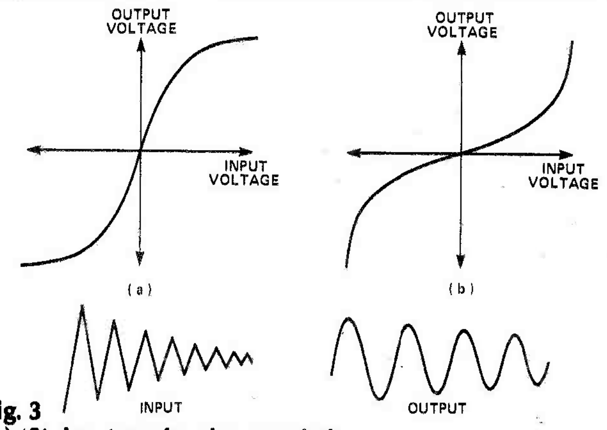


Fig. 3
(a) 'S'—law transfer characteristic.
(b) The characteristic needed to restore the original signal.
The waveforms show a triangular wave of diminishing amplitude before and after processing by (a). Note that the output changes far less in amplitude than the input.

Instead of modifying the signal envelope, as is the case with companders, another possibility is to modify the waveform itself. Imagine we have a circuit with a kind of 's-law' characteristic as in Fig. 3. Any input to the circuit would be amplified much more around the zero-crossing part than it would be at its peaks. An input of varying amplitude would still be compressed, but this time the compression would be achieved by altering the shape of the wave rather than shrinking it as a whole. The waveform would end up very distorted, but could be restored to its original glory by a circuit with the inverse characteristic.

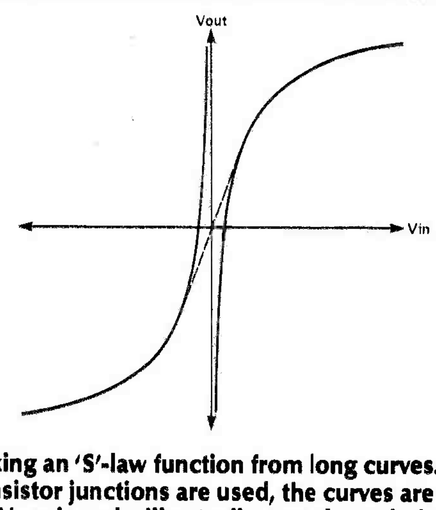


Fig. 4 Making an 'S'-law function from long curves. Note that if transistor junctions are used, the curves are offset along the V_{in} axis and will actually pass through the origin.

A circuit of this nature is not easy to construct as the inverse circuit must be a very precise match to the compressor. I have a feeling that something along these lines could be made by missing out the integrating capacitors on a compander IC, but I haven't really looked into it. If anyone would care to try, please write in and let me know how it turns out.

A circuit I have tried involves using the base-emitter junctions of a pair of transistors to simulate the curved sections (Fig. 4) with a bit of trickery to carry the function across the centre. The results were encouraging, but much more difficult to compensate for the temperature variations than I had anticipated. Log amplifiers exist in IC form (with temperature compensation!) but they only work in two quadrants: you get the right hand side of Fig. 4 or the left, but not both. Perhaps something could be done with two of them? If you have a hot soldering iron and time on your hands....

However, all this is short-circuited by the fact that a similar kind of compression can be performed by the ADC. Just tuck the previous ideas away in the back of your mind for a moment because I'd like to approach the idea of 'digital companding' from a slightly different angle.

Short but Sample

The obvious way to increase the dynamic range of the sampling process is to use a high resolution ADC. A 12-bit ADC will give 4096 quantisation levels and a S/N of 72dB at best; for a 16-bit ADC we have over 65,000 levels and a maximum S/N ratio of 96dB. If we're using 8-bit words to store the data we can't use a 12 or 16-bit ADC (assuming we could afford to buy one in the first place in the case of the 16-bit devices) and using two words for each sample would halve our sample time. Bearing in mind that we want to avoid the degraded S/N for low signal levels, suppose we do this instead:

Around the 0V level, we pretend we've got a 12-bit ADC and space the quantisation levels accordingly so that they are 0.025% of full scale apart. After the first eight levels, 0.05% of full sale apart. The next eight levels will be 0.1% FS apart, the next eight 0.2% FS, and so on. The resolution around 0V is now excellent. The penalty is that in the final section which takes care of the wave peaks the resolution is only equivalent to a 5-bit ADC. There are two very strong points in favour of this as opposed to linear conversion. First of all, audio signals generally have an amplitude spectrum concentrated in small signals rather than large ones and will often have crest factors (the ratio of peak to RMS amplitude) of five or more. Secondly, the human ear is much more sensitive to any inaccuracies of the wave around the zero-crossing point than it is to slight variations in the peaks. At the end of the day, the justification for this type of conversion is that it sounds so much better!

In IC form, there are two versions of the companding DAC. The first follows a law known as μ255, developed by Bell Laboratories. The idealised law is:

$$Y = 0.18\ 1n(1+\mu X)$$

where μ has the value 255 for an 8-bit converter. This law is approximated by seven 'chords' which double in step size as described above. The rival system, the A-law, approximates the function:

$$Y + 0.18\ (1+1nAX) \text{ for } 1/A<X<1$$

$$Y + 0.18\ AX \text{ for } 0<X<1/A$$

Where A has the value 87.6 for an 8-bit converter.

In both these cases, X is the analogue signal level as a fraction of full-scale. The formulae give the magnitude of the signal levels; a sign bit in the DAC is used to say whether they are above or below zero.

The main difference between the two laws is that the approximation of the A-law results in the first two 'chords' having the same step size, so the maximum resolution is only equivalent to an 11-bit linear DAC.

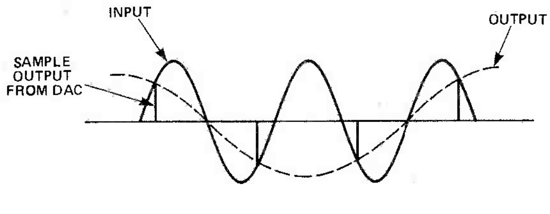


Fig. 5 Alias distortion. A case of mistaken identity?

To tie in with the earlier idea of modifying the waveform with an 's-law' analogue circuit, just imagine that the sample in memory from the variable-step ADC was fed out through an ordinary DAC. With allowances for the chord approximation, the waveform would look just as if it had been processed by the analogue 's-law' circuit!

The advantage of companding during A-D and D-A conversion is that the technology required is just the same as that needed to produce a 12-bit DAC, which is not very difficult these days. To get the same degree of precision in a non-linear analogue circuit would be virtually impossible.

Sampling Rates

A well known rule of thumb is the need to sample at more than twice the rate of the highest frequency component of any waveform that is to be reproduced — the famous Nyquist theorem. If you disobey the rule, you let yourself in for a dose of the dreaded alias distortion.

Alias distortion is often presented as a kind of 'mistaken identity' of the sampled waveform (Fig. 5).

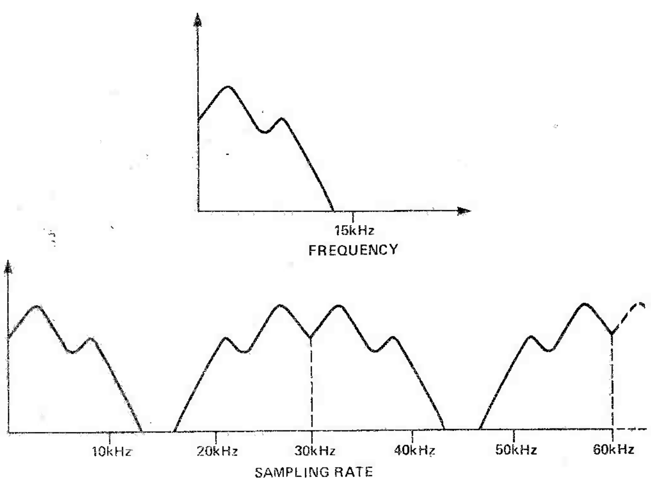


Fig. 6 The frequency spectrum of the input signal (a) and the output from the DAC, (b), showing the additional frequency components generated by sampling.

This is OK for explaining how it might occur, but not much good for deciding what to do about it. A more enlightening view of the situation is to consider the frequency spectrum of the sampled wave, or the output from the DAC.

Two points before we start. First of all, the following discussion assumes that the output from the DAC represents the exact level of the input at the time of sampling. Any practical inaccuracies we have already put into the 'noise' pigeon-hole, and there they can stay for the time being. Secondly, it doesn't matter a damn whether we use linear or log conversion. What we are getting out of the DAC is a stream of voltage levels representing the instantaneous value of the sampled wave, no matter what black magic was used to stuff it into the memory in between.

We'll start off with an analogue input which has a frequency spectrum as shown in Fig. 6a. After sampling at 30kHz, the output from the DAC will have a frequency spectrum as shown in Fig. 6b. No doubt you've seen similar diagrams before. To get a feel for why it should be so, take a look at Fig. 7.

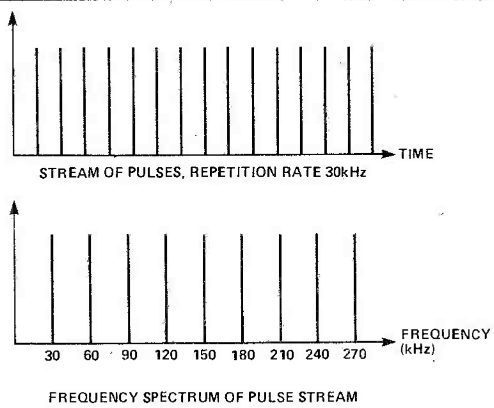


Fig. 7 A stream of sampling pulses and their frequency spectrum, which extends indefinitely.

First of all we have a series of sampling pulses of zero duration. Not very practical? OK, I admit it, it's a mathematical fudge. But bear with me for a moment.It so happens that a string of pulses like that has a frequency spectrum consisting of evenly-spaced sine waves all with the same amplitude. Now, if I took just one of these sine waves and amplitude modulated it, remembering your AM theory, you'd expect to see sidebands on either side, right? And varying the amplitude of the sample pulses in accordance with the amplitude of the input is pretty much like amplitude modulation. So Fig. 6b shows all the 'sidebands'. The argument has as many holes as a string vest, but the conclusions are OK.

So what happens when the DAC output consists of real pulses that have a finite width? Well, if I can lean on the previous rickety argument a little more, the unmodulated output spectrum from the DAC will now be a series of sine waves which diminish in amplitude as their frequency increases. So what we'd expect to see is the amplitude of the higher frequency 'sidebands' of the modulated spectrum decreasing in amplitude, too, as their frequency increases. This is exactly what happens.

The original spectrum of Fig. 6a is all we want to end up with, so it won't cause us any great sadness that the upper frequencies diminish in amplitude. We're going to filter them out anyway. What *would* cause us concern would be any alteration to the amplitude of the original spectrum, the part we want to keep.

At this point the intuitive argument collapses under the strain and we must take account of the results of a full mathematical analysis. Yes, the amplitude of frequency components of the part of the spectrum we want to keep will diminish. The wider the output pulses from the DAC, the more significant this effect becomes. With a stair-step output from the DAC, which retains the previous output until another digital code comes along, the frequency response will gently roll off until, at half the sampling frequency, the output will be down by about 4dB. No need to panic, but it should be taken into account. Remember that this has got nothing to do with any filtering or whatever, we're just looking at the raw output from the DAC.

It seems sensible that if we're looking for perfection, the best thing to do would be to return the DAC output to zero in between sample outputs. Sad to say, this can cause more problems than it solves.

We've been looking at nice clean sterilized theory up to now. Unwanted odds and ends creep in, but they stay in their proper place and behave themselves and we know just what to do about them. When you actually come to build a circuit in real life, the results are much less predictable. For instance, DACs don't instantly jump to a new output level when a digital code is applied, they have a certain settling time and what happens at the output during that settling time is anybody's guess. Additional frequency components will be generated and they won't be in predictable places.

The answer is to make them small in comparison with the spectrum we want, which in essence means making the output hold time long in comparison with the settling time. In general, it is often better to put up with a predictable fall in performance that can be compensated for rather than to try correcting it at the expense of introducing factors that can't be removed.

To return to Fig. 6, although there is no frequency component at the input which is above half the sampling frequency, there are already unwanted frequencies from the DAC which occur within the audio range. If we could block off all frquencies above 10kHz at the input, the unwanted frequency spectrum would at least be above 10kHz. This is not very sensible. The unwanted frequencies could burn out tweeters or beat with the bias oscillator of a tape recorder and produce audible products, for instance. There is the more obvious problem of losing bandwidth for no particular reaoson. Output filtering is the answer here.

Figure 8 shows the situation when frequencies above half the sampling frequency are present at the input. The overlap of wanted and unwanted frequencies is our alias distortion. The practical result is a kind of harshness or coarseness in the reproduced sound. These frequencies could also be eliminated by filtering at the output, at the expense of a good deal of usable bandwidth. Far better to have a filter at the input to prevent frequencies above half the sample rate entering the system in the first place.

The result of all this is that although we could, at a pinch, get away with filters just at the input or output, the maximum system bandwidth and best possible sound will be achieved by filtering both. Obvious, you think? Well, maybe, but a design for a fairly expensive self-contained unit was recently published with no input filtering whatsoever and a pathetic and totally inadequate 2-pole filter on the output. The author claims it can 'also be used as a treble control'. Surprisingly often, designers of commercial equipment, who really ought to know better, try to get away with inadequate filtering or even no filters at all.

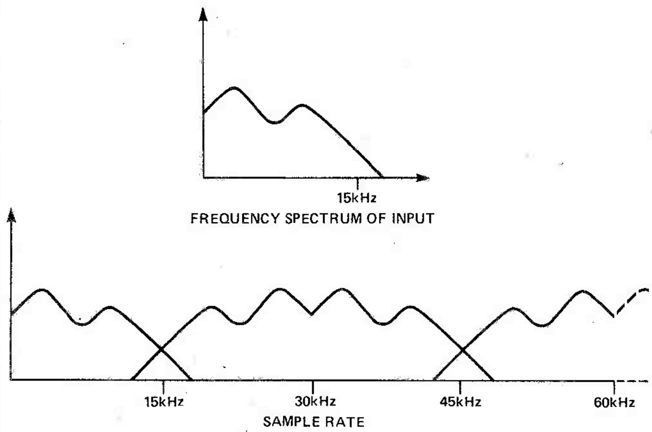


Fig. 8 The frequency spectrum of an input signal containing components above half the sampling frequency and the corresponding spectrum of the DAC output.

So, how much practical difference does it make? The answer is that it depends very much on the sampling frequency. At sample rates of 15 to 20 kHz, which are often used in 'sample stretch' or 'double time' commercial devices, the distortion will be very noticeable indeed. We're talking about the potential sound quality of good AM radio as opposed to the achieved quality of a noisy telephone line. At higher sampling frequencies the distortion is still present, however, and is quite obvious when the sampled sound is compared with the original. To extend the previous analogy, you would be settling for AM radio quality without adequate filtering when the system is capable of FM quality sound. The results with a fairly high sample rate can, in some circumstances, sound quite acceptable, but will have as much in common with the original sound as a banana milk shake has in common with bananas.

Pre-emphasis

Yet another way to improve sound quality is to apply pre-emphasis to the input signal. The theory is much the same as that employed in Dolby systems and the like. The higher frequencies of the passband are selectively amplified before A-D conversion, then attenuated after D-A conversion, taking a portion of the noise spectrum with them.

Circuits for this purpose are frequently tacked on to samplers almost as an afterthought. Often the degree of pre-emphasis is limited because the designer has realised that it will mess up the anti-alias filtering. The designer has gone to a lot of trouble to give a nice sharp cut-off to higher frequencies, and here's a circuit amplifying them all up again! There's no doubt that pre-emphasis can be effective, but it must be a part of the overall frequency tailoring, not an add-on.

These are a few of the considerations that led to the design of the ETI sampler. Will it be a revolution in sound sampling, or just another variation on the theme? You'll have to wait and see. 'What do you think, Alf?' 'Dunno.' Well, that about sums it up. **ETI**

ETI SORCERER STRING SYNTHESIZER

Having unravelled the circuit diagrams, Graeme Durant wraps up the project and ties up the loose ends.

Construction of Sorcerer should prove to be quite straightforward, especially if the suggested PCB layouts are used.

Each board requires a number of wire links to be fitted, so these should be tackled first. If you are playing safe and using IC sockets, fit these next. Sockets are recommended for the MOS devices, especially the expensive delay-line chips. Now you can solder in the passive components, remembering that all 213 diodes must go in the correct way round! Note also that some resistors must be mounted vertically. Finally, insert the presets and the panel mounting potentiometers. Since the latter are PC mounting, ensure that they are all straight, so that they will go into the front panel cutouts first time.

After scrubbing off all that nasty flux on the backs of the PCBs, with meths, it is time to fit the boards into the main case, which has by now been drilled and punched to accept them. Note that the VCO board and the envelope board are fixed in only by their front panel potentiometers; they require no further fixing, unlike the other PCBs, which must be bolted into the case. It is recommended that the boards are fitted with veropins or similar terminals, prior to encasing them, to ease the job of interwiring *in situ*.

All power connections should be made from each board to a common point at the power supply board. If power connections are strung from board to board, all manner of nasty noise will be the end result. The power supply itself should be connected to mains via a suitable panel on/off switch and a 500mA fuse. Be careful to insulate all points at mains voltages with sleeving. If a metal case is being used, a connection should be made between it and earth, using a bolt and solder tag.

Interconnections must be made between the two chorus boards using tinned copper wire (Fig. 10). Connections to the power supply should be made as shown, using Veropins, but with the interconnection wires still soldered underneath. The chorus boards are stacked and bolted, but plastic spacers must be used to avoid accidental short circuits occuring across the closely spaced tracks on the boards. As a last resort (and I mean a last resort!) use empty plastic biro tubes.

Connections to the front panel switches should be made from the various boards (Fig. 11). The front panel 'Attack LED' is wired between 0V (cathode) and the attack LED pin on the envelope board. Note that none of the connections in Sorcerer are critical and they can all be safely made using ordinary hook up wire.

The keyboard is built on two

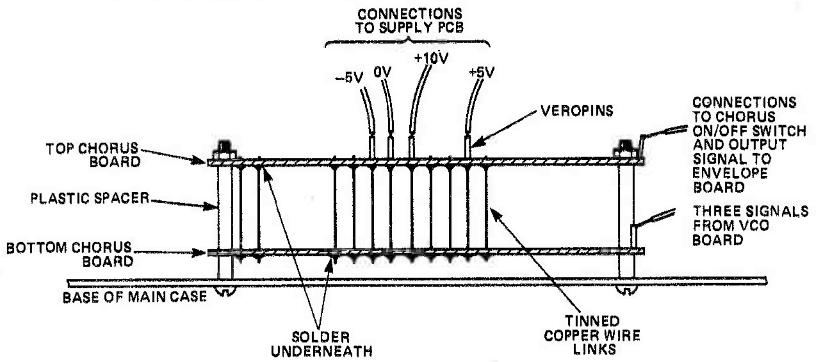


Fig. 10 Interconnecting the two chorus boards.

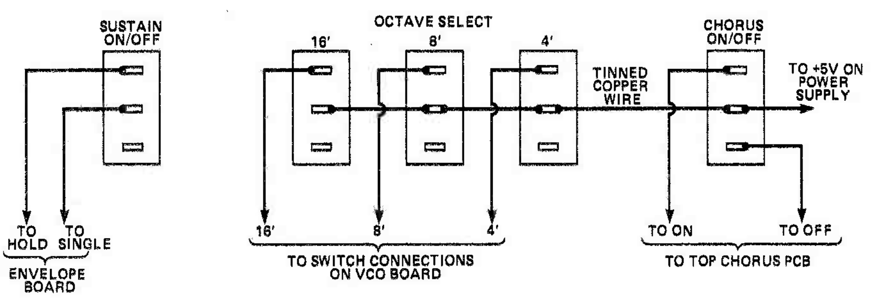


Fig. 11 Connections to front panel switches and pots.

boards. The keyboard interface PCB is the small one, and when complete is stacked about 12mm above the copper side of the main keyboard PCB using spacers and bolts with its copper side up, too. Connections are made to the large board using eleven vertical tinned copper wire links, as on the chorus boards. If the keyboard is to be housed separately to the main electronics, five connections (+5V, 0V, gate, trigger and key voltage) must be made between it and the main unit. In the prototype a five pin DIN lead was used with corresponding DIN sockets, but any suitable method could be employed.

The actual insertion of components is similar to the rest of the boards apart from resistors R60 to R96 and diodes D3 to D39 on the main board. These are soldered together in pairs, in series before insertion into thePCB. (Fig. 12). This was necessary for space reasons.

The keyboard case for the prototype was made from wood and required only simple carpentry skills. The reverse side of the actual keyboard surface of the main PCB was glued, using a contact adhesive, to a strip of chipboard some 12mm thick, the full depth of the keys. From this base, simple wooden ends were glued on, to form the case sides; then a thin strip to form a front edge, to cover up the chipboard, and a rear wider strip to form a back panel, were added. Another thin strip formed the back edge of the keys themselves, then two painted aluminium plates were used as a top and bottom panel. These were fixed using wood screws to allow later removal and access to the circuits inside. Finally, four rubber feet were added to make a stable construction. So, the case is actually built around the main PCB, and should be done carefully after inserting the components.

Modifications

The more serious musician aiming to use the Sorcerer string synthesiser will no doubt prefer to use a real keyboard with moving keys. This will enable the musician to play faster and more reliably, as well as giving a familiar feel.

Such a modification would be quite straightforward. IC9 to IC18 would no longer be required. Instead, a three octave keyboard unit, fitted with single pole 'make' contacts, would be used. One connection to each switch should be commoned to all the other similar ones, and connected to 0V. Each of the other connections to each switch should be soldered to the appropriate key on the solid-state keyboard PCB. Then, to bypass the spaces left by IC9 to IC18, wire links should be inserted, connecting the tracks which originally went to the op-amp non-inverting inputs, to the tracks which went to their outputs. The result is that each row in the diode matrix can be effectively grounded by pressing a key, thus setting up the keycodes as before. Resistors R20 to R56 pull each row up to five volts when that key is unpressed. These resistors could be reduced in value to 100K, for less susceptability to noise and faster matrix switching.

The rest of the keyboard circuitry could remain as before, with perhaps a couple of component value changes. R97 to R112 and C7 to C14 can stay, to debounce the mechanical contacts. IC19a and IC19b detect the presence of more than one key being pressed, and having altered the type of keyboard switching, the sensitivity of this detection circuit must be altered to suit. Simply alter the value of R58 until the output of IC19b goes low for two or more keys pressed, but high otherwise — this could be achieved by fitting a 220k potentiometer. The setting could be measured using a multimeter on the ohms range, and a fixed resistor then put in its place.

Finally, the value of R122 could be experimentally reduced, to allow faster keyboard response. Now that the square pulse signals of the touch detectors have been removed, the reaction delay can be safely reduced whilst still maintainting a reliable response to keys pressed.

Setting Up And Use

Sorcerer contains seven preset potentiometers, so requires a little setting up. Although no test gear is essential, access to an oscilloscope is useful. After having built up all the PCBs, checked for faults and wired up everything except the connections to the power supply outputs, it is time to plug the PSU in to the mains. Check that the PSU outputs are at the correct voltages, then make the final connections between each PCB and the power supply.

Connect the keyboard unit to the main box of tricks and a pair of headphones or an amplifier/speaker set at low volume to the output. Ensure all seven presets are set to their midway positions. Select the middle octave range on the switches, turn off the chorus effect and apply the power. A sound of some kind may be audible, if it is, do not worry. Press a key. The Attack LED should light, and the sound should get louder

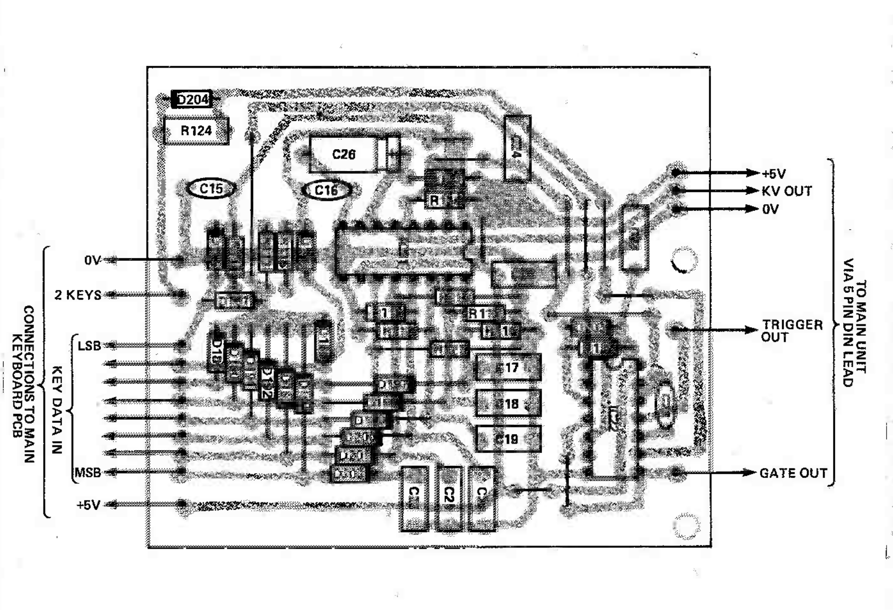


Fig. 12a Component overlay for the keyboard interface PCB.

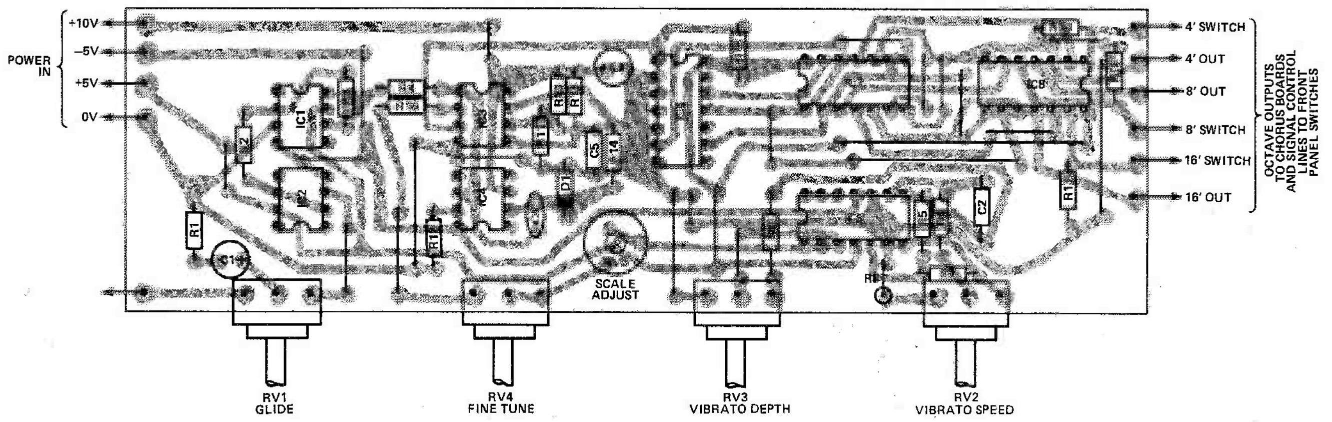


Fig. 13 Component overlay for the VCO board

with an envelope according to the attack and release control settings. If not, turn off. Check your wiring. Check to see if a signal is being produced by the VCO. Check the keyboard output voltage and timing pulses.

If all is OK, try the other octave switches. Try the sustain on/off switch, and different setting of the attack and release controls. Check the vibrato controls work, and the glide and tune functions. Finally, see that the chorus mode has at least some effect (but do not worry about the din it is probably making!).

Once you are convinced that all the functions have some effect, it is time to set the presets. Switch off the chorus effect, and set the attack and release controls to minimum. Turn up the amplifier volume control until you can hear the signal breaking through the envelope shaper, then adjust RV8 on the envelope board until the minimum signal is heard.

Switch out all the octave ranges, then, with the sustain set to off, press a key. A sharp click will probably be heard. Turn RV9 also on the envelope board, until

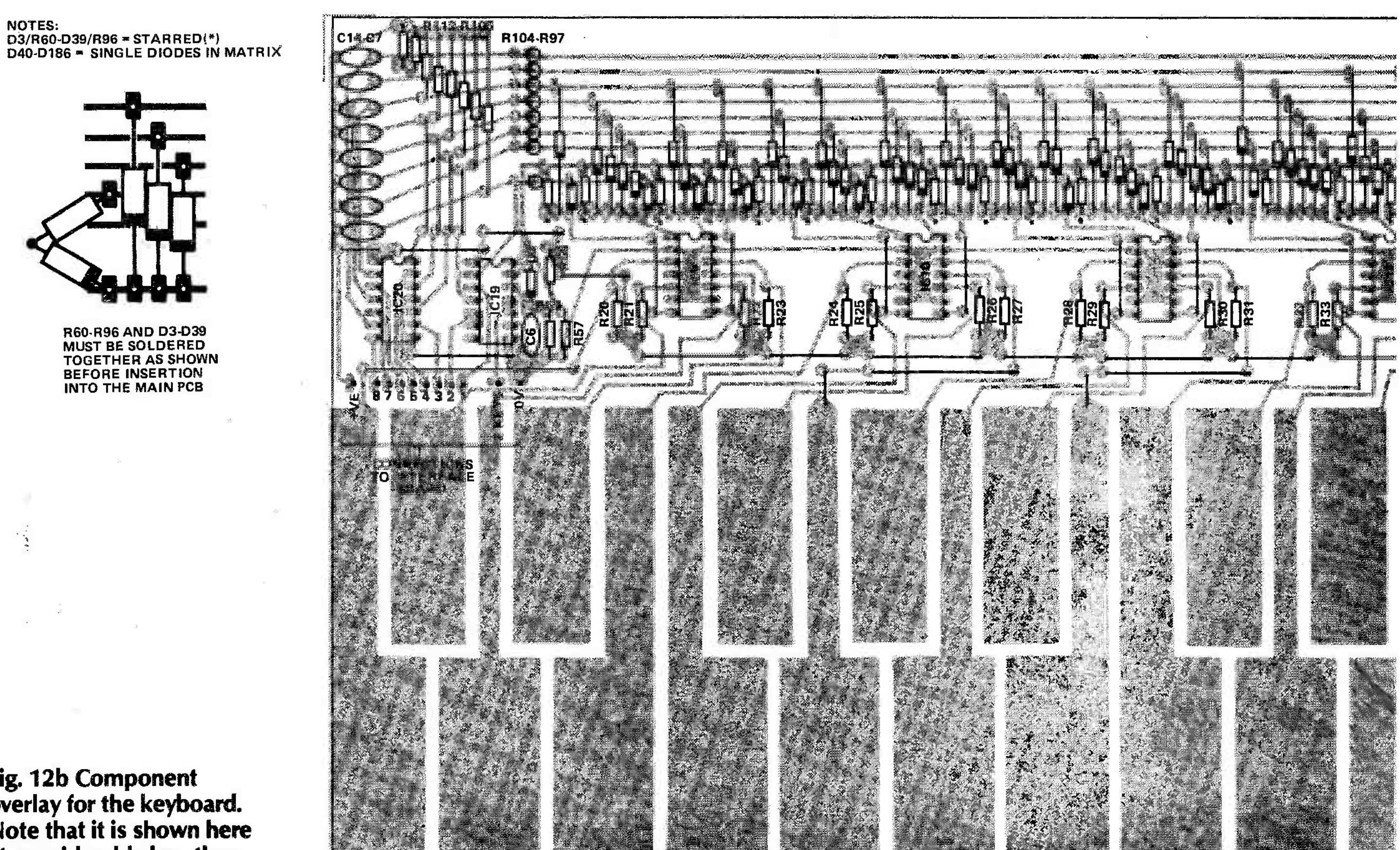


Fig. 12b Component overlay for the keyboard. Note that it is shown here at considerably less than its full size.

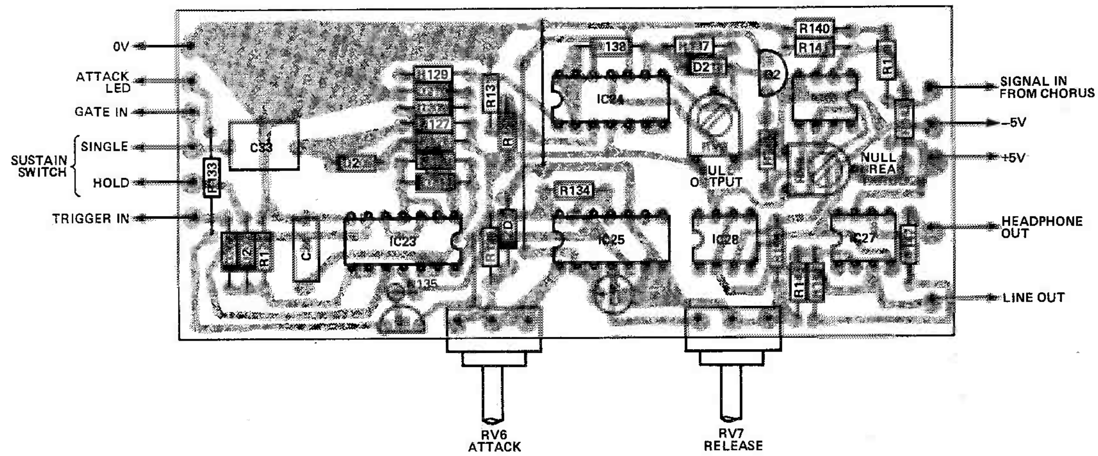
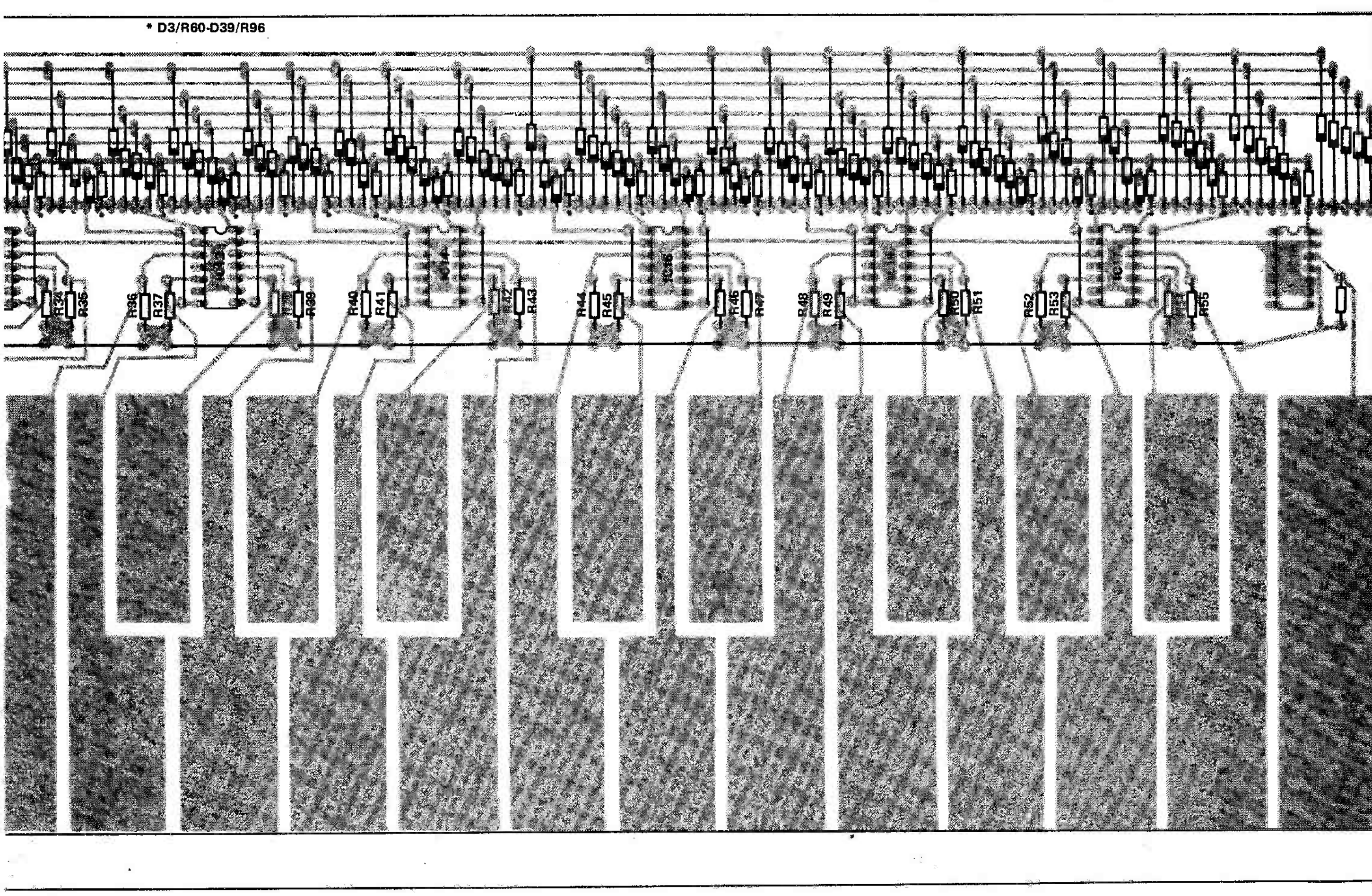


Fig. 14 Component overlay for the envelope board.

pressing a key produces the minimum effect. The envelope shaper is now set up.

Now, reduce the amplifier volume to a reasonable level, and set the attack and release controls about midway. Switch in all the octave ranges. Select the chorus mode, and hold down a note on the keyboard. Turning RV10 through the hole in the top chorus board should, at one extreme, fuzz the sound and, at the other, stop the signal. RV10 sets the operating point of the delay-line chips and should be in the middle of its undistorted range of travel. Finally, we set up RV11, 12, and 13 on the top chorus board. If an oscilloscope is unavailable, set these midway — they are not too critical. Their function is to cancel out some of the high frequency clock signals imprinted onto the outputs of the delay line devices. If an oscilloscope is to hand, connect its input to the slider of RV11, and adjust until the minimum high frequency noise appears on the signal. This may be easier to see with all the octave ranges switched off. Repeat for RV12 and RV13. This completes



the setting up of the chorus board.

The last preset to deal with is RV5, on the VCO board. This simply acts as a coarse tuning control. Set the front panel tune control to its central position, then turn RV5 until the instrument is in tune with a known reference.

The line output is about one volt peak-to-peak and so should drive most amplifiers, but if it is too high, fit an attenuator. The touch keyboard should work in most environments, provided there is enough mains hum around the place. If problems are encountered, try planting both feet firmly on the floor (I am serious, it does work!). If the problems persist, try removing the 10Mohm input resistors on the keyboard, to increase its sensitivity. Also check earth continuity and connection to the 0V line.

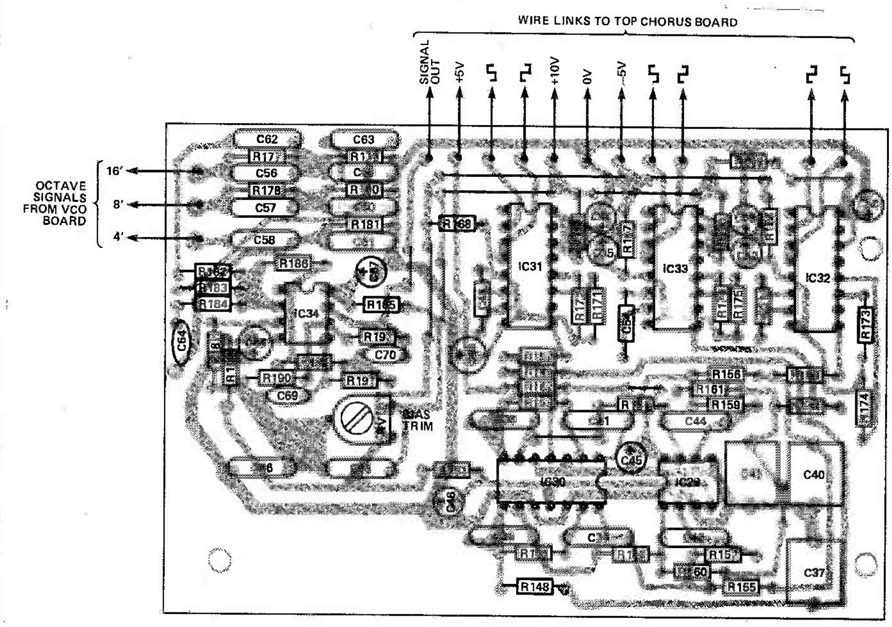


Fig. 15 Component overlay for the chorus clock board.

PARTS LIST
VCO SECTION

RESISTORS	(all ¼W, 5% unless otherwise stated)
R1,8	1k0
R2,3,4,7,12	100k
R5	47k
R6,9	390k
R10,11,15,17,18,19	10k
R13,16	6k8 1% metal film
R14	2k2
Rv1	100k log. PC mounting
RV2	10k lin. PC mounting
RV3	47k lin. PC mounting
RV4	2k2 lin. PC mounting
RV5	4k7 Cermet preset
CAPACITORS	
C1	3u3 16V tantalum
C2	150n polycarbonate
C3	10u 16V tantalum
C4	4n7 mylar
C5	2n2 polycarbonate
SEMICONDUCTORS	
IC1,4	LF351
IC2	741
IC3	LM331 or RC4151
IC5	LM324
IC6	4024
IC7	4011
IC8	4081
D1	1N4001

MISCELLANEOUS

PCB; solid tinned copper wire; control knobs; veropins.

BUYLINES

Most of the parts used in Sorcerer can be found in any supplier's catalogue, but there are a few more-difficult-to find parts required. The MN 3010 delay line chips are available from Digisound Limited, 14/16, Queen Street, Blackpool, Lancs FY1 1PQ at a cost of £18.98 for the three all inclusive. The MN3010 delay line chips are available from Maplin, as is the ZN428 keyboard D-to-A converter. The particular subminiature single ended electrolytic capacitors used on the chorus PCBs, and the PC mounting potentiometers, were also from Maplin. The case used in the prototype to house the main electronics is one of the Modular 5 range of enclosures available from West Hyde Developments Limited, 9/10, Park Street Industrial Estate, Aylesbury, Bucks, HP20 1ET. The model used was the MD5 AFL and costs £17.33 including postage, packing and VAT. The encapsulated transformer used in the prototype — Clairtronic type 9641 — can be obtained from Verospeed, Stansted Road, Boyatt Wood, Eastleigh, Hants SO5 42Y (tel: 0703 644555). The price is £3.89 and the order code, 89-35985D. The PCBs are available from the ETI PCB Service, but see the note in News Digest.

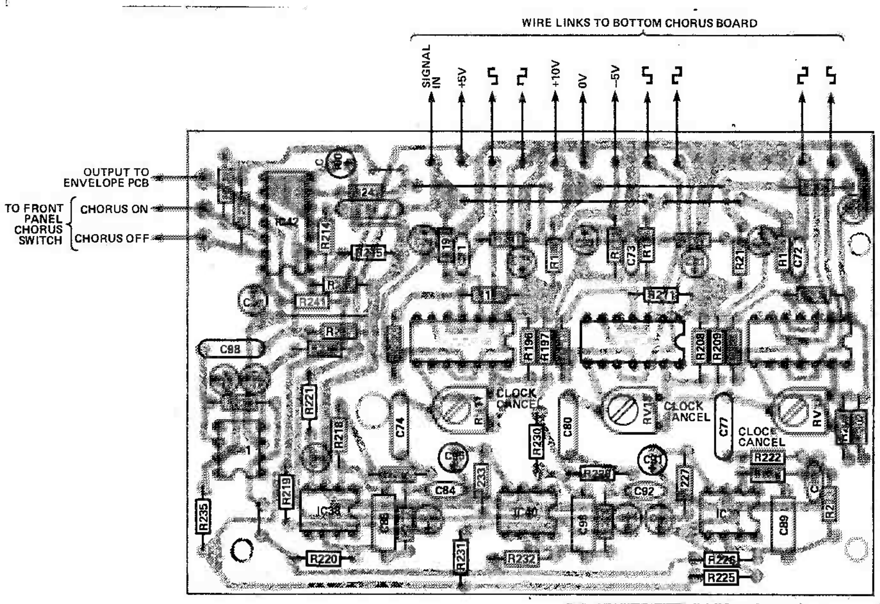


Fig. 16 Component overlay for the chorus audio board.

PARTS LIST

KEYBOARD

RESISTORS (all ¼W 5%)

R20 to 56	10M
R57,123	470k
R58,60 to 104,113	100k
R59	330k
R105 to 112	820k
R114 to 121	2M2
R122	390k
R124	10k
R125	390R

CAPACITORS

C6,23,24	220n polycarbonate
C7 to 22,25	100n polycarbonate
C26	1u0 axial electrolytic
C27	1n0 polycarbonate

SEMICONDUCTORS

IC9-18	LM324
IC19,20	40106
IC21	ZN428
IC22	4093
D2 to 204	1N4148

MISCELLANEOUS

PCBs; solid tinned copper wire; IC sockets; spacers; bolts; five way connector for keyboard connection to main unit.

ENVELOPE SHAPER

RESISTORS (all ¼W, 5%)

R126,128,130,134, 137	100k
R127,129,131,132, 135,143,144	10k
R133	150R
R136,140,141	470R
R138	4k7
R139,145	47k
R142	1M
R146	82k
R147	100R
RV6	1M0 log. PC mounting
RV7	1M0 log. PC mounting
RV8	10k miniature horizontal preset
RV9	100k miniature horizontal preset

CAPACITORS

C33	33n polycarbonate
C34	220n polycarbonate
C35	2u2 16V tantalum

SEMICONDUCTORS

IC23	4093
IC24	LM324
IC25	4066
IC26	CA3080
IC27,28	741
Q1	BC557
Q2	BC108
ZD1	2V7 400mW zener diode
D206-212	1N4148
LED1	to choice

MISCELLANEOUS

PCB; solid tinned copper wire; control knob; veropins.

CHORUS CIRCUITS

RESISTORS (all ¼W, 5%)

R148,155,160	680k
R149,156,161	820k
R150,151,157	1M5
R152,158,164,171, 173,175,182,183, 184,196,197,202, 203,208,209,215, 237,238,239,240	100k
R153,154,159	150k
R162,163,185,188, 198,201,204,207, 210,213,241,242	100R
R165,166,167,168, 169,170,177,178, 187,200,206,212, 219,221,225,227, 231,233,235,236	1k0
R172,174,176	2M2
R179,180,181	2k2
R186,192,216,217, 222,223,228,229	22k
R189,191,193,194, 195	10k
R190	39k
R199,205,211	15k
R214,234	47k
R218,224,230	27k
R220,226,232	120k
Rv10	22k horizontal miniature preset
RV11,12,13	10k horizontal miniature preset

CAPACITORS

C36,38,39,41,42, 44,56,57,58,59,65, 66,83,98	100n polyester
C37,40,43	1u polycarbonate
C45,46	100u 6.3V sub-min electrolytic
C47,49,50,52, 53,55,67,68, 75,76,78,79, 81,82,86,87, 90,91,94,95, 96,97,99,100	10u 16V sub-min electrolytic
C48,51,54	100p polystyrene
C60,61,74,7,80	47n polyester
C62	22n polyester
C63	10n polyester
C64	4n7 polycarbonate
C69,70	1n5 polycarbonate
C71,72,73,84.88, 92	1n0 polycarbonate
C85,89,93	330p polystyrene

SEMICONDUCTORS

IC29,34	LM1458
IC30	LM324
IC31,32,33	4046
IC35,36,37	MN3010
IC38,39,40,41	741
IC42	4066

MISCELLANEOUS

PCBs; solid tinned copper wire; IC sockets; plastic spacers; veropins.

PSU CIRCUIT

CAPACITORS

C28,29	1000u 16V axial electrolytic
C30,31,32	10n mylar

SEMICONDUCTORS

BR1	W005 or similar 1A 50V bridge rectifier
IC43	7805
IC44	79L05
IC45	78L05
D205	1N4148

MISCELLANEOUS

T1	9V-0-9V, 8VA PC mounting transformer.

PCB; solid tinned copper wire; mains on/off switch; fuseholder and 500mA fuse; case; cable and connectors to go between keyboard and main unit; five single pole changeover switches (chorus, sustain, three octave select); hook up wire; mains lead; nuts, bolts,etc.

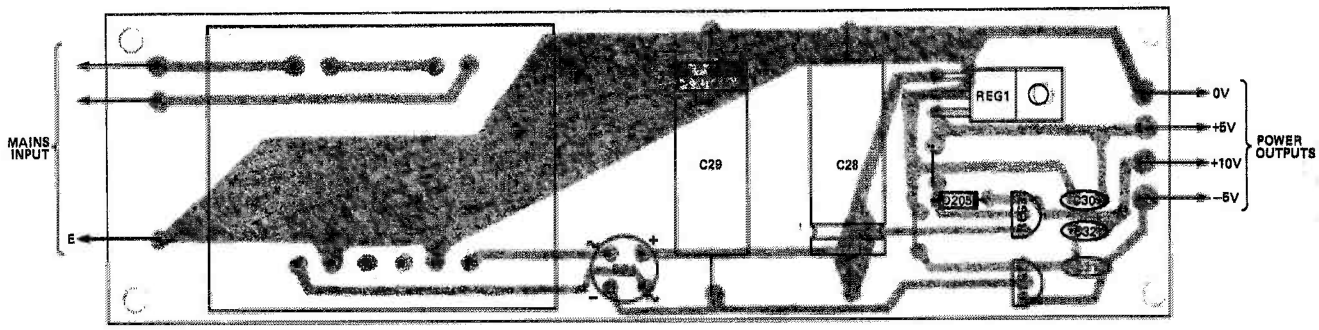


Fig. 17 Component overlay for the PSU.

MODULAR TEST EQUIPMENT

Mike Meakin considers the curious case of the expensive electronics project and suggests a solution.

A look at the average home constructor's workbench will usually reveal a motley collection of test equipment, built as necessity dictated and often in the obligatory biscuit tin with pencilled calibrations! Low cost test equipment is available but often contains little more than an industry standard IC used in the manufacturers' application circuit, and the cost of acquiring a complete system can be daunting.

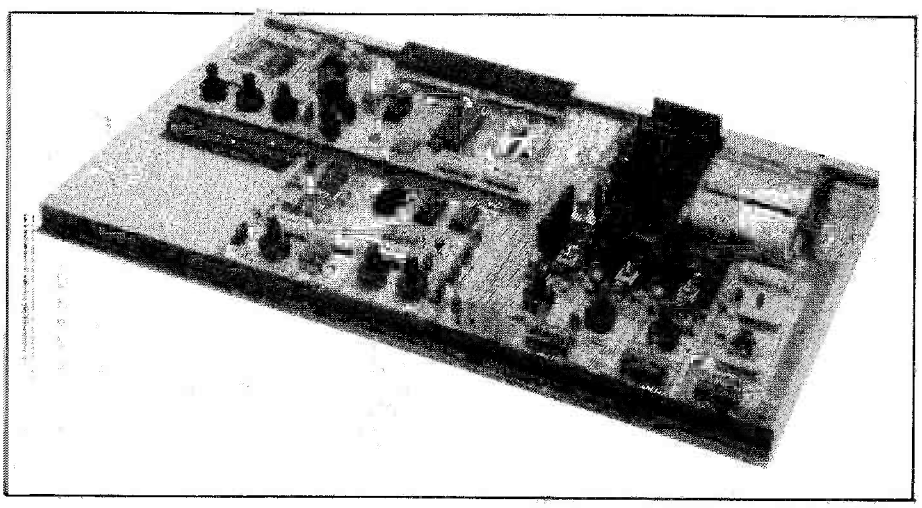
But where does the cost come from? Have you noticed when budgeting for new projects that the electronics cost very little but the cases, front panels, knobs, hardware and power supplies all add up to a horrifying sum? If these costs could be dispensed with, more money could be spent on the electronics with a consequent improvement in the performance and hence the usefulness of the equipment.

The ETI Workstation has no case, no front panel, and no knobs. It consists of a series of printed circuit boards, each carrying one test instrument and designed to interconnect to form a complete system. The modules include a bench power supply, a pulse generator, a universal counter-timer and a logic probe cum analogue indicator, and as well as providing voltages for equipment under test the power supply also drives the other modules. This removes the need for individual power supplies on each board and so helps keep costs down.

The constructor can choose to build any or all of the modules as required, if necessary assembling the system over a period of time as finances allow. In theory, the power supply has to be built before any of the other modules can be used, but there is no reason why an existing power supply could not be pressed into service, or even batteries as a temporary measure if one of the other modules is to be built first and the power supply later.

The boards all have a depth of 100mm (or just over 200mm in the case of the power supply) which allows a neat finished unit to be assembled using plastic guides. To avoid the need for external controls and panels, all of the potentiometers mount directly onto the PCB and are of the enclosed preset type with integral knob. PCB mounting switches have been used throughout and the counter-timer display and power supply LEDs are also mounted directly onto the board. The only part of the system not mounted on a board is the mains transformer, which for safety reasons is housed in a small metal case with only the low voltage AC output fed to the power supply PCB.

Since the power supply is the logical starting point in this project, its design and construction will be dealt with in this first article. The other modules will form the subject of further articles in subsequent issues.



Power Supply Board

The power supply board is of conventional design and provides both fixed voltage supplies for the modules and variable supplies for bench use. Additionally a voltage reference of 10.00V and a constant current source of 10.00mA are available. The voltage reference can be used whilst prototyping circuits and even checking DVMs whilst the current source is most useful for checking LEDs and zeners and can of course be used for ramp generators during breadboarding.

A 4BA screw mounted on the board provides a 0V reference point and something handy to which crocodile clips can be attached. Connection to the fixed supplies for the modules is made by soldering to the underside of the board on the thick bus bars. This may not be particularly elegant but it is simple and above all cheap.

The mains transformer is housed in a small metal case along with a fuse, mains on-off switch and neon indicator. The low voltage AC is taken via a DIN connector to the power supply PCB. Housing the mains transformer separately

HOW IT WORKS

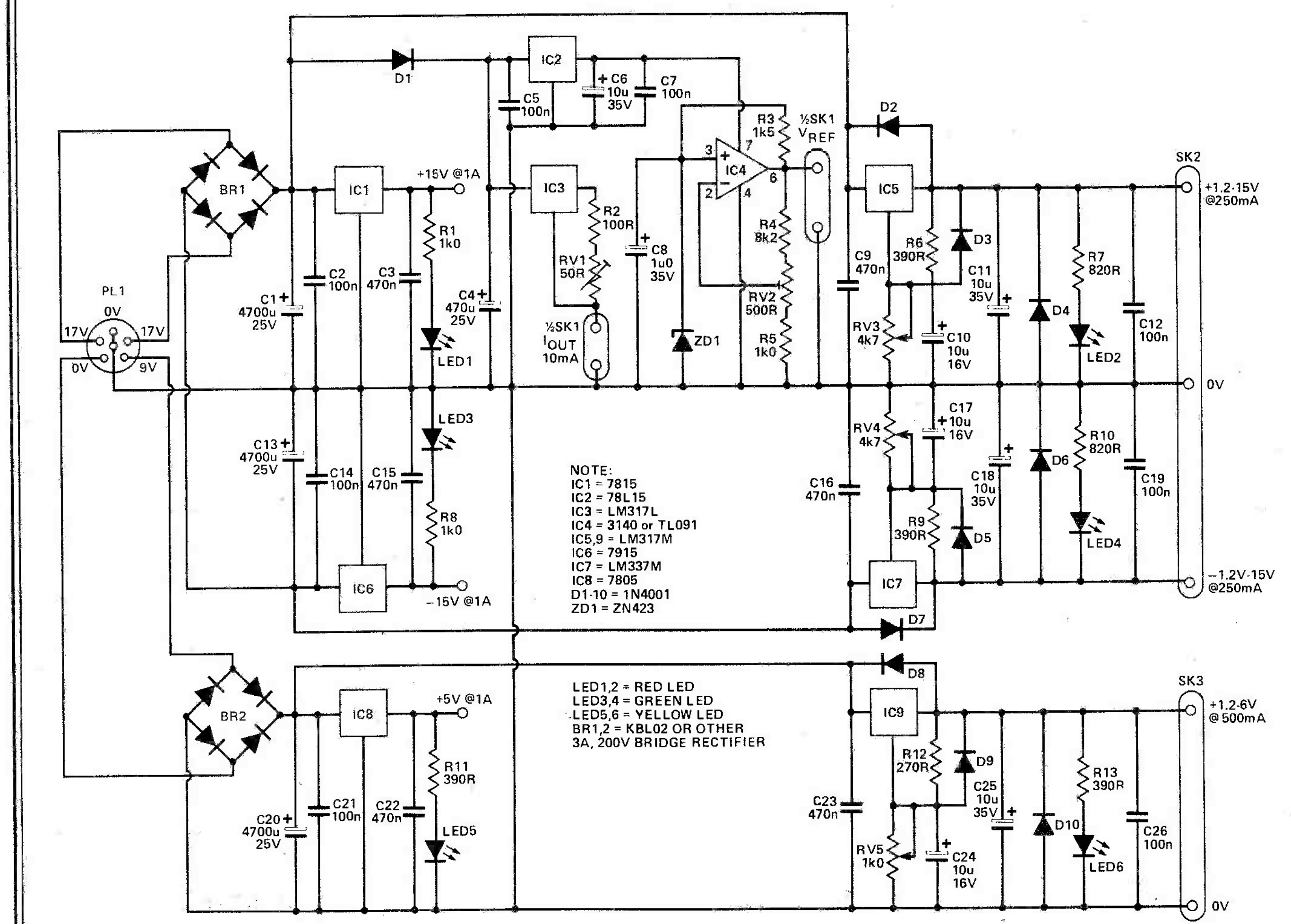
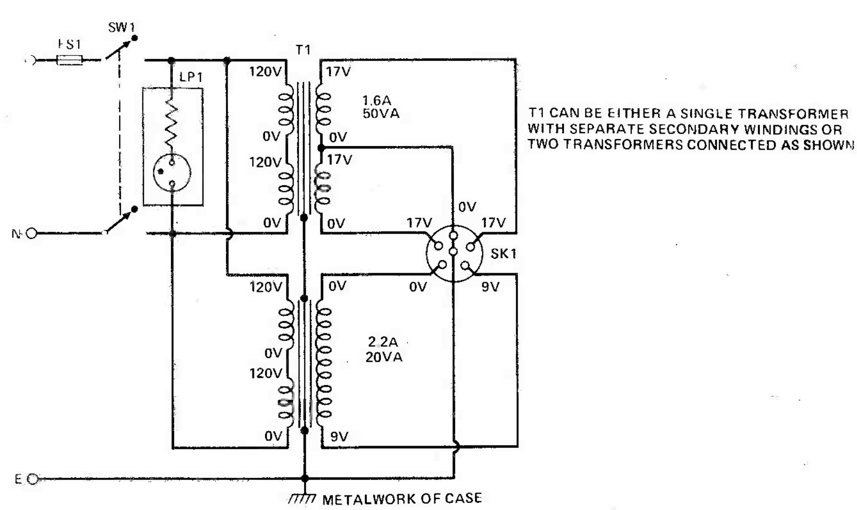


Fig. 1 (above) Circuit diagram of the power supply and Fig. 2 (below) the circuitry inside the transformer box.



The 9V AC supply from T1 is bridge rectified and fed to reservoir capacitor C20. A 5V regulator provides the fixed 5V supply at a maximum current of 1A for the modules and an LED indicates that the supply is present.

The unregulated supply is also fed to IC9, a variable voltage regulator which has additional components around it to provide protection against misuse. The supply can be set to voltages within the range 1.2V to 6.0V by variable resistor RV5. Capacitor C24 provides additional ripple rejection while capacitors C23, C25 and C36 stabilize the IC and improve transient load response. Diode D8 provides a discharge path for any large capacitors that may be hung on the output when the input supply voltage is removed. Diode D9 discharges C24 on switch off and D10 protects the regulator if reverse voltages are fed into its output. An LED again indicates when the supply is present. The input voltage and heatsinking allow this regulator to supply up to 500mA before thermal shutdown.

The operation of both the fixed and variable plus and minus 15V supplies is similar to that of the 5V supplies described above. However the current drawn from the variable supplies should be limited to about 250mA (dependant on the output voltage) because of heatsinking limitations.

The unregulated positive supply is also fed via D1 to an additional smoothing capacitor C4 to provide supplies for the constant current source and the voltage reference. This arrangement gives some isolation of transient loads on the main 15V supply. A low power 15V regulator supplies IC4 which is configured in a classic buffered zener arrangement. The bandgap voltage is amplified to give an adjustable 10.00V reference voltage at IC4 output. As both output and reference voltages are fixed a constant current flows through the reference voltage. The inputs of IC4 operate at 1.2V above 0V and a 3140 or TL091 op-amp must be used in this position. A 317L regulator is used for the cosntant current source and is set to 10.00mA under short circuit conditions by RV1.

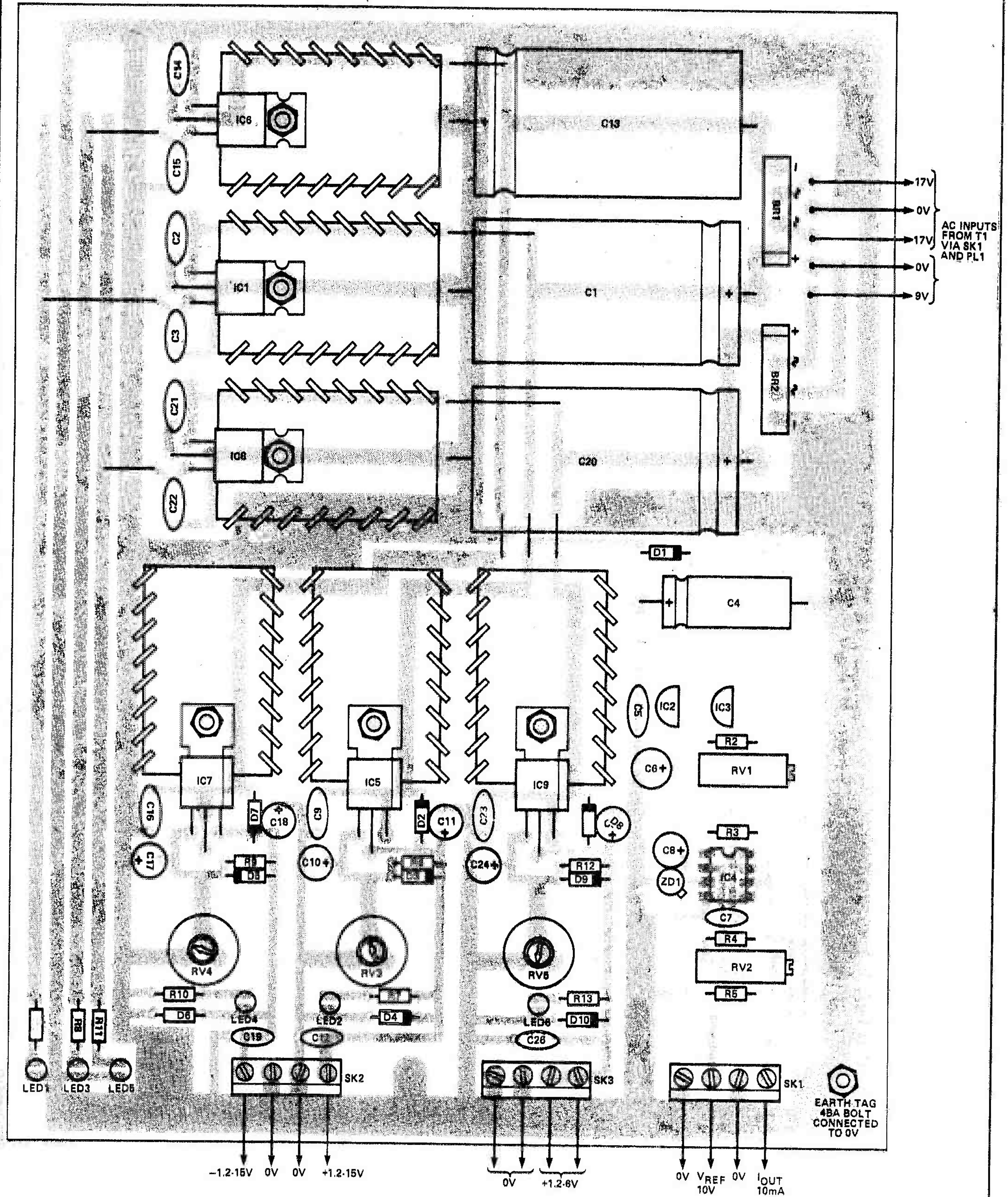
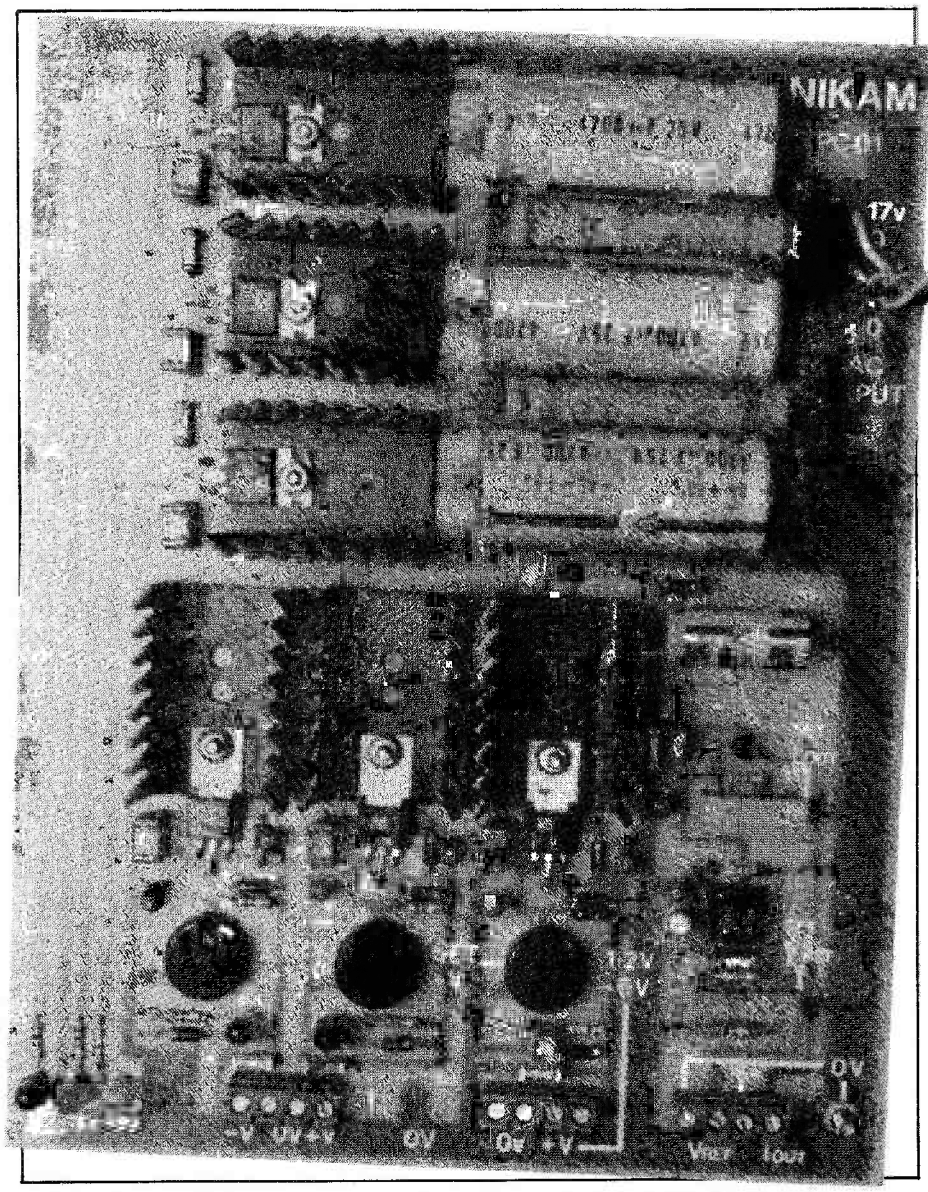


Fig. 2 Component overlay for the power supply PCB.

PARTS LIST

RESISTORS	(all ¼W 5%)
R1, 5, 8	1k0
R2	100R
R3	1k5
R4	8k2
R6, 9, 11, 13	390R
R7, 10	820R
R12	270R
RV1	50R, 20-turn, ¾" cermet preset
RV2	500R, 20-turn, ¾" cermet preset
RV3, 4	4k7 carbon track preset with integral knob
RV5	1k0 Carbon track preset with integral knob
CAPACITORS	
C1, 13, 20	4700u 25V axial electrolytic
C2, 5, 7, 12, 14, 19, 21, 26	100n 100V multi-layer polyester
C3, 9, 15, 16, 22, 23	470n 100V multi-layer polyester
C4	470u 25V axial electrolytic
C6, 11, 18, 25	10u 35V tantalum or radial electrolytic
C8	1u0 35V tantalum or radial electrolytic
C10, 17, 24	10u 16V tantalum or radial electrolytic
SEMICONDUCTORS	
IC1	7815
IC2	78L15
IC3	LM317L (100mA)
IC4	3140 or TL091
IC5, 9	LM317M (500mA)
IC6	7915
IC7	LM337M
IC8	7805
D1-10	1N4001
ZD1	ZN423
LED1, 2	red LED
LED3, 4	green LED
LED5, 6	yellow LED
BR1, 2	KBL02 or other 3A, 200V bridge rectifier
MISCELLANEOUS	
FS1	500mA anti-surge fuse and panel-mounting holder
LP1	mains neon, panel mounting
PL1	6-pin DIN plug
SK1	6-pin DIN socket
SK2-4	4-way 10A PCB-mounting screw terminals
SW1	DPDT mains toggle switch
T1	17-0-17V (or 15-0-15V — see text) 50VA plus 9V 20VA mains transformer

PCB; case for transformer; 8-pin DIL IC socket; heatsinks, 6 off; four-core screened cable, heavy duty, for AC connections to power supply board from transformer; mains plug, cable and strain relief bush to suit; 6BA nuts, bolts and washers for heatsinks; 4BA nut, bolt and washer for 0V tag.



and feeding only low voltages to the boards is an essential safety requirement if the system is to be used, as intended, without a case.

Construction

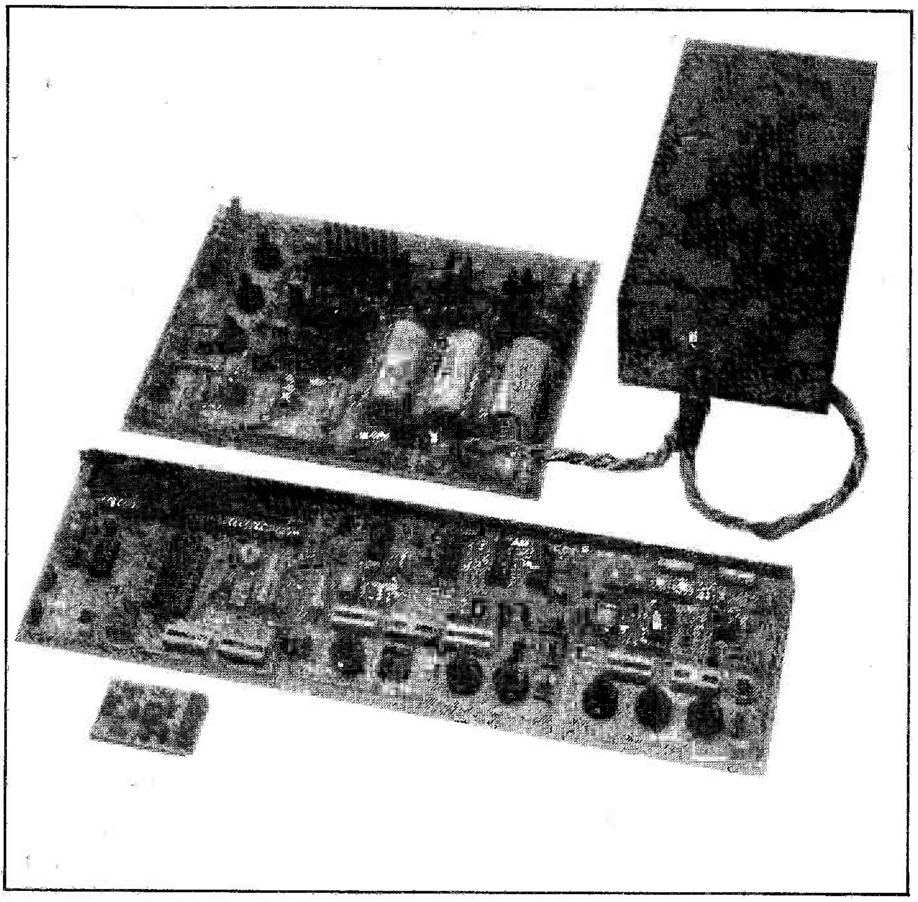
Whilst care has been taken to make the modules easy to construct, the usual precautions are necessary. Frequent reference should be made to the PCB layout diagram and attention to the polarity of diodes, LEDs capacitors and ICs is very important. A socket is recommended for IC4 and LEDs should be spaced away from the surface of the board before soldering. It is not necessary to fit insulating kits on the heatsinks but a little thermal grease should be smeared around each IC tab before mounting to ensure efficient heat transfer.

The mains transformer should be installed in a small metal case, the exact size of which will be determined by the transformer or transformers you choose. Ideally a single transformer with separate 0-9V and 17-0-17V windings should be used, but these are not widely available. Two separate transformers will work just as well but will, of course, require more space. If a 17-0-17V transformer cannot be found a 15-0-15V one can be used in its place, but this will lead to a loss of regulation if the power supply is used at full load.

Take care with the mains wiring inside the box and make sure that the incoming mains cable is secured by a good strain relief bush. Solder leads from the secondary of the transformer to a six-pin DIN socket mounted in the opposite end of the box to the mains wiring. In view of the exposed nature of the test equipment boards, it is most important that there is a good earth connection to the boards. To this end, make sure that the incoming mains earth, the transformer screen (if present), the box metalwork and the DIN socket 0V pin are all reliably connected together. Similar attention should be paid to the DIN plug and lead which carry the transformer output to the power supply board.

Testing

The transformer box should be tested on its own before plugging in the board. Double check the earthing arrangements and then switch on. If all is well, connect to the power supply board and switch on again. You should be rewarded either by twinkling LED's or smoke! If the latter then rapid disconnection of power is recommended. Otherwise, check that the fixed supply voltages are correct to within plus or minus 5%, then check the variable supplies. Finally, adjust the voltage reference against the best DVM you can borrow and adjust the current source under short circuit for 10.00mA.



BUYLINES

The resistors and capacitors are all widely available and so are most of the semiconductors. The exception is IC3, the LM317L 100mA variable voltage regulator. The only supplier we know of for these is RS components (stock no. 303-179), who will only accept orders from trade and professional customers. Crew-Allan & Co of 51 Scrutton Street, London EC2 will obtain RS parts for you on payment of a small handling charge, but you may prefer to use another LM317M instead. There is no harm in using the higher-rated device and it should not be too difficult to bend the pins to fit.

RS are also the only source we know of for the moulded presets with integral knob used in the RV3/4 and 5 positions (stock no.s 184-344 and 184-322 respectively). Different types from other suppliers could be used but the PCB may have to be modified slightly to accept them.

We do not know of anyone who stocks a single transformer offering the required voltages, but Maplin have a multi-tapped type which gives 17-0-17V at 2A and RS can supply a 4.5+4.5V type rated at 2.2A (stock no. 207-122). Electrovalue have a 9V 2A type which could be used at a pinch. Some manufacturers of toroidal transformers claim that their products can be used with the secondaries in parallel, in which case a 0-9 + 0-9 30VA toroid could be used. However, we have our doubts about this practice, so unless it is specifically recommended by the manufacturer we advise against it.

The PCBs will be available from our PCB Service, for details of which see the note in News Digest. Please note that, to save costs, they will not be screen printed as are the prototypes shown in this article.

ETI

AUTOMATIC TEST EQUIPMENT

Love it or 'ate it, automatic test equipment is here to stay. W.P. Bond begins a short series in which all will be revealed.

Automatic test equipment has been around in one form or another for nearly three decades. In recent years, the introduction of LSI and VLSI circuits has totally changed the requirements for ATE, especially since the equipment and procedures must meet the needs of volume production. Cost is perhaps the most important consideration today, and this must be understood in relation to the two general types of test procedure: functional and in-circuit testing.

Functional testing looks at all the functions of a circuit — taken in isolation from a whole system of which the circuit may be a part. The circuits involved (and, of course, the test procedures) can be digital or analogue. Digital — or logic — circuits are simpler than analogue circuits from the viewpoint of automatic functional testing. There are simple 'go/no-go' results obtainable with logic circuits, while analogue devices need to be tested within a broad range of acceptable performances. It makes sense to begin an examination of ATE with logic circuits.

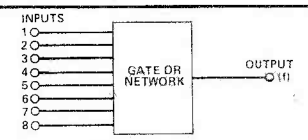


Fig. 1 In the simple case, 256 test patterns would be needed to cover every input combination.

Some Logical Steps

There are four main categories of logic circuit:

★ Combinational Logic (outputs are dependent solely on the present inputs).

★ Sequential Logic (outputs are dependent on present inputs and on previous outputs: circuits with memory or feedback).

★ Bus Structured Logic (combined circuitry of the above types on MPU-type boards with components connected by a bus-structure).

★ Random Logic (combined circuitry without a bus-structure).

The testing procedure for any given circuit or circuit assembly will depend on the category it belongs to.

There are a number of other considerations that have to be borne in mind when devising test procedures, apart from the categorisation of the circuit concerned. Even in simple cases, functional testing may have to be uneconomically elaborate in order to detect all possible faults. The 8-input gate in Fig. 1 would require 256 test patterns if all input conditions were to be covered. In general, a combinational logic circuit with n-inputs requires 2^n test patterns for 100% truth-testing. Such 'exhaustive testing' (ET) very quickly becomes unwieldy — even with straightforward combinational circuits.

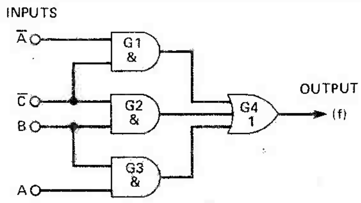


Fig. 2 Redundant gates can result in fault-masking.

Most circuits are not straightforward. One particular problem is caused by the presence of redundant logic, often built-in for reliability. The circuit in Fig. 2, for example, includes a redundant gate (G2) — which can be shown by simplifying the output function, $\bar{A}.\bar{C}+\bar{B}.\bar{C}+\bar{A}.\bar{B}$, using Boolean algebra or Karnaugh mapping. In this case, a fault in the redundant gate may 'mask' faults in the non-redundant circuit elements. For example, in this case if the output from the redundant gate is permanently low ('stuck at 0' or SA0), it will have no effect on the network output. But if it is permanently high ('stuck at 1' or SA1), then the network output will be permanently high regardless of what's happening on the other gates. In effect, the SA1 condition on the redundant gate masks any faults on either of the other gates.

The typical test points are shown in Fig. 3 for a sample circuit. From Fig. 4, it should be clear that the same symptoms can follow from a variety of faults. An SA0 pin fault on the B input to the NAND gate in the figure will be indistinguishable at the output from an SA1 node fault —the same input test patterns will result in the same outputs. To locate faults successfully, it is important to test the circuit in question at more points than its inputs and outputs. Figure 5 shows a small logic circuit with redundancy in which

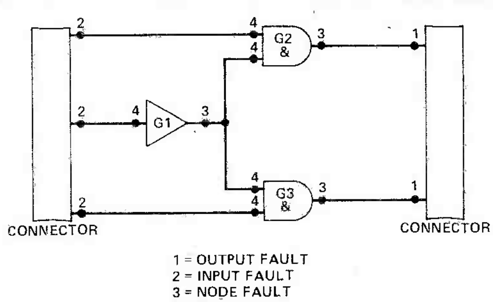
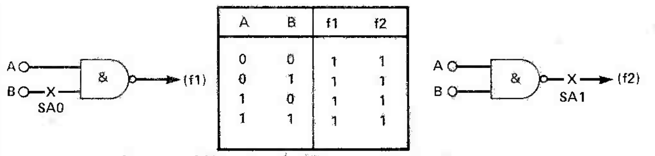


Fig. 3 Test points in a typical circuit section.

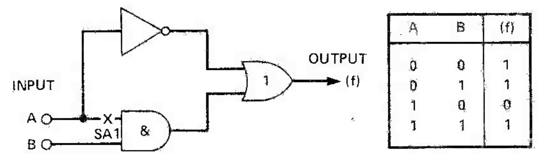
an SA1 pin fault would go undetected if the circuit were tested at inputs and outputs only. This sort of fault would be seen where an open circuit existed at the pin, since open circuit inputs float high. Because of this, inputs tied to V_{cc} are sometimes classified as 'undetectable' for fault-finding purposes.



A	B	f1	f2
0	0	1	1
0	1	1	1
1	0	1	1
1	1	1	1

Fig. 4 Different fault, same truth table.

It's worth noting that there are two kinds of redundancy in circuits: fault-masking and self-checking. In the first, faults are masked by multiple circuits performing the same task. In the second, faulty circuits are switched out of the system and good circuits switched in to take their places.



A	B	(f)
0	0	1
0	1	1
1	0	0
1	1	1

Fig. 5 The fault here is undetectable.

Sequential logic presents the test procedure with yet more problems. Figure 6 shows a circuit configuration in which there is no direct path between the fault (SA0 at input 1) and any output. Here again, the importance of good 'test-pointing' becomes obvious. This kind of fault is described as latent and its detection requires a series of test-patterns to 'walk' it to an output pin. The example shown would require three consecutive test-patterns to clock it through gates G2 and G3. With less than three test-patterns, the fault would simply not appear at any output. The number of patterns required to propagate the fault to the output is called the degree of latency.

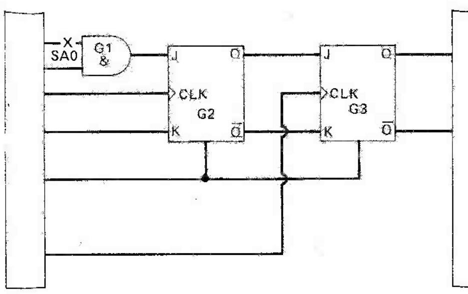
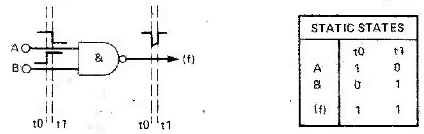


Fig. 6 A latent fault.

Changing inputs can give rise to their own problems. The commonest is called racing. Race hazards take the form of unwanted transients (signal spikes) caused at the output to a logic circuit when two or more inputs change at the same time, These are often known as glitches. In Fig. 7, for example, inputs A and B are meant to change simultaneously from 1 and 0, respectively to 0 and 1. If B reaches the 1 state slightly before A reaches the 0 state, then the output will display the negative-going spike shown. (Such glitches often occur in latching circuits with feedback — dividers, for example). Testing at the output can lead to spurious results in this situation. The simplest solution is to build-in a time delay at the output test point greater than the propagation delay of the gate.

Untestability Is Detestible

Testability must be designed into electronic modules if they are to be properly tested in the first place. Obvious though this sounds, it is all too often overlooked by circuit designers — perhaps because 'testability' itself is an awkward and ill-understood notion.



STATIC STATES	t0	t1
A	1	0
B	0	1
(f)	1	1

Fig. 7 Generating glitches in a NAND gate.

Testability implies not only the possibility of testing a module or circuit but also the existence of a set of guidelines aimed at maximising test efficiency. Because of the specialized nature of individual complex analogue designs, I will limit the present discussion to functional testing of static digital circuits — although the principles do not lose in generality. (It's worth noting that functional testing, although perhaps more easily understandable, is actually more rigorous than in-circuit testing and as much as ten times more costly).

Test procedures can be considered to have three main aspects: initialising, observing and controlling. For a circuit to be testable, each of these aspects must be catered for.

★ **Initialising.** This is the process by which all nodes of the unit under test (UUT) are set to known states after power-up and before test patterns are applied. Initialising (or initialisation) is essential for reliable and meaningful testing.

★ **Observing.** In the context of ATE, this means minimising the amount of human intervention needed to identify faulty components. Observing entails the correct monitoring of a circuit and involves the provision of suitable 'test points' in the design. Observability is the key to maximising the effectiveness of ATE.

★ **Controlling.** For proper functional testing, the ATE must be capable of controlling the UUT — usually by means of an edge-connector. If all functions of the UUT cannot be exercised, then testing will be inadequate.

In The Beginning

LSI designs are most commonly sequential and the failure to initialise can mean testing circuits in forbidden or indefinite states. There are four main factors in designing-in the ability to initialise a circuit:

★ There should be access to deep sequential circuits — which is a criterion of observability.

★ There should be a means of isolating or breaking feedback loops.

★ There should be access to reset and preset lines in memory elements.

★ In certain cases (for example, VLSI devices where there is no access to reset or preset lines), it should be possible to use 'software initialisation'.

Figure 8 shows a simple sequential circuit — a counter or shift register, for example — without and with testability built-in. If appropriate test points have not been provided on power-up all the memory elements, f(1) to f(n), will be in an unknown state (an x-state). The output will also be in an x-state. Without access to reset or preset, a 'homing sequence' would have to be provided by the tester. Further, if a fault existed the failure could be observed at the output, but without the use of a guided probe routine and suitable test points fault isolation would be impossible. This is a failure of observability or diagnostic visibility.

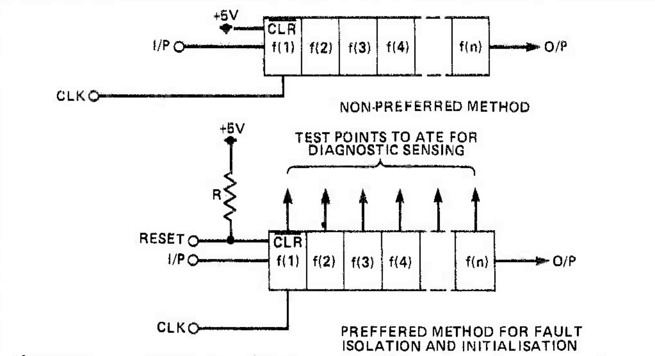


Fig. 8 Sequential circuit in non-preferred and preferred configuration for testing.

In the lower diagram, test points and a reset line have been provided. Since the reset line, in particular, is no longer hard-wired to V_{cc} we need only apply a clear signal to initialise the circuit rather than go through the elaborate motions of a homing sequence.

In Fig. 9, a feedback loop has been introduced in to the sequential circuit. Even if test points and the reset line are accessible, so that initialisation — at least — does not require a homing sequence, the problem of fault diagnosis remains. Because of the feedback loop, a fault may be propagated to all points around the loop. To overcome this, the loop must be breakable. The lower diagram shows how this is done — when the control point goes low, the loop is broken.

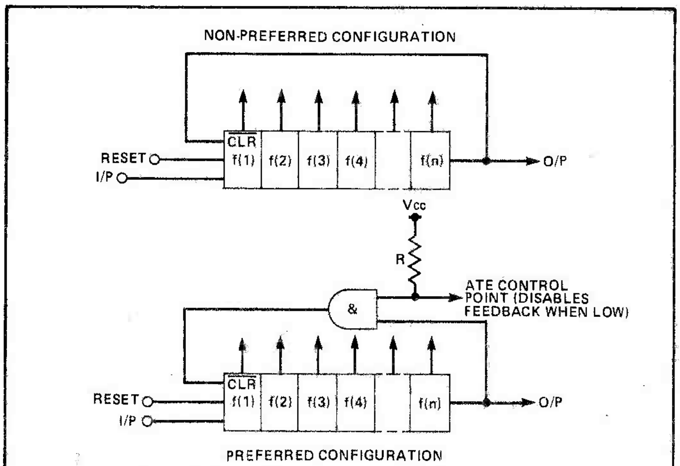


Fig. 9 Breaking a feedback loop.

In Fig. 10, a typical cross-coupled latch is shown. By itself, this poses no initialisation problem, even though the circuit will power-up into an x-state. However, if such latches are deeply embedded in a circuit and if component gates are from different chips, there may be a serious test problem. The preferred method of control, shown in the lower diagram, is to use three-input gates as components so that access points exist to break the feedback loops.

In general, initialising combinational ciruits presents no problems, since outputs are purely dependent on inputs. The first test pattern to be applied will set all nodes to a predetermined state. Initialising sequential circuits is always more complicated since such circuits contain x-states after power-up. These must be flushed out of the system before testing can begin. Since ATE programs must themselves be tested by means of a computer simulation or model circuit, a further problem is encountered. The model circuit will almost certainly power-up into a different state from any other — model or real — circuit.

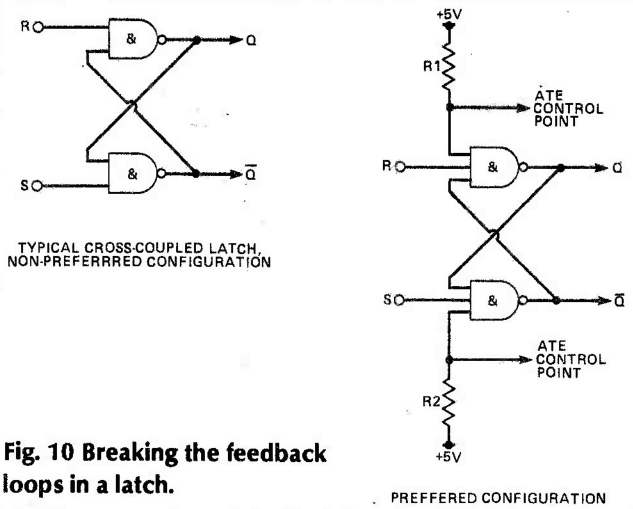


Fig. 10 Breaking the feedback loops in a latch.

A set of test patterns needs to be devised which, when applied to the UUT, will set it to a known state, regardless of its initial condition. This is known as a synchronizing sequence. In a simulation test, the model is then put into the same condition using the same synchronizing sequence before testing proceeds.

The synchronizing sequence can act as a homing sequence in the absence of a reset line. A simple example might involve a synchronous counter — for example, a 74163 — in which all data inputs are set low, the parallel load is enabled and the clock pulsed. Obviously, access to the reset would achieve the same object at a lower overhead.

The difference between a synchronizing sequence and a homing sequence, in general, is that the synchronizing sequence is always the same in each particular, while the homing sequence involves an algorithm to modify its stages in the light of the circuit behaviour. Homing sequences are, in effect, programs with loops and branches and are commonly known by the abbreviation AHS which stands for 'adaptive homing sequence'.

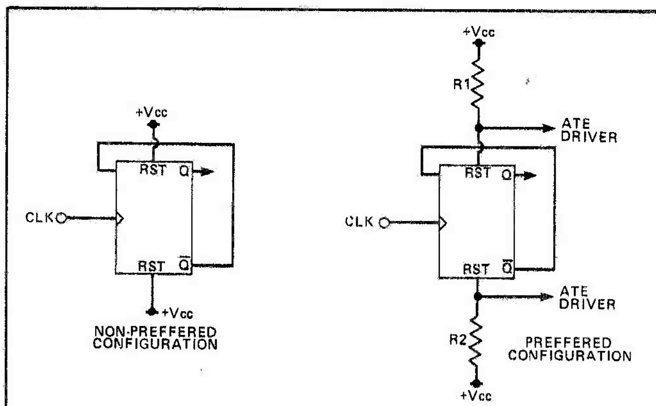


Fig. 11. Homing sequence versus synchronised sequence.

Figure 11 shows a standard divide-by-two circuit. While the right diagram illustrates a simpler arrangement — from a test point-of-view — in which initialisation would require only a single-step synchronizing sequence (reset or preset directly), the left diagram shows a simpler circuit which can be handled by use of an AHS.

The following algorithm would provide a suitable sequence:
1. Set CLK to 0
2. Set CLK to 1
3. If Qis 0, then go to step 1
4. Return to test (output Q, known to be 1).

Bad design is the bane of the tester's life. An example of unhelpful design is shown in Fig. 12 — a section of an actual circuit used in a currently operational ship's navigation system. Basic principles should immediately suggest that it was bad practice to tie J, K and the preset inputs on IC1 (the 7476). Even though the reset lines are available to the tester, close examination reveals another problem. Reset on the 7476 is asynchronous — which is to say, it works independently of the clock — while reset on the 74163 is synchronous — which is to say that it needs an appropriate clock pulse to operate.

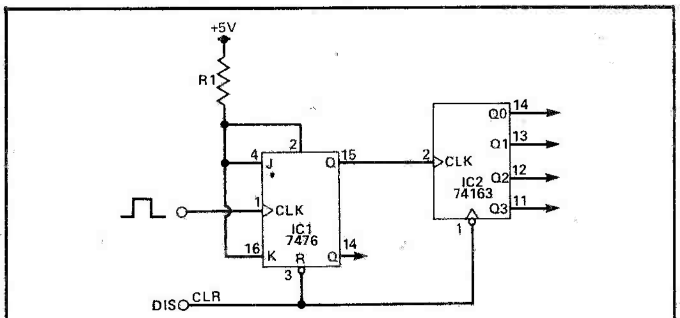


Fig. 12 An actual unhelpful design.

Since the clock pulse for the 74163 is derived from th 7476's Q output, the '163 will never receive a clock pulse when the '76's reset line is low. In other words, in this design configuration it is impossible to reset both ICs at the same time. To make matters worse, there were no direct outputs available from the '163. All of which makes it very difficult to initialise the circuit.

Now You See It

As has been suggested, the observability aspect of testing and the ability to initialise circuits are not totally separable. Observability is really a way of talking about the effectiveness of ATE, which is clearly influenced by the position with respect to initialisation. It's already been shown how feedback loops and the lack of circuit isolation can make it impossible to achieve the desired degree of diagnostic resolution — to use the jargon.

There are three ways in which the circuit designer can improve observability:

★ By partitioning circuitry (for example, by function).

★ By providing ways to break feedback loops.

★ By providing means of isolating faults (for example, the inclusion of suitable test points).

Walking The Dog

Functional testers are, in practice, 'edge connector oriented' and good controllability demands careful attention to the board design of any circuit. Effective ATE must be able to readily and properly exercise every component on the board. Good design, from the test point-of-view, will reduce the number of steps that need to be taken in order to cover all detectable faults.

The control functions that need to be available to the ATE can be grouped under five headings:

★ 1) Reset and preset inputs.

★ 2) Tri-state contol lines, enable and disable signals.

★ 3) Feedback disable.

★ 4) Isolation and control inputs for free-running devices, in particular clocks.

★ 5) Synchronization signals, especially where microprocessor based modules are being tested, so that the UUT and the ATE may be synchronized.

Reset and preset lines should never be tied together or hard-wired to V_{cc} or GND. They should be 'soft-wired' by use of pull-down or pull-up resistors, to which test-points are connected. CMOS input can be pulled high or low through an appropriate resistor, because CMOS requires only a very small bias current (about 1μA) to establish logic high or low states. TTL, however, can only be successfully pulled high through a resistor, because it requires quite a high sink current (about 2mA) to establish a logic low state Active pull-downs should be used, if over-driving is required, as illustrated in Fig. 13. Passive resistors would have to be of too low a value for the ATE's drivers to source a high on to the input. For example, pulling four TTL inputs low would demand a resistor passing 8mA across a maximum potential drop of 0.8V. It would have to be approximately 100ohms.

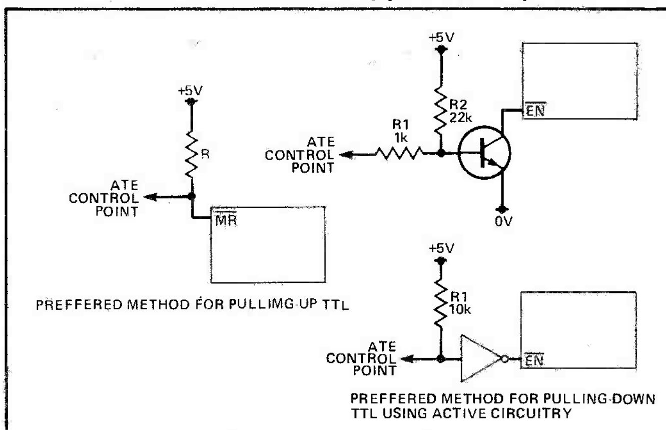


Fig. 13 Pulling down and pulling up TTL.

Access to tri-state control lines is particularly important when testing memory boards or bit-slice processors in which circuit operation depends on ROM contents. Without access to the tri-state lines, it may be very difficult to control the circuit since the ROM contents may make it impossible to exercise all the circuit nodes. The ATE must be able to override such memory-based constraints.

Feedback loops have been dealt with above and the preferred method, shown in Fig. 9, requires no operator intervention but can be handled entirely by the ATE software. Of course, switches or links could be used instead.

Control of free-running devices and synchronization can be treated as two sides of the same problem, since one relates to situations in which the ATE must control the UUT — perhaps, to single-step through a sequence of states — and the other to situations in which the ATE must simply proceed in step with the UUT.

In the first case, serious synchronization problems will in any case occur where a clock-controlled circuit is operating at a greater rate than the fastest operation of the ATE. Figure 14 shows one way of controlling free-running devices. Under normal operating conditions G1 and G2 would both be enabled allowing the clock pulse through. Under test, control point 1 would disable the clock when taken low by the ATE, allowing an ATE controlled clock to be injected in to control point 2. This is the preferred method, although the same effect could be achieved manually by the use of switches or links.

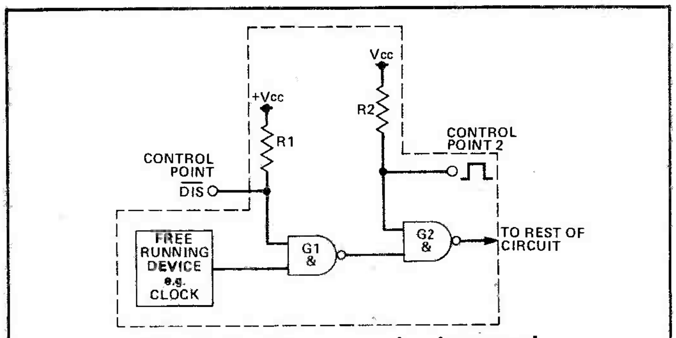


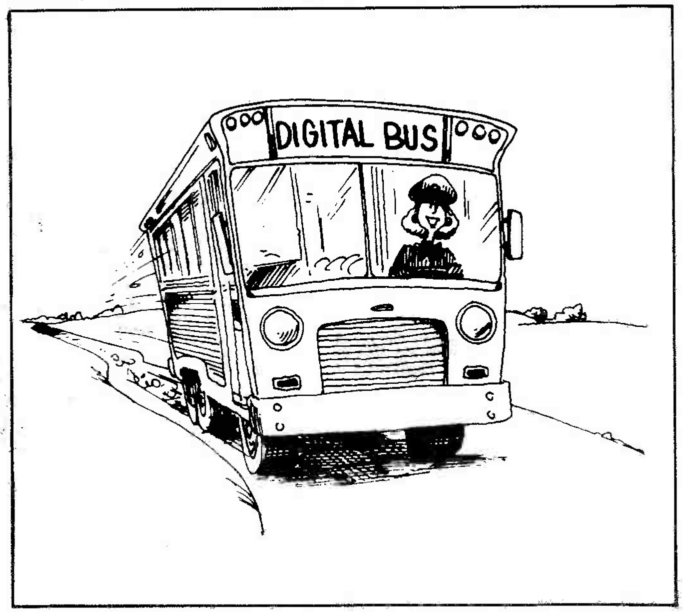
Fig. 14 Asynchronous circuit control.

Synchronization itself is best achieved if the use of multiple clocks is avoided whenever possible. This subject will be dealt with more fully later in this series, when we come to the topic of 'signature analysis'. Multiple-phase clocks present no problems, but multiple clocks cannot be synchronized with. If a multiple clock system cannot be avoided, it should derive each clock signal from a master clock, divided down. This allows a common sync point for the ATE to latch on to.

On The Buses

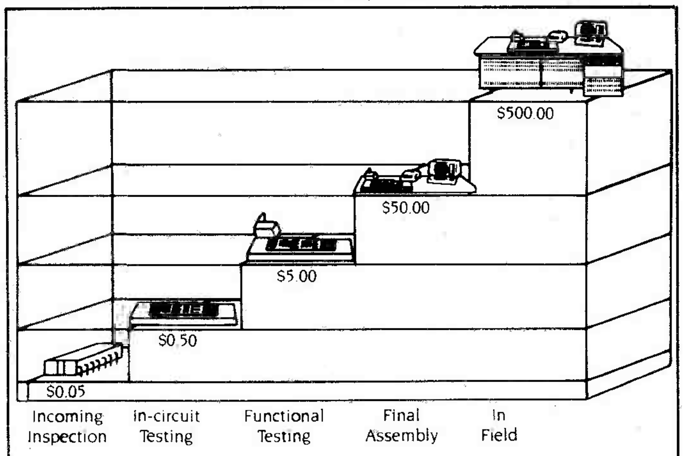
When testing bus-structured circuits, synchronization alone is not enough. The ATE must be able to force the circuit's controlling microprocessor to relinquish control of its address and data buses.

If an MPU is used in conjunction with a 'direct memory access' (DMA) device, the DMA device must be capable of instructing the MPU to release its buses



so that I/O or memory block transfers can take place without involving the MPU. Suitable control signals are available on many common MPUs which enable them to put their bus outputs into a high impedance state. Normally, a DMA controller would be used to handle the procedures involved.

The Z80, for example, features a bus request line, BUSRQ, and the 8085 features a similar HOLD line which are used to flag the MPU when the DMA device is about to make a data transfer. On the next cycle, the MPU will finish its present task and flag the DMA device that it has released its buses using — in the above examples — the BUSAK or HOLDKL lines. The DMA device then takes control of the buses. MPUs that do not contain built-in tri-state buffers on the bus lines (for example, the 6502) must be augmented by external tri-state devices if they are to be used with DMA devices or, indeed, with ATE.



Cost comparison for various testing procedures.

In the case of MPU-controlled bus-structured circuits, effective testing can only be achieved if the ATE has direct memory access either through control lines on the MPU itself or through enable/disable lines on external tri-state buffers.

The Story So Far...

The requirements for testability apply equally to manual and automatic testing. While manual testing can proceed even with a badly thought-out and laid-out module or circuit by the application of a little ingenuity, automatic testing is often impossible with inadequate circuit design. In essence, the circuit designer's responsibility is to provide all the necessary test-points and control lines to enable the ATE to track down all possible faults.

So far, we have only dealt specifically with the functional testing of digital boards. This makes the most rigorous demands on the circuit designer. In subsequent issues, we will turn our attention to in-circuit testing and to analogue circuits and, most importantly of all, to actual test techniques and procedures.

The author and ETI would like to thank the following ATE manufacturers for their help and co-operation in the preparation of these articles. Factron-Schlumberger provided us with the cartoons used in the series and with some valuable information. Zehntel Performance Systems, Genrad Inc., and Hewlett Packard have given permission to re-print details of products and software — Zehntel's Columbia 2000 and their 'timing emulation' technique; Genrad's 'memory emulation' technique; and HP's DTS-70 and 3065 machines, simulation techniques and 'Safeguard' in-circuit software package.

ETI

SUNRISE LIGHT BRIGHTENER

Do you ever get the feeling that rising would be a lot easier if it weren't for the shine? Margaret Blake describes a project to lighten your mornings — gradually!

Picture the scene: it is 7.30 am on a cold and dark Monday morning in winter. The previous evening you were out celebrating with friends and are a bit under the weather. The radio alarm clock switches on and you are awakened gently by its melodic outpourings. All is well until a lone hand ventures from beneath the warm blankets to switch on the table lamp . . . . AAAAAARG !!!

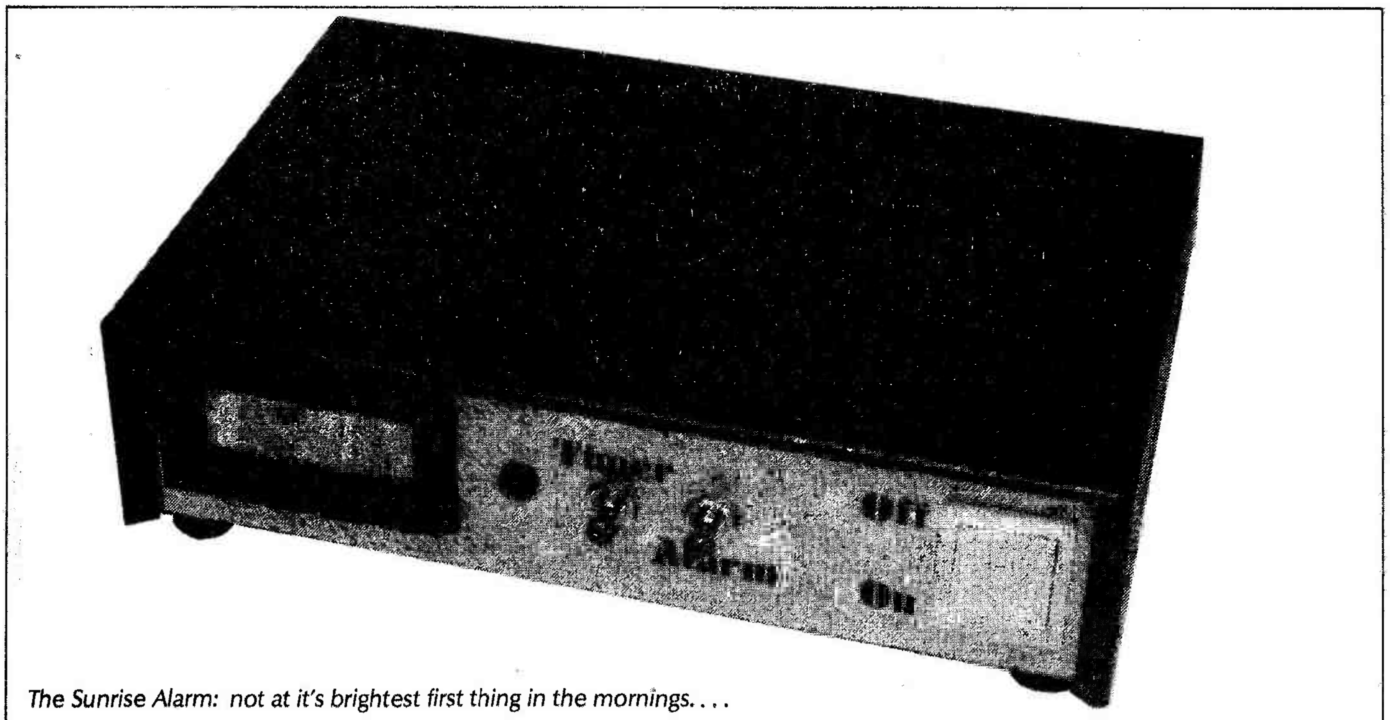
The advent of the clock-radio removed the sudden noisy start to the morning, but what about the switch-on of the bedroom light? Couldn't something be done to remove that shock too?

This article describes the constrution of a unit which will gradually illuminate a mains-powered lamp when it is triggered by an alarm clock or other input. The lamp will take several minutes to progress from darkness to full brightness and will then remain on for either 16, 32, 64 or 128 minutes as desired or until the mains supply is switched off. The circuit is so arranged that the lamp can still be switched on at full brightness in the normal way when required.

The control circuitry is completely isolated form the mains and operation is triggered by a 1.5V pulse to an Enable input. This allows the unit to be used in other applications, for example, in an animal hutch, with a simple switch being used to trigger the lamp brightening process. With a few simple modifications the circuit can also be arranged to dim progressively when triggered instead of brightening.

If the unit is to be built as a self-contained alarm clock, some sort of timing circuitry and display will be required. Rather than use separate timing ICs or a single clock chip which would then have to be interfaced to a display, the prototype was built around a complete clock module. This consists of a liquid crystal display with an integral clock circuit and comes complete with a mounting bezel. It costs around £16.00 plus VAT but this is probably not a lot more than the cost of using individual components and construction is made a lot simpler.

The module requires a supply of 1.5V DC. It is advisable to



The Sunrise Alarm: not at it's brightest first thing in the mornings. . . .

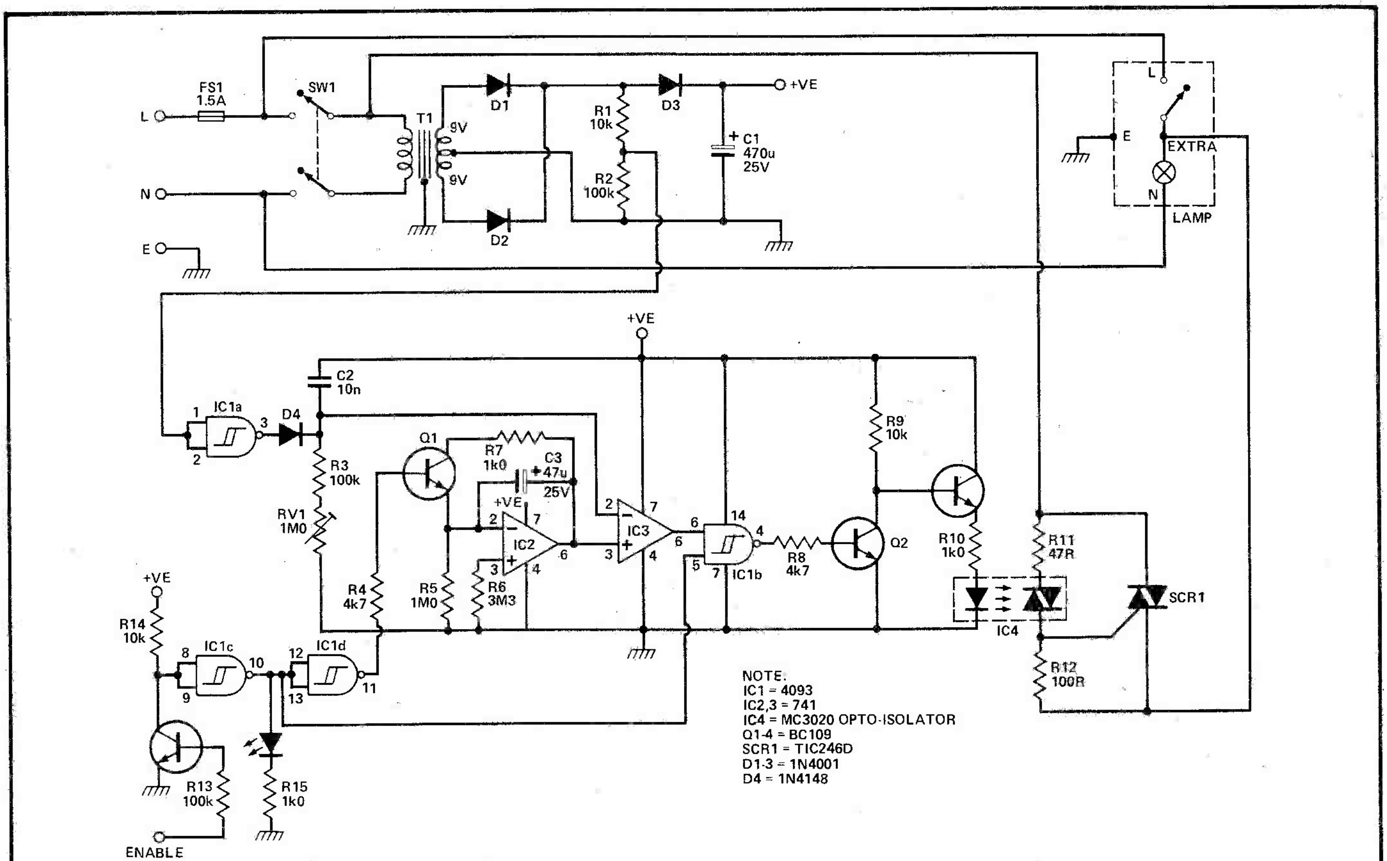


Fig. 1 Complete circuit diagram of the Sunrise lamp brightener.

switch off the lamp brightener when not in use, so, to avoid having to re-set the clock each time the unit is switched on, a 1.5V dry-cell battery is used. A separate mains power supply could be incorporated but the clock consumes so little current that it would be a very long time before the supply paid for itself in saved battery costs.

The clock module includes an incandescent back-light to illuminate the display. This also operates at 1.5V but draws rather more current than the clock. Since the lamp brightener would normally be plugged in overnight ready for the morning, the back light could be connected to the lamp brightener's supply via a suitable dropper arrangement. The light would then also operate at night when it is most needed. This facility was not included on the prototype but should be simple enough to add.

Construction

The lamp brightener components all mount onto the PCB with the exception of the mains transformer, the LED and, of

HOW IT WORKS

The incoming mains is stepped down by T1 and then full-wave rectified by D2 and D3 before being applied to the voltage divider chain, R1 and R2. The voltage at this point consists of a series of positive half cycles at the mains frequency. A proportion of this voltage is fed from the divider chain to the Schmitt trigger, IC1a, which squares-off and inverts the signal to produce a positive pulse each time the applied mains goes through zero. The full-wave rectified voltage, meanwhile, is fed to C1 which produces a smooth DC output while D3 prevents the action of this capacitor affecting the voltage on the divider chain.

The pulses from IC1a are fed via diode D4 to the network consisting of C2, R3 and RV1. At switch on, the DC supply voltage will appear across R3 and RV1 and the junction of C2 and D4 will be more or less at the same potential as the supply rail. As C2 charges, however, more and more of the voltage will appear across the capacitor instead of the resistors and the voltage at the junction will drop towards 0V. When the mains next passes through zero and a pulse is delivered by IC1a, the capacitor will be discharged and the process will be repeated. The voltage appearing at the inverting input of IC3 will therefore be a series of ramps synchronised with the mains frequency.

R5, R6, C3 and IC2 form an integrator whose voltage will rise linearly with time over a period of several minutes. When the Enable input is taken above about a volt or so, Q4 will start conducting and pull down the input of IC1c. The output of this Schmitt will then go high and illuminate LED1. The input of IC1d will also be taken high causing its output to go low and this will turn off Q1. The output of IC2 will then start to rise.

IC3 acts as a comparator of the signals from IC2 and the ramp signal from IC1a and D4. The output of this IC will go high when the voltage coming from D4 is below the voltage from IC2. IC3's output will be mostly low at first, but as the voltage from IC2 rises steadily IC3 will go high earlier in each mains cycle. IC1b is another Schmitt trigger and acts to sharpen up the transient of IC3, its output switching cleanly between the positive supply rail and ground.

R8, R9, Q2, Q3 and R10 provide the drive for the LED which is contained within the opto-isolator, IC4. The other half of the opto-isolator is a small triac which, when triggered by a current through the LED, conducts and causes current to flow from R11 and R12 into the gate of the main triac, SCR1. Thus, as the voltage from IC2 rises steadily, the triac will conduct for a larger percentage of each half-cycle and the lamp will slowly brighten. Swopping over the two inputs to IC3 will cause the lamp to dim gradually instead.

PARTS LIST — LIGHT BRIGHTENER

RESISTORS	(all ¼W, 5%)
R1, 9, 14	10k
R2, 3, 13	100k
R4, 8	4k7
R5	1M0
R6	3M3
R7, 10, 15	1k0
R11	47R
R12	100R
RV1	1M0
CAPACITORS	
C1	470u 25V electrolytic
C2	10n
C3	47u 25V electrolytic
SEMICONDUCTORS	
IC1	4093
IC2, 3	741
IC4	MC3020 opto-isolator
Q1-4	BC109
D1-3	1N4001
D4	1N4148
LED1	red LED with panel-mounting bush
SCR1	TIC246D
MISCELLANEOUS	
FS1	1.5A fuse and PCB-mounting holder
SW1	DPDT mains toggle switch
T1	9-0-9V 100mA chassis-mounting mains transformer

PCB; case; IC sockets if desired, 1 off 14 pin and 3 off 8 pin DIL; four-core mains cable and either four-pole plug and socket or strain relief bush to suit; three-core mains cable and strain relief bush to suit; heatsink for triac (used only if heavy load is being driven); nuts and bolts; veropins; PCB stand-off pillars; connecting wire, etc.

BUYLINES

Most of the parts are widely available from our advertisers and the usual mail-order suppliers and few of the component values are critical anyway. The opto-isolator is available from Watford Electronics and Maplin stock four-core mains cable and plugs and sockets to suit. The clock module is an RS part and can only be obtained directly by trade and professional customers, but Crewe-Allan of 51 Scrutton Street, London EC2 can obtain it for you on payment of a small handling charge. Other clock modules which offer similar functions and operate from a 1.5V supply should be suitable, and there is no reason why a unit built up from individual parts or an existing electronic alarm could not be used provided a 1.5V signal can be obtained from them to drive the brightener circuit. The PCB will be available from our PCB Service, for details of which see the note in News Digest.

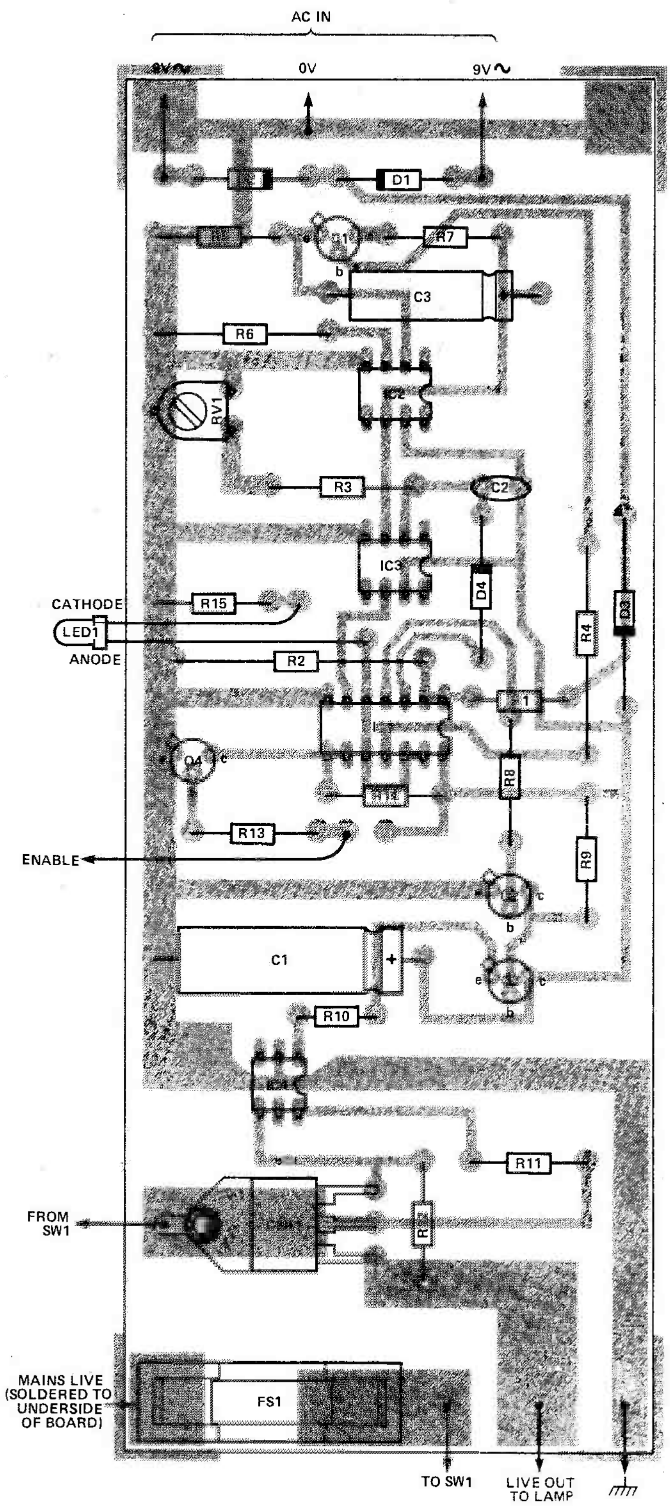


Fig. 2 Component overlay for the lamp brightener PCB.

course, the on-off switch. The triac is run well within its rating and doesn't need a heatsink so it too is mounted directly onto the PCB.

Begin assembly by soldering into place the hardware items such as the circuit board pins, the fuse holder and the IC sockets (if you are using them), then install the passive components (resistors, capacitors, etc) and finally the semiconductors (the diodes, transistors, triac and ICs). Secure the triac to the board with a nut and bolt and include a solder tag ready for the connection from SW1. If IC sockets have been used, the ICs should be placed in them only when all of the soldering is complete.

Install the PCB in the case, making sure that the end which carries the mains circuitry is well clear of the switches and any other projections with which it might come into contact. If you are using a metal case it should be well earthed, and you should take particular care to ensure that the live end of the board is well clear of the case sides.

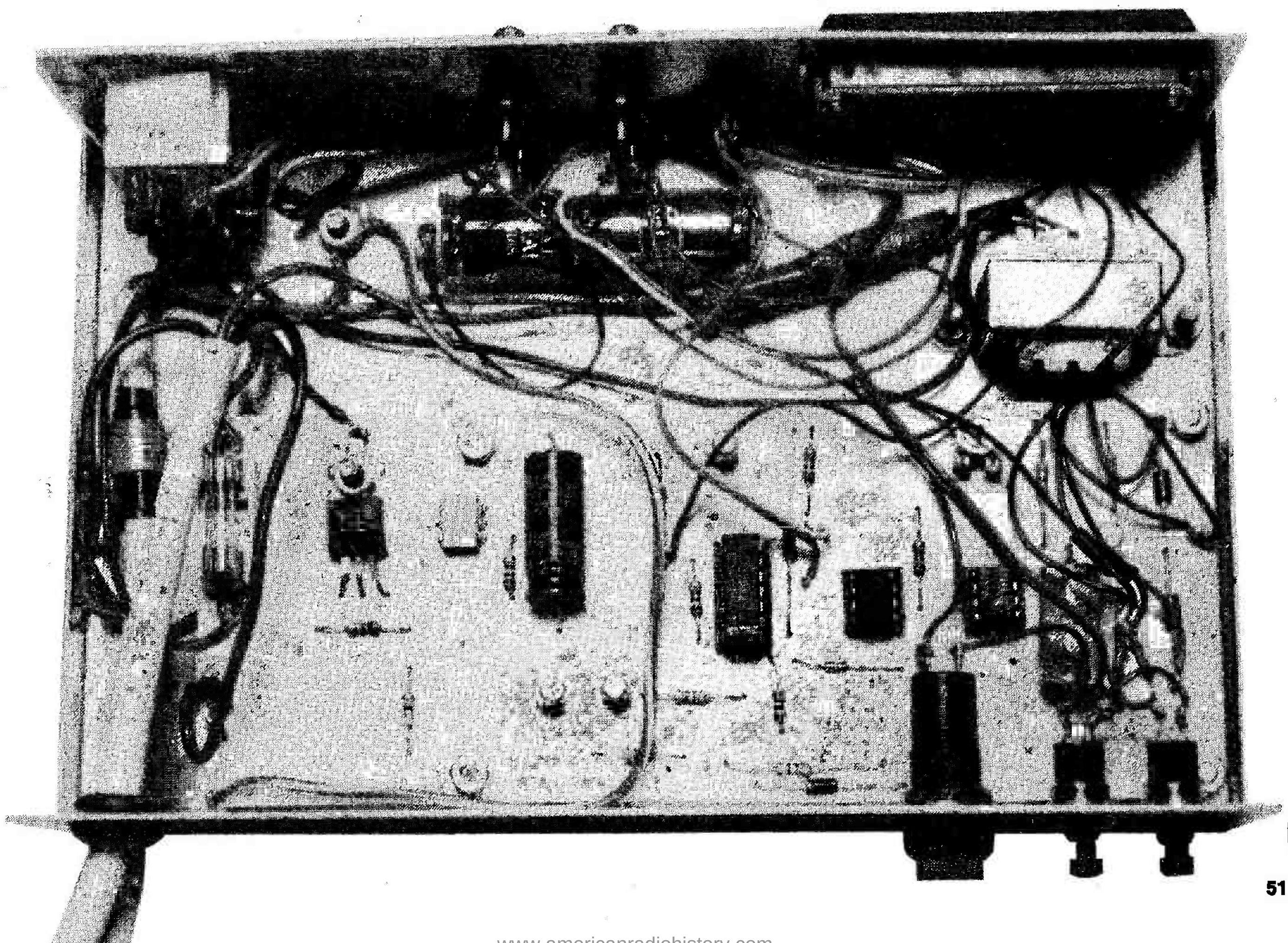
Bolt the transformer into place and then install the on-off switch and the mains wiring. Use a four-core mains cable for the output to the table lamp and route it through a grommet and some kind of strain relief arrangement in the rear panel. Alternatively, if you don't want the table lamp to be permanently attached to the lamp brightener, a four-pole socket can be used on the rear panel and the table lamp fitted with a matching plug. Wire up the LED on the front panel and temporarily attach a bayonet lampholder and bulb to the end of the four-core cable.

Temporarily short the two pins at the timer input on the PCB and then connect the unit to the mains and switch on. The LED should light up to show that the circuit has triggered and the light bulb should come on slowly over the next few minutes. Don't get too worried if nothing seems to be happening early on — even after two minutes the lamp should still only be glowing faintly and it should take a further five minutes to reach full brightness. If that seems a long time, remember that Murphy's law states that five minutes in the morning is longer than five minutes at any other time of the day! If all is well, switch off to reset the circuit then switch on again and set the initial brightness as desired by adjusting RV1.

Disconnect the unit from the mains and install the clock module, the battery and the push buttons which select the clock functions. SW2, SW3 and SW4 should be mounted on the rear panel and SW5 and SW6 should be on the front panel. The connections to the clock module are shown in Fig. 3.

Break the temporary short circuit across the PCB timer pins and connect the CNT lead from the module to the Enable pin. Don't forget to provide a connection from the negative side of the clock battery to the negative rail of the brightener circuit and the mains earth. The parts all fitted fairly tightly into the case used for the prototype, so if a similar case is used a degree of care is essential if the wiring is not to become a real mess.

The final stage in the construction is to re-wire your table lamp with a four-core lead. The connection arrangement is shown in Fig. 1. The only mains rated four-core

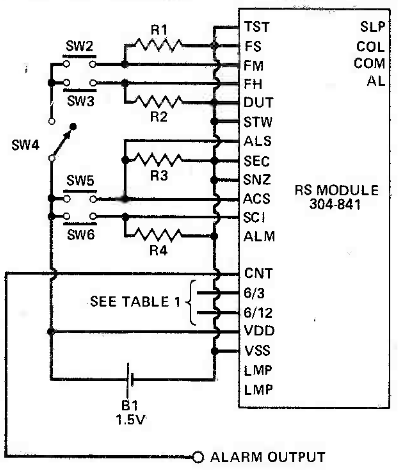


PARTS LIST — CLOCK

R1-4	100k
SW2,3,5,6	momentary action push-to-make switches
SW4	latching push button switch
B1	1.5V AA battery and holder
Clock module	LCD clock module RS type 304-841 or similar

cables we know of are all 8.5mm diameter or more — rather larger than the three-core leads fitted to many table lamps. Because of this you may have to enlarge the cable entry on the lamp and provide a new strain relief bush. Don't be tempted to use any thinner four-core cables you might happen to have in the junk-box; many of these are only intended for signal applications and are rated at 60V or so maximum.

With all the wiring complete, begin the final tests by setting the time on the clock module. SW2 sets the minutes and SW3 the hours, and SW4 must be switched on while the setting is taking place.



FM = ADVANCE MINUTES
FH = ADVANCE HOURS
ALS = SHOW ALARM TIME
SCI = START TIMER
CNT = TIMER OUTPUT
ACS = CANCEL TIMER

Fig.3 Connection details for the clock module.

The inclusion of this switch prevents the time being accidentally altered if either of the other buttons are knocked.

Set the mains switch at off, plug in the lamp brightener and check that the table lamp can be switched on and off in the normal way using its own switch. Now switch on the brightener and press SW6 until the LED comes on. The table lamp should come on at the previously-set minimum and then progressively brighten until it is fully on.

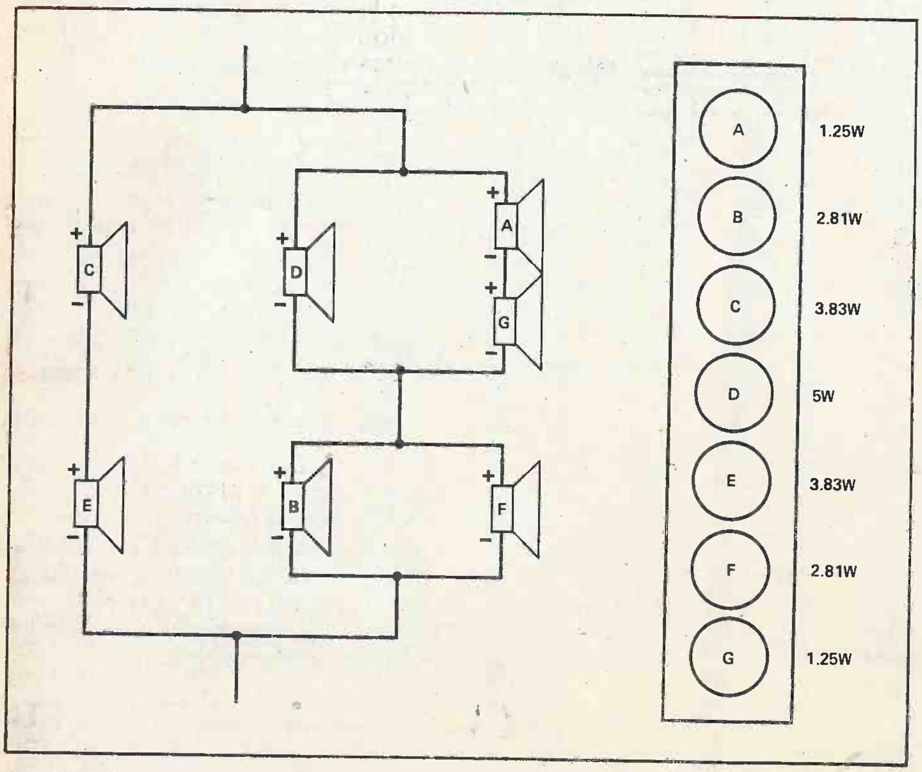
6/3	6/12	Timing Period
+1.5V	+1.5V	16 minutes
+1.5V	0V	32 minutes
0V	0V	64 minutes
0V	+1.5V	128 minutes

Table 1 Connecting the 6/3 and 6/12 pins on the clock module to select the lamp 'on' period.

In use, the alarm time is set by pressing SW5 and then using SW2, SW3 and SW4 in the normal way. Pressing SW5 at any other time will display the alarm time set. The brightener should be plugged in before retiring at night and will then operate at the preset time in the morning. Pressing SW5 will cancel the alarm.

ETI

TECH TIPS



COLUMN LOUDSPEAKER DESIGN

Rev. A. Sharp
Aberdeen

Column loudspeakers consist of a number of individual loudspeaker units arranged in a vertical line. They are highly directional and when used in a PA system can be pointed away from the microphone to reduce the risk of feedback. The directional characteristics are enhanced if the units are wired so that the central loudspeaker gives the highest output power and the level tapers off towards the ends. The principle was described in an article by David Hornsby in ETI November 1982.

This arrangement uses seven 5 watt loudspeakers instead of the five 10 watt ones suggested in the article. This allows cheap 16R car radio loudspeakers to be used and, because of the extra 'speakers and the increased efficiency, still gives almost as much output as the original arrangement. The total impedance of the network is 11.8R. The circuit has proved very effective in a church PA system.

NOVEL INPUT STAGE AND GAIN CONTROL

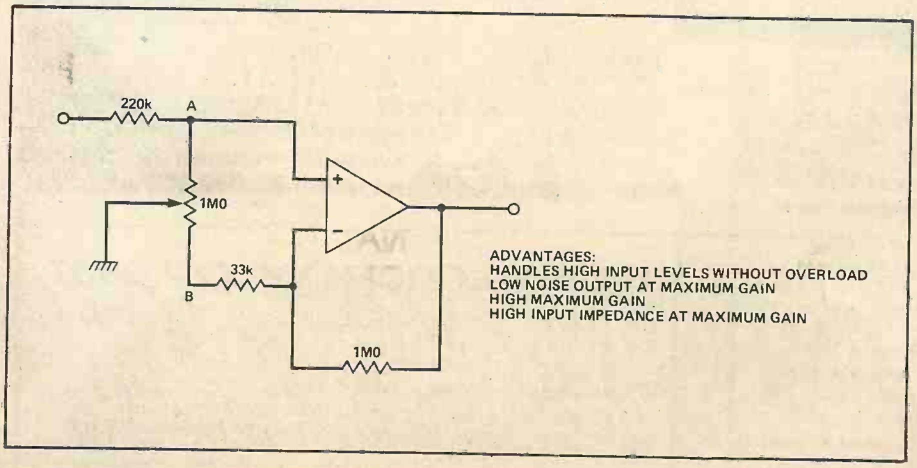
P. Day
Newcastle

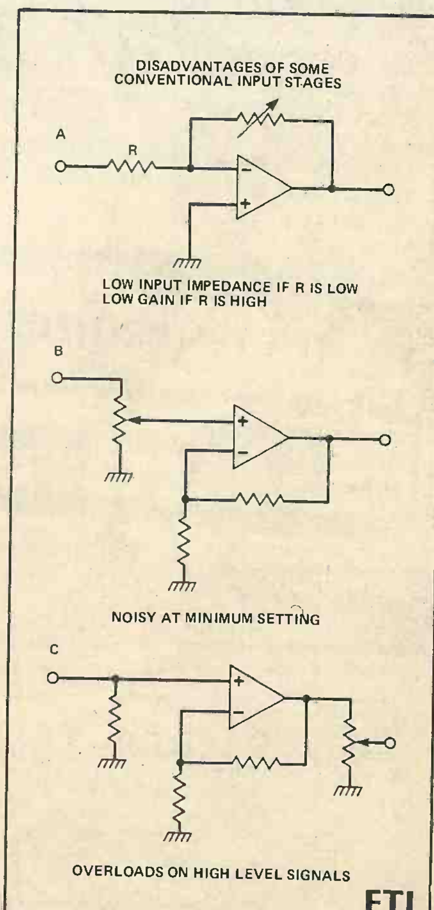
The circuit shown can be used as a general purpose input stage and enables a number of apparently conflicting requirements to be met. It can handle input signals with a wide range of voltage levels without suffering from the noise and overload problems usually encountered.

The potentiometer acts as two rheostats, controlling both the input level and the negative feedback. When the slider is near A the input is heavily attenuated, allowing high signal levels to be handled without running into overload. The feedback is high so the circuit noise level is low.

When the slider is at B the input signal suffers negligible attenuation. The op-amp has a high gain and the impedance is also high. With the component values given the maximum gain is 30 dB.

I have built and tested a number of these circuits and have been using them as the input stages of a mixer.





ETI

NEXT MONTH

AN ARGUS SPECIALIST PUBLICATION
electronics today INTERNATIONAL

'Well, winter's coming back again.'
'I didn't notice it had ever gone away.'
'Oh, you can always tell.'
'How?'
'The weather...'
'Yes...'
'And the days get longer in the summer...'
'Yes...'
'And the names of the months change.'
'Okay, you've convinced me. But how do you know it's coming back?'
'Well the names of the months change...'
'Yes...'
'And the days get shorter...'
'Yes...'
'And the weather...'
'Why do you keep going on about the weather? It's terrible.'
'That's why I keep going on about it.'
'Of course, there's another way of telling when winter's on its way.'
'Oh, what's that?'
'Well, ETI publishes an issue that's absolutely jam-packed with projects.'
'Oh, yes. The November Ten Project Special.'
'That's the one. Gives you enough projects to keep you occupied all year at a rate of one per month.'
'Hold on. There are twelve months in a year.'
'I know that and you know that, but whatever you do don't tell ETI.'
'Why not?'
'If they find out, they'll have to have this whole page printed again.'

THE TEN PROJECT SPECIAL

This year, the November issue offers more variety than ever before.
Among the ten projects lined-up for your delectation are:

The Memory Scope Display

An add-on unit for any oscilloscope which uses digital techniques to slow down the trace and lets you freeze the display. Slow-changing waveforms like sound envelopes and charge-discharge characteristics of capacitors can now be captured and examined without the need to resort to expensive storage devices or long-persistence phosphors.

Switch Mode Regulator

The first project in a series intended to demonstrate the virtues of discrete circuitry, this regulator delivers 5V at up to 1A and hardly gets warm. A perfect replacement for any 7805 with a heat sink large enough and hot enough to fry an egg on.

Rhythm Chip

This canny device uses an EPROM as a metronome or to measure beat-rates directly. All you need to do is tap out a rhythm and the Rhythm Chip will tell you how many beats per minute there are.

Millifaradometer

A voltage window detector, a simple clock and an electro-mechanical counter are the ingredients of this ingenious instrument which will give reliable read-outs of the actual value of large capacitors.

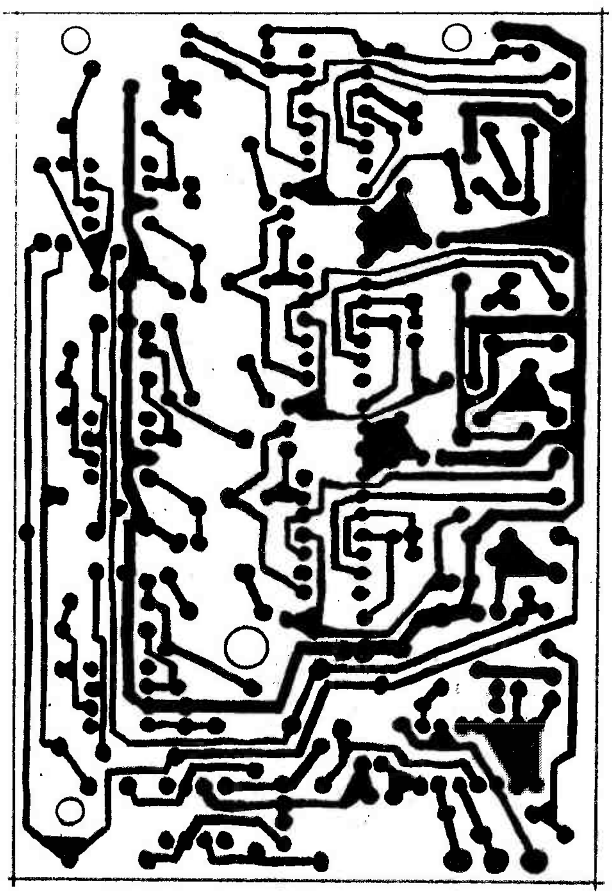
PLUS:

Digital Sound Sampler . . . Electron Interface . . . Chorus Unit . . . Exposure Meter and more.
Oh, we nearly forgot to mention the features, but perhaps we'll leave them until next month.

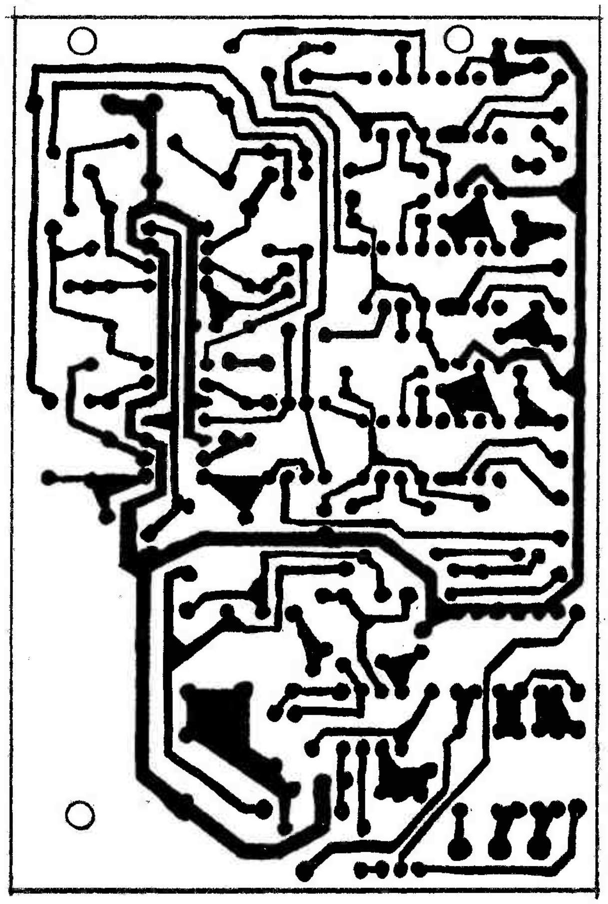
**NOVEMBER TEN PROJECT SPECIAL EDITION OF ETI.
ON SALE OCTOBER 4TH.
SO YOU KNOW WHAT SEASON IT IS.**

Articles described here are at an advanced stage of preparation. However, circumstances beyound our control may dictate changes to the list of contents.

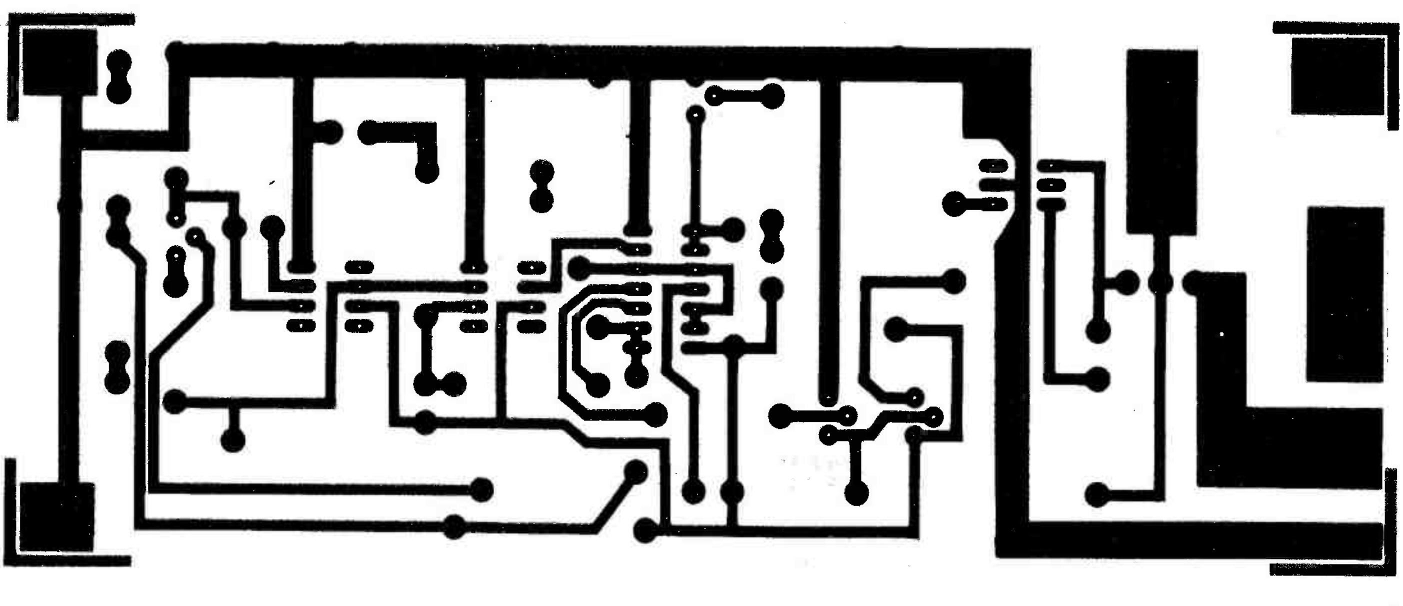
PCB FOIL PATTERNS



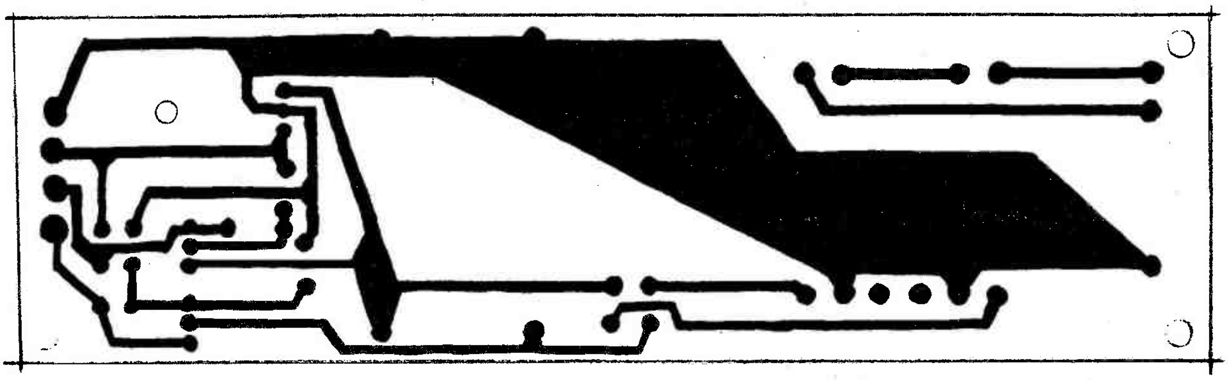
The foil pattern for the Sorcerer chorus audio board.



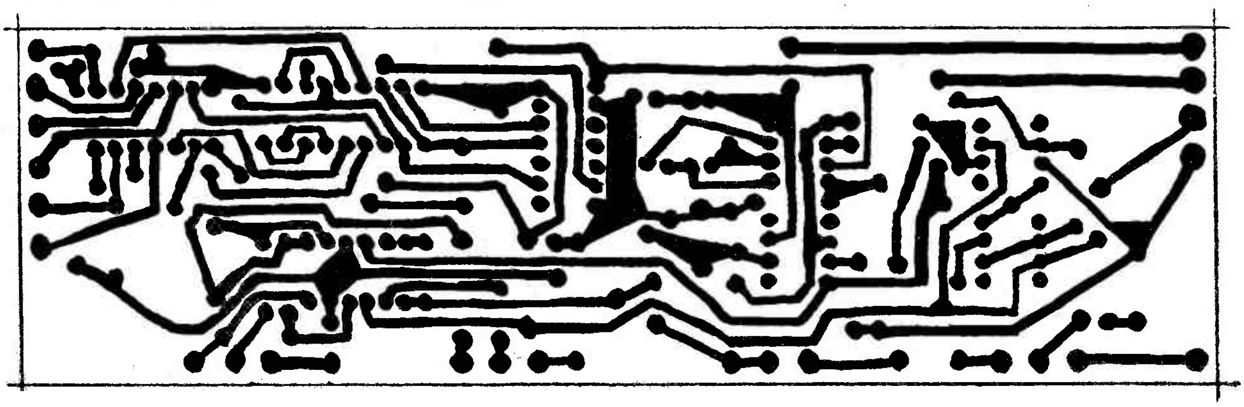
The foil pattern for the Sorcerer chorus clock board.



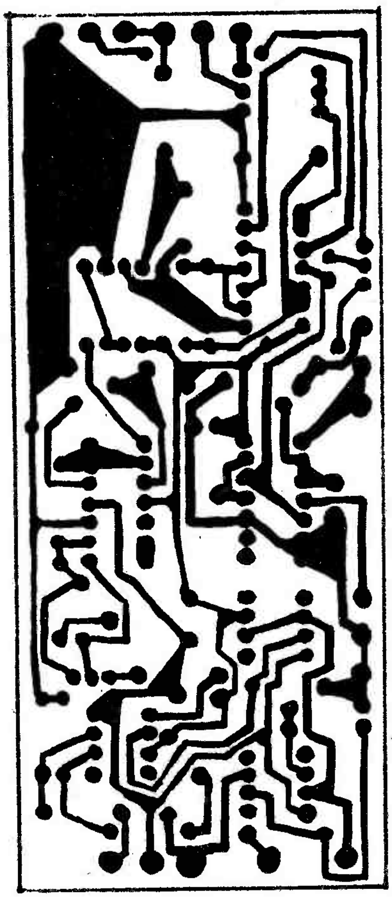
The foil pattern for the Sunrise light brightener.



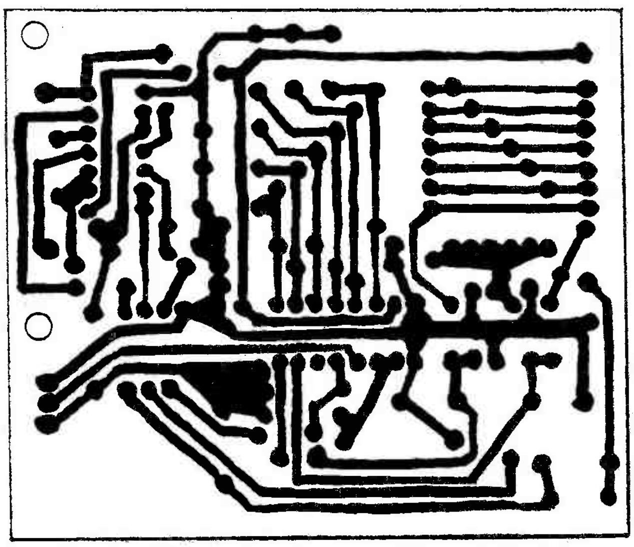
The foil pattern for the Sorcerer power supply board.



The foil pattern for the Sorcerer VCO board.

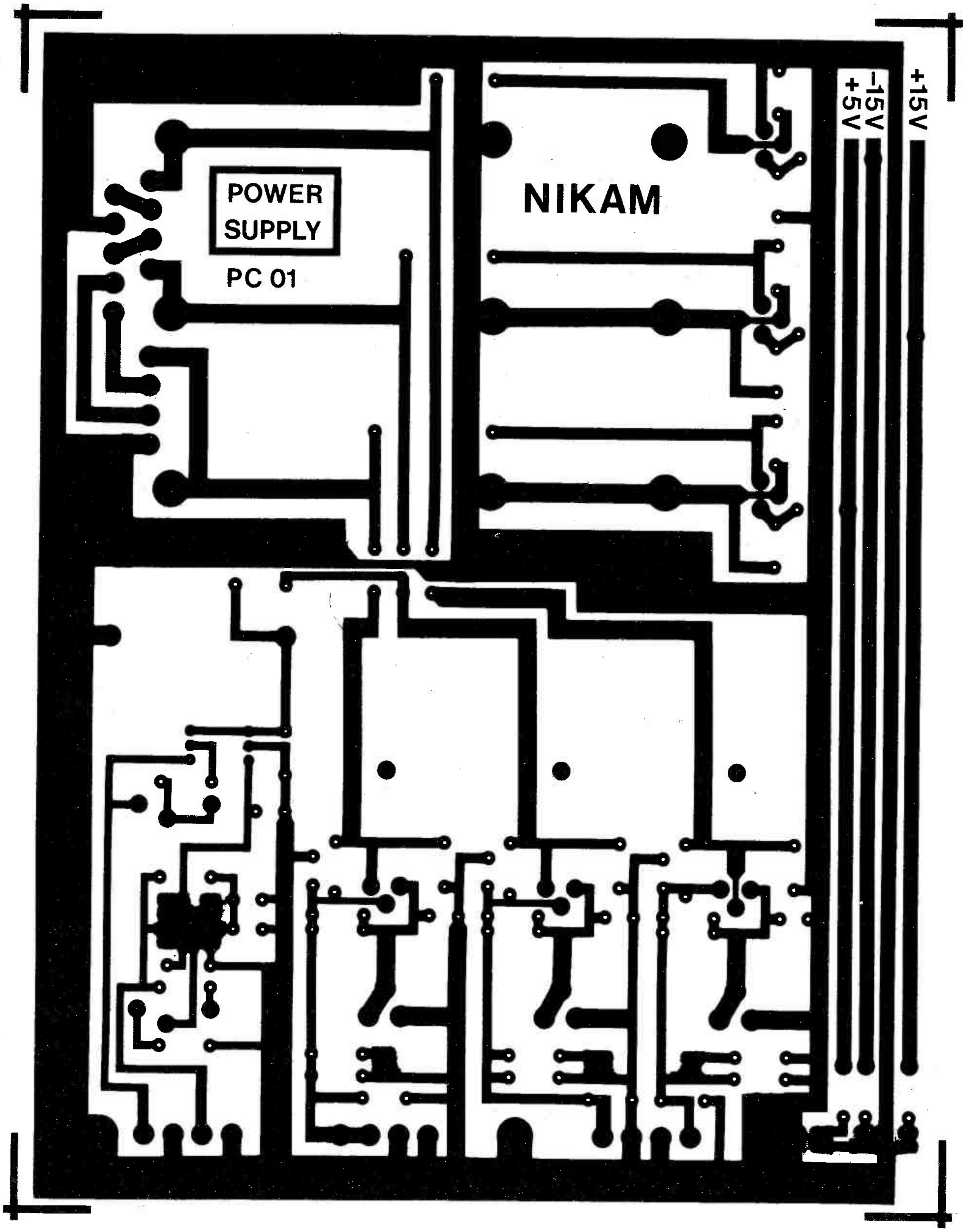


The foil pattern for the Sorcerer envelope board.



The foil pattern for the Sorcerer keyboard interface board.

The foil pattern for the Sorcerer keyboard is too large to print here (it measures about 500 x 230 mm). It is also too large for us to photocopy. We can prepare clear film copies photographically but the cost is likely to be between £15.00 and £20.00. All in all, it will probably be easier for you to purchase a ready made board from our PCB Service (when it becomes available!)



The foil pattern for the modular test gear PSU board.

SERVICE SHEET

Enquiries

We receive a very large number of enquiries. Would prospective enquirers please note the following points:

● We undertake to do our best to answer enquiries relating to difficulties with ETI projects, in particular non-working projects, difficulties in obtaining components, and errors that you think we may have made. We do not have the resources to adapt or design projects for readers (other than for publication), nor can we predict the outcome if our projects are used beyond their specifications;

● Where a project has apparently been constructed correctly but does not work, we will need a description of its behaviour and some sensible test readings and drawings of oscillograms if appropriate. With a bit of luck, by taking these measurements you'll discover what's wrong yourself. Please do not send us any hardware (except as a gift!);

● Other than through our letters page, Read/Write, we will not reply to enquiries relating to other types of article in ETI. We *may* make some exceptions where the enquiry is very straightforward or where it is important to electronics as a whole;

● We receive a large number of letters asking if we have published projects for particular items of equipment. Whilst some of these can be answered simply and quickly, others would seem to demand the compiling of a long and detailed list of past projects. To help both you and us, we have made a full index of past ETI projects and features available (see under Backnumbers, below) and we trust that, wherever possible, readers will refer to this before getting in touch with us.

● **We will not reply to queries that are not accompanied by a stamped addressed envelope** (or international reply coupon). **We are not able to answer queries over the telephone.** We try to answer promptly, but we receive so many enquiries that this cannot be guaranteed.

● Be brief and to the point in your enquiries. Much as we enjoy reading your opinions on world affairs, the state of the electronics industry, and so on, it doesn't help our already overloaded enquiries service to have to plough through several pages to find exactly what information you want.

Subscriptions

The prices of ETI subscriptions are as follows:

UK:	£16.30
Overseas:	£18.30 Surface Mail
	$24.00 Surface Mail (USA)
	£43.30 Air Mail

Send your order and money to: ETI Subscriptions Department, Infonet Ltd, Times House, 179 The Marlowes, Hemel Hempstead, Hertfordshire, HP1 1BB (cheques should be made payable to ASP Ltd). Note that we run special offers on subscriptions from time to time (though usually only for UK subscriptions, sorry).

ETI should be available through newsagents, and if readers have difficulty in obtaining issues, we'd like to hear about it.

Backnumbers

Backnumbers of ETI are held for one year only from the date of issue. The cost of each is the current cover price of ETI plus 50p, and orders should be sent to: ETI Backnumbers Department, Infonet Ltd, Times House, 179 The Marlowes, Hemel Hempstead, Hertfordshire HP1 1BB. Cheques, postal orders, etc should be made payable to ASP Ltd. We suggest that you telephone first to make sure there are still stocks of the issue you require: the number is (0442) 48432. Please allow 28 days for delivery.

We would normally expect to have ample stocks of each of the last twelve issues, but obviously, we cannot guarantee this. Where a backnumber proves to be unavailable, or where the issue you require appeared more than a year ago, photocopies of individual articles can be ordered instead. These cost £1.50 (UK or overseas surface mail), irrespective of article length, but note that where an article appeared in several parts each part will be charged as one article. Your request should state clearly the title of the article you require and the month and year in which it appeared. Where an article appeared in several parts you should list these individually. An index listing projects only from 1972 to September 1984 was published in the October 1984 issue and can be ordered in the same way as any other photocopy. If you are interested in features as well as projects you will have to order an index covering the period you require only. A full index for the period from 1972 to March 1977 was published in the April 1977 issue, an index for April 1977 through to the end of 1978 was published in the December 1978 issue, the index for 1979 was published in January 1980, the 1980/81 index in January 1982, the 1982 index in December 1982, the 1983 index in January 1984 and the 1984 index in January 1985. Photocopies should be ordered from: ETI Photocopies, Argus Specialist Publications Ltd, 1 Golden Square, London W1R 3AB. Cheques, postal orders, etc should be made payable to ASP Ltd.

Write For ETI

We are always looking for new contributors to the magazine, and we pay a competitive page rate. If you have built a project or you would like to write a feature on a topic that would interest ETI readers, let us have a description of your proposal, and we'll get back to you to say whether or not we're interested and give you all the boring details. (Don't forget to give us your telephone number).

Trouble With Advertisers

So far as we know, all our advertisers work hard to provide a good service to our readers. However, problems can occur, and in this event you should:

1. Write to the supplier, stating your complaint and asking for a reply. Quote any reference number you may have (in the case of unsatisfactory or incomplete fulfilment of an order) and give full details of the order you sent and when you sent it.
2. Keep a copy of all correspondence.
3. Check your bank statement to see if the cheque you sent has been cashed.
4. If you don't receive a satisfactory reply from the supplier within, say, two weeks, write again, sending your letter recorded delivery, or telephone, and ask what they are doing about your complaint.

If you exhaust the above procedure and still do not obtain a satisfactory response from the supplier, then please drop us a line. We are not able to help directly, because basically the dispute is between you and the supplier, but a letter from us can sometimes help to get the matter sorted out. But please, don't write to us until you have taken all reasonable steps yourself to sort out the problem.

We are a member of the mail order protection scheme, and this means that, subject to certain conditions, if a supplier goes bankrupt or into liquidation between cashing your cheque and supplying the goods for which you have paid, then it may be possible for you to obtain compensation. From time to time, we publish details of the scheme near our classified ads, and you should look there for further details.

OOPS!

Corrections to projects are listed below and normally appear for several months. Large corrections are published just once, after which a note will be inserted to say that a correction exists and that copies can be obtained by sending in an SAE.

Audio Design Buffer (September 1984)
There has been some confusion due to the cases of the various transistors (Fig 4, p.61). Q1 and Q11 are T092(E) (gate, source and drain for pins 1, 2 and 3), while Q2 and Q12 are T092(F) types (gate, drain and source). Q3, Q 4, Q13 and Q14 should be 'L' types with a T092(A) case (base, collector and emitter). The pin positions marked on the overlay are correct. The pins themselves may need to be bent to fit the PCB.

Spectrum Centronics Interface (December 1984)
Pin 18 of IC3 on Fig. 1a (page 57) should be marked pin 17. The mistake seems to have been carried over to the PCB (p.58). The track leading from pin 18 to the 0V rail should be cut. A correspondent informs us that he has had success with only this modification — in other words, with pin 17 left floating, too.

Single Board Controller (March 1985)
There were a number of errors in the parts list. RP2 is listed as a 10k SIL pack but is actually four separate resistors, and the same applies to RP3. RP4 is also listed as a SIL pack but should consist of seven commoned resistors. R13 is always required, not just when a cassette interface is used as stated.

The Real Components (May 1985)
In Fig. 1 on page 20, the connections for the Texas L and 2N transistors are incorrectly shown. They should read B, C and E from the top.

Heat Pen (June 1985)
The instruction in the penultimate paragraph on page 49 should read "... adjust RV2 for 2.73V...", not 2.37V as stated.

Low Cost Audio Mixer (June 1985)
In Fig. 6 on page 39, the PCB foil pattern has been incorrectly shown as though from the copper side. The board is shown correctly from the copper side in the foil pattern pages. In Fig. 10 on page 40, the positive power rail at lower left should be shown connected to pin 8 of the TL072s, IC1-5).

Noise About Noise (July 1985)
In Fig. 5 on page 24, no connection should be shown between the cathode of the diode and the negative side of the 470u capacitor.

Printer Buffer (July 1985)
The case specified is actually larger than the one used for the prototype. It will, of course, work perfectly well, but if you want to a compact unit use a Verocase 202-21038H (180 x 120 x 65mm) rather than a Verocase 202-21035. The regulator IC17 should be bolted to the back of the case to provide heatsinking or, alternatively, fitted with a TO220 heatsink.

Please note that the designer, Nick Sawyer, has been in touch to inform us that the refresh problem we mentioned last month (page 52) is dealt with in the printer buffer software. In this case there is no need to replace the TMS 4416 dynamic RAMs, although as far as we know the replacement parts mentioned (Hitachi HM48416 DRAMs) will cause no problems. The full text of Nick Sawyer's letter will appear next month. Meanwhile, our apologies for any confusion caused.

Intel 8294 Data Encryption Unit (September 1985)
It should be apparent from the text, page 35, that an actual program has been omitted. This program is for use with the SDK 8085 kit only, and copies may be obtained from us on receipt of a stamped addressed envelope.

REVIEWS

A GUIDE TO PRINTED CIRCUIT BOARD DESIGN

Book

Charles Hamilton
The Butterworth Group, Borough Green, Sevenoaks, Kent TN15 8PH.

price: £7.50.

Could there be anything useful here for our own PCB designs? That was my first thought on seeing this book. Let's face it, just like you lot out there in hobby land, we at ETI have to turn our hand to everything from metal bashing to screen printing and a few tips from the experts are always welcome.

As it turns out, the book is aimed at those who intend to make a career of PCB layout in a large company drawing office and much of the information is not possible to apply to the occasional PCB layout.

The first chapter is a guide to understanding circuit diagrams, which I sincerely hope ETI readers can do already. Next we have advice on how to compile a file of component shapes and sizes - useful in a company that standardises its component stocks, but not much good if you're going to build a circuit with odds and ends from your spares box.

Chapters on the design layout and master artwork have one or two useful hints, but on the whole they are geared to company procedures. For one thing, we wouldn't produce a design layout (with component placing and interconnections all on the same artwork) in the first place. We just plunge straight into the master artwork, and it usually turns out alright on the night.

Other short chapters cover computer aided design (the book assumes you already have £50,000 of CAD equipment and explains how to provide the input), preparing assembly drawings, flow soldering (we use a soldering iron), and so on.

By all means buy the book if you are thinking of making a living from PCB design, but for the general reader I don't think there is enough relevant information to make it worthwhile.

Paul Chappell

INTRODUCTION TO MICROCOMPUTER ENGINEERING

Book

D.A. Fraser et al.
Ellis Horwood, Market Cross House, Cooper Street, Chichester, West Sussex, PO19 1EB

price: £13.75 (student edition).

There are six authors credited for this one book. Since there are nine chapters, either some authors worked harder than others or they wrote 1½ chapters each. Perhaps each author wrote every sixth word? Anyway, no matter how it was written the authors have come up with a very useful book indeed.

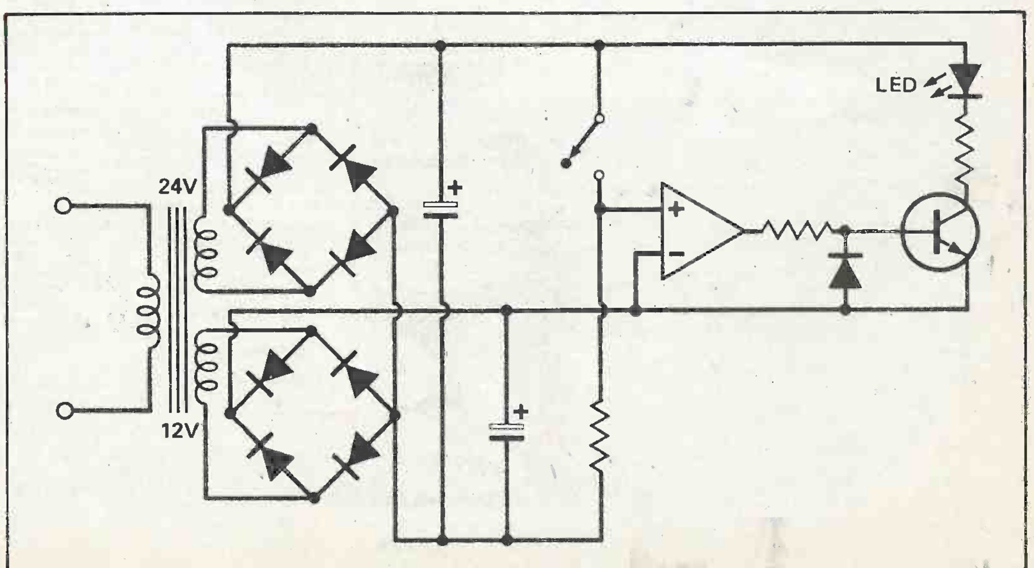
There are chapters on four of the most popular 8-bit microprocessors: the 8085, Z80, 6800 and 6502. There is enough detail for the reader to be able to use these devices in relatively simple systems without reference to any other data - a point I thoroughly approve of. Electrical specifications and timing limits are not included, but unless you're trying to squeeze every ounce of performance from the device you can probably do without them.

Sixteen-bit microprocessors are dealt with in considerably less detail, all in one chapter. Devices mentioned include the 8086, Z8000, 68000 and several others. If you want to use these devices you will certainly have to seek further information from manufacturers data sheets, but the book may help you select the best one for your purposes.

The rest of the book consists of a mixed bag of odds and ends, some of which are not often included in a book of this type. You will find descriptions of the IEEE 488 and S100 buses, some useful ideas on the use of interrupts and DMA, a brief description of fault signature analysis, and much more. If there is any fault in these chapters it is lack of detail, which is understandable in a book that covers so much ground. You get a taste of everything from video graphics to operating systems (CP/M and UNIX) without enough to satisfy you once your appetite has been whetted. However, there is a bibliography of books for further reading at the end...

Paul Chappell

ALF'S PUZZLE



History tells of many men of genius who failed to achieve recognition in their own lifetimes. This could so easily have been the case with Alf. Some of you may know of him as the inventor of the lithium raincoat, or perhaps as the founder of the Snipe Nosed Pliars Owners Club, a very exclusive organisation which to this day has only one member (Alf). To many of you he will be completely unknown.

How can this be when he has been beavering away in the basement of ETI headquarters for the past 15 years, barely taking the time to snatch forty winks in the broom cupboard each night before he's back at the workbench again?

The great tragedy of Alf's life is that none of his designs ever quite work. The circuit pictured here is one of his finest efforts. The idea is that as soon as the switch is turned on, an LED lights up to remind you to turn it off again. Sad to say, what actually happens is that the LED turns on for a few seconds and then stays off.

We can't let such a brilliantly conceived idea go to waste, so can any of you fathom out what's wrong with it? If you can, please don't write in because it would only upset Alf and distract him from work on his welly-bootstrap circuit. We'll let you know our solution next month and you can see if it agrees with your own.

PLAYBACK

Whenever some new development comes along which might become a money-spinner for the makers and a fact of life for the rest of us, it is usually launched with vigor and determination in at least two incompatible formats. We have the many world TV standards, the various cassette audio tapes (though fortunately all have fallen by the wayside except the now standard compact cassette) and the still active three video formats.

Now that the CCR (Camera Cassette Recorder) has come along to oust the cumbersome separate camera/recorder outfits, a ful-scale format war is once more under way, This has given rise to all the old problems, not least of which is indecision on the part of potential buyers. First-generation CCRs used standard VHS and Beta cassettes and were pretty hefty to lug around, so JVC produced their Compact VHS system. This uses half-inch tape in a tiny cassette, but can be played in a standard VHS machine by means of an adapter shaped like a normal VHS cassette.

That was back in 1981, the year after Sony announced their 8-mm system. Sony obtained the signatures of some 130 manufacturers to give them manufacturing rights and thereby virtually established it as the standard CCR system. However, many of these companies signed just to avoid being left out of the act and were not enthusiastic about the appearance of yet another video system.

When C-VHS appeared, many felt that the Sony system would die. It hasn't, and the new CCD-V8 camera recorder from Sony which fairly bristles with advanced features will undoubtedly ensure that 8-mm video will at least co-exist if not supercede the C-VHS system.

Metal particle tape is required to record video on such a narrow tape-width. There have been problems with metal tape in the past but it seems that these are being overcome. High-quality FM sound is a standard feature of the 8-mm system but may or may not be used with C-VHS, just as with standard VHS. Cassette running time is up to 90 minutes for 8-mm compared with 60 minutes for C-VHS.

So what about the incompatibility of 8-mm? Sony have overcome this one and at the same time upstaged JVC adverts by making a CCR which plugs directly into any TV or video monitor: you don't need another recorder to play their tapes back. JVC's claim that their system has 6 million advantages over 8-mm (these being the number of compatible VHS recorders in use) is therefore trumped by Sony's reply that they have 15½ million, which is the number of colour TV's in the UK. And that, they add, is only counting those who pay their licences.

Those of us who do not have £1000 to spare, — which I suspect is more than a few — can just sit back and enjoy the fun. Can't help thinking though, that an awful lot of effort is being wasted in these skirmishes.

Vivian Capel

GONE TO THE DOGS: the separate camera/recorder system has had its day, but strife dogs its successors.

TRAINS OF THOUGHT

To the railway modeller, the equivalent of the Holy Grail is a system that allows independent control of several trains simultaneously on the same layout. The two most frequently encountered methods are command control and cab control.

Command control makes the entire layout permanently live — normally with AC although DC systems have been developed — and each locomotive is equipped with a module which is effectively an on-train controller. This responds to instructions superimposed on the traction voltage by a master control unit.

Probably best known is Hornby's Zero-1 system. This makes extensive use of Texas Instruments TMS-1000 4-bit microprocessors in both the modules and the master control units. Up to 16 trains can be controlled at any of 16 speeds, forwards and reverse. A large number of trackside accessories can also be operated, drawing both power and data requirements from control codes superimposed on the square-wave traction supply.

In contrast to the advanced digital techniques employed by Hornby's system, the Airfix MTC (Multiple Train Control) uses some subtle analogue circuitry. Each on-train module is essentially a radio receiver responding to a pulsed radio-frequency carrier superimposed on the sine-wave traction supply. Again up to 16 trains can be used (though only four at a time), the 16 frequencies being digitally synthesised in the master control. Train direction is determined by the polarity of the traction supply during the RF pulses and speed by the duration of the pulses.

Both systems are reliable and easy to install, except that it can be awkward finding room for the modules in some smaller model locomotives. A disadvantage is that the system is not compatible with conventional operation — an unmodified locomotive will emit real smoke in a matter of seconds if placed on a live command control track. To adopt the system you must make the changeover and modify all your locomotives at once.

Switching Cabs

The alternative is cab control. In its simplest form this is not electronic but simply an arrangement of switches. The layout is divided into a number of control zones each of which can be connected by switches to any of several conventional (rheostat or electronic) controllers. As the trains progress around the layout passing from zone to zone, the switches are thrown manually so that each train keeps the same controller (or cab) for the whole of its journey.

However, with the availability of reliable train detection systems (discussed in the second article of this series) an automated version of cab control is feasible. This is called progressive cab control. Its implementation is tedious rather than difficult, requiring banks of logic circuitry (the complexity is proportional to the square of the number of controllers), but it should be possible to arrange for a microcomputer to perform the bulk of the logic. The computer would need a large number of input and output ports — an Apple IIe or BBC Micro with backplane suggest themselves — and also an interface unit containing the train detectors and relays to switch the contollers between sections.

Cab control systems, whether manual or automatic, result in festoons of spaghetti beneath the baseboard and debugging is a nightmare! By contrast, the two-wire command control system is utter simplicity. But an advantage of cab control is its compatibility with conventional control, enabling it to be extended across a layout zone by zone as time and money permit.

Roger Amos

OPEN CHANNEL

A number of press releases landed on my desk recently from British Telecom, announcing the launch of their advanced digital communications service. The service, says the press release, sets a new standard in business communications, with such benefits as:

- — an A4 page sent by facsimile in six seconds
- — photographic-quality colour pictures on videotex
- — slow-scan television
- — greater reliability

The new service is called integrated digital access (shortened, thankfully, to IDA). It is part of British Telecom's advancing programme of communications technology which will eventually lead to a digital telephone network providing all these facilities to every business or household in the nation. The complete network is called the integrated services digital network (shortened, again thankfully, to ISDN), and will be accessed by the user through the IDA service. So, you'll have gathered, British Telecom wants every user to have an IDA point through which all digital communications facilities will be routed, in much the same way that existing telephone points allow facilities such as computer communications (via modems), videotex services (Prestel), answering-phones etc.

IDA will be operated initially from the first System X exchange, opened recently at Baynard House in the City of London. It will cover Euston, the West End, the City and Southbank in London as well as parts of Bracknell, Bristol, Croydon, Reading and Slough. More local exchanges, in London, Milton Keynes, the Midlands and South Lancashire, are expected to be linked in to the network by the end of the year. By the end of 1987, British Telecom hope to have IDA available at 190 centres throughout Britain.

So what advantages are being forced upon us? Well, in the ISDN all communications are digital. That is, the actual telephone which the user speaks into and listens to converts the analogue audio signals directly into digital ones ready for transmission through the network. Contrast this with the existing telephone network where most signals are analogue and only some (over main trunk routes) are digitised for part of the journey. In theory at least, a digital network should provide a more reliable, higher quality and, best of all for the user, a *cheaper* service.

Anyway, that's the theory. And certainly, I for one, always thought this to be the case. I was looking forward to high quality speech and data communications and was ready to apply for an access point as soon as it became available (I live in one of those areas which is to get the service by the end of the year). I'm pretty fed up with having to shout down my telephone mouthpiece so that the other party can hear what I'm saying whenever I make anything other than a local call. As a freelance journalist I would also find the data transmission aspects of the network useful to download copy to editors, ready for publication. Perhaps readers have similar feelings. However, the same press release which brings the good news about IDA also gives prices — and these aren't so good.

For example, the cheapest IDA access consisting of a digital telephone with on-hook calling, (known as version NTE1) a keypad, a display, and one data port which can be configured to support a variety of terminals, will be installed for £890. It then costs £710 per year to rent. And if that's not all, customers outside the London, Birmingham, or Manchester areas will be subject to an out-of-area connection charge of either £350 (within the 'A' rate call charge area) or (like me) £700.

Excuse me for being so pessimistic, but if British Telecom thinks it can sell ISDN and IDA to potential customers at these prices, I believe it will have to think again. If the economic benefits of a digital network which British Telecom will derive (ie, lower maintenance costs, lower call costs etc) can't be passed on to the customer in the form of cheaper rentals and reasonable installation charges, then I can't see many potential customers buying the service. I'll certainly shout down a scratchy analogue line and post my copy to editors if it means I don't have to pay telephone bills of that order. British Telecom can, as the saying goes, stick it!

And There's More!

If you're a typical telephone user and use the 'phone quite regularly, you'll probably just dial a number you want to contact without thinking where the call is going to. After all, even calls to the far end of the country have a cost per unit of only about 5p. At standard rate times this amounts to only about 16p per minute. However, bear these two numbers in mind: 0860 and 0836. If the number you're about to ring is prefixed by either of these, then consider carefully the cost of dialling before you actually do it. These two prefixes indicate numbers that belong to cellphones, ie, telephones which are linked by a radio connection on one of the two existing cellular radio telephone systems. The cost per unit charge when making a call to a cell phone remains the same, but the call is charged *at the same rate as it would be if it were a call to the Irish Republic*, about 43p per minute for standard rate calls!

Its for yoo-hoo. I'll just reverse the charges!.

Keith Brindley

SCRATCH PAD

by Flea-Byte

My most profound apologies for my unexplained absence last month. Many of you may have thought that, like most of the other giants of British electronics, I too had been swept under by the encroaching tide of Japanese goodies, the fickle dollar exchange rate, the ridiculous postures that pass for economic policies in the Cabinet and the general subterranean level of competence among that noble breed - the British manager. No such luck! While the share tumbled, companies teetered, the Daily Maxwell played footsie with Uncle Clive and Sir Kenneth Corfield topped his recent failure to win the British Electronics Personality of the Year award by an even more astonishing failure to steer STC through the stormy seas of his own chairmanship, good ole Flea-byte was taking a well-earned rest from the solder and the sweat in a small but reasonably well-appointed guest house somewhere on the Costa Packet.

Fortunately, the Sun journalists were too busy identifying miscreants evading the formerly long arm of the law to recognise me. Almost certainly, were I not such a master of disguise, I would have been whisked back to the height of the English 'summer' to rescue Thorn-EMI, STC, GEC, Acorn and Sinclair Research - all of whom, should it have escaped your notice, sailed perilously close to the rocks during the balmy July days.

Now refreshed after many pleasant days spent discussing tax shelters with a man who introduced himself to me as 'A. Bank Robber', I have returned to the fray. To avoid misunderstanding, I must make it clear that, following Sir Kenneth's untimely departure from the helm of STC, I shall not be available to mount one of the economic rescues for which I am so deservedly unknown.

It's not that I have any principled objection to helping STC out of a scrape. On the contrary, Sir Kenneth Corfield's chairmanship has resulted in this company becoming a flagship for British industry. Among his more notable achievements - to be counted with the acquisition of ICL and the promise that shareholder dividends would be maintained at a time when share prices were going through the floor and profits were disappearing into the negative zone - was his audacious acceptance of a 48% pay rise in 1984. In case you think the labourer should be worthy of his hire, let me tell you that Sir Kenneth's salary at that point amounted to £297,000 a year. Any company that pays that sort of money is alright by me!

No, my reason for not wishing to shoulder the burden of STC's undoubted recovery is simply that I feel it would be far too partisan of me. After all, there are so many companies in need of a guiding hand that to devote all my considerable talent to just one would, I fear, be selfish. Thorn EMI's downturn in profits had already led to the departure of chairman Peter Laister before Corfield announced his resignation. GEC have remained profitable, thanks largely to their legendary cash-mountain (a billion or more pounds just collecting interest). Even so their recent profit announcement revealed disappointing figures. Acorn and Sinclair seem to have one foot permanently inside the bankruptcy court.

Looking at the way all this news has given the entire British electronics industry the shakes, duty dictates that I remain on the side-lines, egging the teams on to greater things. Readers can rest assured that Flea-byte will not take another holiday until confidence is restored and our electronics industry returns to its former glory. Well....

* * *

Crystal Balls

I notice that a company in North London has just launched the first all-British, electronic time machine. Anthony Bassett of Number One Electronics claims that the machine generates 'electromagnetic waves' which, apparently, encourage visions of the past to spring before your 'third eye' (that's the one we all have in the middle of our foreheads, you know!). Such machines have, of course, been known for some

PLAYBACK PLUS

The British Music Fair

The British Music Fair was open to the public for the first time this year, instead of being confined to the trade. To mark this it was held at Olympia 2, normally the site of computer shows and the Ideal Home Exhibition, in early August.

The big attraction was that you could try out the instruments. Anything from a penny whistle it said. I think I can avoid penny whistles.

Although there were plenty of instruments to try, and in some cases soundproof booths to try them in, you had to wait your turn, and compete with other people using the same demonstration room. Some stands had thoughtfully provided headphones. A friend of mine sensibly took a headphone amplifier and used that all day. The drum synthesizers in the lower hall were definitely not in a soundproof booth! It was noisy, so I wouldn't make a final decision about parting with green stuff there unless I had more patience than I actually have.

Even so there were a number of interesting new electronic instruments and sound modifying boxes there. For yonks I have wondered why musicians on stage don't make more use of radio microphones and guitar transmitters. Maybe their popularity will increase with the introduction of an economically priced guitar transceiver by TOA. They also do a more expensive version with two receiving antennas to remove the problem of RF dead spots. Trantec have produced an even lower cost one, priced at a mere £300.

Home recording addicts are being well looked after these days. Up to four instruments can be recorded at a time, it says, on the new Teczon Multi Dub 4x4 home recorder, and up to thirty three instruments recorded by bouncing from one track to another and overdudding. It costs £492 from John Hornby Skewes. They were also showing off an Audio Technica machine called the AT-RMX64, four track, six input cassette recorder. Being more steeply priced at £1100, it's probably aimed at professionals or very serious home recordists.

There were lots of new amplifiers, but the most interesting innovation is the Peavy Digital Energy Conversion Amplifiers. Does this mean class D (switched time - but they only used to work during the summer months when the television companies transmit nothing but repeats. By the way, Number Ones's previous big seller is a crystal ball or, in the technical jargon, gas-filled lightbulb.

* * *

A Knight To Remember

The saga of Sir Clive continues unabated, I'm afraid. Undaunted by the Daily Maxwell's strange will-he? won't-he? dance routine with Sinclair Research, unruffled by a 'Which?' report on the C5 which demonstrated that it would get you from A to B, as long as B was downhill and downwind of A and as long as the traffic fumes and towering juggernauts didn't get you first, the pert, ginger-haired genius is reported to have been observed setting up a new company. Another new company.

My usual reliable sources in the Goat and Feathers tell me that this one will be different. Sinclair Research's Nigel Searle says that, 'the new company will exist to provide services to Sinclair Research, which will primarily be the availability of Sir Clive himself.' Sir Clive, of whom it has been said that availability is his strongest suit, is currently reassuring the world that the Maxwell's departure from the scene is probably a blessing in disguise. Apparently, several other parties are interested in the possibilities Sinclair Research holds out for losing a great deal of money. Dixons - the high street store - have just agreed a deal with Sinclair and the Spectrum is selling well. In the Goat and Feathers, we nibble on such announcements with our beer — they're saltier than crisps.

Confirmation of Sir Clive's foresight, however, can be obtained from the gist of a speech he made earlier this year to the Radio, Electrical and Television Retailers Association (RETRA). The assembled high street dealers heard him say they could sell as many C5's as video recorders, that his pocket TV would soon be selling over 2 million units a year and that the future of the computer market was a portable with 'a real TV screen'. Sir Clive thinks the Japanese have got it all wrong with their concentration on LCD screens. 'The Japanese will fail,' he said, 'because they have continued to back LCDs.' At Sinclair Research, they have big plans for the 'no compromise' portable: pocket-sized, no doubt, featuring a high resolution colour monitor and all powered by a single PP3. Well, where would we be if it wasn't for our dreams?

* * *

Old Guard?

The editor tells me an appealing little story about Conservative Central Office, whom he phoned in order to get hold of some pictures to illustrate an ETI article. The pictures in question were photographs of John Butcher, Parliamentary Under Secretary at the Department of Trade and Industry, and Geoffrey Pattie, Minister with special responsibility for Information Technology. The photograph of Butcher was not too much of a problem, despite the fact that it arrived with a rubber-stamp mark threatening to engulf the Under Secretary. Pattie was another matter, how-ever. The man at Central Office wasn't even sure they had a photograph of him. When at length he managed to dig one up it proved to be ten years old, badly focused and scratched. The Minister was shown in pre-IT days — desporting himself with a small group of Tories from the Chertsey constituency party. Some might say this demonstrates the low regard in which Pattie and, by association, Information Technology are held by the Conservative Party. I prefer to think it has nothing to do with IT or Pattie's position, but rather reflects the man. Butcher, you see, is young, reasonably good-looking and decorated with a full head of hair. Poor Geoffrey Pattie, on the other hand, is old, bald and distinctly odd of aspect. Not at all the image of a Thatcher man!

* * *

Say That Again

Wading through the accumulated press releases on my desk, I came across this shining example of English as she is spoken: This JMS Drum Unit produces sounds which are indistinguishable, and in some cases better, than the real thing. Presumably, this means that some real drum sounds are indistinguishable from their synthesized equivalents and, at the same time, noticeably inferior. And now for the grammar....

mode) we wonder? They claim 90% efficiency and are applying for a stack of patents on the design. Odd, because class D was old when I was at college (many years ago). The DECA 700 and DECA 1200 amplifiers include compression circuits, overload protection and no measurable transient intermod distortion or slew rate distortion.

Then there's the Accessit Aphex aural exciter, a low cost domestic version of a professional product I had never even heard of. Apparently it makes any track of an instrument stand out on the recording, in a way which cannot be simulated by even the most sophisticated equalizer. How it works is secret, but my guess would be some kind of non-linear amplitude response, or perhaps some kind of digitally controlled attack enhancement. It would be interesting to try one out with a variety of waveforms and a scope...

Casio have produced a four channel sequencer with enough memory for 3600 notes in the manual recording mode (and half this in the real time recording mode). It's MIDI compatible, with a metronome built in for real time recording, and costs £295. Their newest, biggest synthesizer has a similar, eight track sequencer built in.

The Roland SRV-2000 reverb unit also offers MIDI, and it can work effectively in conjunction with the Yamaha synth mentioned below. It costs about £1400, and is rather more than your average reverb stuffed into a 100 watt combo. It allows you to program room dimensions, wall covering effects (damping), as well as special effects such as gated reverb. Thirty two different sets of parameters may be stored in memory, and activated via the MIDI connections.

Yamaha have a number of new products. The DX21 programmable synthesizer is one such - the spec reads like that of a computer, but one of the main features is that it is organised so that the 'non-computerate' can make good use of it. In common with the majority of new electronic instruments, it has MIDI. Among many sounds, it can simulate a guitar. Unlike other guitar synth units, the effect of string bending on only one string out of a chord can be simulated. Other synths just let you frequency shift the whole lot.

Let's hope the experiment pays off and the Music Fair stays open to the public. It's only three days out of six, after all - and for £3 you can see a great deal if you are organised.

Andy Armstrong

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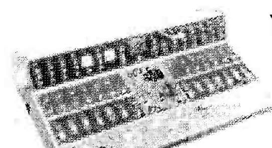

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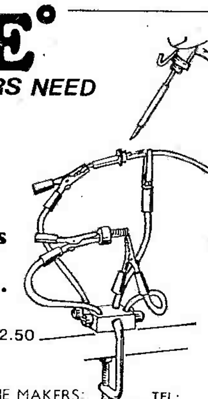

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Colour-coded IDC cables
- 16-way (XR80B) ONLY 32p per metre.
- 20-way (XR81C) ONLY 40p per metre.
- 26-way (XR82D) ONLY 54p per metre.
- 34-way (XR83E) ONLY 70p per metre.
- 40-way (XR84F) ONLY 82p per metre.
- 50-way (XR85G) ONLY 99p per metre.

4-way flat flexible telephone lead (XR86T) ONLY 18p per metre.
Stepper motor 48 steps/rev, 12V 0.13A per phase, 4-phase unipolar, 57g, working torque 8mNm max. ONLY £9.95 (FT73Q).
Driver chip for motor: SAA1027 ONLY £3.75 (QY76H).
★SAVE★ 1 Kit containing everything you need: motor, SAA1027, data sheet and passives ONLY £13.35 (LK76H).

Sounds Terrific

Professional Quality
High Power Loudspeakers
featuring:
- ★ Virtually indestructible high-temperature voice-coil reinforced with glass-fibre.
- ★ 100% heat overload tolerance.
- ★ Advanced technology magnet system.
- ★ Rigid cast alloy chassis.
- ★ Linen or Plastiflex elastomer surrounds.
- ★ 5-year guarantee (in addition to statutory rights).

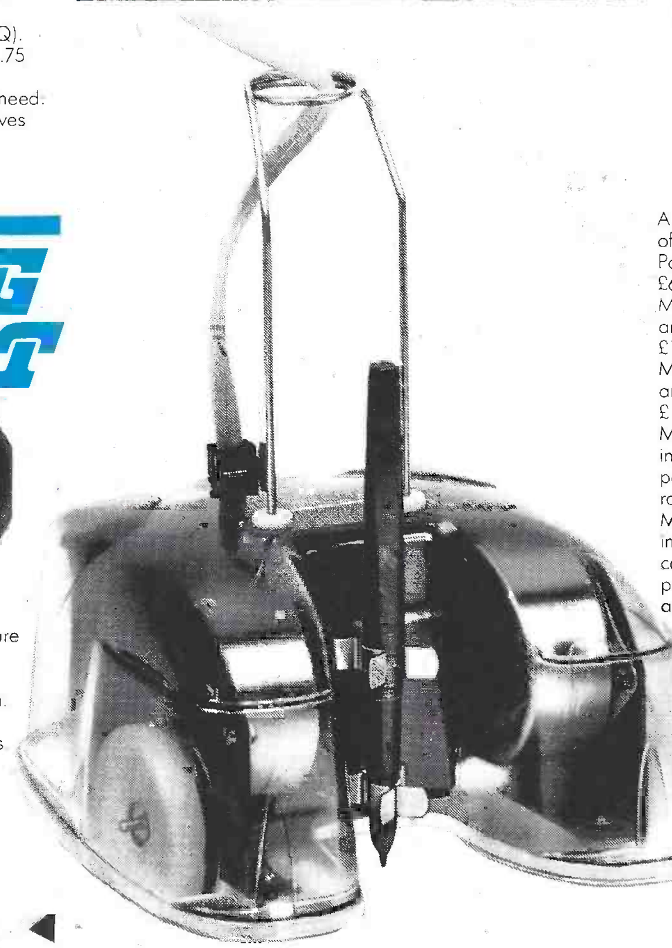
Prices from £18.95.
Send S.A.E. for our free leaflet XH62S.

Top Ten Kits

THIS/LAST MONTH	DESCRIPTION	CODE	PRICE	BOOK
1. (1)	Live-Wire Detector	LK63T	£2.95	14 XA14Q
2. (2)	75W Mosfet Amp.	LW51F	£15.95	Best E&MM
3. (3)	Car Burglar Alarm	LW78K	£7.49	4 XA04E
4. (7)	Logic Probe	LK13P	£10.95	8 XA08J
5. (5)	U/sonic Intrudr Dtctr	LW83E	£10.95	4 XA04E
6. (4)	Partylite	LW93B	£10.95	Best of E & MM
7. (6)	8W Amplifier	LW36P	£4.95	Catalogue
8. (–)	Noise Gate	LK43W	£9.95	Best E&MM
9. (9)	Computadrum	LK52G	£9.95	12 XA12N
10. (–)	DXer's Audio Processor	LK05F	£9.85	7 XA07H

Over 100 other kits also available. All kits supplied with instructions. The descriptions above are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate Project Book mentioned in the list above.

Is it a turtle? Is it a robot? Is it a buggy? Yes! it's Zero 2.



- May be used by any computer with RS232 facility.
- Stepper Motor controlled.
- Half millimetre/half degree resolution.
- Uses ordinary felt-tip pens.
- Built-in 2-tone horn, line-follower. LED indicators.

The Zero 2 Robot is the first truly micro robotic system available and remarkably it costs less than £80. Complete kit (only mechanical construction required) £79.95 (LK66W).
Full details of power supply and simple interfacing for BBC, Commodore 64 and Spectrum, in Maplin Magazine 15 price 75p (XA15R).

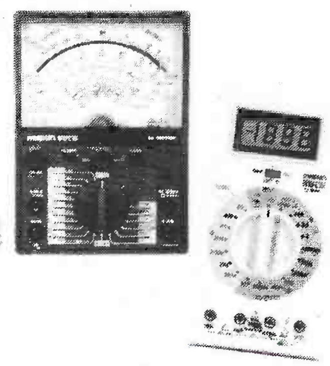
MAPLIN

MAPLIN ELECTRONIC SUPPLIES LTD

Mail-order: P.O. Box 3, Rayleigh, Essex SS6 8LR.
Teephone: Southend (0702) 552911
SHOPS
- BIRMINGHAM Lynton Square, Perry Barr, Tel: 021-356-7292.
- LONDON 159-161 King Street, Hammersmith, W6. Telephone: 01-748 0926.
- MANCHESTER 8 Oxford Road, Tel: 061-236 0281.
- SOUTHAMPTON 46-48 Bevois Valley Road. Tel: 0703-225831
- SOUTHEND 282-284 London Rd, Westcliff-on-Sea, Essex. Telephone: 0702-554000. *Shops closed all day Monday.*

More Choice In Multimeters

A new range of very high quality multimeters offering truly amazing quality at the price.
Pocket Multimeter, 16 ranges, 2,000Ω/V DC/AC £6.95 (YJ06G)
M-102BZ with continuity buzzer, battery tester and 10A DC range, 23 ranges, 20,000Ω/V DC £14.95 (YJ07H)
M-2020S with transistor, diode and LED tester and 10A DC range, 27 ranges, 20,000Ω/V DC £19.95 (YJ08J)
M-5050E Electronic Multimeter with very high impedance FET input, 53 ranges, including peak-to-peak AC, centre-zero and 12A AC/DC ranges £34.95 (YJ09K)
M-5010 Digital Multimeter with 31 ranges including 20Ω and 20μA DC/AC FSD ranges, continuity buzzer, diode test, and gold-plated pcb for long-term reliability and consistent high accuracy (0.25% +1 digit DCV) £42.50 (YJ10L)



The Maplin Service

All in-stock goods despatched same day for all orders received before 2.00 pm.
All our prices include VAT and carriage (first class up to 750g).
A 50p handling charge must be added if your total order is less than £5.00 on mail-order (except catalogue).

☎ Phone before 2.00 p.m. for same day despatch.

Top Ten Books

1. (1)	Loudspeaker Enclosure Design and Construction	WM82D	£3.25
2. (4)	Mastering Electronics	WM60Q	£4.70
3. (3)	Remote Control Projects	XW39N	£2.75
4. (9)	How to Build Your Own Solid State Oscilloscope	XW07H	£2.10
5. (5)	International Transistor Equivalents guide	WG30H	£3.25
6. (8)	How to Design and Make Your Own PCBs	WK63T	£2.05
7. (2)	Power Supply Projects	XW52G	£2.10
8. (–)	Radio Control for Beginners	XW66W	£1.95
9. (–)	How to Use Op-amps	WA29G	£2.45
10. (7)	Electronic Synthesiser Projects	XW68Y	£1.95

All offers subject to availability.
Prices firm until 9th November 1985.