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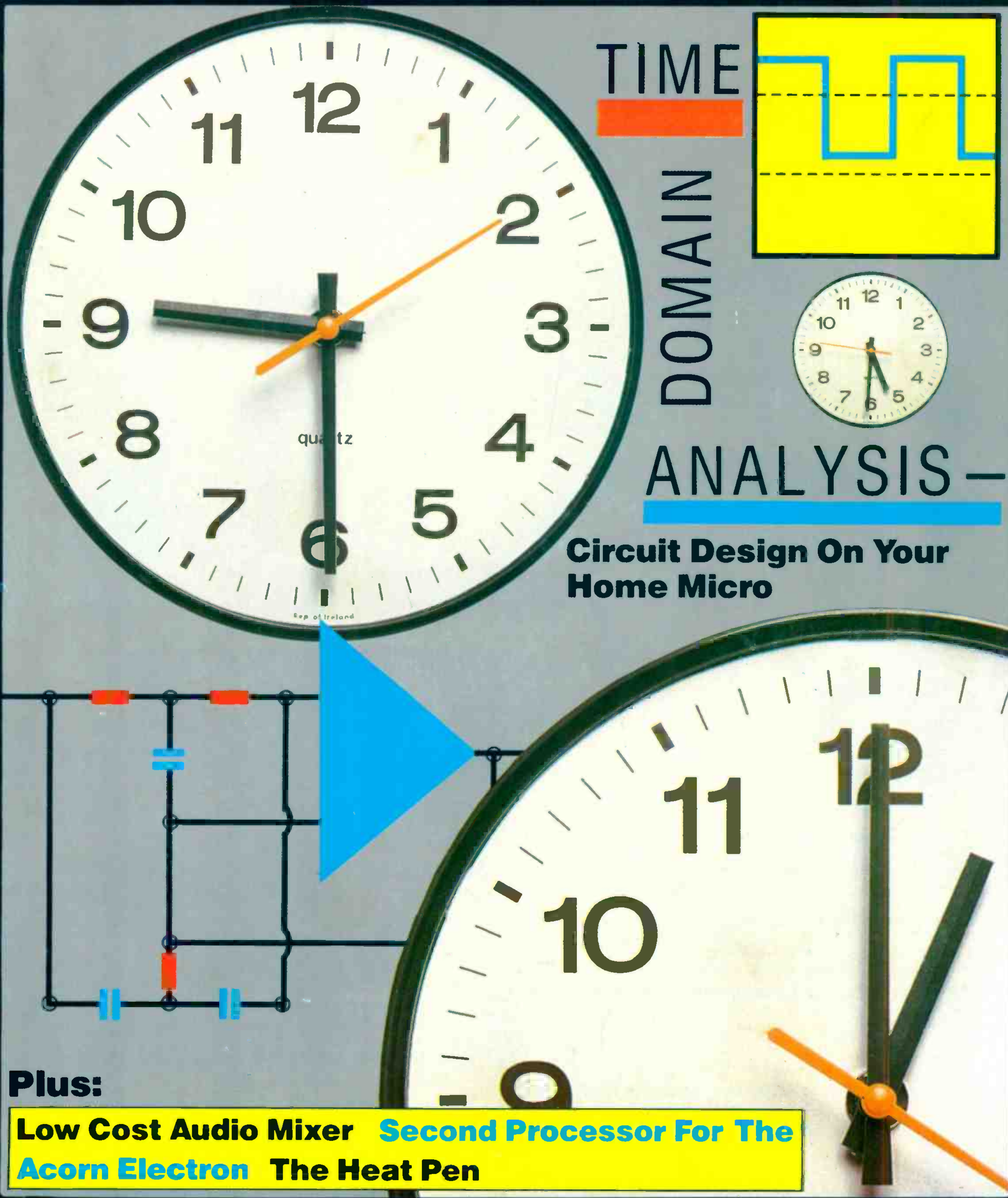

TIME DOMAIN ANALYSIS —

Circuit Design On Your Home Micro

Plus:

Low Cost Audio Mixer **Second Processor For The Acorn Electron** **The Heat Pen**

AUDIO.... COMPUTING.... MUSIC.... RADIO.... ROBOTICS...

Genesis P
Micro Grasp

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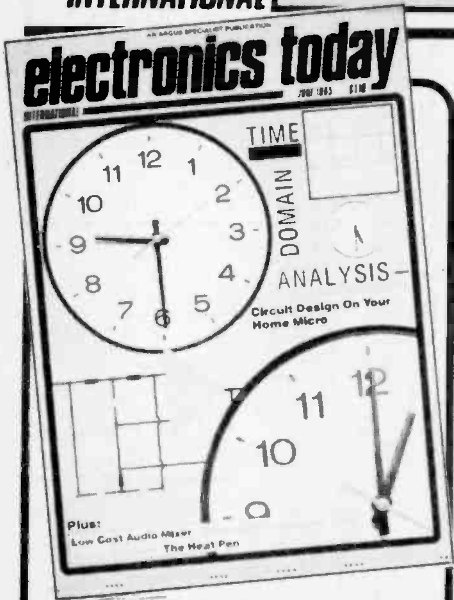
JUNE 1985 VOL 14 NO 6



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FEATURES

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INFORMATION

WATFORD ELECTRONICS

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ELECTROLYTIC CAPACITORS: (Values in uF) 500v: 10uf **52**; 47 **78p**; 63V: 0.47, 1.0, 1.5, 2.2, 3.3, 4.7 **8p** 10 **10p**; 15, 22 **12p**; 33 **15p**; 47 **12p**; 68 **20p**; 100 **19p**; 220 **26p**; 1000 **70p**; 2200 **99p**; 50V: 68 **20p**; 100 **17p**; 220 **24p**; 40V: 22 **9p**; 33 **12p**; 330, 470 **32p**; 1000 **48p**; 2200 **90p**; 25V: 1.5, 4.7, 10, 22, 47 **8p**; 100 **11p**; 150 **12p**; 220 **15p**; 330 **22p**; 470 **25p**; 680, 1000 **34p**; 1500 **42p**; 2200 **50p**; 3300 **76p**; 4700 **92p**; 16V: 47, 68, 100 **9p**; 125 **12p**; 330 **16p**; 470 **20p**; 680 **34p**; 1000 **27p**; 1500 **31p**; 2200 **26p**; 4700 **72p**.

TAG-END CAPACITORS: 64V: 2200 **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 **42p**; 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/300V **7p**; 200nF/6V **8p**.

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

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

SILVER MICA (Values in pF)
2, 3.3, 4.7, 6.8, 8.2, 10, 12, 15, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180pF **15p each**
200, 220, 250, 270, 300, 330, 360, 390, 470, 800, 820 **21p each**
1000, 1200, 1800, 2200 **30p each**
3300, 4700pF **80p**

Hitachi 256K DRAM £35
2764 250ns £4.25
27128 250ns £9.75

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 **25p**
8 Commoned (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K & 100K **26p**

DIODES

AA119	8
AA129	10
AAY30	8
BA100	10
BY100	15
BY126	12
BY127	10
CRO33	198
OA9	10
OA47	18
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	17
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	60

BRIDGE RECTIFIERS

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	30
2A/50V	28
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

ZENERS

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

TRIACS

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

VARICAPS

BA102	50
BB105B	40
BB106	40
BB109B	45

75 SERIES

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

[illegible]

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

DIAC

ST2	25

COMPUTER ICs

2102L	160	81LS95	175	RO-3-2513U	650
2114	275	81LS96	175	SAA5050	875
2147	300	81LS97	175	SFF9364	800
2516	350	81LS98	175	SP0256	850
2532	400	8202	£25	SPO256AL2	475
25L32	450	8205	225	TCJ3101J	£13
2564	600	8212	220	TMS2716-3V	725
26501	75	8214	495	TMS4047	100
2716-5V	350	8216	150	TMS4164	395
2732-4	450	8224	300	TMS4416-2	595
2764-250	425	8226	300	TMS4500	£12
27C64	1000	8228	310	TMS4532-3	350
27128-250	995	8236	00	TMS5100	600
"NEW" 256K "D"		8243	290	TMS6011	500
RAM 150NS	£25	8250	£11	TMS9914	895
3242	675	8251A	350	TMS9927	£14
4027	95	8253	1370	TMS9928	£16
4116-200n	125	8255	400	TMS9929	£16
4164-150n	425	8256AC	£15	TMS9980	£12
4416-2	425	8257-5	400	TMS9995	£12
4532-3	250	8259	400	ULN2003	75
4532-4	250	8271	£50	UPD7002	725
4816-100ns	200	8272	£15	WD1691	£14
4864-15	425	8279	750	WD1770	£20
5514	250	8282	450	WD2143	850
6116-150	325	8283	450	Z80CPU 2.5	295
6116L-120	350	8284	550	Z80ACPU 4M	380
6117-100n	575	8288	£11	Z80 CTC	285
6167-6	795	8748	£55	Z8002CPU	00
6264L-15	£16	8T26A	99	Z80A CTC	310
63A03	£14	8T27	150	Z80BCPU	£11
6402	350	8T31	350	Z80 DART	650
6464L-15	£11	8T95	90	Z80A DART	800
6502CPU	325	8T97N	90	Z80B	£8
6502A	545	9602	220	Z80 DMA	795
6503	350	AM26LS31C	125	Z80ADMA	925
6503	650	AM26LS32A	125	Z80 PIO	250
6504	600	AM26LS33	150	Z80A PIO	315
6504 250	550	AM7910	£30	Z80 SIO-1	850
6505	650	AY-3-1015	300	Z80A SIO	£9
6505	600	AY-5-1013	300	Z80ASIO-2	£9
6520PIA	175	CD4724	150		
6522VIA	340	COM8017	275		
6530	£11	COM8116	700		
6532RRIOT	650	D8748	£55		
6545RTC	899	DM8131	275		
6551ACIA	650	DP8303	450		
6592	00	DP8304	350		
6592PC	£20	DS3647	00		
6800	220	DS3691N	£5		
6802	275	DS88LS120	495		
6803	850	DS8820	110		
6805	670	DS8830	140		
6808	520	DS8831	125		
6809E	880	DS8832	200		
6810	150	E9364	800		
6821	150	E9365	£28		
68B21	220	FD1691	£15		
6840	375	FD1771	£15		
6843	800	FD1791	£22		
6845	650	FD1795	£28		
6845SP	750	HD26501	75		
6847	650	HD63AO3RP	£14		
6850	120	HM6845SP	755		
6852	250	IM6402	380		
6854	625	INS8060N	1250		
68B54	750	MC1488	100		
6859	£4	MC1489	100		
6875	500	MC14411	675		
68000	£30	MC14412	725		
8035	350	MC3242	590		
8080A	425	MC3446	250		
8085	£8	MC3447P	315		
8085A	950	MC3486	225		
8088	£15	MC3487	225		
8123	160	IM6402	350		
8131	475	MC6845	625		
8150	800	MC6846	625		
8154	750	MK3886-2M	£7		
8155	400	MM5280D	696		
8156	400	MM5303	638		
		MM5307	1275		
		MM5387A	865		
		MM58174	875		
		MM74C922	420		
		RO-3-2513L	700		

LINEAR ICs

555Cmos	95	CA3081	180	MC1303	96	TDA2020	320
702	75	CA3085	160	MC1304P	260	TDA2030	190
709C 8 pin	35	CA3086	60	MC1310P	150	TDB0791	420
710	48	CA3089E	200	MC1445	250	TL170	50
741 8 pin	16	CA3090AQ	375	MC145106	695	TL430C	90
747C 14 pin	70	CA3123E	165	MC1455	50	TL497A	500
748C 8 pin	30	CA3130	90	MC1458	35	TL507	110
735 8 pin	185	CA3140	45	MC1469	300	TL509	110
810	158	CA3160	90	MC1494	694	TL061CP	40
9400CJ	375	CA3161	180	MC1495	350	TL062CP	65
ADC0808	1000	CA3162	525	MC1496L	70	TL064CN	95
AY-1-1320	225	CA3189	275	MC1596	225	TL071CP	40
AY-1-5050	99	HA1336W	175	MC1648	290	TL072CP	75
AY-1-5051	160	HA1388	235	MC1709G	90	TL074CN	130
AY-1-6720	210	ICL7106	675	MC3302	75	TL081CP	35
AY-3-1270	730	ICL7107	975	MC3401	50	TL082CP	55
AY-3-1350	350	ICL7611	99	MC3403	95	TL083CP	75
AY-3-8910	150	ICL7660	248	MC3404	85	TL084CN	110
Booklet for		ICL8038CC	345	MC3405	150	TL091CP	60
AY-3-8910	150	ICL8211A	750	MC3422	00	UA2240	120
AY-3-8912	500	ICM7205A	1150	MC3423	80	UA78540	230
AY-5-1317A	630	ICM7215	1050	MC3442	00	ULN2003	90
AY-5-1350	366	ICM7216AJ	£22	MC3487	00	ULN2004	90
CA3011	130	ICM7216C	£22	MC4016	00	ULN2283	150
CA3012	175	ICM7217A	750	MF10	300	ULN2803	190
CA3014	275	ICM7224	£11	MFC6040	75	UPC575	275
CA3018	85	ICM7240	300	ML924	275	UPC1025H	375
CA3019	90	ICM7555	105	NE515	275	UPC1156H	295
CA3020	210	ICM7556	150	NE529	225	UPC1182	425
CA3023	210	LA3550	250	NE531	140	UPC1366	195
CA3028A	110	LA4031P	340	NE543K	225	XR2206	375
CA3035	255	LA4032	295	NE544	200	XR2207	400
CA3036	270	LA4400	350	NE555	25	XR2211	575
CA3043	275	LA4422	320	NE556	65	XR2216	675
CA3045	385	LC7130	320	NE558	170	XR2266	360
CA3046	70	LC7120	300	NE560	350	ZN414	80
CA3059	325	LC7137	350	NE562B	410	ZN419E	180
CA3075	213	LF347	150	NE564	420	ZN423E	130
CA3080E	70	LF351	60	NE565A	120	ZN424E	130
		LF353	90	NE566	155	ZN425E	595
		LF355	90	NE567V	140	ZN426E	200
		LF356	90	NE570	410	ZN427E	600
		LF357	100	NE571	400	ZN428E	450
		LF398	495	NE5532	175	ZN429E	240
		LM10	325	NE5534A	160	ZN459	615
		LM301A	30	OM335	750	ZN1034E	200
		LM307	45	RC4136D	60	ZN1040E	665
		LM308T	75	RC4558	55	ZNA234E	925
		LM311	60	S566B	225		
		LM318N	150	SAB3209	425		
		LM319	180	SAB3210	325		
		LM324A	45	SAB3271	485		
		LM334Z	150	SAB4209	585		
		LM335Z	135	SG3402	295		
		LM337	275	SL490	350		
		LM339	40	SL6270CD	150		
		LM348	60	SN76227N	95		
		LM349	125	SN76477	470		
		LM358	50	SN76488	525		
		LM377	210	SP8629	350		
		LM379	495	SP0256AL	475		
		LM380	115	TA7120	140		
		LM381N	175	TA7204	150		
		LM382	200	TA7205	90		
		LM384	225	TA7222	150		
		LM386	110	TA7310	125		
		LM387	200	TAA661A	190		
		LM389	160	TAA700	275		
		LM393	85	TAA900	395		
		LM394CH	380	TAB1042	110		
		LM558	170	TAD100	159		
		LM725CN	300	TBA120S	70		
		LM733	65	TBA900	395		
		LM1458	35	TAB1042	110		
		LM1871	300	TAD100	159		
		LM1889	400	TBA120S	70		
		LM2907	395	TBA920Q	200		
		LM2917	325	TBA990Q	350		
		LM3900	70	TCA220	350		
		LM3909N	85	TCA270Q	350		
		LM3911	185	TCA280A	220		
		LM3914	300	TCA940	175		
		LM3915	345	TCA965	180		
		LM3916	300	TDA1004	350		
		LM13600	150	TDA1008	310		
		LS7220	280	TDA1010	235		
		M706B1	150	TDA1022	499		
		MS1513L	230	TDA1024	115		
		MS1515L	320	TDA1034	350		
		MS1516L	475	TDA1490	350		
		MB3712	200	TDA2002	325		
		MB3756	440	TDA2003	250		
		MC1204	250	TDA2004	270		
		MC1301	90	TDA2006	320		

TRANSISTORS

AC126/7	35	BC327	15	BF336/7	35	MPSU06	60	ZTX107/8	12	2N3820	60	2SC2335	200
AC141/2	35	BC337/8	15	BF394	40	MPSU52	65	ZTX109	12	2N3822/3	60	2SC2547	40
AC176	35	BC441/61	34	BF451	40	MPSU55	60	ZTX212	28	2N3866	90	2SC2612	200
AC187	35	BC477	40	BF494/5	40	MPSU56	60	ZTX300	13	2N3903/4	18	2SD234	74
AC188	35	BC516/7	40	BF594/5	30	OC26	170	ZTX302	16	2N3905/6	15	2SK45	80
ACY19/21	75	BC547/8	12	BFR39/40	30	OC28	220	ZTX303	25	2N3908	17	2SK288	225
ACY22/41	75	BC549C	15	BFR41/79	25	OC35	50	ZTX304	17	2N4037	60	2SJ83	225
AD142	120	BC556/7	15	BFR80/81	25	OC36/41	75	ZTX326	30	2N4058	15	2SJ85	225
AD149	79	BC558/9	15	BFR98	105	OC42/75	75	ZTX451	23	2N4061/2	15	3N128	115
AD161	42	BCY39/40	85	BFX29	35	OC71/72	50	ZTX500	14	2N4264	30	3N140	115
AD162	42	BCY41/42	30	BFX81	45	OC75/76	55	ZTX501/2	15	2N4286	25	40315	90
AF115/6	80	BCY45	50	BFX84	35	OC81/82	50	ZTX503	18	2N4289	25	40316	95
AF188	80	BCY58/59	36	BFX85/6	35	OC83/84	70	ZTX504	25	2N4314	78	40324	100
AF124/26	70	BCY70/71	18	BFY50/51	30	OC170/71	75	ZTX531	125	2N4400	25	40326/7	70
AF139	40	1BCY72	25	BFY52	30	OC70	40	ZTX550	25	2N4427	80	40347	90
AF178	75	BCY78	30	BFY53	35	OC200	75	2N697	23	2N4871	55	40348	120
AF186	70	BD114	190	BFY55/56	56	TIP29A	32	2N698	40	2N5135/6	30	40360	60
AF239	55	BD121	95	BFY64	40	TIP29C	38	2N699	48	2N5138	25	40361/2	70
BC107	12	BD124	115	BFY81	120	TIP30A	35	2N706A	25	2N5172	25	40407/8	75
BC107B	14	BD131/32	65	BFY90	80	TIP30C	37	2N708	25	2N5179	45	40411	285
BC108	12	BD133	70	BRY39	50	TIP31A	38	2N918	40	2N5180	45	40412	90
BC108B	14	BD135	45	BSX20	30	TIP31B	39	2N1131/2	40	2N5190/1	75	40467A	130
BC108C	14	BD136/37	40	BSX26/29	45	TIP31C	45	2N1302	45	2N5194	80	40468	85
BC109	12	BD138/39	40	BSY26	35	TIP32A	43	2N1307	70	2N5305/8	30	40594	105
BC109B	14	BD140	40	BSY95	35	TIP32C	45	2N1671B	160	2N5457/8	30	40603	110
BC109C	14	BD144/45	198	BU105	180	TIP33A	70	2N2160	325	2N5459	30	40673	75
BC114/5	30	BD158	68	BU205	180	TIP33C	75	2N2219A	28	2N5485	36	40871/2	90
BC117/8	25	BD205/6	110	BU206	200	TIP34A	85	2N2220A	28	2N5777	45		
BC137/9	40	BD245	65	BU208	200	TIP34C	105	2N2221A	25	2N5879	180		
BC140	38	BD378	70	BUY69C	225	TIP35A	120	2N2222A	25	2N6027	32		
BC142/3	38	BD434	70	MD8001	250	TIP35C	130	2N2358	25	2SA671	250		
BC147	12	BD517	75	MJ2955	90	TIP36A	130	2N2369A	18	2SA715	75		
BC147B	15	BD645	80	MJE170	150	TIP36C	140	2N2483/4	27	2SC495	85		
BC148	12	BD695A	150	MJE180	150	TIP41A	50	2N2646	48	2SC496	85		
BC148B	15	BD696A	150	MJE340	54	TIP41B	52	2N2904/5	28	2SC1061	250		
BC149	12	BF115	45	MJE370	100	TIP42A	55	2N2906/7	28	2SC1096	85		
BC149C	15	BF154/8	30	MJE371	100	TIP42B	58	2N2907A	28	2SC1162	45		
BC182L	10	BF167	35	MJE520	85	TIP120	70	2N2926G	10	2SC1173	125		
BC183L	10	BF173	35	MJE521	96	TIP121/2	73	2N3053	25	2SC1306	100		
BC184	10	BF177	35	MJE2955	98	TIP141/2	120	2N3054	55	2SC1307	150		
BC184L	10	BF178	35	MJE3055	70	TIP147	120	2N3055	50	2SC1449	95		
BC186/7	28	BF179	40	MPF102	40	TIP2955	70	2N3252	48	2SC1678	140		
BC188 6/7	25	BF184/5	38	MPF103	30	TIP3055	70	2N3441/2	140	2SC1679	180		
BC12	10	BF194/5	12	MPF104	30	TIS43	50	2N3614/5	180	2SC1923	65		
BC212L	12	BF198/9	18	MPF105	30	TIS44/5	45	2N3663	20	2SC1945	225		
BC213	10	BF200	60	MPF106	40	TIS88A	50	2N3702/3	10	2SC1963	80		
BC213L	12	BF224A	40	MPSA05	30	TIS90/91	30	2N3704/5	10	2SC1957	80		
BC214	10	BF224B	40	MPSA08	30	UC	65	2N3706/7	10	2SC1969	160		
BC214L	12	BF245	50	MPSA12	32	VK1010	99	2N3708/9	10	2SC2028	85		
BC237/8	15	BF256A	45	MPSA55	30	VN10KM	70	2N3713	140	2SC2029	200		
BC256B	35	BF256B	50	MPSA56	30	VN46AF	95	2N3771	179	2SC2078	170		
307B	15	BF257/8	32	MPSA70	40	VN66AF	110	2N3772	195	2SC2091	85		
BC308	16	BF259	40	MPSU02	58	VN88AF	120	2N3773	210	2SC2314	86		
BC318	80	BF275	55	MPSU05	60	VN89AF	120	2N3819	35	2SC2166	105		

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

TTL74

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

74C

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

74S

S00	49
S02	40
S03	40
S04	40
S05	40
S08	40
S09	40
S10	40
S11	40
S15	60
S20	40
S22	40
S30	60
S32	50
S37	50
S38	70
S40	40
S51	40
S64	40
S65	40
S74	70
S85	295
S86	100
S112	150
S113	120
S114	120
S124	300
S132	90
S133	50
S134	60
S135	110
S138	170
S139	170
S140	60
S151	140
S153	140
S157	200
S158	190
S162	300
S163	300
S174	250
S175	300
S188	200
S189	225
S194	280
S197	300
S201	250
S225	500
S226	350
S240	375
S241	375
S244	474
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
S471	600
S472	400
S474	400
S475	425
S571	300
S573	450

74LS

LS00	25	LS195	75
LS01	25	LS196	85
LS02	25	LS197	85
LS03	25	LS221	85
LS04	25	LS240	80
LS05	25	LS241	80
LS08	25	LS242	95
LS09	25	LS243	95
LS10	25	LS244	80
LS11	25	LS245	120
LS12	25	LS247	105
LS13	35	LS248	105
LS14	50	LS249	105
LS15	25	LS251	75
LS19	45	LS253	75
LS20	25	LS256	120
LS21	25	LS257	75
LS22	25	LS258	75
LS24	50	LS259	125
LS26	25	LS260	70
LS27	25	LS261	100
LS28	25	LS266	60
LS30	25	LS273	120
LS32	50	LS275	350
LS33	25	LS279	70
LS37	25	LS280	180
LS38	30	LS283	80
LS40	25	LS290	80
LS42	50	LS293	80
LS47	80	LS294	999
LS48	90	LS295	140
LS49	100	LS297	850
LS51	25	LS298	100
LS52	25	LS299	225
LS54	25	LS320	210
LS55	25	LS322	360
LS63	55	LS323	400
LS73	30	LS324	150
LS74	35	LS325	150
LS75	45	LS326	290
LS76	40	LS327	290
LS78	40	LS347	120
LS83	70	LS348	140
LS85	70	LS352	110
LS86	35	LS353	110
LS90	50	LS355	220
LS91	90	LS356	200
LS92	55	LS363	150
LS93	55	LS264	150
LS95	70	LS365	50
LS96	90	LS366	50
LS107	40	LS367	50
LS109	45	LS368	50
LS112	45	LS373	100
LS113	40	LS374	100
LS114	40	LS375	70
LS122	70	LS377	130
LS123	100	LS378	95
LS124	125	LS379	130
LS125	100	LS380	310
LS126	50	LS382	310
LS132	60	LS384	460
LS133	50	LS385	330
LS135	28	LS386	50
LS136	45	LS390	60
LS138	60	LS393	100
LS139	60	LS395	110
LS145	95	LS396	300
LS147	165	LS398	195
LS148	130	LS399	135
LS151	70	LS445	125
LS153	70	LS447	80
LS154	155	LS465	140
LS155	70	LS490	150
LS156	70	LS540	140
LS157	60	LS541	140
LS158	60	LS624	155
LS160	70	LS629	130
LS161	70	LS640	200
LS162	70	LS641	150
LS163	70	LS645	195
LS164	75	LS668	90
LS165	110	LS669	90
LS166	150	LS670	170
LS168	140	LS673	890
LS169	100	LS674	800
LS170	140	LS678	275
LS173	100	LS682	250
LS174	75	LS684	350
LS175	70	LS687	350
LS181	190		
LS183	190		
LS190	85		
LS191	85		
LS192	100		
LS193	100		
LS194	75		

SWITCHES

TOGGLE 2A 250V
SPST 35p DPDP 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	
SPDT latching	150p
DPDT latching	200p
SPDT moment	150p
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

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: (Mak-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	38p
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	165p	240p	380p
Double ended DIP (Header Plug) Jumper				
6 inches	185p	205p	300	485
12 inches	198p	215p	315p	480p
24 inches	210p	3235p	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	280p	300p
Double ended	290p	370p	480p	525p

VEROBOARD 0.1in

2½ x 3¾	95p
2½ x 5	110p
3¾ x 3¾	110p
3¾ x 5	125p
3¾ x 17	420p
4¾ x 17	590p
Pkt of 100 pins	55p
Spot face cutter	150p
Pin insertion tool	185p

VQ Board	195p
DIP Board	395p
Vero Strip	95p

PROTO DECs

Veroblock	480p
S-Dec	395p
Eurobreadboard	590p
Bimboard 1	575p
Superstrip SS2	1350p

VERO WIRING PEN

+ spool	380p
Spare spool	75p
Combs	8p

DALO ETCH RESIST PEN

Plus spare tip **100p**

FERRIC CHLORIDE

1 lb bag Anhydrous
195p + 50p p&p

ULTRASONIC TRANSDUCER

40KHz **475 pr**

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

2x6 way	—	111p
2x12 way	—	160p
2x15 way	—	165p
2x18 way	210p	175p
2x22 way	215p	250p
2x23 way	175p	—
2x25 way	285p	275p
2x28 way	190p	—
2x30 way	310p	—
2x36 way	360p	—
2x40 way	380p	—

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

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	205p	236p	160p	320p
40 way	220p	250p	180p	340p
50 way	235p	270p	200p	395p
60 way	—	—	230p	495p

EURO CONNECTORS

Gold Flashed Contacts	Female Strt Pins	Socket Angle Pins	Male Strt Pins	Plug Angle Pins
DIN41617 31 way	170p	—	—	175p
DIN41612 2 x 32 A + B	275p	·	220p	285p
DIN41612 2 x 32 A + C	295p	·	240p	300p
DIN41612 3 x 32 A + B + C	360p	385p	280p	395p

DIL PLUG (Header)

	Solder	IDC
14 pin	40p	90p
16 pin	48p	105p
24 pin	88p	178p
28 pin	290p	295p
40 pin	250p	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	160p	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	465p	460p
36 way Centronix	450p	475p
36 way Female	480p	450p

PANEL METERS

FSD
60 x 46 x 35mm
0–50µA
0–100µA
0–500µA
0–1mA
0–5mA
0–10mA
0–50mA
0–100mA
0–500mA
0.aA
0.2A
0.25V
0.50V AC
0.300V AC
"S"
"VU" **490p each**

CRYSTALS

32.768KHz	100
100KHz	545
200KHz	370
455KH	370
1MHz	265
1.008M	275
1.28MHz	450
1.6MHz	200
1.8MHz	545
1.8432M	230
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	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	140
6.5536MHz	225
7.0MHz	150
7.168MHz	200
7.7328MHz	250
7.68MHz	200
8.0MHz	150
8.089333M	395
8.86723M	220
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	200
16.0MHz	200
18.0MHz	180
18.432M	150
19.968MHz	150
20.0MHz	200
24.0MHz	170
24.930MHz	325
26.69M	150
27.648M	170
27.145M	180
38.6667M	240
48.0MHz	240
100.0MHz	295
116.0MHz	300

RELAYS

Miniature, enclosed, PCB mount.

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

DOUBLE POLE Changeover, 6A 30V DC or 250V AC
RL-100 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	550p

BUZZERS

miniature, solid-state 6V, 9V & 12V	70p
PIEZO TRANSDUCERS PB2720	70p

LOUDSPEAKERS

Miniature, 0.3W - 8	
2in, 3¼in, 2½in, 3in	80p
2½in 40Ω 64Ωor 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, 14" Colour RGB Input. Connecting cable incl. **£165**
- 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	425	415
27128-250nS	975	965
6116LP-120nS	325	310
6264LP-150nS	995	965

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-0.1A **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-1.3A, 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)
Specially wound for Multirail computer PSUs
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 **965p** (75p)

P&P charge to be added over and above our normal postal charge

VOLTAGE REGULATORS

1A TO220 Plastic Casing

	+ ve		− ve	
5V	7805	50p	7905	50p
12V	7812	50p	7908	60p
15V	7815	45p	7912	50p
18V	7818	45p	7915	50p
24V	7824	50p	7918	50p
			7924	50p

100mA TO92 Plastic package

5V	78L05	30p	79L05	50p
6V	78L06	30p	—	—
8V	78L08	30p	—	—
12V	78L12	30p	79L12	50p
15V	78L15	30p	79L15	60p

ICL7660	248p	TAA550	50p
RC4194	375p	TDA1412	150p
RC4195	160p	78H05 + 5V/5V	550p
LM309K	135p	78H12+12V/5A	640p
LM317K	250p	78HG + 5V to + 25V 5A	585p
LM317KP	450p	79HG − 2.25V to −24V; 5A	685p
LM323K	450p		
LM337	175p		
LM723 Var	30p		
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
5 x 4 x 2"	120p
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

CMOS

4000	20	4072	25	4536	275
4001	25	4073	26	4538	80
4002	25	4075	25	4539	90
4006	70	4076	68	4541	95
4007	25	4077	25	4543	70
4008	60	4078	25	4548	40
4009	45	4081	25	4549	400
4010	45	4082	25	4553	245
4011	25	4085	80	4554	180
4012	25	4086	60	4555	35
4013	35	4089	125	4556	55
4014	60	4093	37	4557	250
4015	60	4094	70	4558	120
4016	40	4095	95	4559	395
4017	60	4096	100	4560	180
4018	60	4097	275	4561	104
4019	58	4098	80	4562	350
4020	80	4099	110	4566	165
4042	43	4160	95	4568	250
4021	58	4161	96	4569	175
4022	67	4162	96	4572	45
4023	30	4163	96	4580	255
4024	50	4174	96	4581	125
4025	22	4175	105	4582	99
4026	90	4194	105	4583	100
4027	40	4408	850	4584	60
4028	50	4409	850	4585	70
4029	75	4410	725	4597	330
4030	35	4411	750	4599	158
4031	130	4412	805	40085	90
4032	70	4415	590	40097	45
4033	130	4419	280	40098	42
4034	146	4422	770	40100	215
4035	70	4435	850	40101	130
4036	275	4440	900	40102	140
4037	115	4450	360	40103	412
4038	75	4451	350	40104	120
4039	280	4490	450	40105	220
4040	60	4500	395	40106	60
4041	57	4501	38	40107	55
4042	50	4502	60	40108	325
4043	42	4503	40	40109	100
4044	50	4504	99	40110	235
4045	110	4505	385	40114	240
4046	60	4506	100	40161	194
4047	60	4507	45	40163	75
4048	55	4508	130	40174	75
4049	38	4510	55	40175	75
4050	35	4511	55	40181	220
4051	70	4512	55	40182	80
4052	60	4513	150	40192	75
4053	60	4514	115	40193	95
4054	85	4515	115	40194	70
4055	85	4516	55	40195	75
4056	85	4517	275	40244	196
4057	1000	4518	48	40245	196
4059	435	4519	32	40257	196
4060	68	4520	53	40373	220
4061	500	4521	115	40374	220
4062	986	4522	125	45106	586
4063	85	4526	60		
4066	45	4527	65	**OPTO**	
4067	245	4528	68	OCP71	120
4068	25	4529	150	ORP12	85
4069	25	4530	90	ORP61	86
4070	25	4531	130	BPX25	250
4071	25	4532	65	BPW21	320
		4534	400	TIL139	225

OPTO ELECTRONICS

LEDs with clips

TIL209	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	278

ISOLATORS

IL74	145
ILD74	145
ILQ74	275
TIL111/2/4	70
ILCT6 Darlington	135
TIL117	125
4N33 Photo Darlington	138

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 4 Digits	530
LCD 6 Digits	625
Reflective Switch	225
SLOTTED Optical Switch similar to RS Comp's	295

COMPUTER CORNER

- EPSON RX80 Printer **£209**
- EPSON RX80 F/T Printer **£219**
- EPSON FX80 Printer **£316**
- EPSON FX100 Printer **£429**
- KAGA/TAXAN KP810 Printer **£252**
- 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 builtin 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.

DRIVES

CASED with PSU & CABLES

- CS100 — Epson double sided 40 track 200K 5¼" *Single disc drive* £139
- CS400S — Mitsubishi Double sided 40 Track, 400K 5¼" *Single drive* £236
- CD400 — EPSON Double sided 40 track 400K 5¼" *TWIN disc drives* £149
- CD800S — Mitsubishi double sided 80 track 800K 5¼" TWIN disc drives £295
- **DFS Manual** (comprehensive) (NO VAT) £7
- **TWIN Disc drive case** with power supply to house your own drives £38

NB All single drives with power supply will be supplied in a twin case for later inclusion of a second Drive

N.B Carriage on Drives £7 securicor

SPECTRUM 32K UPGRADE

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

£22

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: £1,089

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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, BEEB-CALC, Software (Educational Application & Games), BOOKs, etc. etc. Please send SAE for our description leaflet.

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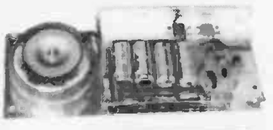
* PRICES INCLUDE V.A.T. * PROMPT DELIVERIES * FRIENDLY SERVICE * LARGE S.A.E. 28p STAMP FOR CURRENT LIST

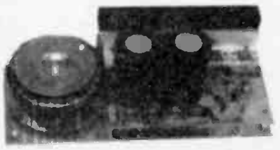
OMP POWER AMPLIFIER MODULES

Now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE all models include Toroidal power supply, Integral heat sink, Glass fibre P.C.B., and Drive circuits to power compatible Vu meter. Open and short circuit proof. **Supplied ready built and tested.**

OMP100 Mk II Bi-Polar Output power 110 watts R.M.S. into 4 ohms, Frequency Response 15Hz - 30KHz —3dB, T.H.D. 0.01%, S.N.R. —118dB, Sens. for Max. output 500mV at 10K, Size 360 × 115 × 72mm. PRICE £32.99 + £2.50 P&P.



OMP/MF100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 80, Slew Rate 45V/uS, T.H.D. Typical 0.002%, Input Sensitivity 500mV, S.N.R. —125dB. Size 300 × 123 × 60mm. PRICE £39.99 + £2.50 P&P.



OMP/MF200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 250, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. —130dB, Size 300 × 150 × 100mm. PRICE £62.99 + £3.50 P&P.

OMP/MF300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 350, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. —130dB, Size 330 × 147 × 102mm. PRICE £79.99 + £4.50 P&P.

Vu METER Compatible with our four amplifiers detailed above. A very accurate visual display employing 11 L.E.D. diodes (7 green, 4 red) plus an additional on/off indicator. Sophisticated logic control circuits for very fast rise and decay times. Tough moulded plastic case, with tinted acrylic front. Size 84 × 27 × 45mm. PRICE £8.50 + 50p P&P.

NOTE: Mos-Fets are supplied as standard (100KHz bandwidth & Input Sensitivity 500mV). If required, P.A. version (50KHz bandwidth & Input Sensitivity 775mV). Order — Standard or P.A.

19" RACK CASED MOS-FET STEREO AMPLIFIERS with twin power supplies and L.E.D. Vu meters plus X.L.R. connectors.
Three models (Ratings RMS into 4 ohms)
MF200 (100 + 100w) £169.00
MF400 (200 + 200w) £228.85
MF600 (300 + 300w) £274.85
Securicor Delivery £10.00

BURGLAR ALARM

Better to be 'Alarmed' then terrified. **Thandar's famous 'Minder' Burglar Alarm System.** Superior microwave principle. Supplied as three units, complete with interconnection cable. **FULLY GUARANTEED.**
Control Unit — Houses microwave radar unit, range up to 15 metres adjustable by sensitivity control. Three position, key operated facia switch — off — test — armed. 30 second exit and entry delay.
Indoor alarm — Electronic swept freq. siren. 104dB output.
Outdoor Alarm — Electronic swept freq. siren. 98dB output. Housed in a tamper-proof heavy duty metal case.
Both the control unit and outdoor alarm contain rechargeable batteries which provide full protection during mains failure. Power requirement 200/260 Volt AC 50/60Hz. Expandable with door sensors, panic buttons etc. Complete with instructions.

IDEAL for Workshops, Factories, Offices, Home, etc. Supplied ready built.

SAVE £148.00 Usual Price £228.85
BKE's PRICE £79.99 + £4.00 P&P
? Why buy a collection of self assembly boards!

OMP LINNET LOUDSPEAKERS

The very best in quality and value. Made specially to suit todays need for compactness with high sound output levels. Finished in hard wearing black vynide with protective corners, grille and carry handle. All models 8 ohms. Full Range 45Hz - 20KHz.
OMP 12/100 watts 20" × 15" × 12" **£125.00** per pair
OMP 10/200 watts 18" × 15" × 11" **£145.00** per pair
OMP 12/300 watts 20" × 15" × 11" **£169.00** per pair

Delivery: Securicor £8.00 per pair

STEREO CASSETTE DECK

STEREO CASSETTE DECK Ideal for installing into Disco and Hi-Fi cabinet/Consoles. Surface mounting (Horizontal). Supplied as one unit with all electronics including mains power supply.
* Metal top panel Black finish
* Piano type keys including pause
* Normal/Chrome tape switch
* Twin Vu Meters
* 3 Digit counter
* Slider Record Level control

Size 171 × 317 mm Depth 110 mm
PRICE £35.99 + £3.00 P&P

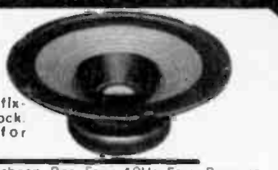
1 K-WATT SLIDE DIMMER

* Control loads up to 1Kw
* Compact Size 4⅗" × 1" × 2½"
* Easy snap in fixing through panel/cabinet cut out
* Insulated plastic case
* Full wave control using 8 amp triac
* Conforms to BS800
* Suitable for both resistance and inductive loads. Innumerable applications in industry, the home, and disco's, theatres etc.

PRICE £12.99 + 75p P&P
(Any quantity)

LOUDSPEAKERS

5 to 15 INCH Up to 300 WATTS R.M.S. All speakers 8 ohm Impedence.



Cabinet fixing in stock. S.A.E. for details.

POWER RANGE
8" 50 WATT R.M.S. Hi-Fi/Disco.
20 oz. magnet. 1½" ally voice coil. Ground ally fixing escutcheon. Res. Freq. 40Hz. Freq. Resp. to 6KHz. Sens. 92dB. PRICE £10.99 Available with black grille £11.99 P&P £1.50 ea.
12" 100 WATT R.M.S. Hi-Fi/Disco
50 oz. magnet. 2" ally voice coil. Ground ally fixing escutcheon. Die-cast chassis. White cone. Res. Freq. 25Hz. Freq. Resp. to 4KHz. Sens. 95dB. PRICE £28.60 + £3.00 P&P ea.
15" 100 WATT R.M.S. Hi-Fi/Disco
50 oz. magnet. 2" ally voice coil. Ground ally fixing escutcheon. Die-cast chassis. White cone. Res. Freq. 20Hz. Freq. Resp. to 2.5KHz. Sens. 97dB. PRICE £37.49 + £3.00 P&P ea.

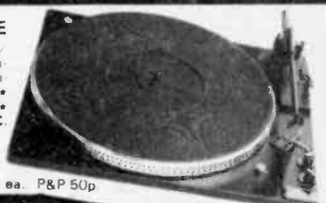
McKENZIE
12" 85 WATT R.M.S. C1285GP Lead guitar/keyboard/Disco.
2" ally voice coil. Ally centre dome. Res. Freq. 45Hz. Freq. Resp. to 6.5KHz. Sens. 98dB. PRICE £24.99 + £3.00 P&P ea.
12" 85 WATT R.M.S. C1285TC P.A./Disco 2" ally voice coil. Twin cone.
Res. Freq. 45Hz. Freq. Resp. to 14KHz. PRICE £24.99 + £3.00 P&P ea.
15" 150 WATT R.M.S. C15 Bass Guitar/Disco.
3" ally voice coil. Die-cast chassis. Res. Freq. 40Hz. Freq. Resp. to 4KHz. PRICE £49.99 + £4.00 P&P ea.

WEM
5" 70 WATT R.M.S. Multiple Array Disco etc.
1" voice coil. Res. Freq. 52Hz. Freq. Resp. to 5KHz. Sens. 89dB. PRICE £20.00 + £1.50 P&P ea.
8" 150 WATT R.M.S. Multiple Array Disco etc.
1" voice coil. Res. Freq. 48Hz. Freq. Resp. to 5KHz. Sens. 92dB. PRICE £27.00 + £1.50 P&P ea.
10" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
1½" voice coil. Res. Freq. 35Hz. Freq. Resp. to 4KHz. Sens. 92dB. PRICE £30.00 + £2.00 P&P ea.
12" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
1½" voice coil. Res. Freq. 35Hz. Freq. Resp. to 4KHz. Sens. 94dB. PRICE £38.00 + £3.00 P&P ea.

SOUNDLAB (Full Range Twin Cone)
5" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.
1" voice coil. Res. Freq. 63Hz. Freq. Resp. to 20KHz. Sens. 86dB. PRICE £9.99 + £1.00 P&P ea.
6½" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.
1" voice coil. Res. Freq. 56Hz. Freq. Resp. to 20KHz. Sens. 89dB. PRICE £10.99 + £1.50 P&P ea.
8" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.
1½" voice coil. Res. Freq. 38Hz. Freq. Resp. to 20KHz. Sens. 89dB. PRICE £12.99 + £1.50 P&P ea.

BSR P295 ELECTRONIC TURNTABLE

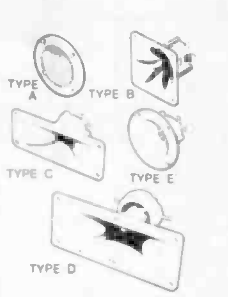
* Electronic speed control 45 & 33⅓ r.p.m. * Plus/Minus variable pitch control * Belt driven * Aluminium platter with strobed rim * Cue lever * Anti-skate (bias device) * Adjustable counter balance * Manual arm * Standard ½" cartridge fixings * Supplied complete with cut out template * D.C. Operation 9-14v D.C. 65mA
Price £36.99 — £3.00 P&P



ADC Q4 mag. cartridge for above. Price £4.99 ea. P&P 50p

PIEZO ELECTRIC TWEETERS MOTOROLA

Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER**



TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. **Price £5.39 each + 40p P&P**
TYPE 'B' (KSN1005A) 3½" super horn. For general purpose speakers, disco and P.A. systems etc. Price **£5.99 each** + 40p P&P
TYPE 'C' (KSN6016A) 2" × 5" wide dispersion horn. For quality Hi-fi systems and quality discos etc. **Price £6.99 each** + 40p P&P
TYPE 'D' (KSN1025A) 2" × 6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. **Price £9.99 each** + 40p P&P
TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-fi monitor systems etc. **Price £5.99 each** + 40p P&P
LEVEL CONTROL Combines on a recessed mounting plate, level control and cabinet input jack socket 85 × 85 mm. **Price £3.99** + 40p P&P

PANTEC HOBBY KITS

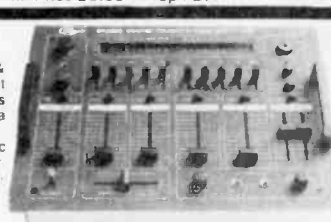
HOBBY KITS. Proven designs including glass fibre printed circuit board and high quality components complete with instructions.

FM MICROTRANSMITTER (BUG) 90/105MHz with very sensitive microphone. Range 100/300 metres. 57 × 46 × 14mm (9 volt) Price: £8.62 + 75p P&P.
3 WATT FM TRANSMITTER 3 WATT 85/115MHz varicap controlled professional performance. Range up to 3 miles 35 × 84 × 12mm (12 volt) Price: £13.74 + 75p P&P.
SINGLE CHANNEL RADIO CONTROLLED TRANSMITTER/RECEIVER 27MHz. Range up to 500 metres. Double coded modulation. Receiver output operates relay with 2amp/240 volt contacts. Ideal for many applications. Receiver 90 × 70 × 22mm (9/12 volt). Price: £17.82. Transmitter 80 × 50 × 15mm (9/12 volt). Price: £11.27 P&P + 75p each. S.A.E. for complete list.

3 watt FM Transmitter

STEREO DISCO MIXER

STEREO DISCO MIXER with 2 × 5 band L. & R. graphic equalisers and twin 10 segment L.E.D. Vu Meters. **Many outstanding features** 5 Inputs with individual faders providing a useful combination of the following:— 3 Turntables (Mag), 3 Mics, 4 Line plus Mic with talk over switch. Headphone Monitor. Pan Pot L. & R. Master Output controls. Output 775mV. Size 360 × 280 × 90mm.
Price £134.99 — £3.00 P&P



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B. K. ELECTRONICS

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DIGEST

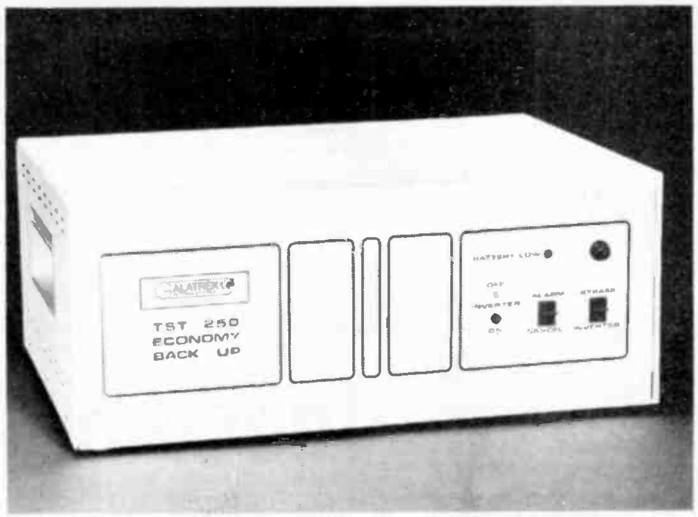
New Single-Chip Micro-computers

Hitachi have developed two 8-bit, CMOS, single-chip micro-computers. They are intended for use in low-end control applications and one includes integral EPROM to facilitate product development and low-volume production.

The HD6305V and HD63705V are available in 1.0, 1.5 and 2.0 MHz versions and have identical functions except that the HD63705V incorporates 4K of on-chip EPROM. They feature 4K of ROM, 192 bytes of RAM, 31 input/output ports and are compatible with the HD6305 family. Other features include an 8-bit timer with a 7-bit pre-scaler, a 15-bit timer which can also be used as a clock divider for serial communications interfacing and a synchronous serial communications interface. Typical power consumptions are 25mW in operation, 10mW in WAIT mode and 10uW in STOP And STANDBY modes. They are available in JEDEC-standard 40-pin DIL packags or in 54-pin flat packages.

The HD63705V has a window for ultra-violet erasing and uses 12.5V for programming. Hitachi expect it to find applications in development and initial production, allowing early samples of equipment to be produced without waiting for the permanent ROM to be prepared.

The HD6305V is available now and the HD63705V should be available from May.



Uninterruptible Power Supply For Microcomputers

Galatrek have introduced a range of low cost Uninterruptible Power Supply (UPS) units which have been specially designed for the smaller and multiple micro-computer user at a price in proportion to the hardware. Three versions are available for 120, 250 and 500 VA outputs, and the prices start at £531.00.

The TST Range of UPS units can handle input voltage swings of +/- 15% and still maintain a stablilised, transient free output voltage, held within +/-5% on combined line and load variations. The wave form distortion is less than 5% and back-up power from the integral maintenance-free, lead acid batteries is normally a 20 minute cycle. However, simply by adding extra battery packs, the cycle can be extended to 24 hours and more if required.

The series offers complete user flexibility which includes extending the frequency of the standard models from 50 HZ to 60 Hz or changing the 220/230 and 240 voltage of the standard range to 110 volts. A further special version is available which has an input voltage window variation in the range +15% to -30%.

The controls include a cancel switch for mains faulure alarm and a manual by-pass switch for coping with high start-up loads. The battery discharge condition is indicated by an audible alarm and visual display which operates two minutes prior to discharge condition and shutdown.

Galatrek International Ltd, Scotland Street, Llanrwst, Gwynedd, North Wales LL26 OAL, tel: 0492-640311.

Just When You Thought It Was Safe To Open The Magazine Again . . .

ETI presents another in its series of cut-out-and-throw-away horror pics for the serious collector. Pictured above after yet another attempt to tidy his desk is former ETI editor Dave Bradshaw. Thankfully, Dave is still with us having been promoted to Group Editor. And the desk? Well, that's still around too and looking a lot tidier these days.

● Weald Electronics produce a range of specialist connectors which includes the BA, D2, SM, SMA, SMC and SREC series, along with the necessary assembly tools. The range is described in a sixteen page A4 illustrated catalogue which is available from their UK distributors, F.C. Lane (Components) Ltd, Slinfold Lodge, Horsham, West Sussex RH13 7RN, tel 0403-790200.

O As from May of this year, the Health and Safety Executive will be making their database available to computer users in hour-long links via the services of Pergamon Infoline. The database contains information on industrial noise regulations, handling of hazardous substances and over 6,000 other factors relating to work-place health and safety and the link-up is free. For details contact Pergamon Infoline Ltd, 12 Vandy Street, London EC2A 2DE, tel 01-377 4050.

● Canford Audio supply a wide range of mail order audio equipment, from tape recorders, mixers and amplifiers down to audio connectors, audio modules, rack-mounting and other cases, audio transformers, linear faders and cables. Their 72 page catalogue is available from the head office, Canford Audio Ltd, Stargate Works, Ryton, Tyne & Wear NE40 3EX, tel 091-413 7171.

● International Rectifier have brought out a new edition of their power semiconductor product guide and data book. It includes a JEDEC/alpha-numeric index and covers thyristors, rectifiers and Schottky devices of up to 300A rating. Contact International Rectifier, Hurst Green, Oxted, Surrey RH8 9BB, tel 988-3215.

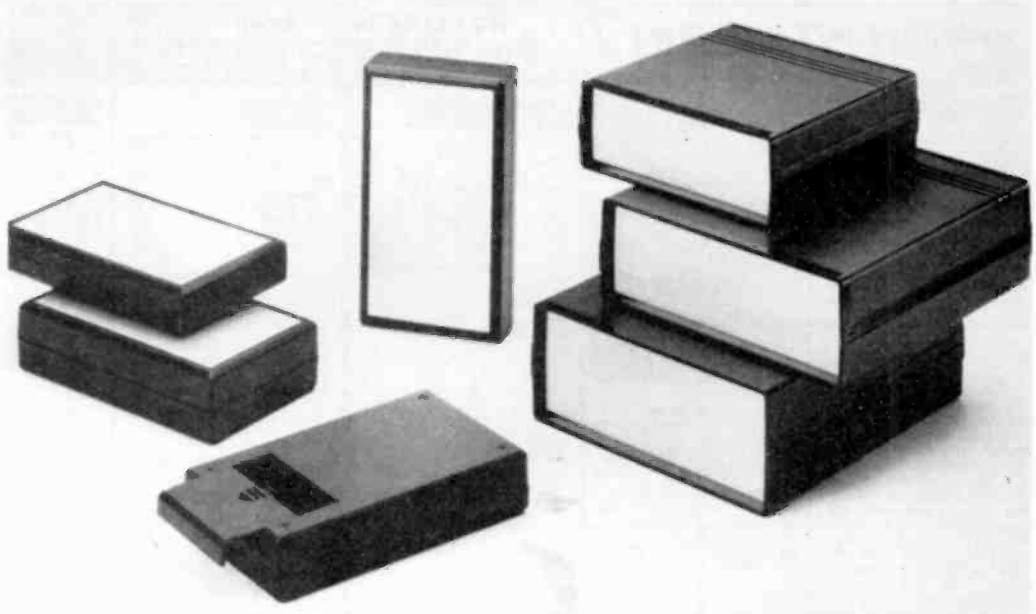
● Yes, Prime have moved to the middle of Nowhere (popularly known as Milton Keynes). The latest in a long line of companies who have decided to set up in the Land of the Concrete Cows, Prime will be spending £6 million on a new research and development centre which will bring 200 jobs to the city when it opens in 1988.

● *Marathon Batteries Ltd have produced a small colour brochure describing their range of rechargeable nickel-cadmium cells. The capacities available range from 0.1 to 7 ampere hours and the brochure gives full details of their technical characteristics, construction and charge/discharge performance. For a free copy contact John Rich at Marathon Batteries Ltd, Union Street, Redditch, Worcestershire B98 7BW, tel 0527-62351.*

● The Data Protection Registrar has published a 36 page, A5 booklet which provides an introduction and guide to the workings of the 1984 Data Protection Act. The first of a series of guidelines, it is intended to help those covered by the Act to assess its implications. Copies are available from the Office of the Data Protection Registrar, Springfield House, Water Lane, Wilmslow, Cheshire SK9 5AX, tel 0625-535777.

● Citec Ltd have produced a brochure which outlines the potential uses of cermet and polymer thick film technologies. It describes some of the work of the company in applying these technologies to a diverse range of problems, and copies can be obtained from the Product Manager, Special Products Group, BICC-Citetc Ltd, Cheney Manor, Swindon, Wiltshire SN2 2PZ, tel 0793-487301.

● *Over half of the workforce of Factron Schlumberger are giving up a day's holiday entitlement in aid of Ethiopia. The company, which makes test equipment and information management systems, employs over 400 staff at its headquarters in Dorset and the £5,000 raised will be used by Oxfam in Ethiopia, Sudan and Mali.*



A, A, What's going in 'Ere Then?

West Hyde Developments have added two new designs to their range of small cases, one intended for hand-held application and the other for portable or bench-top equipment. The hand-held case incorporates a compartment for AA or PP3 batteries.

The Novara case comes in three sizes, all designed to fit comfortably into the hand. It is moulded from black ABS in two halves held together with self-tapping screws, and has an aluminium front panel recessed into the moulding. The two larger sizes are available with an optional battery compartment which accepts either one PP3 battery or two AA cells.

The smallest Novara case measures 145 x 85 x 25mm and costs £5.98, the next size up measures 145 x 85 x 31mm and costs £6.80 or £6.96 with the optional battery comparment, and the largest size measures 145 x 85 x 37 and costs £7.61 or £7.78 with a battery compartment. All prices exclude VAT.

The bench-top case is called the Verona and is available in six sizes. It is moulded from either black or grey ABS in two halves which incorporate bosses to support a board or chassis as well as slots to support PCBs vertically. The front and back panels are of aluminium and slot into recessed grooves.

The Verona comes in two standard width/depth combinations, each of which is available in three heights. The smaller sizes measure 134 x 129mm and are either 47, 54 or 61mm high, while the larger sizes measure 173 x 154mm and come in the same range of heights. Prices range from £3.60 to £6.22, excluding VAT.

West Hyde Developments Ltd, Unit 9, Park Street Industrial Estate, Aylesbury, Buckinghamshire HP20 1ET, tel 0296-20441.

Fast 8-Bit A/D Converter

Siemens have introduced an eight-bit analogue-to-digital converter which has a conversion time of just 10ns. The new IC will allow full 8-bit conversion at 100MHz, a task which previously required four ICs and used twice as much power.

The SDA 8010 replaces the earlier six-bit SDA 5200 and dissipates just one watt, compared with two watts for four SDA 5200s to achieve the same speed and word length. A complementary digital-to-analogue converter designated the SDA 8005 is also available and is a mirror image of the SDA 8010. The SDA 8005 can operate at up to 150MHz and both devices are compatible with ECL (emitter coupled logic). The SDA 8010 comes in a 24-pin DIL ceramic package.

Siemens suggest applications for the new ICs in instrumentation, image processing and medical equipment including digital oscilloscopes, transient recorders, diagnostic equipment, radar equipment and high resolution graphic systems. Siemens Ltd, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex TW16 7HS, tel 09327-85691.

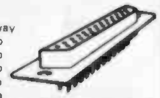
Rapid Electronics

MAIL ORDERS:
Unit 1, Hill Farm Industrial Estate,
Boxted, Colchester, Essex CO4 5RD.
Tel. Orders: Colchester (0206) 36412.
Telex: 987756.

ACCESS AND BARCLAYCARD WELCOME

MIN. D CONNECTORS

	9 way	15 way	25 way	37 way
Plugs solder lugs	55p	66p	90p	150p
Right angle	90p	135p	200p	350p
Sockets solderlugs	80p	100p	135p	260p
Right angle	120p	180p	290p	420p
Covers	100p	90p	100p	110p



CONNECTORS

DIN	Plug	Skt	Jack	Plug	Skt
2 pin	9p	9p	2.5mm	10p	10p
3 pin	12p	10p	3.5mm	9p	9p
5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	12p	13p	4mm	18p	17p

UHF (CB) Connectors:
PL259 Plug 40p. Reducer 14p.
SO239 square chassis skt 38p.
SO239S round chassis skt 40p.
IEC 3 pin 250V/6A.
Plug chassis mounting . . 38p
Socket free hanging . . 60p
Socket with 2m lead . . 120p

SWITCHES

Submin toggle:
SPST 55p. SPDT 60p. DPDT 65p.
Miniature toggle:
SPDT 80p. SPDT centre off 90p.
DPDT 90p. DPDT centre off 100p.
Standard toggle:
SPST 35p. DPDT48p
Miniature DPDT slide 14p.
Push to make 15p.
Push to break 22p.
Rotary type adjustable stop.
1P12W, 2P6W, 3P4W all 55p each.
DIL switches:
4SPST 80p 6 SPST 80p. 8 SPST 100.
Min. DPDT slide 14p. Push-make 15.

27128-250 £7.50

Brand new Hitachi product. Ideal for use with the BBC Micro. Please note this price is not a misprint!!

TRANSFORMERS

3VA PCB Mounting
2x6V@0.25A;2x9V@0.15A
2x12V@0.12A;2x15V@0.1A 180p

6VA PCB Mounting
2x6V@0.5A;2x9V@0.4A
2x12V@0.3A;2x15V@0.25A 270p

Standard. Chassis Mounting
6VA: 2x6V@0.5A; 2x9V@0.4A
2x12V@0.3A;2x15V@0.25A 240p

12VA: 2x6V@1A; 2x9V@0.6A
2x15V@0.4A;2x20V@0.3A 350p

SOLDERING IRONS

Antex CS 17W Soldering iron	430
2.3 and 4.7mm bits to suit .	85
Antex XS 25W soldering iron	530
3.3 and 4.7mm bits to suit	85
Solder pump desoldering tool	480
Spare nozzle for above .	70
10 metres 22 swg solder .	100
0.5kg 22 swg solder . .	750

VERO

Verobloc	395
Veroboard Size 0.1 in matrix	
2.5 x 1	26
2.5 x 3.75	95
3.75 x 5	120
3.75 x 17	350
4.75 x 17	455
VQ board	190
Veropins per 100:	
Single sided	55
Double sided	65
Spot face cutter	145
Pin insertion tool	185
Wiring pen	375
Spare spool 75p Combs	6

MICRO

		27128-250	750	6800	200	6522	330
		6116P3	390	6802	280	6532	520
		6264P15	2250	6809	600	6551	540
2716	310	4116P4	70	6810	140	8085A	320
2532	380	4164-15	480	6821	140	8156	380
2732 one time programmable	280	41256-15	2850	6840	360	8251	350
		Z80A CPU	290	6850	165	8253	370
		Z80A P10	320	6852	240	8255	320
2732	430	Z80A CTC	320	6875	500	8259	400
2764-250	430	Z80A S10	880	6880	100	MC1488	70
2764 88C	430	Z80A DMA	880	6502	370	MC1489	70

SOCKETS

	Low profile	Wire-wrap
8 pin	7p	28p
14 pin	8p	45p
16 pin	10p	55p
18 pin	12p	60p
20 pin	13p	68p
22 pin	15p	75p
24 pin	17p	82p
28 pin	15p	95p
40 pin	25p	135p

Professional ZIF sockets
24 pin 430p 28 pin 480p
40 pin 595p

COMPONENT KITS

0.25W Resistor Kit. Contains 1000 0.25W 5% resistors from 4.7 ohms thru to 10M. Quantities depend upon popularity i.e. 10x10R, 30x470R, 30x10K, 25x470K. Just £7.90

Ceramic capacitor Kit. Total of 250 miniature ceramic capacitors from 22p to 0.1u. Just £6.90

Polyester capacitor Kit. Total of 110 miniature polyester capacitors from 0.01u to 0.47u. Just £6.90

Preset Kit. Total of 110 miniature preset resistors from 100R to 1M. Horizontal mounting type. Just £6.90

Radial Electrolytic Capacitor Kit. A pack containing a total of 93 miniature caps from 1u to 2200u Just £7.50

Nut and Bolt Kit. Contains 800 assorted items. 100 each 6BA ¼in, ½in, nuts and wshrs, 4BA ¼in, ½in, nuts and wshrs. Just £3.20

CABLES

20 metre pack single core connecting cable ten different colours.	75p
Speaker cable	10p/m
Standard screened	16p/m
Twin screened	24p/m
2.5A 3 core mains	23p/m
10 way rainbow ribbon	26p/ft
20 way rainbow ribbon	47p/ft
10 way gery ribbon	14P/ft
20 way grey ribbon	28p/ft

REGULATORS

78L05	30	79L05	45
78L12	30	79L12	45
78L15	30	79L15	45
7805	40	7905	45
7812	40	7912	45
7815	45	7915	45
LM317K	270	LM723	40
LM317T	90	78H05	550
LM323K	420		

DIODES

		▶1N4001	3
BY127	12	1N4002	5
OA47	10	1N4006	7
OA90	8	1N4007	7
OA91	7	1N5401	12
OA200	8	1N5404	16
OA202	8	1N5406	17
1N914	4	400mW zen	6
▶1N4148	3	1.3W zeners	13

OPTO

3mm red	8	5mm red	8
3mm green	11	5mm green	11
3mm yellow	11	5mm yellow	11

Clips to suit - 3p each.

Rectangular:		TIL32	40
red	12	TIL111	60
green	17	TIL78	40
yellow	17	ORP12	85
ILD74	95	ILQ74	185
TIL38	35	TIL100	75
2NS777	45	Tri-color Led	35

Seven segment displays:

Com cathode.		Com anode	
DL704 0.3"	95	DL707 0.3"	95
FND500 0.5"	100	FND507 0.5"	100

10 bar DIL LED display, red 180
5mm superbright LED 250mcd red 30

HARDWARE

PP3 battery clips	8
Red or black crocodile clips	6
Black pointer control knob	15
Pr Ultrasonic transducers	390
▶6V Electronic buzzer	65
▶12V Electronic buzzer	70
▶PB2720 Piezo transducer	75
▶64mm 64 ohm speaker	70
▶64mm 8 ohm speaker	70
20mm panel fuseholder	25
Red or black probe clip	35
4mm terminals	33
12 way 'chocolate' block	21
ultra-min. 6 or 12v rel. SPDT	130
ditto, but DPDT	195

EURO CONNECTORS

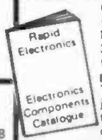
Gold flashed contacts:	Rt. angle plug	Wirewrap socket
64 way A+B	195	230
64 way A+C	220	270
96 way A+B+C	320	330

TRIACS

		400V 8A	65
		400V 16A	95
400V 4A	50	BR100	25

* * * * * * * * * * * *

NEW 1985 CATALOGUE



Our new fully illustrated 50 page detailed information on over 3000 product lines at the most competitive prices in the market. The catalogue costs just 70p including postage or free with orders over £20 in value. Send for your copy today!

* * * * * * * * * * * *

COMPUTER CONNECTORS

ZX81 2 x 23 way edge connector wire wrap for ZX81 150
SPECTRUM 2 x 28 way edge connector wire wrap. . . . 200
AMPHENOL PLUGS
24 way IEEE IDC. . . . 450
36 way Centronix IDC . . . 490

RIBBON CABLE

Grey Ribbon cable. Price per foot

10 way	14	34 way	58
16 way	25	40 way	68
20 way	28	50 way	90
26 way	38	60 way	100

CAPACITORS

Polyester, radial leads. 250v. C280 type: 0.01, 0.015, 0.022, 0.033 - 6p; 0.047, 0.068, 0.1 - 7p; 0.15, 0.22 - 9p; 0.33, 0.47 - 13p; 0.68 - 20p; 1u - 23p.
Electrolytic, radial or axial leads: 0.47/63V, 1/63V, 2.2/63V, 4.7/63V, 10/25V - 7p; 22/25V, 47/25V - 8p; 100/25V - 9p; 220/25V - 14p; 470/25V - 22p; 1000/25V - 30p; 2200/25V - 50p.
Tag end power supply electrolytics: 2200/40V - 110p; 4700/40V - 160p 2200/63V - 140p; 4700/63V - 230p
Polyester, miniature Siemens PCB: 1n, 2n2, 3n3, 4n7, 6n8, 10n, 15n, 7p; 22n, 33n, 47n, 68n, 8p; 100n, 9p; 150n, 11p; 220n, 13p; 330n, 20p; 470n 26p; 680n, 29p; 1u 33p;

Tantalum bead:
0.1, 0.22, 0.33, 0.47, 1.0 @ 35V - 12p. 2.2, 4.7, 10 @ 25V - 20p; 15/16V - 30p; 22/16V - 27p; 33/16V - 45p; 47/6V - 27p; 47/16V - 70p; 68/6V - 40p; 100/10V - 90p.
Cer. disc. 22p-0.01u 50V, 3p each.
Mullard miniature ceramic plate: 1.8pF to 100pF 6p each.
Polystyrene, 5% tol: 10p-1000p, 6p; 1500-4700, 8p; 6800 0.012u, 10p.
Trimmers. Mullard 808 series: 2-10 pF, 22p; 2-22pF, 30p; 5.5-65pF, 35p

BRIDGE RECTIFIERS

		2A 200V	40
		2A 400V	45
		6A 100V	80
		6A 400V	95
1A 50V	20	VM18 DIL 0.9A	
1A 400V	35	200V	50

IOC CONNECTORS

	PCB Plug St.	PCB Plug Rt. ang.	Socket	Edge Conn.
10 way	70	70	70	—
16 way	75	80	80	—
20 way	90	90	95	130
26 way	105	110	115	155
34 way	115	130	130	180
40 way	140	140	145	210
50 way	165	165	170	240
60 way	195	195	200	—

LINEAR

		IC7611	98	LM358	50	LM3916	265	NE567	130	TDA1024	115
		ICL7621	190	LM377	210	LM13600	110	NE570	370	TL061	40
555CMOS	80	ICL7622	200	LM380	80	MC1310	150	NE571	370	TL062	65
556CMOS	150	ICL8038	295	LM381	150	MC1496	70	NE5532	160	TL064	105
709	35	ICL8211A	220	LM382	130	MC3302	75	NE5534	105	TL071	38
741	16	ICM7224	785	LM384	140	MC3340	130	RC4136	65	TL072	60
748	35	ICM7555	80	LM386	90	MF10CN	330	RC4558	40	TL074	110
AY31270	720	ICM7556	150	LM387	120	ML922	390	SL486	195	TL081	30
AY38910	390	LF347	150	LM393	60	ML924	290	SL490	220	TL082	50
AY38912	430	LF351	40	LM710	48	ML925	290	SN76018	150	TL084	105
CA3046	65	LF353	75	LM711	60	ML926	210	SN76477	380	TL170	50
CA3080E	65	LF356	90	LM725	70	ML927	210	SP8629	250	UA2240	140
CA3089	200	LM10C	325	LM733	70	ML928	210	SP0256AL2	425	ULN2003	80
CA3090AQ	375	LM301A	30	LM741	16	ML929	210	Speech data	50	ULN2004	80
CA3130E	85	LM311	45	LM747	60	NE529	225	TBA800	70	XR2206	365
CA3140E	38	LM318	135	LM748	35	NE531	135	TBA810	90	ZN414	80
CA3160	96	LM324	46	LM1458	35	NE544	170	TBA820M	65	ZN423	135
CA3136	100	LM3342	85	LM2917N8	195	NE555	20	TBA950	220	ZN424P	130
CA3189	260	LM3352	125	LM3900	45	NE556	45	TCA940	165	ZN425E	350
CA3240E	100	LM339	40	LM3909	85	NE565	115	TDA1008	320	ZN426E	300
ICL7106	680	LM348	60	LM3914	265	NE566	140	TDA1022	490	ZN427E	600
										ZN428E	450
										ZN459	285
										ZN1034E	200

TRANSISTORS

				BC548	5	BFR40	23	2N1613	30	2N3906	10		
				BC549	10	BFR80	23	2N2218A	45	2N4037	45		
				BC557	10	BFR81	23	2N2219A	28	2N4058	10		
AC125	35	BC168	11	BC558	10	BFX29	30	2N2221A	25	2N4060	10	TIP35C	125
AC126	30	BC158	10	BCY70	16	BFX84	30	2N2222A	20	2N4061	10	TIP36A	115
AC127	30	BC159	10	BCY71	16	BFX85	30	2N2368	25	2N4062	10	TIP36C	130
AC128	30	BC160	40	BCY72	16	BFX86	30	2N2369	18	40360	40	TIP41A	45
AC176	25	BC168C	10	BD115	55	BFX87	30	2N2484	27	40361	50	TIP42A	45
AC187	25	BC169C	10	BD131	40	BFX88	30	2n2646	60	40362	50	TIP120	60
AC188	25	BC170	8	BD132	40	BFY50	27	2N2904	28	40408	50	TIP121	60
AD142	120	BC171	10	BD133	50	BFY51	27	2N2904A	28	2N5457	30	TIP122	60
AD161	42	BC172	8	BD135	35	BFY52	27	2N2905	28	2N5458	30	TIP141	110
AD162	42	BC177	16	BD136	35	BFY53	30	2N2905A	28	2N5459	30	TIP142	120
AF124	60	BC178	16	BD137	35	BFY55	30	2N2906	28	2n5485	35	TIP147	120
AF126	50	BC179	18	BD138	35	BFY56	30	2N2906A	28	2N5777	45	TIP2955	70
AF139	40	BC182	10	BD139	35	BRY39	50	2N2907	24	2N697	20	TIP3055	60
AF186	70	BC182L	10	BD140	35	BSX20	22	2N2907A	24	2N698	40	TIS43	40
AF239	55	BC183	10	BD204	110	BSX29	35	2N2926	10	2N706A	20	TIS43	40
BC107	10	BC183L	10	BD206	110	BSY95A	30	2N3053	28	2N708	25	TIS44	45
BC107B	12	BC184	10	BD222	85	BU205	160	2N3054	55	2N918	35	TIS45	45
BC108	10	BC184L	10	BF180	35	BU206	200	2N3055	50	TIP29	35	TI590	30
BC108B	12	BC212	10	BF182	35	BU208	170	2N3442	120	TIP29A	35	TI591	30
BC108C	12	BC212L	10	BF184	35	MJ2955	99	2N3702	9	TIP29B	35	VN10KM	65
BC109	10	BC213	10	BF185	25	MJE340	50	2N3703	10	TIP29C	35	VN46AF	94
BC109C	12	BC213L	10	BF194	12	MJE520	50	2N3704	9	TIP30	35	VN66AF	110
BC114	22	BC214	10	BF195	12	MJE521	90	2N3705	10	TIP30A	35	VN88AF	120
BC115	22	BC214L	10	BF196	12	MJE3055	70	2N3706	10	TIP30B	35	ZTX107	11
BC117	22	BC237	7	BF197	12	MPF102	40	2N3707	10	TIP30C	40	ZTX108	11
BC119	35	BC238	7	BF198	15	MPF104	40	2N3708	10	TIP31A	35	ZTX109	11
BC137	40	BC308	10	BF199	18	MPSA05	23	2N3709	10	TIP31B	35	ZTX300	14
BC139	38	BC327	8	BF200	35	MPSA06	25	2N3772	170	TIP31C	40	ZTX301	16
BC140	29	BC328	8	BF244B	35	MPSA12	29	2N3773	195	TIP32A	35	ZTX302	16
BC141	30	BC337	8	BF245	35	MPSA55	30	2N3819	32	TIP32B	38	ZTX304	20
BC142	28	BC338	12	BF256B	45	MPSA56	30	2N3820	50	TIP32C	40	ZTX341	20
BC143	30	BC477	22	BF257	32	MPSU05	55	2N3823	65	TIP33A	65	ZTX500	13
BC147	10	BC478	22	BF258	30	MPSU06	55	2N3866	90	TIP33C	75	ZTX501	18
BC148	10	BC479	22	BF259	30	MPSU55	55	2N3903	10	TIP34A	70	ZTX502	18
BC149	10	BC517	30	BF337	35	MPSU56	65	2N3904	10	TIP34C	80	ZTX503	18
BC157	11	BC547	5	BFR40	35	2N118L	22	2N3905	10	TIP35A	105	ZTX504	25

RESISTORS

Carbon film	1+	25+
¼W 5% 4.7ohm - 10M	2p	1p
½W 5% 4.7ohm - 4M7	3p	2p
Metal film		
¼W 1% 10ohm - 1M	4p	3p

25+ price applies to 25+ per value not mixed.

CRYSTALS

		4.194MHz	150
		4.43MHz	100
100KHz	235	5.008MHz	240
1MHz	275	6.0MHz	140
1.8432M	200	6.144MHz	150
2.0MHz	225	7.0MHz	150
2.4576M	200	8.0MHz	140
3.276M	150	10.0MHz	170
3.579M	95	12.0MHz	170
4.0MHz	140	16.0MHz	200

BOXES

		Aluminium	
		3 x 2 x 1"	65
Plastic with lid & screws		4 x 2¾ x 1½"	95
		4 x 2½ x 2"	95
71x46x22mm	50	6 x 4 x 2"	120
95x71x35mm	86	7 x 5 x 2½"	165
140x90x55mm	140	8 x 6 x 3"	205

TTL

		7412	25	7440	25	7476	40	74107	40	74157	80	74180	85
		7413	36	7442	74	7480	50	74109	60	74160	90	74181	230
		7414	60	7444	105	7483	65	74121	50	74161	90	74182	85
7400	25	7416	43	7446	130	7485	110	74122	50	74162	90	74190	120
7401	25	7417	43	7447	98	7486	38	74123	92	74163	90	74191	120
7402	25	7420	25	7448	98	7489	170	74125	50	74164	115	74192	120
7403	25	7421	30	7450	25	7490	55	74126	50	74165	90	74193	110
7404	25	7422	30	7451	25	7491	80	74132	60	74167	200	74194	80
7405	25	7427	30	7453	25	7492	55	74141	80	74170	170	74195	63
7406	45	7428	30	7454	25	7493	55	74145	85	74173	100	74196	120
7407	45	7430	25	7460	25	7494	90	74147	130	74174	100	74197	85
7408	25	7432	35	7472	35	7495	70	74148	105	74175	80	74198	195
7409	25	7433	35	7473	40	7496	80	74150	130	74176	80	74199	195
7410	25	7437	43	7474	36	7497	170	74153	70	74177	80		
7411	25	7438	45	7475	55	74100	125	74154	135	74179	90		

CMOS

		4016	26	4034	145	4054	70	4081	18	4502	50	4529	80
		4017	43	4036	270	4055	70	4082	20	4503	45	4532	65
		4018	55	4039	270	4059	400	4085	60	4507	45	4534	390
4000	18	4019	35	4040	46	4060	70	4086	60	4508	115	4538	70
4001	18	4020	48	4041	55	4063	80	4089	120	4510	48	4543	65
4002	18	4021	55	4042	45	4066	24	4093	26	4511	60	4549	390
4006	65	4022	60	4043	45	4067	230	4094	70	4512	50	4553	215
4007	18	4023	18	4044	50	4068	18	4095	70	4514	115	4555	50
4008	50	4024	35	4046	60	4069	18	4097	260	4515	115	4556	50
4009	40	4025	18	4047	52	4070	22	4098	70	4516	48	4559	390
4010	40	4026	120	4048	50	4071	18	40106	38	4518	48	4560	110
4011	18	4027	28	4049	26	4072	18	40109	100	4520	48	4584	38
4012	18	4028	40	4050	26	4073	18	40163	75	4521	110	4585	65
4013	26	4029	45	4051	48	4075	24	40173	100	4526	70	4724	140
4014	50	4030	18	4052	48	4076	60	40175	75	4527	60		
4015	42	4031	125	4053	60	4077	24	40193	90	4528	45		

LS TTL

		LS20	22	LS75	38	LS123	70	LS161	60	LS221	78	LS365	42
		LS21	22	LS76	28	LS125	37	LS162	60	LS240	105	LS366	42
		LS22	22	LS78	28	LS126	37	LS163	60	LS241	80	LS367	42
LS00	22	LS26	22	LS83	68	LS132	53	LS164	70	LS242	80	LS368	42
LS01	22	LS27	22	LS85	82	LS136	35	LS165	95	LS243	80	LS373	80
LS02	22	LS30	22	LS86	35	LS138	48	LS166	88	LS244	80	LS374	80
LS03	22	LS32	22	LS90	40	LS139	48	LS170	120	LS245	88	LS375	55
LS04	22	LS37	22	LS92	50	LS145	92	LS173	80	LS247	77	LS377	100
LS05	22	LS38	22	LS93	45	LS147	130	LS174	60	LS251	55	LS378	88
LS08	22	LS40	22	LS95	58	LS148	115	LS175	60	LS257	55	LS390	82
LS09	22	LS42	60	LS96	120	LS151	55	LS190	75	LS258	55	LS393	82
LS10	22	LS47	78	LS107	42	LS153	80	LS191	55	LS259	90	LS399	115
LS11	22	LS48	78	LS109	42	LS154	220	LS192	75	LS266	28	LS541	115
LS12	22	LS51	22	LS112	42	LS155	55	LS193	75	LS273	80	LS670	170
LS13	36	LS55	22	LS113	32	LS157	48	LS195	60	LS279	56		
LS14	45	LS73	28	LS114	32	LS158	48	LS196	75	LS283	70		
LS15	22	LS74	28	LS122	56	LS160	60	LS197	75	LS353	85		

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Events Diary

Surface Mounting Techniques & Packaging — May 9th
London west Hotel, West Brompton, London. Seminar organised by Hitachi on all aspects of surface mounting techniques and including question and answer session. Begins with lunch at 1.00 pm and runs until 5.15 pm. Cost is £25.00 inclusive. Contact Julie Richardson on 01-861 1414.

Unix Training Course — May 14/15th
Plessey Microsystems Training Centre, Towcester. Training in Unix system III or V, including hands-on experience using a Plessey System 68. Aimed at data managers and software staff interested in multi-user computer techniques. Contact Plessey Microsystems, Sales Office, Water lane, Towcester, Northamptonshire NN12 7JN, tel 0327 50312.

New IEE Wiring Regulations — May 14-16th
Production Engineering Research Association, Melton Mowbray. Three-day non-residential course on the 15th edition of the IEE Regulations. Cost is £300.00 plus VAT with reductions for participants from companies who are members of PERA. Contact the Booking Bureau, PERA Training, Melton Mowbray, Leicestershire LE13 0PB, tel 0664 64133.

Scottish Electronics Production Show — May 14-16th
Anderston Centre, Glasgow. Exhibition of the latest semiconductor and PCB production equipment, assembly equipment, inspection and test systems, interconnection systems, chemicals and laminates. Contact Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham TW1 3SZ, tel 01-891 5051.

Automated Manufacturing Exhibition & Conference — May 14-17th
NEC, Birmingham. Exhibition of industrial robotics and automated manufacturing systems. Contact Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham TW1 3SZ, tel 01-891 5051.

Power '85 — May 21-23rd
Metropole Hotel, Brighton. See February issue for details or phone 01-437 4127.

Gallium Arsenide Integrated Circuits — June 3rd
Royal Lancaster Hotel, London. Seminar covering gallium arsenide technology, circuit design and applications. Cost is £145.00 plus VAT and includes lunch, etc. Contact Miss Louise Marriott, Oyez Scientific and Technical Services Ltd, 3rd Floor, Bath House, 56 Holborn Viaduct, London EC1A 2EX, tel 01-236 4080.

Phone '85 — June 4-6th
Kensington Exhibition Centre, London. See February issue for details or phone 0280 815226.

Unix Training Course — June 11-12th
Plessey Microsystems Training Centre, Towcester. See above for details.

European Unix User Show — June 12-14th
Olympia 2, London. an exhibition designed to focus attention on the Unix system and attended by over 120 leading suppliers of Unix software, hardware, systems, peripherals and services. Contact EMAP International Exhibitions Ltd, Durrant House, 8 Herbal Hill, London EC1R 5JB, tel 01-837 3699.

Computers In Manufacturing Show — June 24-27th
Olympia 2, London. Exhibition and conference which aims to cover the use of computers in design, production engineering and manufacturing. Contact Independent Exhibitions Ltd, 154 Heath Road, Twickenham, Middlesex TW1 4BN, tel 01-891 3426.

Condition Monitoring In Hostile Environments — June 26th
Regent Crest Hotel, London. Seminar organised by ERA Technology and COMRAD which covers equipment monitoring techniques aimed at predicting failure and thus reducing downtime. Contact Terri Ecclestone, Seminar Organiser, ERA Technology Ltd, Cleeve Road, Leatherhead, Surrey KT22 7SA, tel 0372 374151.

Leeds Electronics Show — July 3-5th
University of Leeds. The show is in its 22nd year and hopes to have 223 stands on display. Contact Evan Steadman Services Ltd, The Hub, Emson Close, Saffron Walden, Essex CB10 1HL, tel 0799 26699.

Readers' Survey Draw Results

At long last we have finished sifting through the several thousand completed Readers' Survey forms we received. A statistical analysis is being prepared and we plan to spend some time in the near future going through your comments and suggestions. We hope to present some of the results of all this effort in a short article in a forthcoming issue.

Meanwhile there is the matter of the free subscriptions we promised to the authors of the first ten survey forms drawn from a hat. We couldn't find a hat large enough, so with the forms securely placed in a cardboard box we carried out this important ceremony with due pomp and what little dignity we could muster.

Our handsome Classified Sales Executive Caroline Faulkner groped diligently around in the box until she could no longer avoid removing some of its contents while her lovely assistant, ETI Editor Gary herman (38-40-45") shook the box in an unhelpful manner. Assistant Editor Ian Pitt tried vainly to pretend to passers by that all this had nothing whatsoever to do with him while several hangers-on leapt around crying "lights, action," and so forth. The ceremony reached its climax with a brief competition to see who could throw most forms in the air whilst doing the splits.

Somewhere in the midst of all this, ten forms were separated from the mass and passed to the subscriptions department where, with tears in their eyes, staff signed the necessary cash slips. The ten luck winners are:

A. Armstrong, 12 Grays Walk, Bishopmill, Elgin, Morayshire; L.C. Boothman, 35 Spalding Road, Fens Estate, Hartlepool, Cleveland; E. Habets, Gosperstreet, 47/4700 Eupen, Belgium; G. Hodgson, 2 Marlborough Avenue, High Harrington, Workington, Cumbria; M. Jones, 26 Whitchurch Avenue, Broadstone, Dorset; B.L. Marshall, 3 Blandford Road, Chilwell, Nottingham; A.J. Wills, 28 Cedar Drive, Kingsclere, Newbury, Berkshire; A. Woodroffe, 'Ranworth', The Glebe, Felbridge, East Grinstead, West Sussex; M. Woodward, 75 Nelson Road, Aston, Perry Barr, Birmingham; and J. LePirie, 72, City Way, Rochester, Kent.

These readers will all receive one year's free subscription beginning with this issue. Our commiserations to those who were not lucky enough to be picked but we will leave them with the thought that ETI is almost as enjoyable when paid for as when obtained free-of-charge.

electronics today international BOOK SERVICE

How to order: indicate the books required by ticking the boxes and send this page, together with your payment to: ETI Book Service, Technical Book Service, Oak House, Cannon Hill Way, Maidenhead SL6 2EY. Make cheques payable to Technical Book Service. Payment in sterling only please. All prices include P & P. Prices may be subject to change without notice.

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COOKBOOKS

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☐ **TTL Cookbook** Lancaster	£13.50
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ELECTRONICS

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☐ **Principles of Electronic Instrumentation** De Sa	£11.45
☐ **Giant Handbook of Computer Software**	£12.95
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☐ **Giant Handbook of Electronic Projects**	£13.60
☐ **Electronic Logic Circuits** Gibson	£6.45
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☐ **Introduction to Digital Electronics & Logic** Joynson	£6.25
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☐ **Essential Electronics A-Z Guide** Loveday	£7.50
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☐ **Power FETs and their application** *Oxner*	£10.80
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☐ **Active Filter Handbook**	£13.30
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☐ **Digital Computer Fundamentals** Barter	£11.75
☐ **Microprocessor Interfacing** Carr	£8.50
☐ **Microcomputer Interfacing Handbook A/D & D/A** Carr	£10.50
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☐ **Let your BBC Micro Teach you to program** Hartnell	£7.95
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REFERENCE BOOKS

☐ **Electronic Engineers' Handbook** Fink	£66.60
☐ **Electronic Designers' Handbook** Giacoletto	£77.75
☐ **Handbook for Electronic Engineering Technicians** Kauffman	£40.50
☐ **Handbook of Electronic Calculations** Kauffman	£42.25
☐ **Modern Electronic Circuit Reference Manual** Marcus	£57.45
☐ **Handbook of Microcircuit Design & Applications** Stout & Kaufman	£49.95
☐ **International Transistor Selector** Towers	£14.50
☐ **International Microprocessor Selector** Towers	£16.00
☐ **International MOS Power and other FET Selector**	£10.95
☐ **International Digital IC Selector** Towers	£10.95
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VIDEO

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☐ **Video Recording: Theory and Practice** Robinson	£16.00
☐ **Video Handbook** Van Wezel	£24.00
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NEW TITLES

☐ **Electronic Devices and Circuits** Bell	£13.50
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☐ **Introduction to PASCAL** Welsh/Elder	£9.45

ELECTRONIC DATA BOOKS

☐ **THT 83/84 Data dictionary and comparison table**	£9.50
☐ **TVT A-Z Transistor equivalent book**	£5.00
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☐ **DAT 3 Part 3 covering 2N21-2N6735**	£9.30
☐ **DAT 4 Part 4 covering 2SA,2SB,2SC,2SD,2SJ, 2SK,3N,3SJ,3SK,4000**	£10.50
☐ **LIN 1 Linear operational amplifiers data and comparison tables**	£6.50
☐ **LIN 2 Linear voltage stabilizers, data and comparison tables**	£6.50
☐ **TTL TTL digital data and equivalent book**	£7.80
☐ **DDV/1 Part 1 European diode data equivalent book**	£7.90
☐ **DDV/2 Part 2 American and Japanese diode data and equivalent book**	£7.90

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Signed ....

Name ....

Address ....

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● *Rental Electronics have brought out their 1985 catalogue of electronic test equipment available on hire. The range extends from basic items through to the more exotic digital 'scopes, spectrum analysers, etc and even includes CAD/CAM/CAE equipment and 32-bit scientific computers. Rental Electronics Ltd, 7 Arkwright Road, Reading, Berkshire RG2 0LU, tel 0734-876377.*

● Barry Porter's audio designs for ETI always prove popular but most constructors have difficulty getting hold of the radial non-polarised electrolytic capacitors he specifies. N.P. Electronics tell us that they stock a full range of Roederstein EKU non-polarised electrolytics and can offer kits of these components for Barry's recent designs at favourable rates. Contact them at The Mill House, Watlington, Kings Lynn, Norfolk PE38 9DW, tel 0553-810096.

● Voluntary Service Overseas are looking for six people who hold a full City and Guilds, TEC, or other equivalent qualification to work in the Third World for two years. The posts are in Egypt, Sri Lanka, Belize, Kenya and on the Maldive Islands and mostly involve teaching electronics or training others to maintain electronic equipment. Applicants should be between 23 and 65 and have British or EEC passports, and if posted will receive local rates of pay and free accommodation. Contact the Enquiries Unit, VSO, 9 Belgrave Square, London SW1X 8PW, tel 01-235 5191.

35" Colour Tube And Television

Mitsubishi have developed a colour television tube which measures 35" across the diagonal and is claimed to be the largest in the world. The tube will be used in a new 35" colour television set which will feature audio-visual and RGB inputs.

The tube is said to be the largest direct-view tube ever produced and offers a picture size previously achieved only by projection televisions. Computer simulation was used to optimise the distribution of glass thickness so as to achive minimum weight and facilitate mass production. A deflection angle of 110 degrees has been used which allows a fairly compact overall size to be achieved, and the complete television is 23" (580mm) deep and 36" (910mm) wide.

The screen area of the new tube is 3.1 times as large as that of a standard 20" television and Mitsubishi claim that the picture remains crisp and clean in spite of the large size. The television includes three sets of audio-visual inputs to permit connection of videocassette and videodisc machines and for the reception of satellite broadcasts and there is also an RGB input for teletext and personal computers.

For details contact the Peripheral Products Group, Mitsubishi Electric (UK) Ltd, Hertford Place, Denham Way, Maple Cross, Rickmansworth, Hertfordshire WD3 2BJ, tel 0923-770 000.

QL Monitor From Microvitec

Microvitec have produced a colour monitor which is designed both technically and visually to suit the Sinclair QL microcomputer and which includes a tilt and swivel stand. The monitor is aimed particularly at business users of the QL and is designed to satisfy the demand for a 'workstation' type display.

Microvitec were the first company to produce a colour monitor which was fully compatible with the QL's 85-column width display and also capable of doing full justice to the machine's colour graphics potential. The new monitor retains the same technical specification, including a 653 pixel-per-line CRT and an 18MHz bandwidth. It has a black finish which matches the external appearance of the QL and the integral stand allows it to be angled to provide the most comfortable working position.

The QL-compatible monitor is expected to sell for just under £300.000. For further information contact the Sales Department, Microvitec PLC, Futures Way, Bolling Road, Bradford, West Yorkshire BD4 7TU, tel 0274-390011.

Passing The Backnumbers

Not before time, we have actually got around to clearing up the ETI office a bit. Amongst the rubble we have found a number of past issues of the magazine, mostly from 1983. Our regular backnumber service does not have the space to handle them, and as some are a bit the worse for wear after kicking around in odd corners for so long it seems unfair to expect people to pay the normal £1.50 a time.

Accordingly, we have decided to make them available to readers in return for fifty pence to cover postage, etc. If you want any of the issues listed below, just write to us at the address given on the contents page and enclose a cheque or postal order made out to ASP Ltd. It would also save us time if you would enclose your address either on a gummed label or at least on a piece of ordinary paper which we can then paste down.

By all means order more than one issue if you wish, but please don't enclose any other requests or enquiries; it would only slow things down. We won't be able to write out explanatory notes or anything, so if your cheque or postal order is returned you should assume that we have run out of copies of the issue you asked for.

The issues we have copies of are:-

NOVEMBER 1982; projects include the first part of the Cortex sixteen-bit computer, a precision pulse generator and a spectrum analyser, and there are features on satellite TV and switched capacitor filters.

JANUARY 1983; projects include the first part of the programmable stage lighting unit, the final Cortex article, a programmable bench power supply, a waveform multiplier for synthesisers and an ADC for ZX81s or Spectrums, while the features include a review of the movie Tron and an article on operational amplifiers.

MARCH 1983; projects include the second part of the ETI Victory electronic organ, a user-defined graphics board for the ZX81, a 6502 sound board and a logic probe, while the features include a second look at satellite TV in the wake of the Part Report and articles on audio output stage design, broadcast standards and laser diodes.

APRIL 1983; projects include the third parts of both the stage lighting unit and the Victory organ, the first part of a ZX81 music board and a real time clock for 6502-based systems, and there are features on both switched mode power supplies and conventional PSUs and articles on voltage multipliers and the use of nested differentiating feedback loops (NDFLs) in audio amplifier design.

MAY 1983; projects include the final parts of both the stage lighting unit, the Victory organ and the ZX81 music board, plus an audio compressor/limiter, a stabilised PSU for hi-fi amplifiers and a sixty watt amplifier designed using NDFL principles. The features include an eight-page buyer's guide to hi-fi and an article on four-channel semiconductor devices.

JUNE 1983; projects include the first part of a switched mode power supply design, a numerical keypad for the Acorn Atom and an electronic compass, and there are features on opto-electronics, buying test gear, and the fabrication of mechanical structures on silicon chips.

DECEMBER 1983; projects include the first part of Barry Porter's modular preamplifier, an EPROM controlled light chaser and a sixteen channel A-to-D board, while the features include articles on tone control design and machine code programming.

ETI

READ/WRITE

You Are Not Alone

Dear Sir,

1. In the Feb 1985 issue of ETI you make a lame excuse for not completing the long-delayed JLH article on his THD meter. Yet on pages 3, 26 and 29 you take up invaluable space with idiotic and vulgar rubbishy 'cartoons' unworthy of a reputable journal.

2. Your mix is about 10 to 1 in favour of computer items, some of them quite silly, over audio ideas. You must know that on our bookshop shelves there is a 20 to 1 preponderance of computer magazines both in England and South Africa. Why not yield a little more space for audio, particularly the brilliant JLH?

3. I wrote to you recently about Newrad's failure to supply my order for components for the JLH amplifier. A parcel arrived two weeks ago and I found that at least 25% of the items were missing, including the more expensive polycarbonate capacitors. I wrote again and I believe another package is on the way. Please don't use their 'activities' in ETI in the future.

Yours sincerely,
Dr. A.H. Barzilag
South Africa.

Well, that may be the first time we've been called reputable. We must be slipping. However, to answer your points in turn:

If you saw the March issue, you would realise that the final part of the THD meter project took up four full pages. The cartoons were not an alternative and, in any case, some people actually enjoy such things. Still, we can't please all the people all of the time — as your second point amply demonstrates. ETI's objective is to cover the whole field of electronics.

It's a big field and in any one issue we will not necessarily be able to get the mix precisely correct. Your figures don't strike me as accurate, but it is undeniable that there is more interest in computer projects right now than in any other part of the electronics field. We reflect that, partly because the proportions apply to our contributors as much as to our readers. If we received more audio projects, we would probably run more audio projects. We do agree with you about John Linsley Hood, though, and we're quite pleased that his contributions to ETI are both frequent and substantial. Perhaps he likes the magazine more than you.

On the final point, we have received a number of complaints about Newrad's delivery of the Linsley Hood MOSFET amp. I've been in touch with the company and they assure me that any problems with the kit are now at an end. The trouble was partly due to necessary alterations in the design and partly to the long lead times for components. Newrad apologise for any inconvenience and ask that you do not phone up with any problems you may have, since this only creates more pressure on time. If you write to them, they will reply — but, they stress, everybody who has ordered a kit will receive a full kit. Delivery times should be acceptable from now on. Naturally, ETI also apologies to any readers who have had trouble with the kit. We can only say that the wait is definitely worth it.

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50	235p	200p	390p

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TIME DOMAIN ANALYSIS

Let your computer do the work after reading Andrew Armstrong's introduction to circuit simulations using BASIC.

There have been complicated and expensive circuit analysis software packages available for some time. Time domain analysis, however, is a simple technique which can be used in BASIC programs on a home computer to analyse circuit performance. The simplicity is due to the fact that analysis is carried out in the time domain rather than the frequency domain..

Frequency domain analysis means calculating the frequency response, and perhaps the phase response, of a linear circuit. The problem is that, even for a very simple-looking circuit, the equations describing the frequency response may be very complicated. Usually, though, the DC behavior of the circuit can be calculated much more easily. What this time domain analysis technique does is to use DC equations for circuit performance, and to apply these equations repetitively at small increments of time. Any required input waveform can be specified as a function, or as a set of data points giving the input voltage at each increment of time.

During each time increment, it is assumed that currents and voltages are constant, while new values for these quantities are calculated. In the first part of the circuit in Fig.1, for example, the charging current of C1 is assumed to be constant during the entire time increment. In reality, the current would decrease steadily as the capacitor charged, so the calculated increase in the charge on the capacitor is greater than the true value. Clearly, the greater the time period, the greater the error. For this reason, a very small time increment is used, and some circuit configurations are analysed using several steps of calculation (ie several time increments) for each point plotted. In effect, time domain analysis involves the integration of equations by numerical approximation. Since they are DC equations, things are relatively simple.

There are a number of circumstances where time domain response is more meaningful than frequency response, of which one obvious example is video. For example, if a low pass filter produces rings and ripples in a square wave signal rather than rounding it off cleanly, those rings will show on the screen - yet the frequency response of the circuit producing the rings may be identical to that of one giving a clean rounding.

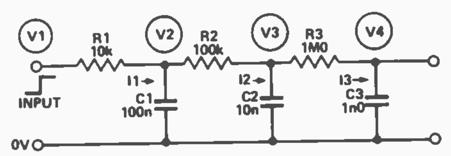
Of course, given that the computer time is available, there is no reason not to carry out frequency response analysis by time domain methods. This transfers the burden of repetitive calculation to the computer rather than the programmer, so that the circuit designer can devote his or her time to thinking about circuit configurations rather than trying to solve equations using complex numbers, which require a piece of paper turned sideways just to write. (And that's only a second order low pass filter!).

DC Analysis

Taking the example of a passive RC low pass filter as in Fig.1, the method of writing the program is, first of all, to write a set of DC equations. These must be chosen so as to be able to be calculated sequentially.

Taking the circuit of Fig.1 as the first example, the equations are:

Fig.1 Low pass filter network.




```
10 '  Analogue circuit analysis program - MAIN PROGRAM
20 '  Andrew Armstrong  06 February 1985
30 '
40 SCREEN 1,0,0 CLS' Select and clear graphics screen
50 '                     Draw grid for graph
60 FOR N=80 TO 430 STEP 50:LINE(N,0)-(N,63)...43690':NEXT N'Vertical lines
70 LINE (30,0)-(30,63):LINE (0,63)-(473,63)'                  Draw axes
80 LINE (30,38)-(473,38)...34952':LINE(30,13)-(473,13)...61680''Horiz. lines
90 GOSUB 170
100 FOR N=1 TO 8:M=(30+(N*50))*79/473:LOCATE M,8:PRINT N;:NEXT N'Number scale
110 LOCATE 2,2:PRINT "-1-":LOCATE 2,5:PRINT"0 5"'                Number scale
120 IF INKEY$ <>"1" THEN 120' Do not print "OK" over the graph immediately
130 END
140 '
150 ' Passive (RC) lowpass filter calculation
160 '
170 R1=10000!:R2=100000!:C1=.0000001
180 C2=1E-08:R3=1E+06:C3=1E-09:DT=.00002
190 FOR N=0 TO 474
200 IF N<30 THEN V1=0 ELSE V1=50
210 I1=(V1-V2)/R1:V2=V2+DT*(I1-I2)/C1'          First node
220 I2=(V2-V3)/R2:V3=V3+DT*(I2-I3)/C2'          Second node
230 I3=(V3-V4)/R3:V4=V4+DT*I3/C3'               Output
240 PSET(N,63-V4):PSET(N,63-V2):PSET(N,63-V3)' Plot output and nodes on graph
250 NEXT N:RETURN
```

Listing 1

Graph 1 Print-out of low pass filter network simulation.

I1 = (V1-V2)/R1
V2 = (I1-I2) * T/C1
and similarly for the second and third parts of the circuit:
I2 = (V2-V3)/R2
V3 = (I2-I3) * T/C2
I4 = (V3-V4)/R3
V4 = (I3-I4) * T/C3

The input waveform, V1, is any arbitrary function which is convenient to generate in software. In this case a simple step is used to demonstrate time delay.

A BASIC program to calculate this is shown in Listing 1, and its print out in Graph 1. The number of steps in the loop is set to be suitable given the response time of the circuit in question. Equally, the value used for V1 is set by the Y scale required, though it would be just as simple to use the value 1 and then scale the answer later on in the program.

The only formulae needed to generate these equations are Ohm's law, and the formula for the change in voltage on a capacitor subjected to a steady current for time T: V = I*T/C. In each small time increment for computing purposes, the current is assumed to be constant, and the change in voltage is added to the previous total. The initial condition used in this program is that all currents and voltages are 0, which is the default condition of the dialect of BASIC in use here.

The shape of the graph showing the response to the input waveform is of interest in that it shows a distinct difference from the exponential charging characteristic of a single R and C. If many stages are added, the result will look like Graph 2 in which a single RC time constant is shown for comparison. In this graph, it is assumed that the current drawn from each RC stage by the succeeding one is negligible, or that they are separated by voltage followers, as in Fig. 2. The effect of ten cascaded time constants is plotted. The routine used is shown in Listing 2.

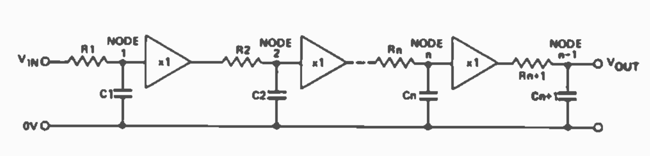
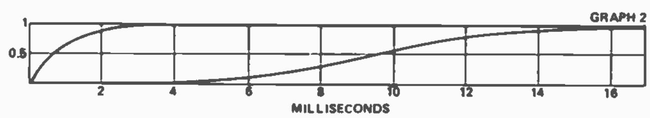


Fig.2 Cascaded time constant circuit.

```
5 DIM V(10)' Array to store node voltages
10 '  Analogue circuit analysis program - MAIN PROGRAM
20 '  Andrew Armstrong  06 February 1985
30 '
40 SCREEN 3,0,0:CLS' Select and clear graphics screen
50 '                     Draw grid for graph
60 FOR N=80 TO 430 STEP 50:LINE(N,0)-(N,63),,,43690':NEXT N'Vertical lines
70 LINE (30,0)-(30,63):LINE (0,63)-(473,63)'                    Draw axes
80 LINE (30,38)-(473,38),,,34952':LINE(30,13)-(473,13),,,61680''Horiz. lines
90 GOSUB 170
100 FOR N=1 TO 8:M=(30+(N*50))*79/473:LOCATE M,8:PRINT N;:NEXT N'Number scale
110 LOCATE 2,2:PRINT "-1-":LOCATE 2,5:PRINT"0.5"'                Number scale
120 IF INKEY$ <>"1" THEN 120' Do not print "OK" over the graph immediately
130 END
140 '
150 ' Cascaded time constant simulation
160 '
170 R1=10000'C1=.0000001:DT=.00001:V(0)=50
190 FOR N=30 TO 474
200 FOR M=1 TO 4'  Extra accuracy loop
210 FOR L=0 TO 9'  Time constant cascading loop
220 I=(V(L)-V(L+1))/R1
230 V(L+1)=V(L+1)+DT*I/C1
240 NEXT L
250 NEXT M
260 PSET(N,63-V(11)):PSET(N,63-V(2))
270 NEXT N
280 RETUPN
```

Listing 2



Graph 2 Print-out of cascaded time constant simulation.

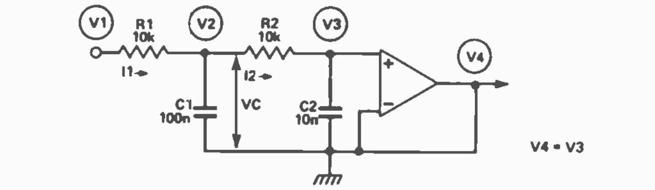
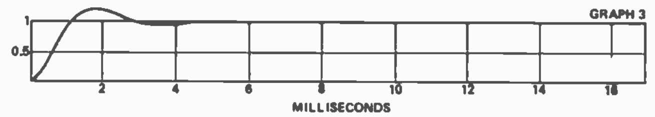


Fig.3 Active low pass filter circuit.

```
10 '  Analogue circuit analysis program - MAIN PROGRAM
20 '  Andrew Armstrong  06 February 1985
30 '
40 SCREEN 3,0,0:CLS' Select and clear graphics screen
50 '                     Draw grid for graph
60 FOR N=80 TO 430 STEP 50:LINE(N,0)-(N,63),,,43690':NEXT N'Vertical lines
70 LINE (30,0)-(30,63):LINE (0,63)-(473,63)'                    Draw axes
80 LINE (30,38)-(473,38),,,34952':LINE(30,13)-(473,13),,,61680''Horiz  lines
90 GOSUB 170
100 FOR N=1 TO 8:M=(30+(N*50))*79/473:LOCATE M,8:PRINT N,:NEXT N'Number scale
110 LOCATE 2,2:PRINT "-1-":LOCATE 2,5:PRINT"0.5"'                Number scale
120 IF INKEY$ <>"1" THEN 120' Do not print "OK" over the graph immediately
130 END
140 '
150 ' Active lowpass filter simulation
160 '
170 R1=10000':R2=10000':C1=1.2E-07:C2=2.2E-08:DT=.00001:V1=50
180 FOR N=30 TO 474
190 FOR M=1 TO 4
200 I1=(V1-V2)/R1
210 VC=VC+(I1-I2)*DT/C1:V2=VC+V3
220 I2=(V2-V3)/R2:V3=V3+I2*DT/C2
230 NEXT M
240 PSET (N,63-V3)
250 NEXT N:RETURN
```

Listing 3



Graph 3 Print-out of active low pass filter simulation.

Overshoot

The technique can easily be applied to active circuits, such as the low pass filter shown in Fig. 3. The component values for this circuit are chosen so that it is underdamped. This results in an overshoot in the response to a step function, as shown in Graph 3.

Conventional wisdom also has it that there will be a peak in the frequency response, but more of this later. Listing 3 shows the equations used - the first part of the program, which draws the scale, is similar in all cases. Note (line 180) that the loop starts at 30 instead of at 0 as in Listing 1. This eliminates the need for the IF statement (Listing 1, line 200), which was only there to illustrate the application of an input step function.

The inner loop of M (Listing 3, line 190 to line 230) allows the calculation of four points for each one plotted on the graph, so that if high rates of change of any variable occur, a reasonable accuracy can be achieved. The size of this loop may be set as large as necessary to achieve good accuracy, but remember that each step of this inner loop is one time increment, so the step size DT should be scaled down appropriately to obtain the benefit from this. Otherwise, the time scale will simply be compressed, and the accuracy the same.

COMMENTS ON LISTINGS

The computer for which the programs were written, an Epson PX8, has available a graphics screen, on which the individual LCD points may be set. It is numbered from 0,0 in the top left hand corner to 479,63 in the bottom right hand corner. The screen contents can be copied to a suitable printer using the screen dump mode. Once the purpose of the graph plotting statements is understood, there should be little difficulty in performing the nearest equivalent operations on another machine.

As well as being able to set individual points, lines can be drawn. It is almost as fast to draw a line as to set a single point, so this is employed in lines 60, 70, and 80, as shown on Listing 1, to draw the framework of the graph. The line is drawn to the bit pattern of a repeating 16 bit binary number corresponding to the number specified after the three commas in the line statement, the default being a solid line.

Character positions may be specified in x,y co-ordinates, starting with 1,1 on the top left, and finishing with 80,8 on the bottom right. Only whole character positions can be used, but the statement in line 100 LOCATEs the nearest position to the vertical scale lines, which are every 50 pixels for ease of calculation.

To avoid the message "OK" being printed over the graph, the INKEYS function is used in line 120 to keep the program twiddling its thumbs in a loop and allow time to press the screen dump button.

The calculation part of the programs is quite straightforward, and is detailed earlier on.

The only particular point of interest is that a smaller time increment is used in programs 2, 3 and 4 than in programs 1 and 5, and four steps of calculation are carried out for each point plotted. This reduces an otherwise unacceptable cumulative error in the cascading loop in program 2. In programs 3 and 4 the same technique copes with the high rates of change or voltage in the circuits being simulated.

Listing 4 shows the use of an input waveform other than a step at time=0. A sine wave is used, though any definable function may be used. R1 makes writing the equations convenient.

The only limitations on the size of the loop are how long you care to wait for an answer, and how long your computer is liable to be left undisturbed chonking away in peace while you do something else. In practice, I have found that the time taken to eat lunch is a reasonable limit but really fast machines may never need this long. Compiled Basic (or any compiled language) is to be preferred for complicated simulations.

The only significant difference between the active and the passive filter simulation is that the voltage across C1 is measured relative to the op-amp output instead of relative to 0V.

Lumped Constant

The same idea is applied to the voltage across the source resistor in the lumped constant transmission line simulation (Fig. 4, Listing 4 and Graph 4). The resistors chosen are of the nominal impedance of the line, $\sqrt{L/C}$, so the output rings only a little. It is left to the reader to experiment with other values of R1 and R2. 50R gives some entertaining rings!

In principle, this simulation could be applied to almost any linear circuit. If many similar stages were to be simulated, even though they had different values, it would be better to use a loop as in Listing 2, and to refer to component values stored in arrays.

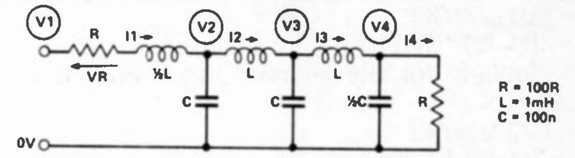
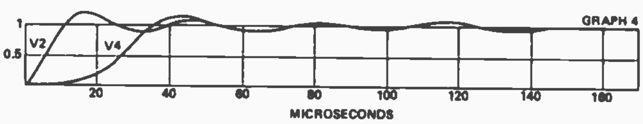


Fig.4 Lumped constant transmission line - equivalent circuit.

```
10 '  Analogue circuit analysis program - MAIN PROGRAM
20 '  Andrew Armstrong  06 February 1985
30 '
40 SCREEN 3,0,0:CLS' Select and clear graphics screen
50 '                  Draw grid for graph
60 FOR N=80 TO 430 STEP 50:LINE(N,0)-(N,63),,,43690':NEXT N'Vertical lines
70 LINE (30,0)-(30,63):LINE (0,63)-(473,63)'                  Draw axes
80 LINE (30,38)-(473,38),,,34952':LINE(30,13)-(473,13),,,61680''Horiz  lines
90 GOSUB 170
100 FOR N=1 TO 8:M=(30+(N*50))*79/473:LOCATE M,8:PRINT 20*N;:NEXT N
110 LOCATE 2,2:PRINT "-1-":LOCATE 2,5:PRINT;0.5"'                Number scale
120 IF INKEY$ <>"1" THEN 120' Do not print "OK" over the graph immediately
130 END
140 '
150 ' Lumped constant transmission line simulation
160 '
170 L=.001:C=.0000001:R1=100:R2=100:DT=.0000001:V1=100
180 FOR N=30 TO 474
190 FOR M=1 TO 4
200 I1=I1+DT*(V1-V2-VR)*2/L:VR=I1*R1:V2=V2+DT*(I1-I2)/C
210 I2=I2+(V2-V3)*DT/L:V3=V3+DT*(I2-I3)/C
220 I3=I3+(V3-V4)*DT/L:V4=V4+DT*(I3-I4)    *2/C:I4=V4/R2
230 NEXT M
240 PSET(N,63-V2):LINE(N,63-V4)-(N,62-V4)'P)ot first node and output
250 NEXT N:RETURN
```

Listing 4



Graph 4 Print-out of lumped constant transmission line simulation.

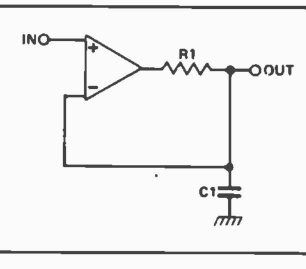
Frequency Response

All the analysis shown so far gives only the time response of a circuit. There are at least two ways in which it can be adapted to provide a plot of frequency response.

The first and most obvious method is to make the input voltage a sinewave, instead of a step function. A large number of cycles is applied to the circuit to allow the circuit to settle, and then the output signal is plotted, or its amplitude measured and the result stored in an array. The frequency is then incremented and the procedure carried out again. It is clear that such a program would take a long time to run, so the writing of code is left as an exercise for the reader.

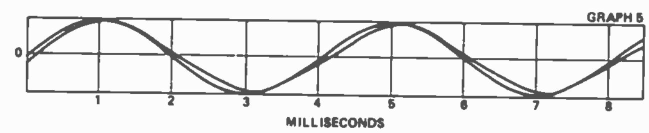
There is another method, still under development, which should turn out more elegant and faster to execute. If the output signal from the circuit were to be spectrum analysed, perhaps by a Fourier transform, and compared with the frequency spectrum of the input, then the frequency transfer function of the simulated circuit could be determined. Phase information would be available as well.

Fig.5 A current limited op-amp configuration.



```
10 '  Analogue circuit analysis program - MAIN PROGRAM
20 '  Andrew Armstrong  06 February 1985
30 '
40 SCREEN 3.0.0:CLS' Select and clear graphics screen
50 '                 Draw grid for graph
60 FOR N=80 TO 430 STEP 50:LINE (N.0) - (N.63) ...43690':NEXT N'Vertical lines
70 LINE (30.0) - (30.63):LINE (30.31) - (473.31)'                Draw axes
80 GOSUB 160
90 FOR N=1 TO 8:M=(30+(N*50))*79/473:LOCATE M.4:PRINT N::NEXT N'Number scale
100 LOCATE 2.4:PRINT "-0-"'                                     Number scale
110 IF INKEY$ <>"1" THEN 110' Do not print "OK" over the graph immediately
120 END
130 '
140 ' Current limited op-amp simulation
150 '
160 R1=470:C1=1.8E-07:DT=.00002:ANGLE=ATN(1')/25:GAIN=1000
170 FOR N=30 TO 474
180 V1=30*SIN(ANGLE*(N-30))
190 V0=GAIN*(V1-V2)+V1
200 IF V0>30 THEN V0=30
210 IF V0<-30 THEN V0=-30
220 I1=(V0-V2)/R1:IF I1>.006 THEN I1=.006
230 IF I1<-.006 THEN I1= -.006
240 V2=V2+I1*DT/C1
250 PSET (N.31-V1):PSET (N.31-V2)
260 NEXT N:RETURN
```

Listing 5



Graph 5 Print-out of current limited op-amp simulation.

This technique should work well, because the frequency spectrum of the input step function is continuous, theoretically from zero to infinity (but only if the simulation is for an infinite period!). Any reasonable range of frequencies is liable to be able to be plotted with little difficulty, once the numerical spectrum analysis is working.

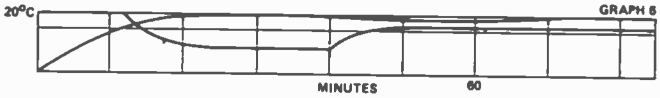
Further Applications

So far, only linear circuits have been considered. It is easy to add the effects of non-linearity anywhere in the circuit by using IF statements. For example, current limiting may be represented by:

IF I>6E-3 THEN I = 6E-3: IF I<-6E-3 THEN I = -6E-3

This limits the current to ± 6 milliamps, typical of the response of some small op-amps. The effect of a current limited opamp connected in the circuit shown in Fig. 5 is simulated by the program in Listing 5, which feeds a sine-wave into the circuit, and gives the output shown in Graph 5.

This circuit is a first approximation to a model for an op-amp. Equally, a conventional model may be used to simulate a transistor, with sets of values stored in arrays to enable a single transistor simulation subroutine to be used for a multi-transistor circuit.



Graph 6 Print-out of heater control simulation.

The technique can be used for digital and control circuits. For example, Graph 6 shows the effects of PID (proportional, integral, and differential) control using a computer in conjunction with a heating system. In this case, the simulation can be very close to the truth, since the measurements would be sampled and the sampling period of the program can be made identical to that of the system to be used. The thick line on the

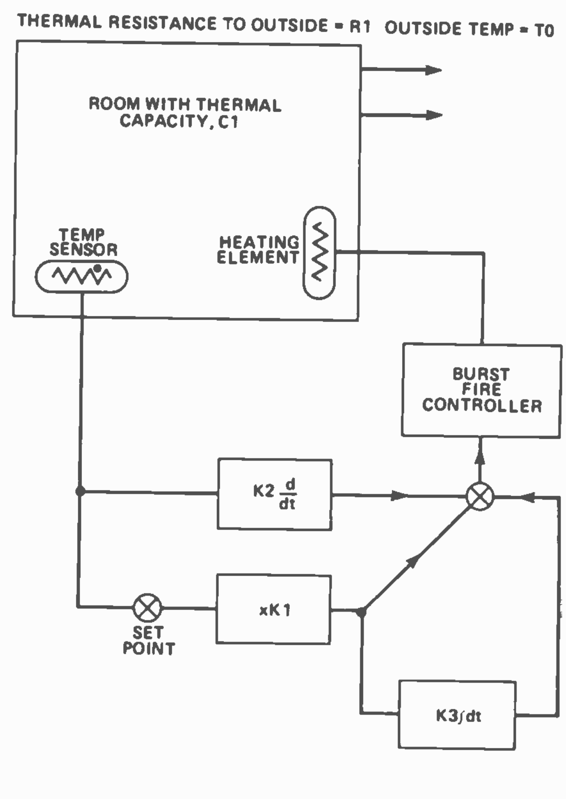


Fig.6 Block diagram of heater control circuitry.

```
10 'Airconditioning simulation program  A. Armstrong 4 Feb. 1985
20 SCREEN 3.0.0:CLS'Select and clear graphics screen
30 '
40 '                  Draw grid for graph
50 '
60 FOR N=80 TO 450 STEP 50:LINE(N.0) - (N.63) ...43690':NEXT N'Vertical lines
70 LINE (30.0) - (30.63):LINE (30.63) - (473.63)'              Draw axes
80 LINE(30.13) - (473.13) ...61680''                           Aiming point
90 GOSUB 130'                            Call calculation routine
100 LOCATE 55.8:PRINT"60"::LOCATE 1.2:PRINT"20^C"'               Scale numbering
110 IF INKEY$ <>"1" THEN 110'TYPE 1 FOR A PRINTED COPY
120 COPY:END'                  THE END OF THE MAIN PROGRAM
130 C1=100:R1=20:T0=0:DAT=2.IAT=15:PB=5:SP=20'DT=.05:HTC=1'Times in minutes
140 X=DT*.36/HTC:Y=1-X'Heater time constant
150 K3=DT/IAT
160 DT=DT*60'convert to seconds
170 BAND=13+(PB*2.5)
180 LINE(30.BAND) - (473.BAND) ...34952'' Draw proportional band lower limit
190 K1=1/PB
200 K2=1/(DAT*DT*PB)
210 ONE = DT'One kilowatt of cooling = 1*time increment
220 FOR N=30 TO 479
230 FOR LOOP=1 TO 4
240 HP=(SP-TEMP)*K1:HD=K2*TD
250 H=HP
260 IF H>1 THEN H=1
270 YI=YI+H*K3'INTEGRATE HEATING DEMAND (WITHOUT INTEGRAL TERM)
280 IF YI<0 THEN YI=0:IF YI>1 THEN YI=1'KEEP INTEGRAL WITHIN LIMITS
290 IF H>.99 THEN YI=0'NO INTEGRATION OUTSIDE LINEAR CONTROL REGION
300 H=HP+YI-HD
310 IF H<0 THEN H=0:IF H>1 THEN H=1
320 IF H>1 THEN H=1
330 TPREV=TEMP
340 HEAT=DT*H*2.5*Y+HEAT*X'THERMAL MASS OF HEATER
350 LOSSES=(TEMP-T0)*DT/R1
360 IF N>229 THEN LOSSES = LOSSES+ONE'ADD 1 KW OF COOLING SUDDENLY
370 TEMP=TEMP+(HEAT-LOSSES)/C1
380 TD=.9*TD+.1*(TEMP-TPREV)'SIMPLE DIGITAL FILTERING ALGORITHM
390 NEXT LOOP
400 T1=2 5*TEMP
410 PSET(N.63-T1)
420 PSET(N.63-50*H)-PSET(N.62-50*H)
430 NEXT N:RETURN
```

Listing 6

graph represents heater power, the thin line represents temperature. At time 40 minutes, an extra kilowatt of cooling is introduced (to model, say, a window being opened). The graph shows the effect of such a disturbance to the system.

In this example, the maximum heater power is assumed to be 2.5 kW, the room to outside temperature insulation is 20°C per kW, and the outside temperature is 0 °C. The thermal capacity of the room is assumed to be 100 kilojoules per degree, and the time constant of the heating element is about one minute.

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THE REAL COMPONENTS

In this, the fourth article in his series, John Linsley Hood looks at transistor parameters and design calculations based upon them.

It is a useful thing to be able to calculate how an electronic circuit will behave, and in the case of valves, this was quite straightforward. Transistors are a different and rather more difficult matter, not helped very much by the fact that there are such a wide variety of terms and symbols used by different manufacturers and text books to describe exactly the same thing.

However, it looks more difficult than it is — at least at low frequencies — to do the sums, and I propose to try and prove this. But first, we must specify the meaning of the terms.

Resistance Well, that is straightforward enough, and just defines that quality in the obstruction of current flow which causes a voltage drop (or potential difference). R=V/I.

Impedance Basically the same thing as resistance, but allowing for the fact that there is some capacitative or inductive component in the resistance to current flow, so that the actual value will be different at different frequencies. Pure resistance is an uncommon thing in real life because most obstructions to current flow are, in truth, impedances, so this is a word which can be used to describe what one means without much risk of contradiction.

Conductance This is the reciprocal of resistance, and is measured in amps per volt (I/V) instead of volts per amp (V/I).

Admittance This is the reciprocal of impedance, and again is given in terms of amps per volt, but at some specific frequency. Both conductance and admittance are expressed in Siemens *(=S). 1S=*1amp/volt, 1mS=1mA/V, and so on.

The symbol R is conventionally used to indicate resistance, and Z to indicate impedance. G is used to indicate conductance, and Y for admittance.

When dealing with transistors it is customary to look at them as small 'black boxes' with four terminals. The input circuit is labelled 1 and the output circuit is labelled 2, as shown in Fig. 1a or in the equivalent circuit shown in Fig. 1b.

Conventionally, again, the currents which flow in circuit 1 as a result of the voltages applied to the input terminals are referred to as 11. Those which flow in the output as a result of voltages in the output are referred to as 22 and those which flow in the output as a result of currents in the input are described as 21 and so on.

Originally, the input characteristic was measured as an impedance, Z, giving rise to terms like Z11 to define the input impedance, and the output circuit defined as an admittance, so that the output admittance would be specified as Y22. Nowadays, it is much more common for these to be known as h or 'hybrid' parameters, so that Z11 becomes h11 or h_i, and the output admittance Y22 becomes h22 or h_o.

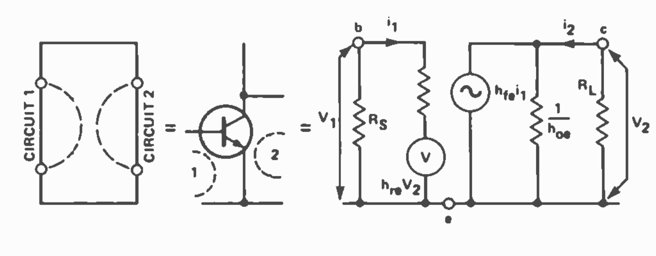


Fig. 1 A 'black box' representation of a junction transistor (left) and the equivalent circuit (right).

However, in addition to these we have the transfer characteristics, such as the forward current transfer ratio. This is written as hF if we are talking about DC values (usually referred to as static conditions) or hf if we are referring to dynamic (AC) characteristics. The reverse, or feedback parameter, h12, becomes h_r.

This is complicated a bit by the fact that all of these parameters are affected by the way in which the transistor is used. If it is used in the common emitter configuration with the signal applied to the base, the output taken from the collector, and the emitter tied to the 0V line, these various parameters become h_{FE} or h_{fe}, h_{oe}, h_{re} and so on. Similarly, if one ties the base to a common supply line potential, and applies the signal to the emitter, these parameters would be defined as h_{fb}, h_{ob}, and h_{rb}.

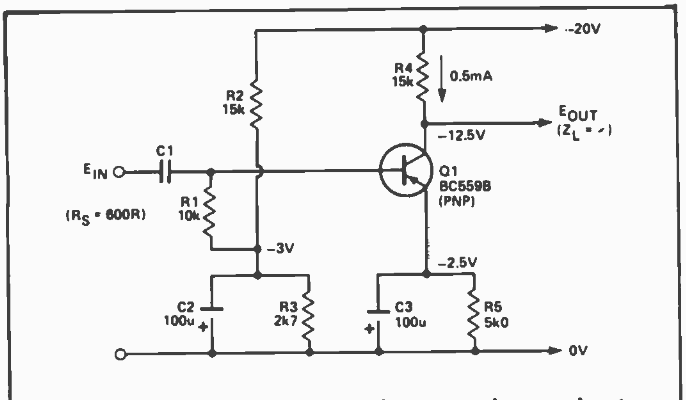


Fig. 2 A practical, common-emitter transistor gain stage which may be used for performance calculations.

Unlike valves and FETs, transistors have a DC conductive path between their three connections, so the output impedance is influenced by the input circuit impedance and vice-versa, and all of these including the current gain, are influenced by the operating current of the device.

A fairly full data sheet for a transistor should include graphs which show the way in which h_{FE} varies as a function of operating current. Ideally it shouldn't vary very much, and in the better modern types it doesn't. The graphs will also show the way in which the input impedance will vary with emitter current, but this will usually be quoted only for the common emitter configuration since this is the most widely used arrangement. If this isn't quoted, a fairly useful rule of thumb is that the input impedance (h_{ie}) is 25x the current gain for a 1mA emitter current, and increases, roughly in proportion, as the operating current is decreased. One should also find values for the output admittance, as μs or μA/V, and the reverse transfer ratio, hre.

The formula for calculating voltage gain, in the common emitter configuration shown in Fig. 2, is —

$$A_v = -\frac{h_{fe} \times R_L}{h_{ie} + R_S + \Delta_{he} \times R_L}$$

Δhe, the common emitter configuration correction factor ($h_{ie} \cdot h_{oe} - h_{fe} \cdot h_{re}$) is often small enough to be ignored, so the gain equation simplifies to —

$$A_v = -\frac{h_{fe} \times R_L}{h_{ie} + R_s}$$

Let's take a genuine example, such as the Mullard BC559, and go through these calculations for an operating current of 0.5mA. The gain of the circuit shown in Fig. 2, at a frequency in the AF range where the impedances of C1, C2 and C3 are small enough to be ignored, can be calculated using the published data:-

h_{fe}=270 h_{ie}=10k

h_{oe}=25uA/V. h_{re}=0.001.

which gives a value of 0.52 for Δhe.

However, we have to take into consideration the source impedance (R_s), which in this case I have assumed to be a signal generator with a 600 ohm output. This must be added to h_{ie}.

$$A_v \quad \frac{270 \times R_l}{10k + 600 + 0.52 \times R_L}$$

so the voltage gain becomes —

$$= -\frac{270 \times 15k}{10k6 + 0.52 \times 15k}$$

This is a very favourable condition, since I have also assumed an output impedance which is very high in relation to R4. If, however, the transistors were driven from a similar stage, where the output impedance is R4//Z_{oe} (40k//15k = 10k9), and it was loaded by the input impedance of a similar transistor, (Z_{ie} = 10k), the gain would come down to —

$$A_v = \frac{-270 \times 10k9//10k}{20k9 + 0.52 \times 5k2}$$

$$= 60$$

which is a much more typical figure.

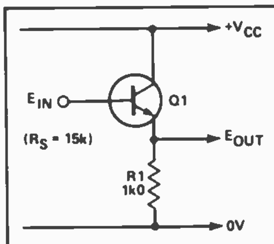


Fig. 3 A transistor arranged as an emitter follower.

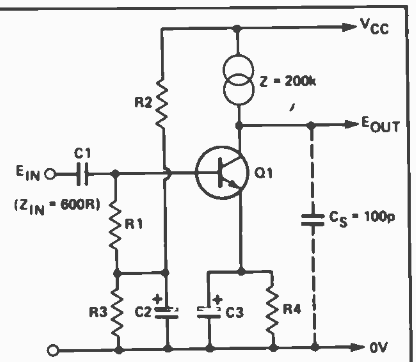


Fig. 4 A high gain transistor stage.

Another useful calculation to be able to make is that to discover the input and output impedances of the impedance converting emitter follower circuit of Fig. 3. This is,

$$Z_{in} = (1+h_{fe}) \times R1,$$

and

$$Z_{out} = R_s/(1+h_{fe}) \; // \; R1.$$

For a transistor such as the BC559, driven from a 15k source, the output impedance will be 52 ohms and the effective input impedance will be 271k.

The lesson which can be drawn from this is that, for high stage gains, low source impedances and high output impedances are imperative. However, there are snags. The first of these concerns the effect of output stray capacitance in parallel with the load.

Let us assume, in the case of the circuit shown in Fig. 4, that we we have contrived a constant current source as the collector load and this has an effective dynamic impedance of 200k at a collector current of 0.5mA. Using the circuit parameters of Fig. 2, this will give us a gain of 471 at lowish audio frequencies, and if we are driving an emitter follower or similar high impedance load we should not diminish this too much.

However, suppose we have a stray capacitance of 100pF in parallel with the output circuit. The output impedance will then decrease with frequency until, at about 7kHz, the stage gain will have fallen to half its low frequency value.

An aspect of this capacitance load effect which is familiar, and worrying, to audio amplifier designers is the combined effect of a constant current source load and stray capacitance when the amplifier is asked to

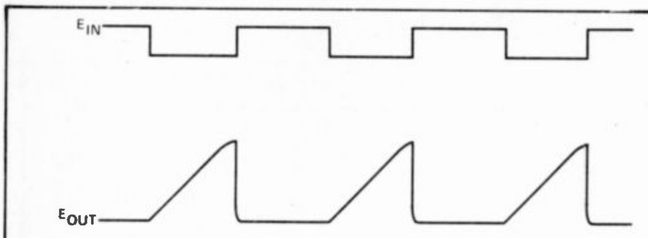


Fig. 5 Slew rate limiting caused by stray capacitance on a constant current source load.

handle a waveform having a rapidly rising voltage transient. I have shown this in Fig 5.

With the circuit shown, the amplifier stage may behave quite well on negative-going transients when the transistor, Q1, can pump current into the load, but on a positive-going waveform, the rate of charge of the capacitor is strictly limited by the constant-current source to 0.5mA, which gives a beautifully linear charging rate to the capacitance. This is lovely in the time base generator of an oscilloscope, but audibly very nasty in an audio amplifier. It gives rise to the defect known as 'slew rate limiting', which is one of the all-too-frequent causes of displeasure in less than high fidelity.

Another related problem inherent in the transistor is that of the Miller effect, due to the capacitance between the base and collector. Since the stage inverts the phase of the signal, at least on non-inductive loads, the side of the internal capacitor electrically connected to the output will rise in potential as the input side falls. If the gain of the stage is M, this has the effect of making the capacitor look like M+1 times its static value, as shown in Fig. 6.

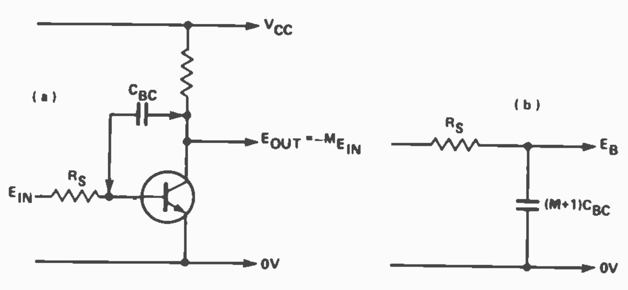


Fig. 6 Miller effect, whereby inherent capacitance between base and collector is magnified in value.

Supposing, therefore, that the stage gain is 150x, and the base-collector capacitance is 5pF, the actual capacitance seen at the transistor end of the source resistor is 5 x 150pF = 750pF, which will have a considerable effect on the HF response of the circuit.

Other Parameters

Noise figure This is expressed in decibels, and is a measure of the extent to which the transistor input noise (output noise divided by stage gain) is worse than that which would have been due just to the input resistance on its own. All resistors generate noise, the higher the resistance value and the higher the temperature the worse this will be. The formula is —

$$V_n = \sqrt{4 \times K \times T \times \delta f \times R}$$

where K is Boltzmann's constant (1.38×10^{-23}), T is the absolute temperature (°K,) and δf is the bandwidth.

A typical graph showing the way the noise figure of a transistor varies with collector current and source resistance is shown in Fig. 7. Since the noise will increase at high input resistance values anyway, the best transistor to use if one wants the lowest noise is the one which will give a low noise figure at the lowest useable input resistance.

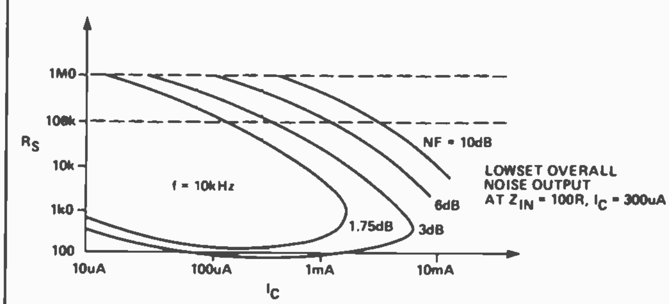


Fig. 7 The noise performance of a BC559 as a function of input resistance and collector current.

Happily, improvements in device manufacture have led to better characteristics, so, if you have a choice, use a device with a high 2N or BC number, rather than a low one. A BC549 is likely to be a better device, at the same cost, than a BC109, since these are both of the same type, only differing in date of design. Surprisingly, PNP small signal devices are better than NPN in this respect because the current flow in the base region — which is of N type — is due to electrons rather than holes.

Transition frequency As the operating frequency increases, so the current gain of a transistor will decrease. NPN devices are normally better than PNP ones in this respect, and since the problem is due to electron/hole mobility in the base and collector regions, devices with thin, highly doped base and collector layers, which will inevitably have a relatively low breakdown voltage, will be best in this application.

The parameter f_T can be thought of as the frequency at which the current gain will have fallen to unity.

Breakdown voltage This can be due to several mechanisms, and is usually destructive unless the current which can flow is limited by some external resistance to a value which does not cause the local thermal dissipation of the device to exceed a safe value.

One of the mechanisms is punch through, which occurs when the depletion layer in the base region resulting from the applied collector voltage extends, as V_c is increased, until it reaches the emitter region. When this happens, the base effectively loses its identity and there is no longer a PN junction to prevent current flow. If the collector region is heavily doped to allow high current flow, the number of minority carriers diffusing into the base will be greater and the depletion layer wider for any given applied voltage, leading to a lower punch through potential.

A second mechanism is the Zener effect. In a highly doped material, a reverse bias will cause the valence band (containing minority carriers) to overlap the conduction band in the semiconductor junction (containing majority carriers, ie, electrons) and current will flow. A small-signal transistor can be used as a cheap

	COMMON EMITTER	COMMON BASE	COMMON COLLECTOR
VOLTAGE GAIN	$\frac{-h_{fe} R_L}{h_{ie} + \Delta_{he} R_L}$	$\frac{(h_{fe} + \Delta_{he}) R_L}{h_{ie} + \Delta_{he} R_L}$	$\frac{(1 + h_{fe}) R_L}{h_{ie} 3 (1 - h_{re} + h_{fe} + \Delta_{he}) R_L}$
CURRENT GAIN	$\frac{h_{fe}}{1 + h_{oe} R_L}$	$\frac{-(h_{fe} + \Delta_{he})}{1 - h_{re} + h_{fe} + \Delta_{he} + h_{oe} R_L}$	$\frac{-(1 + h_{fe})}{1 + h_{oe} R_L}$
INPUT IMPEDANCE	$\frac{h_{ie} + \Delta_{he} R_L}{1 + h_{oe} R_L}$	$\frac{h_{ie} + \Delta_{he} R_L}{1 - h_{re} + h_{fe} + \Delta_{he} + h_{oe} R_L}$	$\frac{h_{ie} + (1 - h_{re} + h_{fe} + \Delta_{he}) R_L}{1 + h_{oe} R_L}$
OUTPUT IMPEDANCE	$\frac{h_{ie} + R_S}{\Delta_{he} + h_{oe} R_S}$	$\frac{h_{ie} + R_S(1 - h_{re} + h_{fe} + \Delta_{he})}{\Delta_{he} + h_{oe} R_S}$	$\frac{h_{ie} + R_S}{1 - h_{re} + h_{fe} + \Delta_{he} + h_{oe} R_S}$

NOTE: $\Delta_{he} = h_{ie} \cdot h_{oe} - h_{re} \cdot h_{fe}$

CIRCUIT LAYOUT

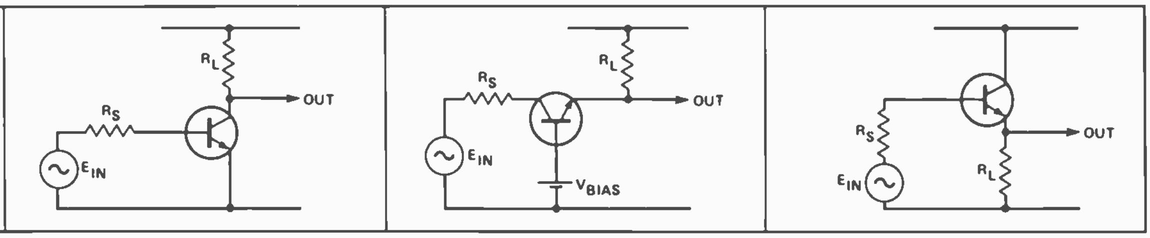


Table 1 Junction transistor performance calculations using h parameters.

zener diode of about 5-6V if it is connected with its emitter reverse biased in relation to its base. This is because the emitter is usually a very heavily doped region. Normally, if the current is held to a sensible level, no damage will occur. The collector should be connected to the base in this application, to keep it from joining in as shown in Fig. 8.

A third mechanism, avalanche breakdown, occurs in lightly doped high voltage transistors if too high a voltage is applied. In this, carriers entering the depletion region are accelerated by the applied potential and, if their velocity is high enough, collisions within the material will generate ion-pairs and further carriers. The result is much like an avalanche, and usually just about as welcome. An exception to this is in avalanche diodes where this mechanism is used to beneficial effect.

In transistors, avalanche effects are greatly influenced by the external base-emitter circuit resistance, and this is the reason why, in general, high voltage and power transistors require conditions of use in which the base circuit resistance is low.

Power Transistors

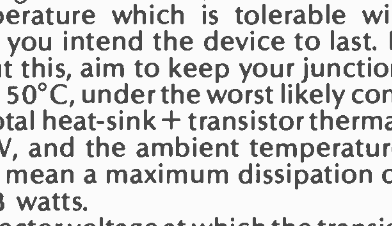
In principle, one can do all the calculations for power transistors that one can for small signal ones, except that the manufacturers are a lot less forthcoming about the input and output h values. This is because power devices are mainly only used in applications where, as emitter followers or drivers of low impedance loads, the stage gain is a lot less important than the ability of the device to feed current into the load or withstand the voltage swings involved without breakdown.

The parameters one is likely to find published in respect of power transistors, in addition to the ones which are obvious like total power dissipation and safe operating area (which we looked at previously), are those which relate to its operational voltages and switching times.

Of these, the ones which are likely to be of interest, say, to an audio amplifier designer, are the collector and base saturation voltages. These will be specified at certain base and collector voltages, and relate to the sort of voltage drop which is going to occur across the device when large quantities of current are delivered by it.

A further quality which would be of interest is the variation of current gain with collector current. Ideally, for lower distortion, this curve should be as flat as possible. Also, if one is seeking a high power output, the 'thermal resistance' of the transistor is important. This is usually specified in °C/watt, and infers a perfect stone-cold heat sink, so in practice, the thermal resistance of the heat sink will have to be added to this to

Fig. 8 A small signal transistor connected as a zener diode.



arrive, perhaps, at a figure like 2.5°C/watt. The maximum junction temperature which is tolerable will depend on how long you intend the device to last. If you are worried about this, aim to keep your junction temperatures below 150°C, under the worst likely conditions. If one had a total heat-sink + transistor thermal resistance of 2.5°C/W, and the ambient temperature was 30°C, this would mean a maximum dissipation of (150-30)/2.5W, or 48 watts.

V_{ceo} sus., is the collector voltage at which the transistor will pass a continuous collector current, even when there is no base drive current at all. The manufacturers quote minimum values for this. In practice it means 'keep well below this voltage — unless you are only operating under pulsed voltage conditions'.

The normal maximum operating voltages (usually under relatively low current conditions) are defined as

V_{cbo}, which is the maximum voltage permitted between collector and base with the emitter open circuited; V_{ceo}, which is the collector/emitter maximum voltage with the base open circuit, and V_{cer}, which is the permitted maximum collector voltage with some specified value of resistance between emitter and base (see avalanche breakdown above).

V_{ebo} is the reverse biased emitter/base zener voltage, and is usually about 5V for power devices.

Where the power transistor is being used for fast switching applications, the various switching times become important. These are the delay time (td), which is the time which elapses after the application of a voltage to the base before any collector current begins to flow; the rise time; the fall time; and the storage times associated with the rise and fall of collector current, and which relate to the length of time it takes for the relatively slow moving holes in the base region to be eliminated.

This is particularly important when the current through the transistor is being turned off. It will not reach a zero value until the stored charge is dissipated, and this is dependent both on the external base-emitter circuit resistance and upon the emitter voltage. If the emitter is reverse biased to some value lower than the zener breakdown level, the stored charge will be removed more rapidly and this may be a critical factor in switching inductive loads.

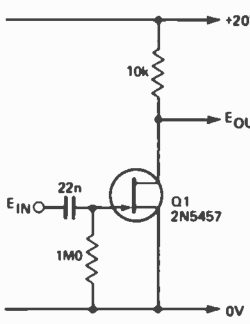


Fig. 9 A practical small signal amplifier stage using a FET.

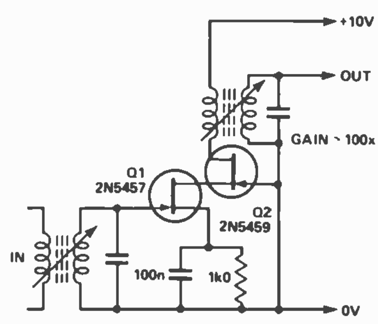


Fig. 10 A stable RF amplifier stage using cascode connected FETs.

Because of the larger junction areas all of the capacitance values for power transistors are much larger than for small signal devices, with values in the range 100-1000pF being common.

Junction Field Effect Transistors

Because these are voltage operated devices with a virtually infinite impedance gate electrode, gain calculations are much simpler, at least at low frequencies. As with junction transistors, HF calculations, usually with deliberate or unintentional inductance in the input and output circuits, are a highly complex business, best left to the specialists in this field.

The parameters which are likely to be specified are Y_{fs}, the forward transfer conductance, or forward trans-admittance, which is similar to the G_m, or mutual conductance, figure for a thermionic valve, and is usually expressed in mA/V; and the Y_{os}, or output admittance, of which the reciprocal is similar to the anode resistance of a valve.

Typical values of these parameters, for a 2N5457 FET, are 4-7mA/V at 0V negative gate bias, and 2μS, or 500k. A 2N5459, which has a gate cut-off voltage of about -5V instead of 1.5-2V for the 2N5457 and a zero gate-bias drain current of 10-15mA instead of 2-5mA, will have a higher zero gate bias Y_{fs}, probably in the range 6-10mA/V. The output impedance is, however, very similar. Junction FETs do have very high drain resistance values, which is why they make such good constant-current sources.

The formula for calculating voltage gain is a simple one:-

$$A_v = -\frac{Y_{fs} \times R_L}{1 + Y_{os} \times R_L}$$

For the common source configuration shown in Fig. 9, and with the component values shown, this becomes:-

$$A_v = -\frac{5 \times 10^{-3} \times 10k}{1 + \frac{10k}{500k}}$$

giving a value for stage gain of 49 at zero gate bias. However, as the negative gate bias is increased the mutual conductance falls, giving proportionately lower stage gains. Once again, I have assumed an infinite impedance load. A load of 10k would halve these stage gain values.

The input capacitance, C_{iss}, is typically 3-6pF, decreasing as the gate becomes more negative. The reverse transfer capacitance (or, more familiarly, the drain-gate capacitance) is typically 1-3pF, becoming less as the drain voltage is increased, and as the gate is made more negative. This is a bit high for stable working as an RF amplifier, but two similar FETs can be connected in cascode as shown in Fig. 10, to make a very stable RF amplifier.

The input noise figure for FETs will be expressed as nV per $\sqrt{Hz}$, and since this is independent of the source resistance value, the FET will have the least effect in worsening the input noise when the input circuit resistance is very high.

For example, the published figure for a 2N5457 at 25°C is 10nV/$\sqrt{Hz}$, which for a 20kHz bandwidth is 1.4μV. However, for the same bandwidth, the noise developed across a 1M resistor is 18μV, giving an effective FET noise figure of 0.6dB when used in this circuit. The break-even 6dB noise figure occurs for an input resistance of about 7k.

One of the areas in which junction FETs (and MOSFETs) score heavily in comparison with bipolar transistors is in terms of linearity, with a typical FET amplifier stage offering THD (Total Harmonic Distortion) figures in the absence of negative feedback some 10x lower than for a similar bipolar gain stage. Say, 0.5% THD instead of 5% THD for 5V RMS output. This arises because the FET has a very linear input voltage/output current relationship, especially at near zero gate bias voltages. This compares with bipolar devices which are only linear at very small input signal levels.

Small Signal MOSFETs

The characteristics of these are very similar so far as gain calculations are concerned to those of junction FETs, and the same formulae apply. However, the typical values of drain resistance are more similar to those of a junction transistor than to the junction FET.

Next month I propose to take a look at diodes, in all their various forms.

ETI

NEXT MONTH

AN ARGUS SPECIALIST PUBLICATION

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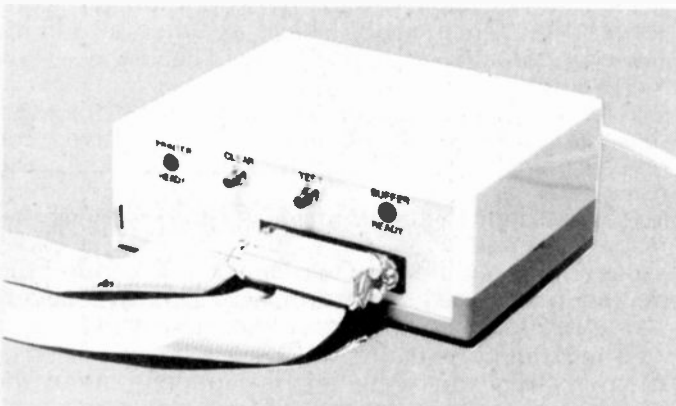
Centronics Printer Buffer

Microcomputers are pretty fast devices, far too fast for even the most speedy of printers to match. The result is that your micro often has to sit idle while it waits for the printer to catch up. The solution is to build our printer buffer, a handy store which holds the data destined for the printer while your micro carries on running. For word-processing, listing programs or printing out screen displays, you will find this a most useful piece of equipment next to your computer and printer.



Noise About Noise

A lot has been written recently about the effects of various types of components on the quality of sound an audio system delivers. Not a little of it has been written in ETI. In this provocative article, amplifier designer and manufacturer Neil Munro argues that we should be worrying less about our components and more about our power supplies.

EPROM Emulator

It's not that long since we last described an EPROM emulator, but you can never have too much of a good thing and this design is sufficiently different to be of interest. It is intended to complement the 6802 Evaluation Board featured in the May issue but should work with almost any system.

Second Processor For The Acorn Electron

This valuable accessory has been shown to increase the speed of an Electron to that of a BBC B and its memory capacity to more than twice that of the Beeb. In the second and final part of this project we describe the software necessary to achieve this remarkable improvement.

The Real Components

John Linsley Hood's in-depth series continues with a Look at some semiconductor devices. The topic is diodes and the article will include a look at such exotic items as tunnel diodes and diacs.

Universal EPROM Programmer

In the third and final part of this series, Mike Bedford and Gordon Bennett describe the software and present a complete listing of the programmer source code.

Plus All The Usual Features . . .

Tech Tips, Scratch Pad, Read/Write, Open Channel, News Digest, Trains of Thought, book and equipment reviews, etc, etc. Everything, in fact, that you'd expect from the UK's leading electronics magazine.

THE JULY ISSUE WILL BE ON SALE FROM JUNE 7TH. GET IT OR REGRET IT!

All of the articles mentioned are at an advanced stage of preparation. However, circumstances beyond our control may prevent us including them.

ELECTRON SECOND PROCESSOR

Speed-up your Electrons and watch your memory expand with a 6502 second processor, designed by John Wike with Electron owners in mind.

This article describes the addition of a second processor board to an Acorn electron, making 30K bytes of RAM available to BASIC (60k to machine code), and giving an increase in processing speed of up to three times.

The hardware will be described this month and the software next month, together with a complete assembly listing.

What about the others?

Although the term 'second processor' is usually associated with Acorn and their 'Tube' system, multiprocessor designs are found in several microcomputers in the business and scientific markets. Even the Sinclair QL contains two microprocessors, one to handle input/output and the other to do all the computing. So, although the circuit shown here is designed specifically for the Acorn machines, the concept is generally applicable.

It is relatively straightforward to design a circuit board with a processor and some RAM on it, and to interface it with an existing computer system. The real problem is the software, machine code of course, to handle the new hardware.

As the host machine probably has the screen RAM within its memory map, it must be assumed that it will retain the input/output handling functions. This means that the language (usually BASIC) will operate in the second processor.

It is necessary to know how to intercept the input/output routines (PRINT, INPUT, SAVE, LOAD, etc.) so that the data will be transferred to or from the second processor's memory instead of the host's. Routines can then be written to reside in each processor's memory and allow them to communicate with each other transparently, so that the user will not be aware of any difference in operation from the basic machine.

All this sounds involved, but given a machine that is well supported by reference material and ROM listings, or your own skill at disassembly, it is by no means impossible. So if you are interested have a go!

2P or not 2P?

The owner of an Acorn machine does not need to worry about the foregoing because this article will cover all the ground. He or she will however have to decide whether it is worthwhile adding a second processor to the system. There are several advantages to balance against the effort involved:

Speed

The benchmark system has gained widespread acceptance as a qualitative assessment of the processing speed of a computer. For a full discussion of benchmarks the reader is referred to the February 1985 edition of Computing Today. Each test consists of 1000 iterations of specific instructions, the times for which are given in Table 1. Also included for interest are the timings for the BBC computer, taken from the Computing Today article. In Mode 6 the unexpanded Eelectron is approximately 50% slower than the BBC, and in Mode 0 it is 250% slower! With the E2P board fitted it is approximately the same as the BBC in all modes.

Memory

The display memory in the Electron can consume between 8K of RAM in Mode 6 and 20K of RAM in Modes 0, 1 and 2. Add to this the 3.5K used as operating system workspace, up to 1.5K for user-defined characters and an extra 3.75K if the Plus 3 disc drive is fitted, and out of a total of 32K there might only be 3.25K available for programs. The E2P board contains 64K RAM, 30K of which can be used from BASIC whatever the configuration. Machine code programs can use a massive 60K.

Processor

The first requirement of the design was that the hardware and software should react with the Electron operating system in the same way as the official 'Tube'.

Benchmark	Mode 6	Mode 0	E2P	(BBC)
1	0.93	2.11	0.68	0.8
2	4.01	9.35	2.99	3.1
3	11.54	26.97	8.43	8.3
4	12.27	28.86	8.95	8.7
5	12.85	30.15	9.37	9.1
6	19.51	45.72	14.35	13.7
7	30.09	69.88	22.24	21.3

Table 1 Benchmark timings for the Electron with and without E2P.

This is a ULA with eight bi-directional registers, addressed at FCE0 h to FCE7 h, of which seven are used by the support software and only one, at FCE5 h, is accessed directly by the operating system for data transfer during, for example, LOAD and SAVE. So the circuit must detect accesses at FCE5 h and interrupt the second processor to allow it to pass the required data. The other registers can be at any convenient address, since they have their own support software.

The only storage device on the board is the RAM. The top 256 bytes of that are accessible to the Electron, so that several locations can be used as the bi-directional registers. Also, as this is the area where the 6502 goes at Reset, the Electron can control its reset and transfer sufficient code there beforehand to allow it to "boot up'. After that the rest of its operating system can be sent via the data byte at FCE5 h.

When deciding where in the Electron memory map to locate this 256 byte block, it was remembered that sideways ROMs are given the opportunity to initialise themselves at BREAK and to declare themselves during the *HELP command. The block is therefore addressed as a sideways ROM and the first eleven or so bytes are taken up with the necessary data for it to be recognised by the operating system. They also contain a jump instruction so that the 'ROM' software can be in the main program in the Electron RAM.

In order to refresh the dynamic RAM the processor is interrupted every 1ms and a specific routine scans 128 bytes in 64 µs. On alternate interrupts it scans another 128 bytes to include all the rows in the RAM. This results in a time overhead of 6% which is considered acceptable by the author. Because the refresh is software controlled there is no facility for a hard reset of the processor. Instead, the 'sideways ROM' routine issues an initialisation request on BREAK.

Interfacing

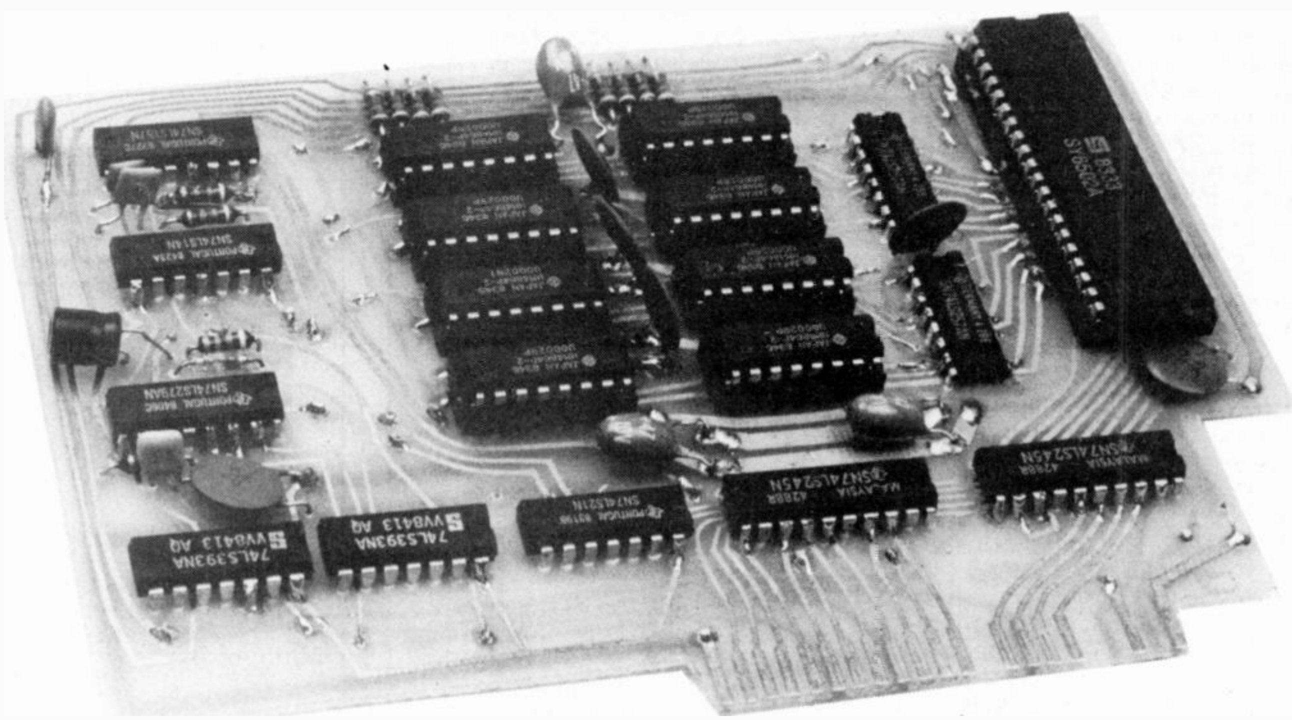
The board is designed to slot into one of the cartridge sockets on the Plus One interface unit, which provides some of the address decoding. For those people without a Plus One, a circuit is shown allowing connection to the basic Electron.

Current consumption of the board is about half an amp, which the author's machine was able to cope with. If a lot of other devices are drawing power, it may overload the supply. A link (LKI) is provided to disconnect the 5 volt line from the edge connector and an alternative supply can then be connected to the board.

Construction

Construction of this project is straightforward but you are recommended to use a fine tipped soldering iron, and to check the board closely to see that no stray bits of swarf or solder are shorting tracks.

As this is a double sided PCB and is not plated through, the first



The author's prototype second processor board (some changes have been made in the final version).

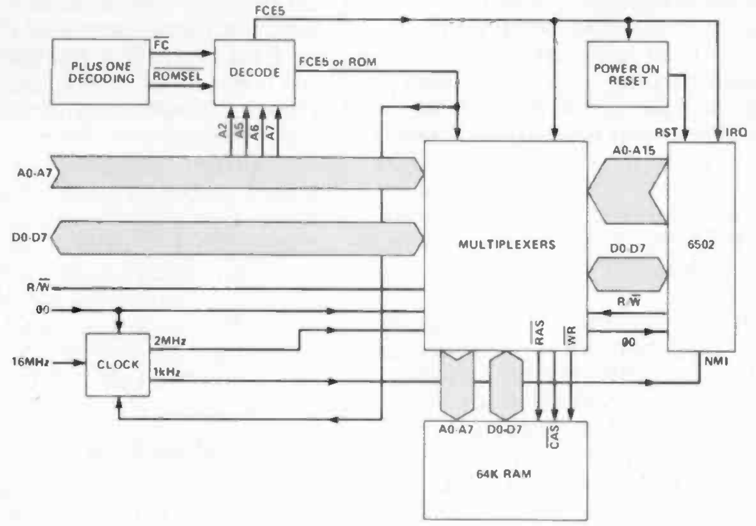


Fig. 1 Block diagram of the second processor board.

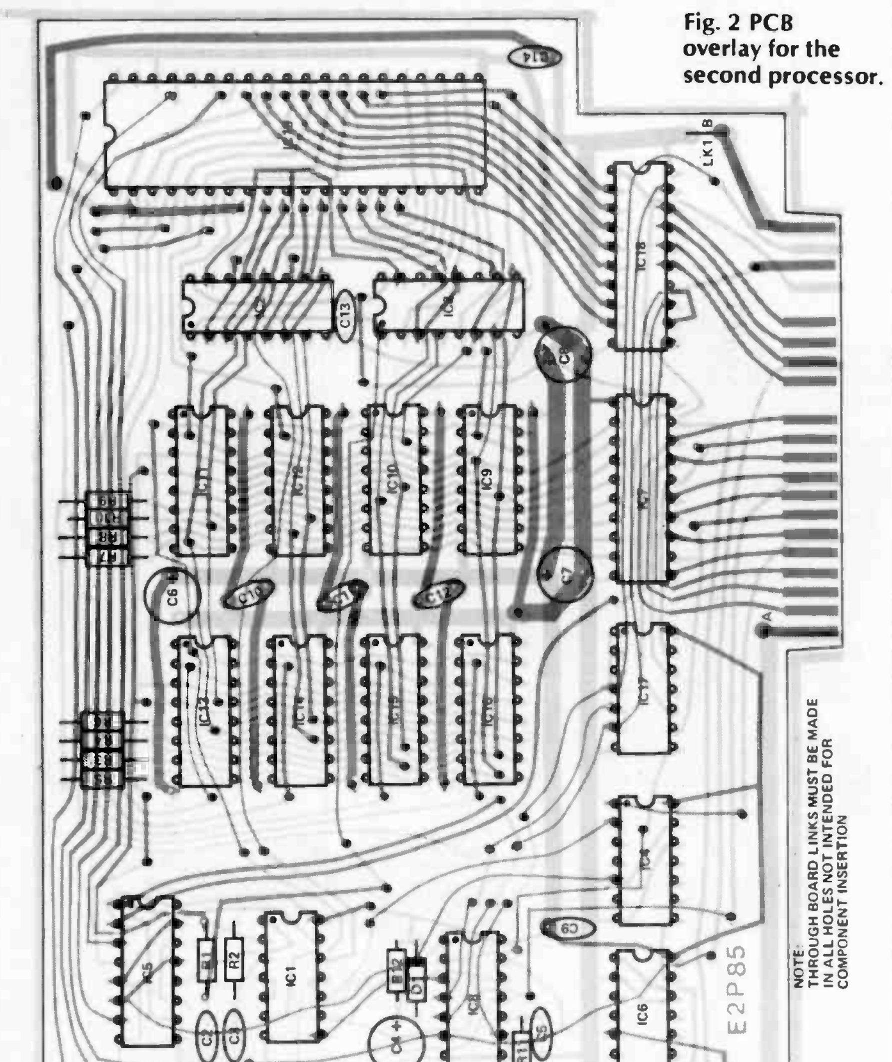


Fig. 2 PCB overlay for the second processor.

thing is to insert all the links and solder them on both sides of the board. Take special care not to miss the ones underneath ICs as these will be impossible to fit afterwards.

Next fit all the ICs except the RAMs and the processor, soldering

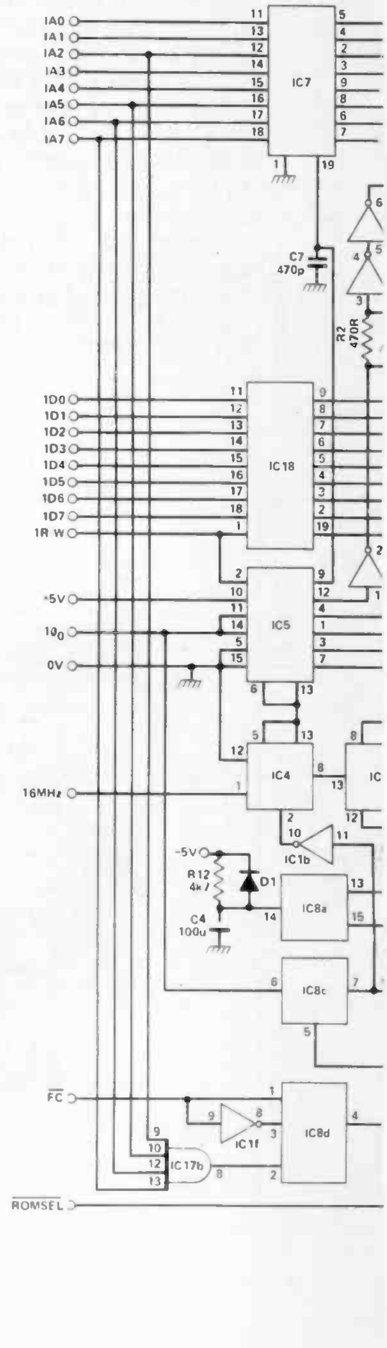


Fig. 3 Circuit diagram of the second processor

their leads on the bottom, top or both, as necessary.

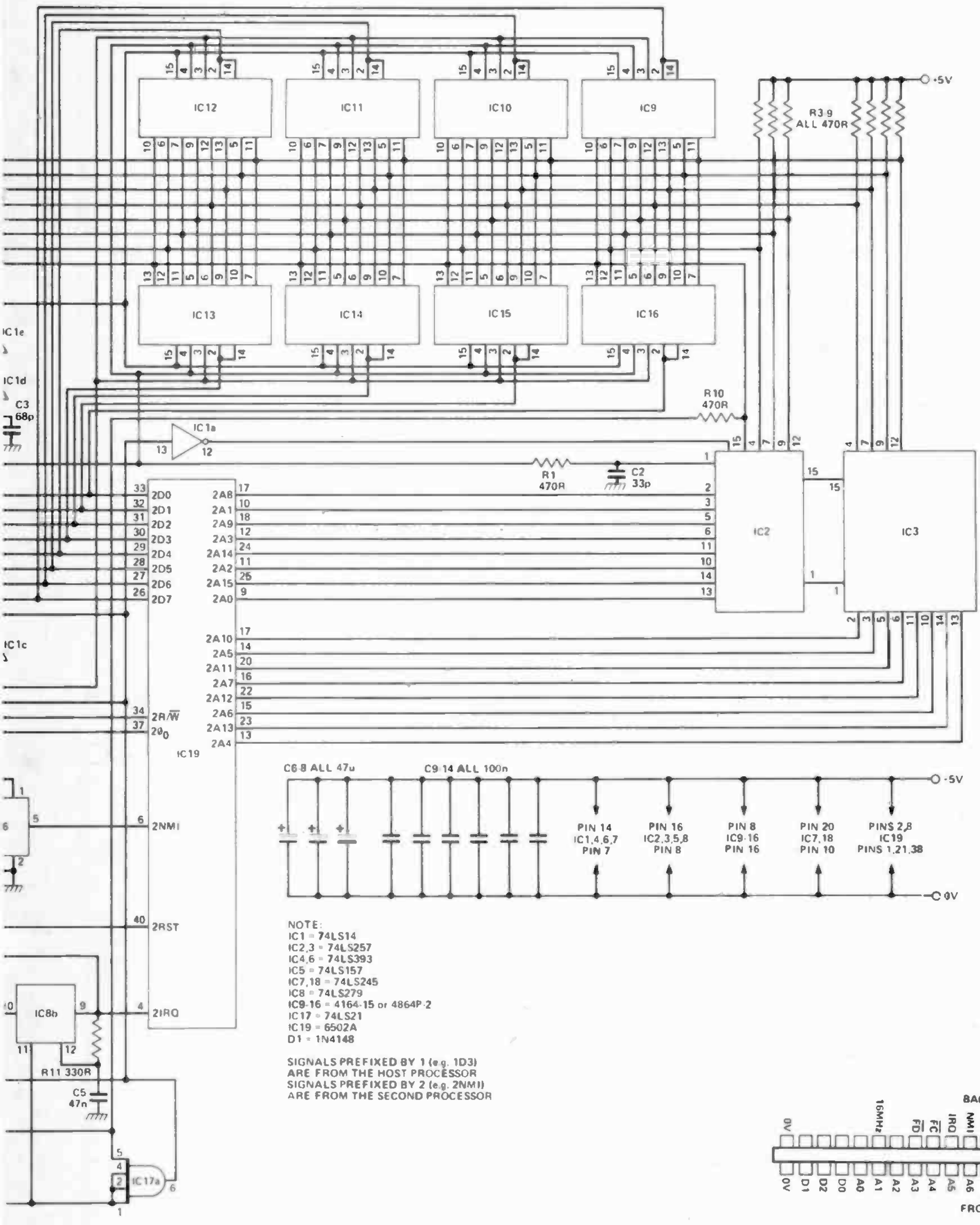
Next fit the resistors, capacitors and diode. Some of these components need to be soldered on both sides of the board.

Now fit the sockets for the RAMs and processor. Use insulating tape to protect the through-board links before inserting the sockets.

If you intend to power the board from the Electron's 5 volt line fit the link LK1. Otherwise, connect the external supply wires to points A (0 volt) and B (5 volts).

Finally, insert the RAMs and processor into their sockets.

If you do not have the Plus One unit you will now have to construct the interface circuit. This could be done on Veroboard and then connected, along with the second processor board, to the



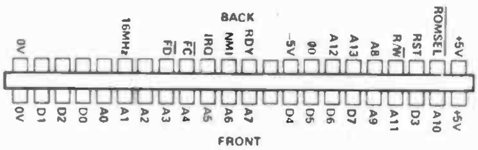


Fig. 4 Plus One cartridge socket edge connector.

board.

HOW IT WORKS

The second processor is reset at switch on by latch IC8a with C4 and R12. Diode D1 ensures that C4 will be discharged quickly at switch off.

IC8 is a quad S-R latch with Set overriding Reset. Sections c and d are used to provide extra AND functions.

Decoding of the host processor address bus is performed by IC17, IC8d and IC1f. When either the sideways ROM or FCE5 h are accessed, the output of IC17a will go low. This signal enables the data bus buffer, IC18. It also disables the second processor address multiplexers IC2 and IC3, after being inverted by IC1a, and it operates the control line multiplexer IC5. IC5 determines which processor's R/W and clock signals will be applied to the RAM — when Pin 1, select, is low the second processor clock and R/W times are effectively disabled.

The second processor 2MHz clock is generated by IC4 dividing down the master 16MHz oscillator. Further division takes place in IC4 and IC6 to give the 1ms NMI singal. Note that as the processor only responds to negative edges there is no need to provide short pulses.

The output of IC17a is combined with the host processor clock in IC8c, which triggers the 15μs IRQ monostable IC8b. The monostable is inhibited during ROM selection by the input at pin 11 so that it will only operate during an access at FCE5h. The monostable output is also fed to IC8a to clear the second processor reset.

The output of IC8c goes via IC1b to set the second processor clock in phase with the host's during host access. Because the clocks are in phase, the control multiplexer IC5 can be guaranteed to switch when they are both low.

Tri-state buffer IC7 with resistors R3-R10 performs the address multiplexing function for host processor addresses. It is enabled during the first part of a host access to give the row addresses for the RAM's. then it is disabled and the resistors provide the column addresses. If it is a ROM address, IC8d output will be high and page FF h will be accessed. For address FCE5 h, IC8d will be low and page FE h will be accessed.

The RAS signal to the RAMs is provided by IC1c and the CAS signal by IC1d and IC1e from the delay circuit R2-C3.

PARTS LIST

INTERFACE

RESISTOR

R13	470R

CAPACITOR

C15	220p

SEMICONDUCTORS

IC20	74LS30
IC21	74LS27
IC22	74LS20
IC23	74LS139
IC24	74LS74

MISCELLANEOUS

Veroboard, 22-way double sided socket to fit E2P edge connector, 25-way double sided socket to fit Electron edge connector.

Electron with a short length of ribbon cable and a 25 pin double-sided edge connector.

Setting up

Before switching on, check the board very carefully for shorted tracks and the orientation of ICs, diodes and electrolytic and tantalum capacitors. To ensure that the Electron will will not be damaged check every contact on the edge connector with a meter for shorts to either the 0 volt or 5 volt supply lines.

Connect the board and switch on. You should get the start-up screen as usual. If not, then switch off and check again for shorts.

If you can get hold of a double-beam oscilloscope, connect a probe to pin 9 of IC8 and enter and run the following program:

```
10 A%=?&FCE5:GOTO10
```

You should see on the 'scope a negative going pulse 15 ms wide. If it is a different width adjust the values of R11 and/or C5 to get it as close as possible.

Now conect one input of the scope to ICI pin 1 and the other input to ICI pin 6. The negative going edge of the signal on pin 6 should occur between 120 and 150 ns after the positive going edge at pin 1. Adjust R2 and/or C3 as necesary.

Before trying the system in earnest you will have to switch off then on again in order to hard reset the second processor.

The necessary software will be included in next month's article, but in the meantime a copy of the assembly code is available on tape from the author. Alternatively, if you send a Plus Three disc it can be stored on that together with the machine code as a !BOOT file so that pressing shift-break will automatically boot in the second processor. See Buylines for details.

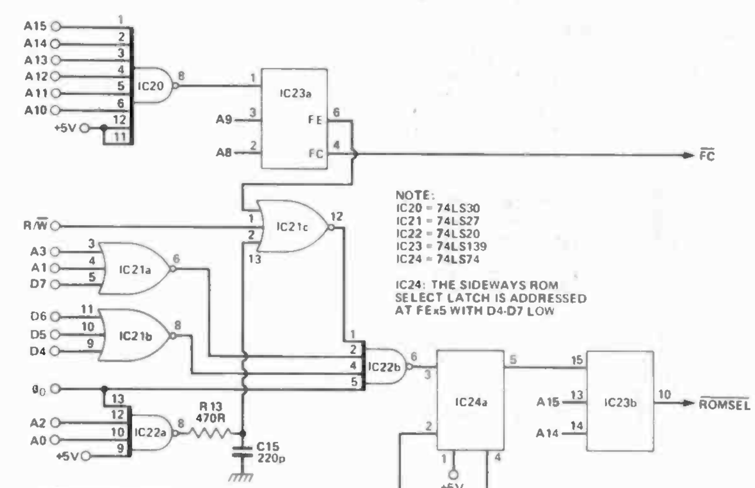


Fig. 4 Suggested interface circuit to link basic Electron and the second processor.

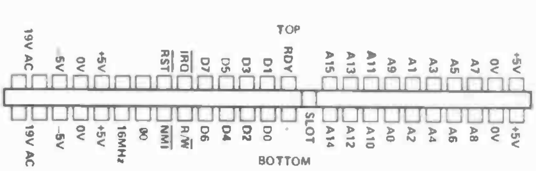


Fig. 5 Electron edge connector

PARTS LIST

MAIN BOARD

RESISTORS (all 1/4 watt)

R1,2,3,4,5,6,7,8, 9,10	470R
R11	390R
R12	4k7

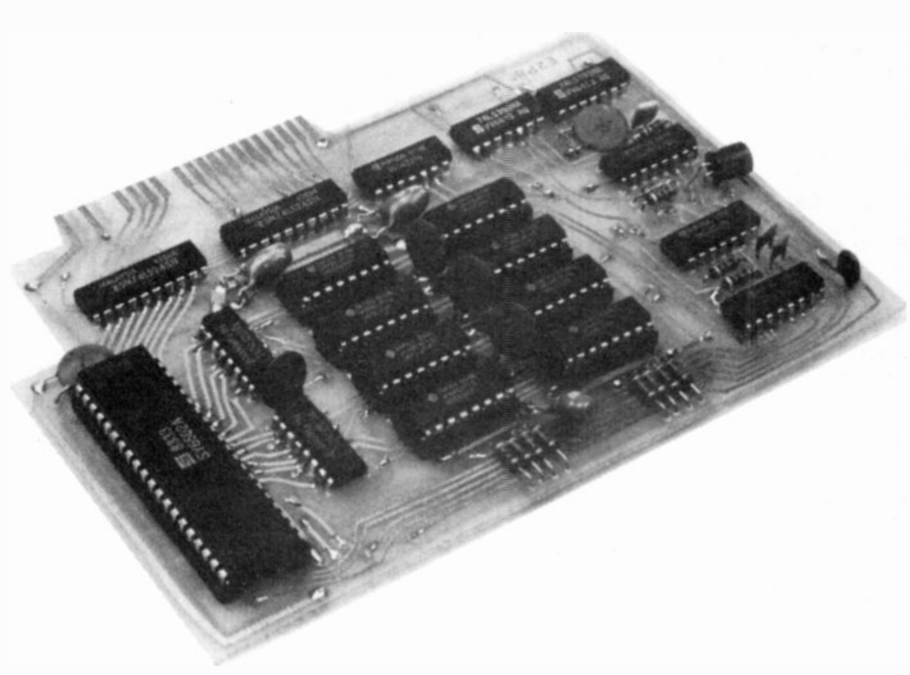
CAPACITORS
(all ceramics unless stated)

C1	470p
C2	33p
C4	100μ electrolytic
C5	47n
C6, 7, 8	47μ 10V tantalum
C9,10,11,12,13,14	100n

SEMICONDUCTORS

IC1	74LS14
IC2,3	74LS257
IC4,6	74LS393
IC5	74LS157
IC7,18	74LS245
IC8	74LS279
IC9,10,11,12,13 14,15,16	4164-15/4864P-2
IC17	74LS21
IC19	6502A (2Mhz)
D1	1N4148

MISCELLANEOUS
40 pin DIL socket, 8x16 pin DIL sockets, wire for links.



BUYLINES

All the components are available readily from advertisers in ETI. The PCB and software are available from the author, John wike, at 9, Lon-y-Garwa, Caerphilly, Mid-Glamorgan. The price of the PCB is £12, software on tape is £3.50, and on your disc £2.00, inclusive of postage. if you send a disc please state whether you wish to have the !BOOT file put on it.

ETI

LOW COST AUDIO MIXER

This modular mixer from John Linsley Hood is not super-fi, but it is cheap, portable and so versatile you can use any source, except the kitchen sink.

The instrument described here was designed and built for the use of the local 'Talking Newspaper for the Blind', and the circuitry shown was specifically tailored for their needs — which were, basically, for a control console containing the necessary electronics, and fader pots, so that the operator could mix in various voices with programme material from other sources — disc, radio or tape — to produce a final stereo tape cassette. This would then be duplicated for distribution to subscribers.

The general layout is versatile enough for the actual inputs to be modified for other types of input. I will show some of the other input circuits which may be slotted in, in place of, or in addition to, the existing layouts.

One general requirement for all such mixer consoles is the provision of a reasonably quality stereo headphone monitor facility, allowing the control engineer to hear just what he or she is putting on to the tape. The unit has been designed to be operable from a battery DC supply. It could be used as a fully portable 'studio' in conjunction with a suitable battery operated cassette recorder.

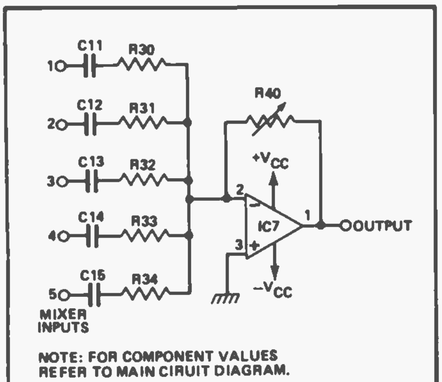


Fig. 1 The central circuit of a virtual earth mixer.

No VU metering system has been provided since it is assumed that the recorder used will have this facility.

Basic Layout

The circuitry is organised around the virtual earth mixer layout shown in Fig. 1, which can be hooked up easily around an IC op amp and allows as many inputs as one wishes to be combined together into a common signal (although only five are shown in the diagrams).

This is a very powerful technique for mixing inputs, and has the great benefit that there is no leakage back from one input into another, since the inverting input of ICl in this layout really does look like an earth point to the incoming signals. This also implies that the input impedance of the circuit is determined by the values chosen for each input resistor, R30, R31 . . . .

The overall gain of the stage is determined, for any one input channel, by the ratio of R40:Rin (Rin being the input resistor). If R40 is variable (as shown in Fig. 1 but *not* in the main circuit diagram), the gain of all the input channels may be reduced or increased simultaneously.

The various inputs to this mixer stage are obtained from input stages of the types described below.

Line Input Stage

In the simplest case, where a signal is obtained from a radio or tape recorder having a line output socket — which will give 300-700mV output at a lowish impedance — all that is required is a simple slider pot connected as shown in Fig. 2. On the other hand, if it is known that the unit may be used with signal sources

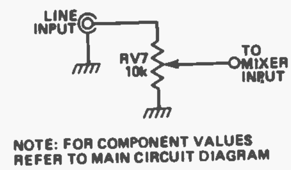


Fig. 2 A mono line input arrangement.

having outputs conforming to the DIN standard — in which the output is arranged to provide 1mV for each 1K of load impedancy — the alternative arrangement of Fig. 3 can be used.

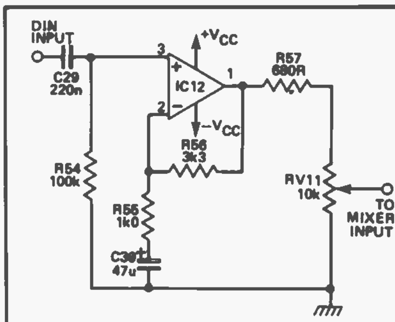


Fig. 3 DIN input stage.

This is quite a versatile system, and can be used with any input source where a flat frequency response is all that is needed, and where the input signal level will not exceed more than about 0.5V RMS.

Microphone Input Stage

This uses an identical circuit layout to that of Fig. 3, but with the values of R55 and R56 changed to R11 and R16 in Fig. 4 to give a higher gain, since the expected output signal level from the mic may be only 2-3mV. The input impedance is also made switchable between 100K and 4K7 (R1 and SW1 in Fig. 4) to suit either crystal or dynamic (moving coil) microphones. Electret mics with a built-in FET buffer output could be used equally well with either.

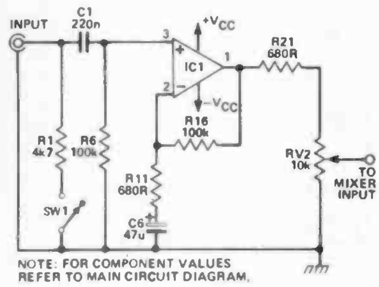


Fig. 4 Mic input stage

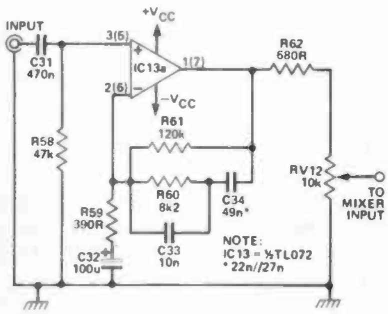


Fig. 5 Optional RIAA input stage.

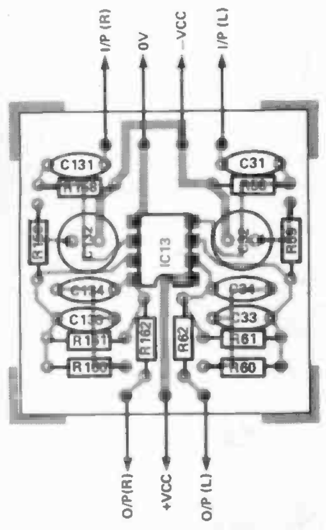


Fig. 6 PCB overlay for RIAA stage.

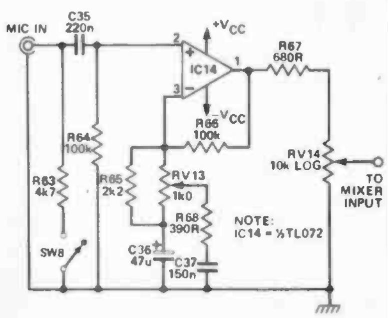


Fig. 7 Optional treble-lift mic input.

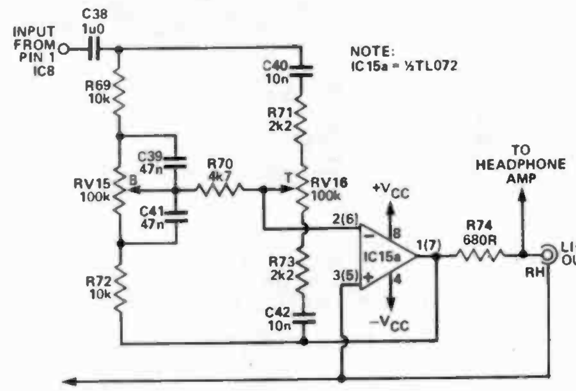


Fig. 8 Optional bass and treble lift-cut tone control stage.

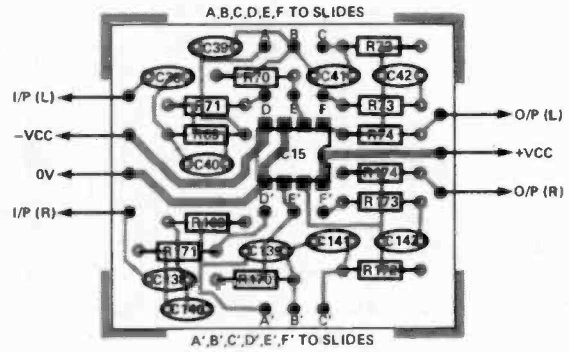
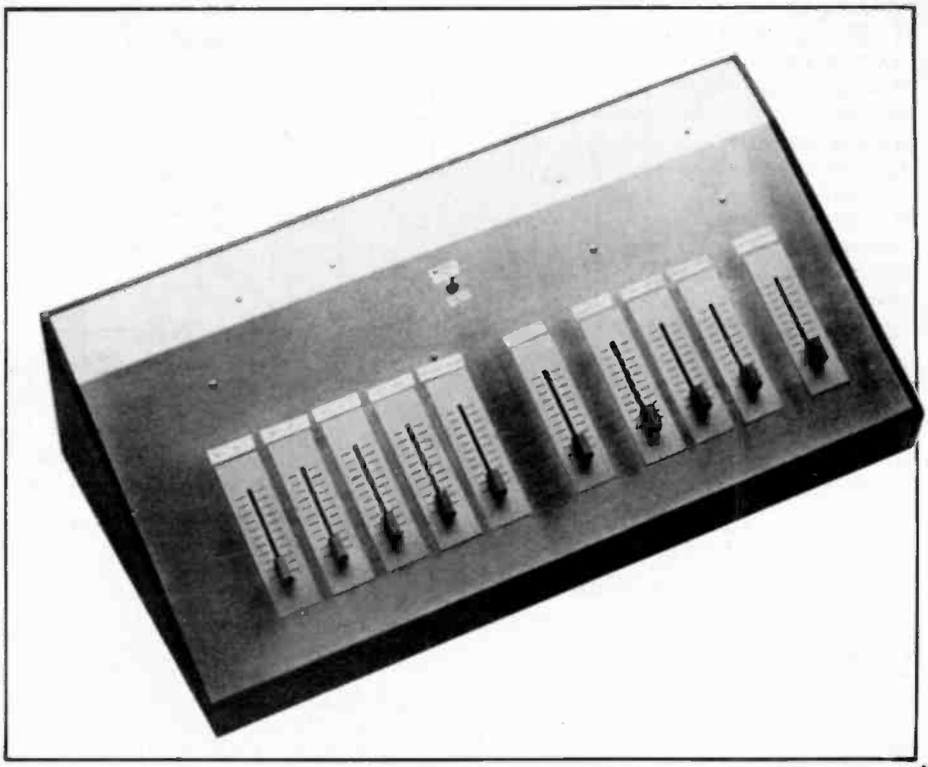


Fig. 9 PCB overlay for optional tone control stage (stereo).



Completed prototype mixer

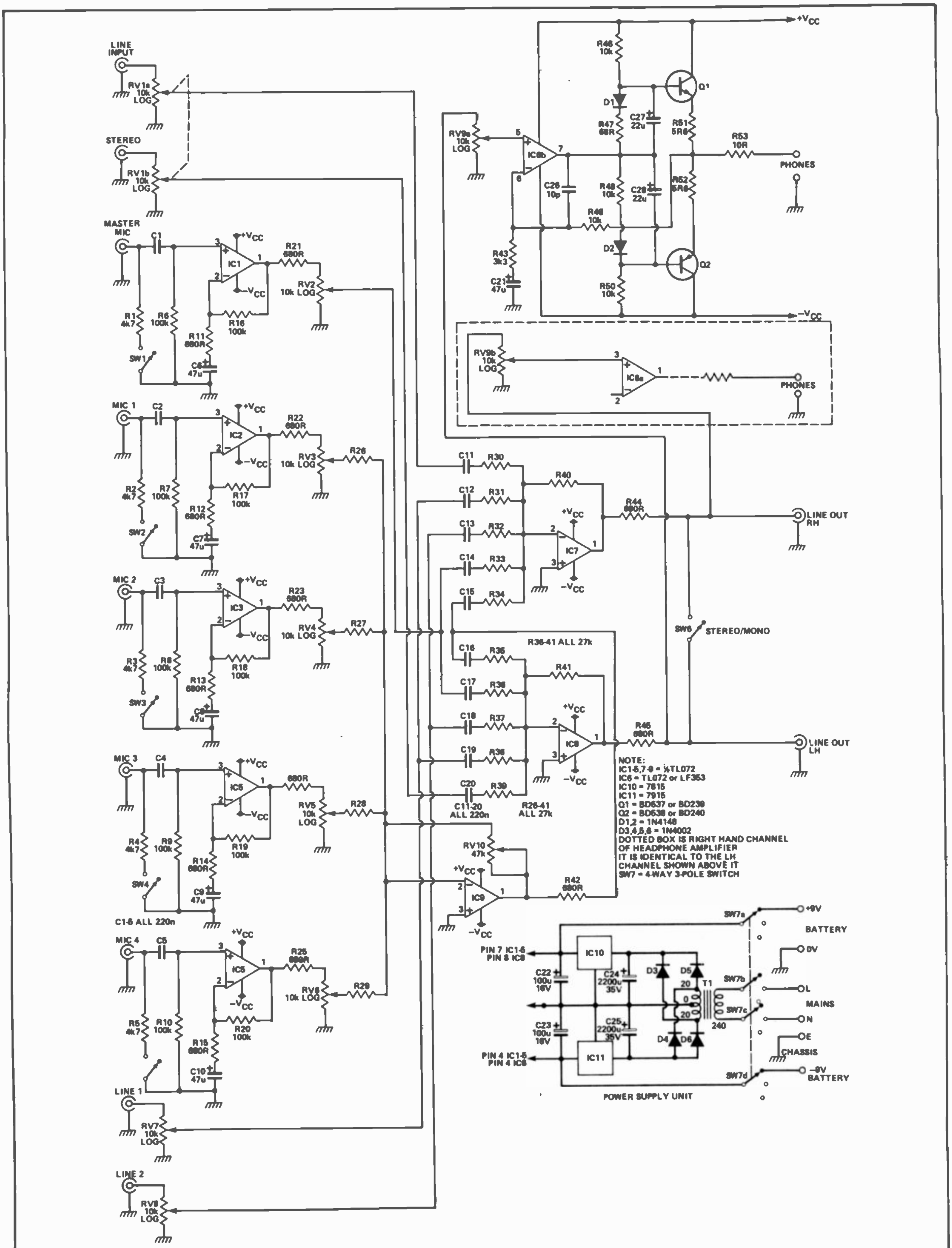


Fig. 10 Circuit diagram of the complete prototype mixer and Fig. 11 (opposite) overlays for the mixer and PSU boards.

Gramophone PU Inputs

This facility was not required for the actual unit which was built, but there is no difficulty in modifying the op amp input stage to provide the required gain and frequency response characteristics. The circuit for this is shown in Fig. 5. Since I am not aiming at the 'ultimate-fi' in this unit, I feel that a conventional series feedback layout, as used in 99.9% of domestic hi-fi amplifiers, will be quite adequate.

The op amp output resistors in the DIN, mic and RIAA stages (R57, R21 and R62, respectively), are included to prevent changes in the loading of the op amp, due to the setting of the output gain controls, which would alter the frequency response characteristically of the gain stage.

Headphone Output Stage

This is fairly conventional, and again uses an op amp as the gain block, to which some muscle power is added by the transistors Q1 and Q2. These are biased into class A by the diode/resistor network R46-R50, D1 and D2. A small capacitor, C26, is connected across the op amp to ensure HF stability. Several pairs of headphones can, if necessary, be connected in parallel, across the output, provided that the isolating resistors (R53) are taken separately to each output jack. This will ensure that there are no problems if phones of dissimilar type of impedance are used. (See Fig. 10).

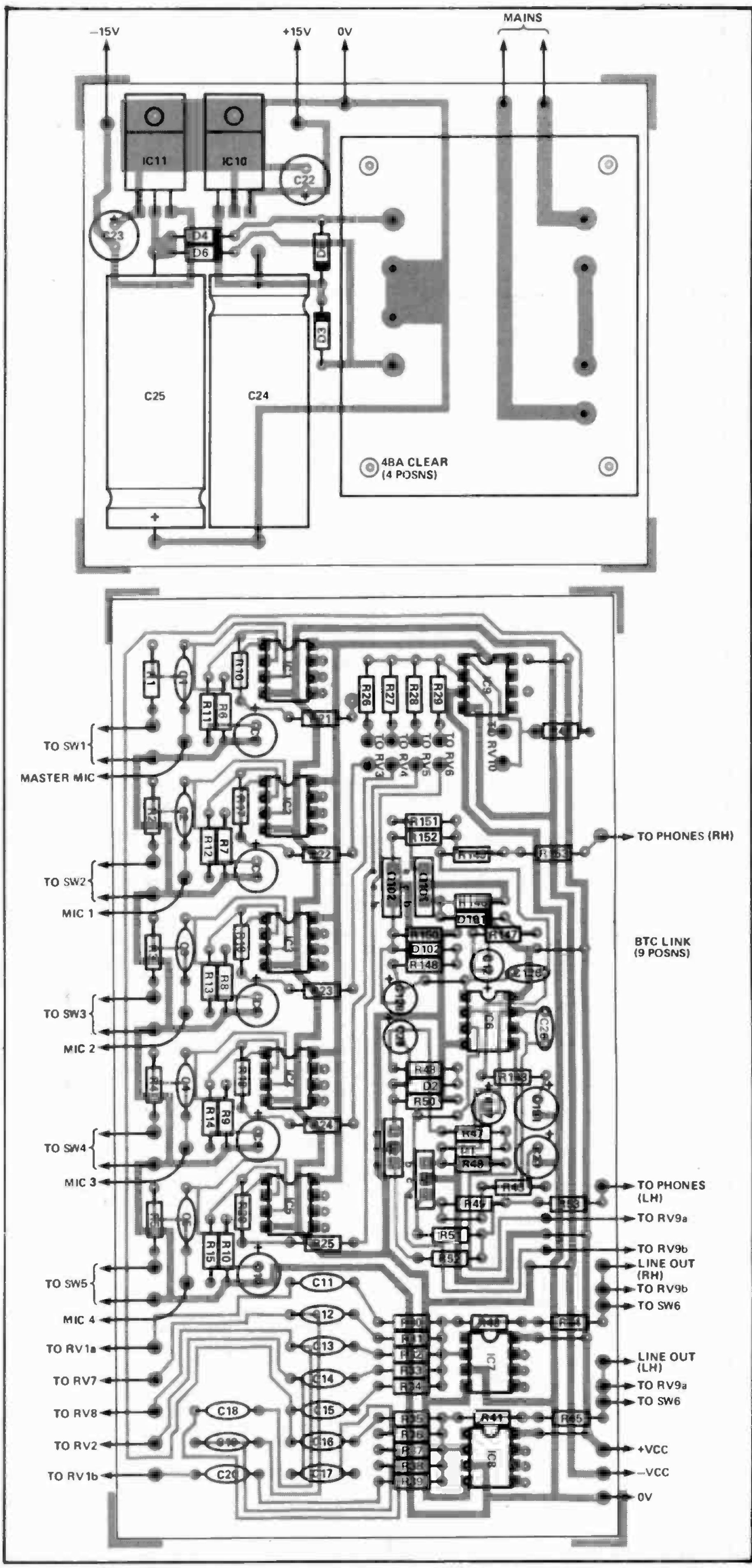
Mains Power Supply

Although the mixer unit can be used quite satisfactorily on a pair of 9V batteries, batteries are expensive and it is probable that it will be powered from the mains on most occasions. A very simple dual power supply, with a couple of voltage regulator ICs, was used on the prototype, as shown in Fig. 10.

Complete System

The whole unit is shown in Fig. 10 and fitted into a shallow sloping fronted box, 19" long, as shown in the photograph.

Since the specification to which this unit was built called for a stereo line input, as well as a pair of mono line inputs, a ganged 10K slider pot was used for RV1, while single slider units were employed for RV7 and RV8. The four main mic inputs are controlled individually by the slider pots RV3 to



RV6, with a master fader, RV10, controlling their overall level so that it can be faded down if, for example, a voice-over commentary is to be superimposed from the master mic.

A dual-gang slider pot, RV9, is used to control the volume level of the headphone outputs. Finally, an overriding stereo/mono control is provided by SW6, which simply parallels the two L and R outputs. In general, however, the unit is used in the stereo mode, with a stereo signal from the line input, over which the (mono) mic input voices appear on 'centre stage'.

No tone control facilities were required for the unit described in its initial emobidment (shown in the photograph), but subsequently a microphone input treble lift facility was added, to give greater clarity to some of the commentators' voices. This was done as shown in Fig. 7. The unit can completely replace the mic input shown in Fig. 4.

A more formal bass/treble-lift/cut tone control stage could be added, at pin 1 of ICs 7 and 8 in Fig. 10. The tone control circuit is shown in Fig. 8.

Full stereo system

It is very easy to organise this layout to provide more stereo input channels than the one stereo line input on the prototype.

This is done by taking each pair of inputs, say those from IC2 and IC3 (Fig. 10) and routing them to a pair of master fader stages, IC16a and IC16b, as shown in Fig. 12, and from there to ICs 7 and 8, as before.

The prototype unit was designed round TL071s or their higher specification equivalents, LF351. To enable the addition of extra facilities with relative ease, we have designed the board using TL072s (or LF353s) exclusively. Pads for the unused halves of the op amps can be found on the main PCB.

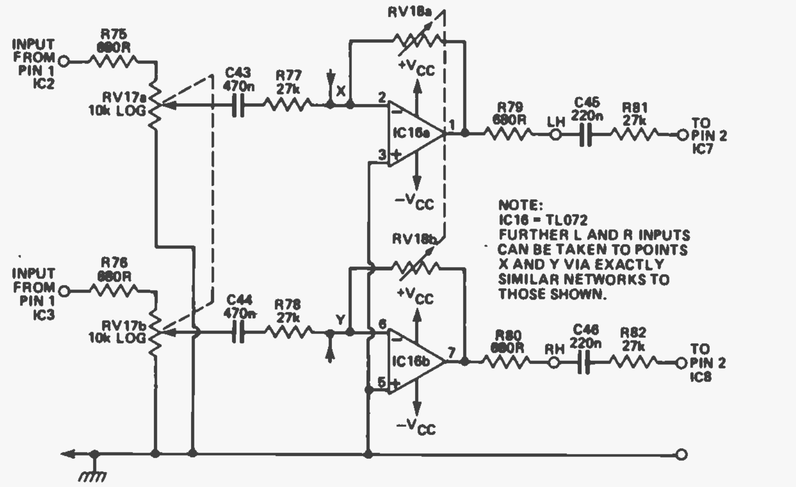


Fig. 12 Single stereo mic input arrangement using two mono input stages.

BUYLINES

There should be no problems with any of the components. Slider pots are widely available, but rotaries would suit. Wirewounds should be available from Watford, Maplin, Electrovalue or any regular ETI advertiser. Watford and Rapid also advertise 3 pole 4 way switches. 19" cases are available from Newrad or through our classifieds. The PCBs are available from the ETI PCB Service

PARTS LIST

MAIN BOARD

RESISTORS (all ⅓ watt unless stated)

R1,2,3,4,5	4k7
R6,7,8,9,10,16,17 18,29,20	100k
R11,12,13,14,15, 21,22,23,24,25,42, 44,45	680R
R26,27,28,29,30 31,32,33,34,35,36, 37,38,39,40,41	27k
R43	3k3
R46,49,50	10k
R47,28,	68R
R51,52	5R6 W/W
R53	10R W/W
RV1,9	10k log ganged sliders
RV2,3,4,5,6,7,8	10k log single sliders
RV10	47k single slider

CAPACITORS

C1,2,3,4,5,11,12, 13,14,15,16,17,18, 19,20	47µ 16V
C6,7,8,9,10,21	electrolytic 100µ 16V
C22,23	electrolytic
C24,25	2200µ 40V electrolytic
C26	10p
C27,28	22µ 16V electrolytic

SEMICONDUCTORS

IC1-6,8,9	TL072/LF353
IC10	7815
IC11	7915
Q1	BD537/BD239
Q2	BD538/BD240
D1,2	IN4148
D3,4,5,6	IN4002

MISCELLANEOUS

SW1,2,3,4,5,6	SPST switches
SW7	3 pole,4 way switch

Standard jack sockets (13 for main board configuration); PP9 battery clips (x2); 20-0-20 20VA transformer, TR1; 19" shielded cabinet.

(Note: R43-53, C21, 26-28, Q1-2, D1-2 have corresponding components for the right-hand headphone amplifier. They are marked R143-153, C121, 126-128, Q101-102, D101-102 on the overlay diagram).

OPTIONAL BOARDS

RESISTORS (all ⅓ watt)

R54,64,66	100k
R55	1k0
R56	3k3
R57,62,67,74,75, 76,79,80	680R
R58	47k
R59,68	390R
R61	120k
R63,70	4k7
R65,71,73	2k2
R69,72	10k
R77,78,81,82	27k
RV11,12,13	10k log sliders
RV13	1k0 slider
RV15,16	100k sliders
RV18	47k ganged slider

CAPACITORS

C29,35,45,46	220n
C30,36	47µ 16V
C31,43,44	electrolytic 470n
C32	100µ 16V
C33,40,42	electrolytic 10n
C34	49n (22//27n)
C37	150n
C38	1µ0 ceramic
C39,41	47n

SEMICONDUCTORS

IC12-16	TL072/LF353

MISCELLANEOUS

Standard jack sockets as required.

(Note: R58-62, RV12 and C31-34 have corresponding components on the second channel of the RIAA equaliser board. They are numbered R158-162. RV112 and C131-134 on the component overlay. Likewise for components R69-74, RV15-16 and C38-42 whose second channel equivalents on the tone control board are marked R169-174, RV115-116 and C138-142).

ETI

UNIVERSAL EPROM PROGRAMMER MKII

Following on from last month's article which covered the theory and described an upgrade modification for existing programmers, Mike Bedford and Gordon Bennett describe an improved EPROM programmer for those building from scratch.

Unlike the MkI board, the MkII board has been made double sided to cope with the greater component density. In order to keep down the costs, plated through holes have not been used which means that the first task to be carried out in building this project is to insert pins into all the holes marked as such on the component overlay diagram, soldering them on both sides of the board. After having carried out this through pinning, the construction is quite straightforward. One point worth noting is that component leads are sometimes relied upon to make a connection from one side of the board to the other. This means that if a component lead passes through a hole with pads on both sides of the board, the lead should be soldered to them both.

The MKII board will be used in conjunction with a programming console housing a 28 pin ZIF (zero insertion force) socket and 2 LEDs (see photograph). The 2 LEDs on the console connect to the main board via a 3 or 4 core cable connected to SK4, the anodes being connected to A1 and A3, the cathode of the green LED to A2 and the cathode of the red one to A4. The ZIF socket is connected via a length of ribbon cable and a 28-pin DIL header to SK3 on the main board on a pin to pin basis. It should be noted that the DIL socket SK3 is the "wrong way round" with respect to all the DIL ICs on the board and accordingly care should be taken in plugging in the ribbon cable to the console. A 0.1uF capacitor should be connected between pin 28 and pin 14 on the ZIF socket.

Construction having been completed, it now remains to configure the board to reside at the required address and to set up the various Vcc and Vpp voltages. The addressing is determined by the links, LK1, which are wired into a

OOPS!

Since the appearance of last month's article, a problem has come to light regarding the programming of 27512 EPROMs.

The problem occurs when using the fast programming algorithm with the 27512 and results from the necessary sequence of operation adopted in the software. The $\overline{OE}$ line is held high until dropped to access the EPROM for reading and the $\overline{CE}$ line goes low as soon as the programming voltage is removed from the EPROM.

But on the 27512 the $\overline{OE}$ line is also the Vpp select line and so, although this line is set low by the software at the correct time, the combined line is still held high by the $\overline{OE}$ bit until it is time to read the EPROM. This is because the hardware combines these two lines in an OR gate. The effect is to hold the 27512 in programming mode for an extra 300 micro seconds at a time when, although the address and data busses should not be varying, the programmer itself is changing from program to verifying mode. It is quite possible that this would cause no ill effects, but it is undesirable and should be corrected.

A software solution would require a separate procedure for the 27512 in an already crowded EPROM, but a far simpler hardware modification is possible. It consists of the removal of two diodes and the substitution of a wire link for one of them. The diodes in question perform an OR function at the input of the active pulldown circuit which operates on pin 22 of the EPROM. They were put there to prevent high dissipation in the 120R resistor by removing the possibility of the software turning on both transistors simultaneously. No problems have been found using the existing software package without these diodes, and their absence has no effect upon the operation of the programmer with other EPROMs.

The modification is:

1) locate and remove the diode in the line from pin 14 of PIO 3 (IC7), the $\overline{OE}$ line;

2) locate and remove the diode in the line from pin 12 of PIO 2 (IC8), the Vpp select line;

3) replace this latter diode with a wire link.

This will prevent the $\overline{OE}$ line from influencing the pulldown of the Vpp/$\overline{OE}$ line.

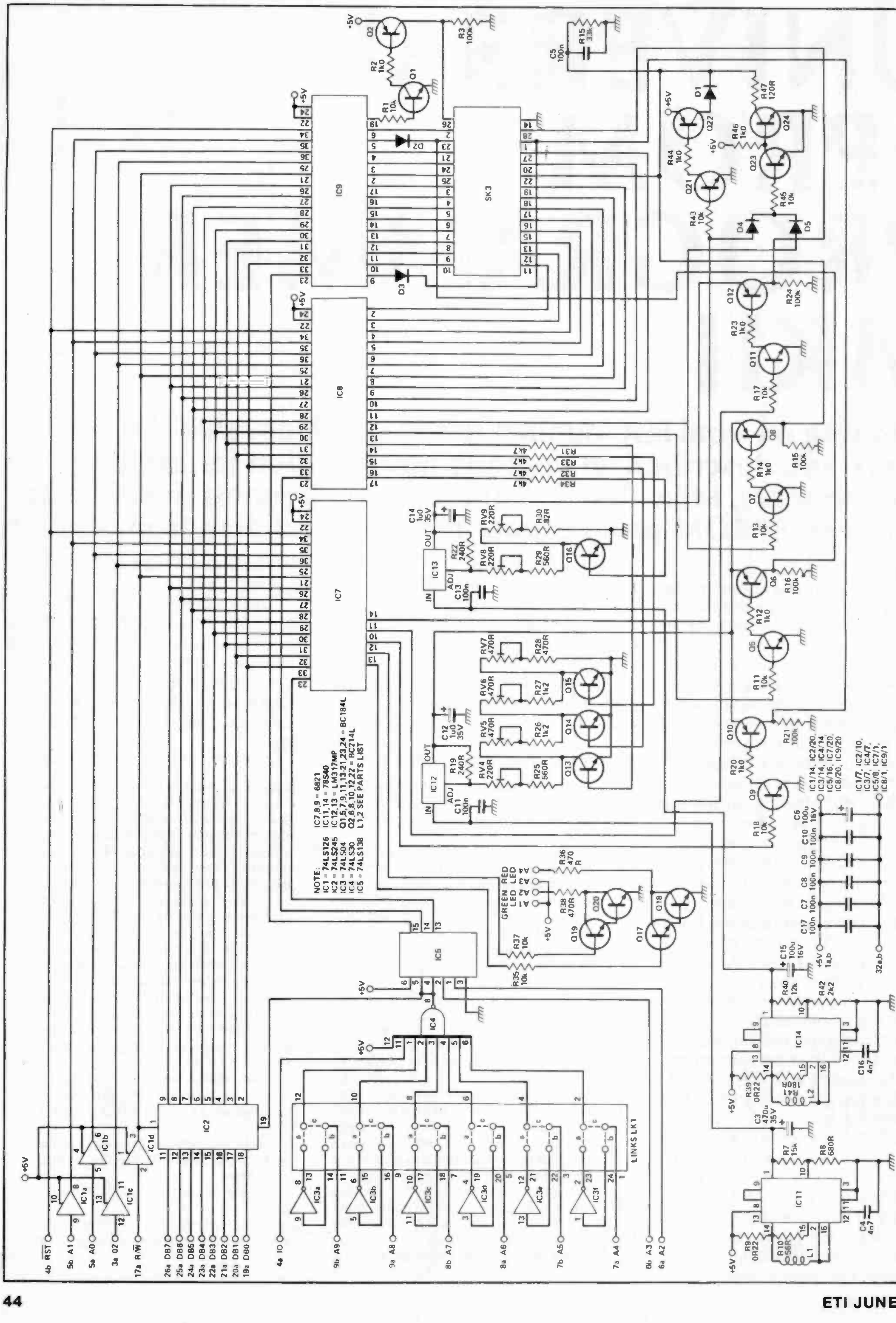


Fig. 1 The circuit diagram for the MkII board.

HOW IT WORKS

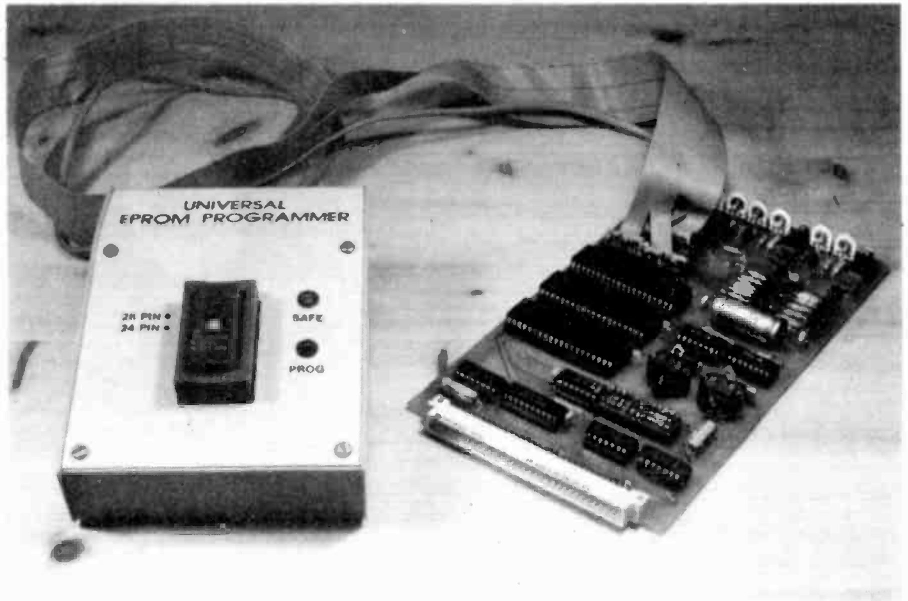
The components in Fig. 1, the circuit diagram of the Mk II board, have been numbered in such a way that they correspond to the component numbers on the Mk I and upgrade boards. Since a few components are removed from the Mk I board when the upgrade board is fitted there will be some gaps in the component numbers on the Mk II programmer. Once this is realised, this arrangement should cause less confusion than if components with the same function were to have different numbers in the two configurations.

The heart of the circuit is three 6821 PIAs which control all the programmer functions. These are interfaced in a standard way to the Tanbus signals on the edge connector. IC1 and IC2 buffer various signals to ensure that only 1 TTL load is applied to a bussed signal and the combination of IC3, IC4, IC5 and the links control the addressing and allow the board to be located within any 16 byte block in the I/O area. The Vpp supply is generated at +30V by the circuitry associated with IC11 which is a step-up circuit and is then regulated to the required level (+25V, +21V, +12.5V or +5V) by a programmable LM317MP regulator, IC12. Since the voltage output of an LM317MP is determined by the value of the resistor between the adjust pin and 0V, the Vpp level is controlled by switching the transistors Q13, Q14 and Q15 from PIA IC8 so cutting out portions of the resistor chain.

A similar approach is used to generate Vcc, IC14 generating +8V and IC13 regulating to +5V or +6V as controlled from IC8. Where a pin on the EPROM (which is connected to SK3) requires a TTL signal level it is connected directly to an output of one of the PIAs. Where a Vpp or Vcc level is required, however, a NPN/PNP transistor pair is used to carry out the switching under the control of a PIA output. In all such cases the transistor pair must be connected to a PIA 'B' port, these having totem-pole outputs which can supply sufficient current to switch a transistor.

The signal level on some pins may be either TTL or Vpp, depending on the EPROM type. In such cases, both signals are connected to the appropriate pin but the two are isolated from each other by use of a diode on the TTL signal line. When a TTL level is isolated by a diode, this is driven by a PIA 'A' port since these outputs have resistive pull-ups and will give a level that is high enough to be a true TTL high even after allowing for the voltage drop across a germanium diode.

The data sheets for the 2732 call for a 100uF capacitor (C5) connected between pin 22 and 0V while programming. This will suppress spikes on the Vpp supply which could be detrimental to the EPROM. Unfortunately the provision of such a suppression capacitor will have the result of slowing down logic edges when a TTL level is applied to pin 22. For this reason, the time constant is kept to a minimum by using Q21 and Q22 as a high current OE drive and Q24 to provide a logic low bypassing C5. Transistor Q23 turns on Q24 when neither the OE nor the Vpp signal driving EPROM pin 22 is present. To complete the circuit description, Q17, Q18, Q19 and Q20 form two darlington pairs which are used to drive a pair of LEDs on the programming console.



Voltage required	ZIF pin to monitor	Register address offset	Value to write to register (HEX)	Potentiometer to adjust
—	-	0B	00	---
—	-	0A	FF	---
—	-	0B	04	---
—	-	0A	03	---
—	-	07	00	---
—	-	06	FF	---
—	-	07	04	---
+5V	1	06	10	RV4
+12.5V	1	06	40	RV5
+21V	1	06	20	RV6
+25V	1	06	00	RV7
+5V	28	06	80	RV8
+6V	28	06	00	RV9

Table 1 The set-up arrangements for monitoring and adjusting program voltages.

PARTS LIST

Programming Console

- 1 x Instrument case with sloping top
- 1 x 28-pin DIL Zero Insertion Force socket
- 1 x Length of 28-way ribbon cable
- 1 x 28-pin DIL header
- 1 x 100 μF ceramic capacitor
- 1 x Red LED
- 1 x Green LED
- 1 x Length of 4-way cable

DIL header and plugged into the appropriate DIL socket. The board occupies a 16-byte block within the 1K Tanbus I/O space, the start address relative to the start of this I/O area being 16 times the binary number represented by the block of links. The examples of link selection in Fig. 2 should make it quite clear how to set up any required addresses. The MkII board has been designed with the voltage setting potentiometers placed along the edge of the board so that they may be easily adjusted once the board has been positioned in a card frame. The voltages may now be monitored on the programming console and adjusted, using the potentiometers, by writing values to the programmer registers using the system monitor (or a BASIC program). Table 1 shows the requisite programming voltages, associated pins, registers, data and potentiometers.

MKII UNIVERSAL EPROM PROGRAMMER: HARDWARE SPECIFICATION

Devices supported	: 2758, 2716, 2516, 2732, 2732A, 2532, 68732, 2764, 2764A, 2564, 68764, 27128, 27128A, 27256, 27512, 27513, 2816, 2864
Device selection	: Software controlled
Programming methods	: Intelligent or fixed pulse
Vpp voltages	: +25V, +21V, +12.5V
Vcc voltages	: +6V, +5V
Indicators	: 2 LEDs on console
PCB format	: 8" x 4½" with indirect connector
Interface	: Tanbus (6502, 6800, 6809 adaptable)
Power requirements	: +5V @ 900mA
Memory space occupied	: 12 bytes selectable to any 16 byte boundary within the I/O area
System requirements	: RAM — 1K for 2758 to 32K for 27256, 27512* and 27513* plus small amount for support firmware. (*: these EPROMs programmed in 2 segments) EPROM — 2K utilities package

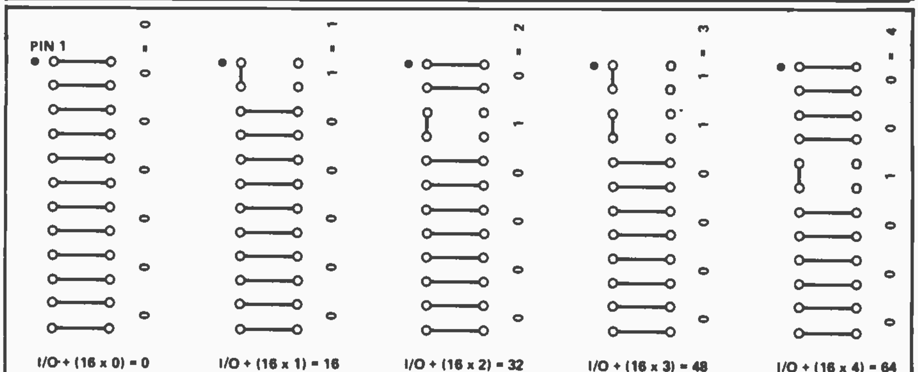
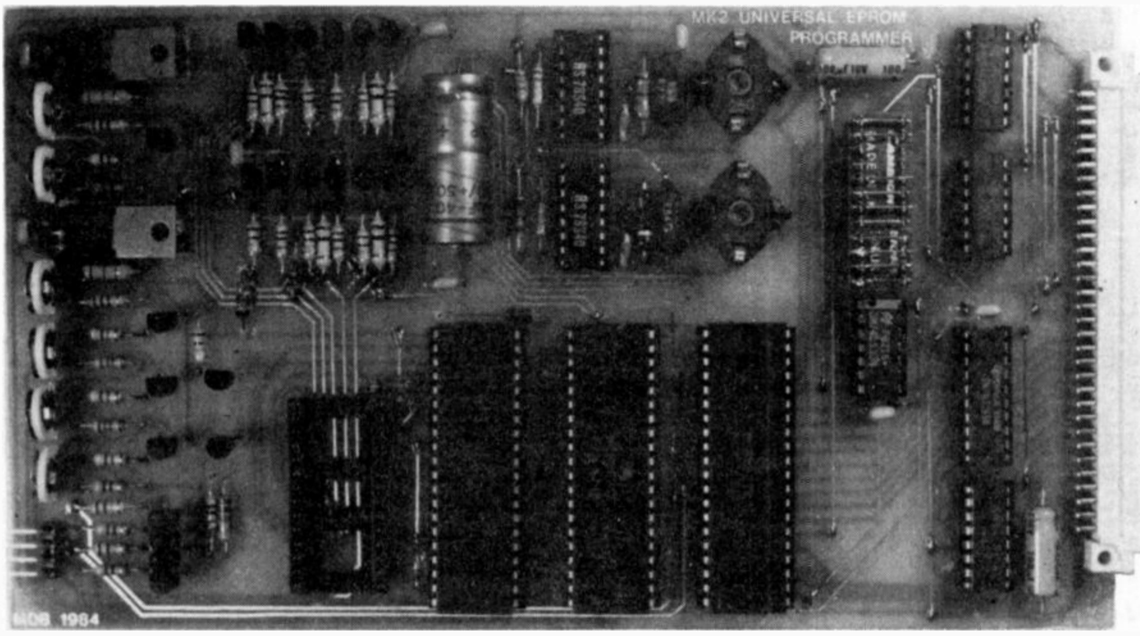


Fig. 2 LK1 address link selection for the MkII board.



PARTS LIST

RESISTORS (All ¼W, 5% unless stated)

R1,11,13,17,18,35, 37,43,45	10k
R2,12,14,20,23,44, 46	1k0
R3,15,16,21,24	100k
R7	15k 2%
R8	680R 2%
R9,39	OR22 W/W
R10	56R, 1W
R41	180R, 1W
R41	180R, 1W
R19,22	240R
R25,29	560R
R26,27	1k2
R28,36,38	470R
R30	82R
R31,32,33,34	4k7
R40	12k
R42	2k2
R47	120R ½W
RV4,8,9	220R vertical miniature preset
RV5,6,7	470R vertical miniature preset

CAPACITORS

C5,7,8,9,10,11,13, 17	100n Ceramic
C3	470µ 35V axial electrolytic
C4,C16	4n7 ceramic
C6,C15	100µ 16V axial electrolytic
C12,C14	1u0 35V tantalum

SEMICONDUCTORS

IC1	74LS126
IC2	74LS245
IC3	74LS04
IC5	74LS138
IC7,8,9	6821 (or 6520 etc)
IC11,14	78S40
IC12,13	LM317MP
Q1,5,7,9,11,13,14, 15,16,17,18,19, 20,21,23,24	BC184L
Q2,6,8,10,12,22	BC214L
D1,2,3,4,5,	OA91

MISCELLANEOUS

L1	34 turns 24 SWG wire on RM6 pot core (AL=250)
L2	13 turns 22 SWG wire on RM6 pot core (AL=250)
SK3	28 pin DIL socket
Connector A	4 way 0.1" pitch right angled molex connector.
Links	Links wired on 24-way 0.3" width DIL header plugged into DIL socket (use 16-way +8-way)

PCB; 1 x 32-way A+B DIN Euro connector, male angled pins.

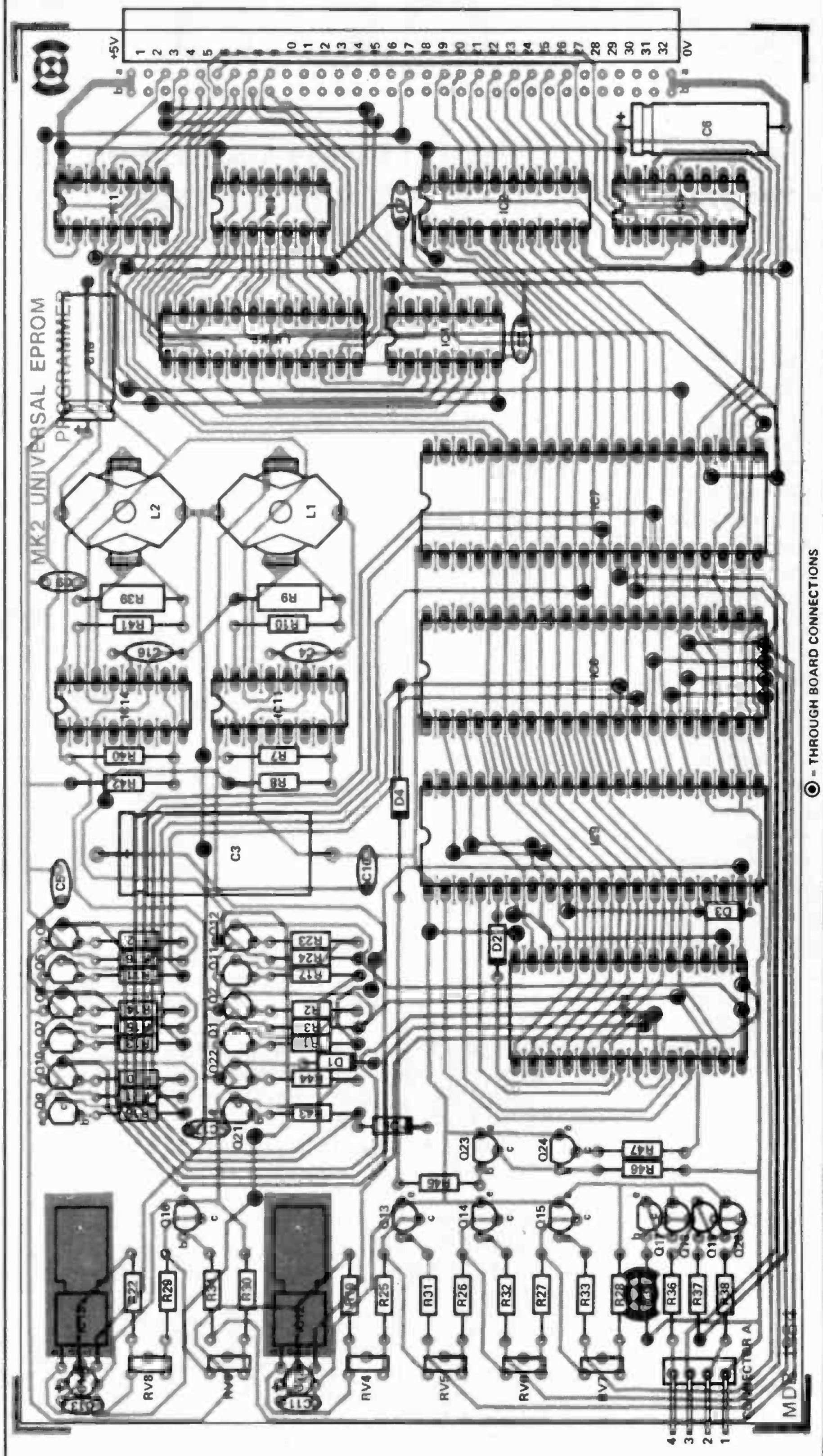


Fig. 3 Overlay diagram of the complete MkII board.

NOTE: Component numbering conforms to original project. R4, R5, R6, C1, C2, IC6, IC10, Q3 and Q4 have not been accidentally omitted. The numbers refer to components which have been removed from the original board in the course of producing the MarkII board.

To be continued. **ETI**

THE HEAT PEN

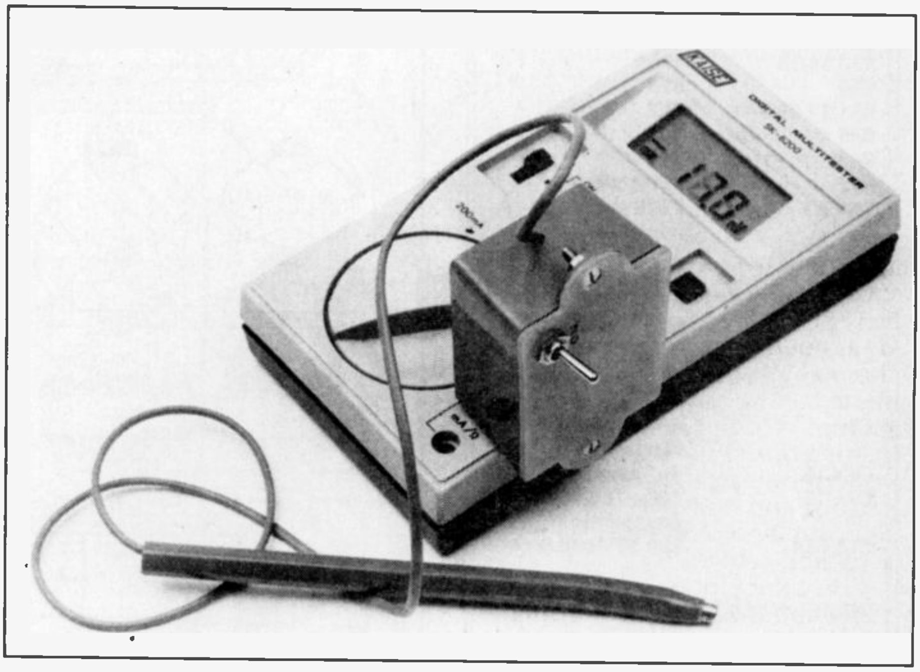
Geoff Phillips' project may make your blood boil or leave you cold — either way you can measure the temperature with this simple digital voltmeter add-on.

The Heat Pen is a low cost temperature probe that transforms a standard DVM into a digital thermometer. Just plug the Heat Pen into any digital voltmeter, place the tip onto a surface, and the DVM shows its temperature directly in °C. Its range is from -50 to +150°C.

Thermocouples are messy: they require cold junction compensation and scale conversion. Stick on labels have their uses but they are expensive and can only be used once. The Heat Pen is an inexpensive solution to your temperature measurement problems.

Temperatures of power transistors can be measured easily. Balance your central heating radiators by measuring inlet and outlet temperatures. Take your own temperature by placing the Heat Pen under your tongue. The uses are endless.

A semiconductor temperature sensor is used as the probe tip. It gives a nominal 1μA per Kelvin. This is converted to 10mV per Kelvin. A bandgap voltage reference is amplified to 2.73V. This is subtracted from the voltage signal derived from the probe tip so that the remaining voltage is equivalent to 10mV per °C. Low power semiconductors are used making the quiescent current drain of the Heat Pen less than 1mA.



Nearly all DVMs are fitted with 4mm input sockets which are pitched ¾" apart. The Heat Pen's PCB, as well as housing the circuitry, also has two 4mm plugs firmly fitted at the ¾" pitch. The PCB, along with a PP3 battery fits neatly into a smart plastic potting box. The probe is mounted in a ball point pen casing and is connected to the PCB via a screened cable.

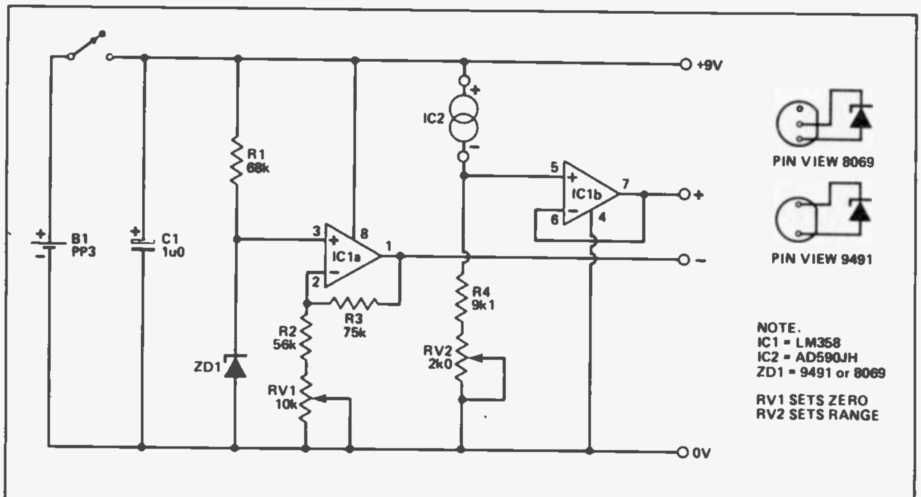


Fig. 1 Circuit diagram of the heat pen.

Construction

Fit the resistors, capacitor then IC1 and ZD1 to the PCB. No special precautions are required. Remove the plastic casing from the two 4mm terminals and using a junior hacksaw, cut 11mm off the hexagonal sections of the terminals so that approximately 12mm remains. The terminals already have one hole drilled in the hexagonal section. Ideally a second hole should be drilled 8mm from the first. If you have metric taps, drill these holes for an M3 tap and then tap out the holes. Secure the two 4mm terminals to the PCB with M3x6mm screws. If you cannot lay your hands on metric taps then the terminal may be fixed to the PCB by passing short lengths of heavy gauge copper wire through the holes and soldering the wires in place. The wires are then passed through the holes in the PCB and soldered in place.

Solder the -ve lead of the PP3 battery clip to the 0V terminal of the PCB and solder a 2" lead to the +9V terminal. Solder the core of the screened lead to the PCB and the screen to +9V terminal. The case must now be prepared for the fitting of the PCB.

First of all it is necessary to make a cover for the potting box. This may be made from glass fibre sheet, paxolin, or plastic sheet. Use the potting box as a template and draw around its shape on the plastic sheet with a scriber. Cut out the shape with a hacksaw. After dressing up the cover with a file, temporarily clamp it to the potting box and drill two M4 clear holes through the lugs of the box and cover. Drill and file a hole in the cover for the on/off switch.

The hole will have to be carefully positioned so that the switch does not foul the PP3 battery when the unit is assembled. Fit the switch to the cover. Drill two 4.7mm holes in the side of the potting box (Fig. 2) to allow the 4mm terminals to protrude from the box and one small hole in the opposite end of the box for the screened cable.

Tie a knot in the screened cable about 25mm away from the PCB and then pass the cable through the small hole in the box. Pass the two 4mm terminals on the PCB through the two holes in the box and continue to pull the screened cable through the hole until the PCB is positioned at the bottom of the box.

Pass the screened cable through the empty ball point pen casing and solder it carefully to the tem-

HOW IT WORKS

Fig. 1 shows the circuit diagram of the Heat Pen. IC2 is a semiconductor temperature sensor which gives a nominal 1µA per Kelvin. This is converted to 10mV per Kelvin by R4 in series with RV2. Thus at 0°C RV2 is adjusted for 2.73V at the output of the buffer amplifier IC1b. ZD1 is a bandgap voltage reference which gives a nominal 1.225V. IC1a is a non-inverting amplifier whose gain is adjusted by RV1 to give 2.73V at pin 1. Thus the differential voltage between the two op-amp outputs is equal to 10mV per °C. The heat pen is plugged into a DVM set to the 100mV scale and a reading in °C is given. (The decimal point has to be implied by the user).

PARTS LIST

RESISTORS (All 1% metal film)

R1	68k
R2	56k
R3	75k
R4	9k1
RV1	10k horizontal lin pre-set
RV2	2k horizontal lin pre-set

CAPACITORS

C1	1µ0 16V axial electrolytic

SEMICONDUCTORS

IC1	LM358N
IC2	AD590JH
ZD1	TSC9491BJ or ICL8069DCZR or any 1.225V bandgap voltage reference with tolerance ± 2% and temperature coefficient of 100ppm/degC

MISCELLANEOUS

PCB; Potting box type GPL2; 4mm terminals; PP3 battery clip; small on/off toggle switch; PP3 battery; ball point pen casing.

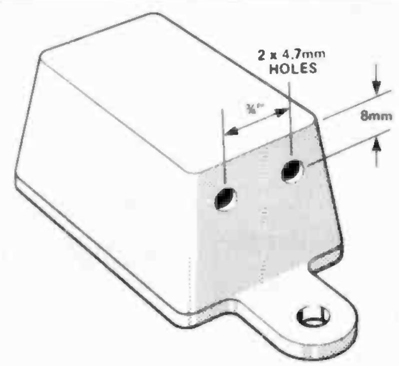


Fig. 2 Case details for the heat pen.

perature sensor AD590JH. Connect the screen to the +ve lead and the case lead of the sensor. Connect the core to the -ve lead of the sensor. Insulate the leads from each other with sleeving then the sensor can be positioned at the tip of the pen casing and secured with adhesive. Solder the +ve lead of the PP3 clip and the +ve lead from the PCB to the two switch terminals. The Heat Pen is now ready for calibration.

Calibration

A crude but effective way of calibrating the Heat Pen is in iced water. Ideally the water should be distilled and free from contaminants which may alter the freezing point temperature. It is important to ensure that water does not penetrate the leads of the temperature sensor as it will cause a leakage current to flow and thus give an erroneous reading. Therefore place the heat pen probe in a

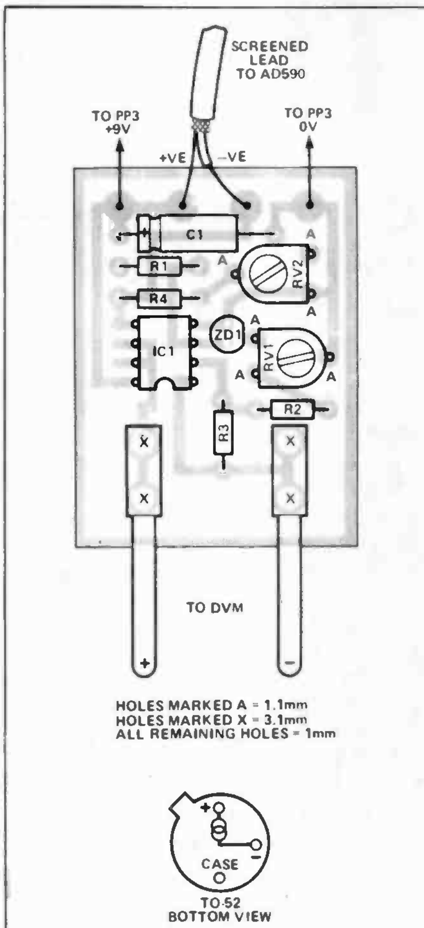


Fig. 3 Overlay diagram and pin-out of the AD590 temperature transducer.

plastic bag and place in a vessel of iced water. Switch on the Heat Pen and with your DVM monitor the voltage at pin 7 of IC1 with respect to 0V. Adjust RV2 for 2.37V.

Now plug the Heat Pen into the DVM. Adjust RV1 until 0.00V is obtained. The unit is now calibrated to 0°C. Cut out a piece of foam rubber to fit on top of the PCB in the box. This is to prevent the battery casing from short circuiting the components, and also to prevent everything from rattling around inside the box. Fit the battery on top of the foam rubber and fit the cover with its switch to the box and secure with two M4 nuts and bolts.

BUYLINES

A complete kit of parts (excluding the PP3 battery) is available from: G.P. Electronic Services, 87 Willowtree Avenue, Durham, DH1 1DZ. The cost is £8.75 inc VAT and postage for the complete kit or £1.75 for the PCB only. Note that the PCB will not be available from our PCB Service.

ETI

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

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- 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;
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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).

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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.

CMOS Tester (August 1984)
C3 and C2 are reversed on the overlay: C3 is the electrolytic and C2 the polyester. R33 is 100K not 1M as given in the parts list, and RV1 is a 1M horizontal skeleton preset. R1-16 are two, eight-resistor SIL packages, the component labelled CI4 on the overlay is SK1, and the connections to D2 shown in Fig. 3 are reversed. On the circuit diagram, the eight lines connecting SW9-16 to the inverters are shown in reverse sequence. Some of the inverters have been given the wrong designations; the correct sequence, reading down from the top, is:- IC1f, IC2a, IC2b, IC1e, IC1d, IC1c, IC1b, IC1a, IC2c, IC2d, IC2e, IC3d, IC3a, IC3b, IC3c, IC2f. Finally, the pin numbers are missing from ICs 3e and f; the input of IC3e is pin 11 and its output pin 12, and the input of IC3f is pin 14 and its output is pin 15. The PCB is correct in all respects.

AM/FM Radio (November 1984)
In Fig. 2, the oscillator and IF sections should be shown connected to ground; the PCB is correct. In Fig. 4, C31 should be 10n to give the 75us deemphasis shown in Fig. 3, but 4n7 has been found to give a brighter midrange. R38 in Fig. 5 should, of course, be 820k rather than 280k and it and the bottom end of C38, C44 etc should be shown connected to ground. In the construction section on page 25, four pieces of 8mm plywood are mentioned but in fact only three are needed — the fourth side is the front panel. See also the note in December News Digest regarding availability of the inductors.

Digital Control Port (November 1984)
The second sentence in the "Testing" section on page 30 should include the words 'without any ICs in place'. In the second paragraph of that section, the check for +5V should be made on pin 3 of IC101, not IC1. At the bottom of the first column on page 31, the last sentence should finish with B3 = 0.

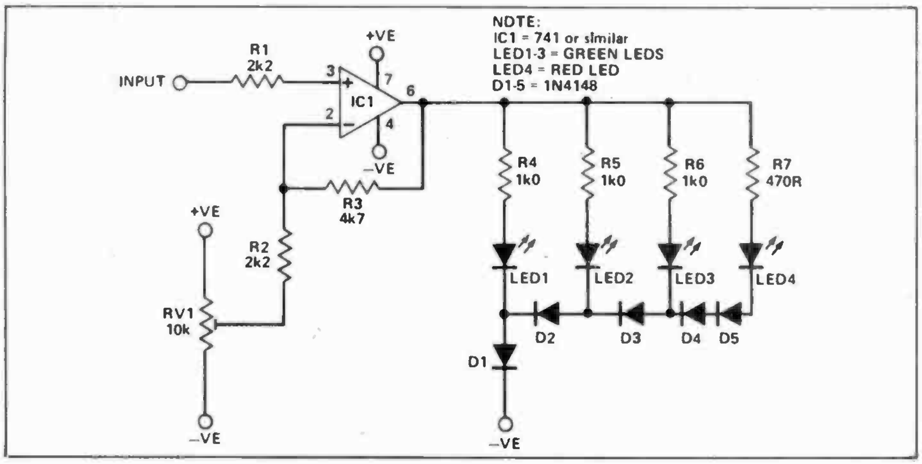
Video Vandal (November 1984)
In Fig. 8 on page 54, R16 and R17 should be shown connected to the base of Q4, and C12 and SW2 should be in the D output line rather than the OV line. It may also be beneficial to add a diode across R3 with its anode connected to the slider of RV1. In Fig. 10, R52 and LED2 are shown connected across the +12V supply but it is better to place them across the −12V supply so as to even-up the dissipation in the ICs.

Digital Delay Line (December 1984 - January 1985)
In Fig. 6 on page 21 of the December issue, C19 and C20 are both 100uF. In Fig. 8 on page 62 of the January issue, C3 should be marked 33p. On the overlay diagram (Fig. 9, p.64), R37 is missing and should be connected between pin 3 of IC9 and the 0V line; R20 is missing and should be located in the holes immediately to the left of R18; R50 is missing and should be connected between pins 1 & 2 of IC14. Some components on the overlay have also been wrongly numbered:- C20 should be marked C19 and C21 should be marked C20; R12 (between ICs 5 & 6) should be marked R22; R48 should be R44, R49 should be R45, R57 should be R46, R51 should be R47, R50 should be R48, and R47 should be R49. The unmarked capacitor directly above what is now C19 is an un-numbered 100n ceramic. C30 does not appear on any diagram or parts list and this is correct.

"Sonneti" Combo (March 1985)
The foil pattern on the overlay diagram has been shown as though from the copper rather than the component side. The foil is correctly shown on the Foil Patterns page from the copper side.

VCDO (March 1985)
RV2 should be 10k (right in parts list, wrong on circuit diagram).

TECH TIPS



Budget VU Meter

J. Green
London

The circuit uses three or more green LEDs and one red LED to indicate the level of a varying input signal. Each LED is connected to a different point on a chain of diodes and will only light up when the applied voltage exceeds the combined conduction threshold of all the diodes connected between its cathode and the negative rail.

About 5.2V is needed to light all the LEDs in the chain, and this is achieved by using an operational amplifier arranged to give a gain of 3.5. This is sufficient to light the red LED from a standard 0dB signal input. RV1 sets the gain of the op-amp and is adjusted so that the red LED just lights up at the required level.

The circuit works well with a supply of ± 5V, but if you wish to use more LEDs in the chain the supply voltage will have to be increased and the value of R3 raised to increase the gain of the op-amp. An op-amp with a higher current rating may also be required.

Divider Output	hours	X mins	secs
2★★6	0.00036	0.0213	1.28
2★★7	0.00071	0.0427	2.56
2★★8	0.00142	0.0853	5.12
2★★9	0.00284	0.1707	10.24
2★★10	0.00569	0.3413	20.48
2★★11	0.01138	0.6827	40.96
2★★12	0.02276	1.3653	81.92

Cheap Hour Counter

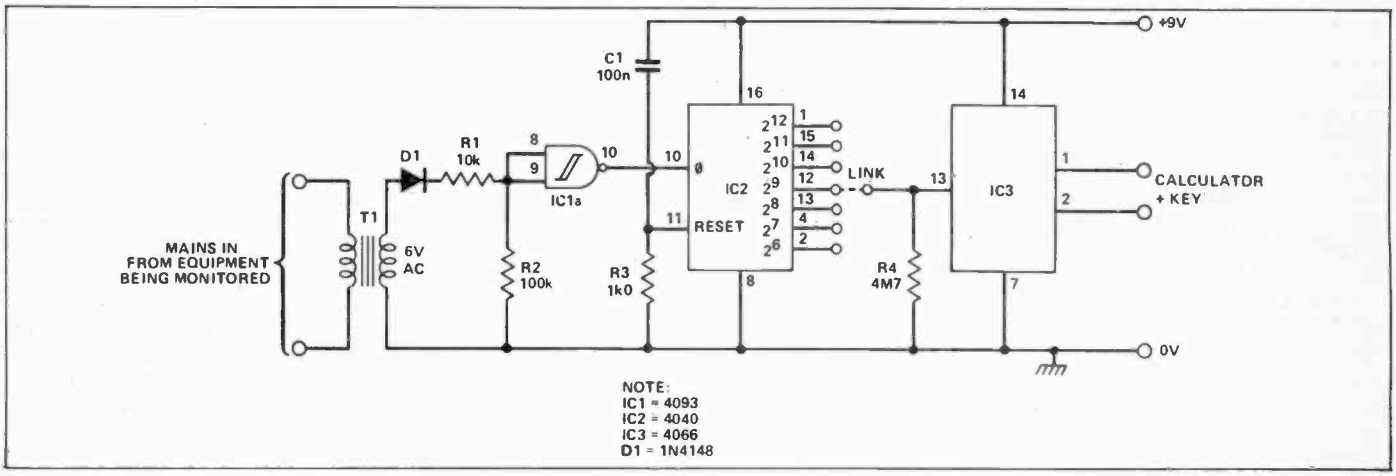
P. Roch
Luxembourg

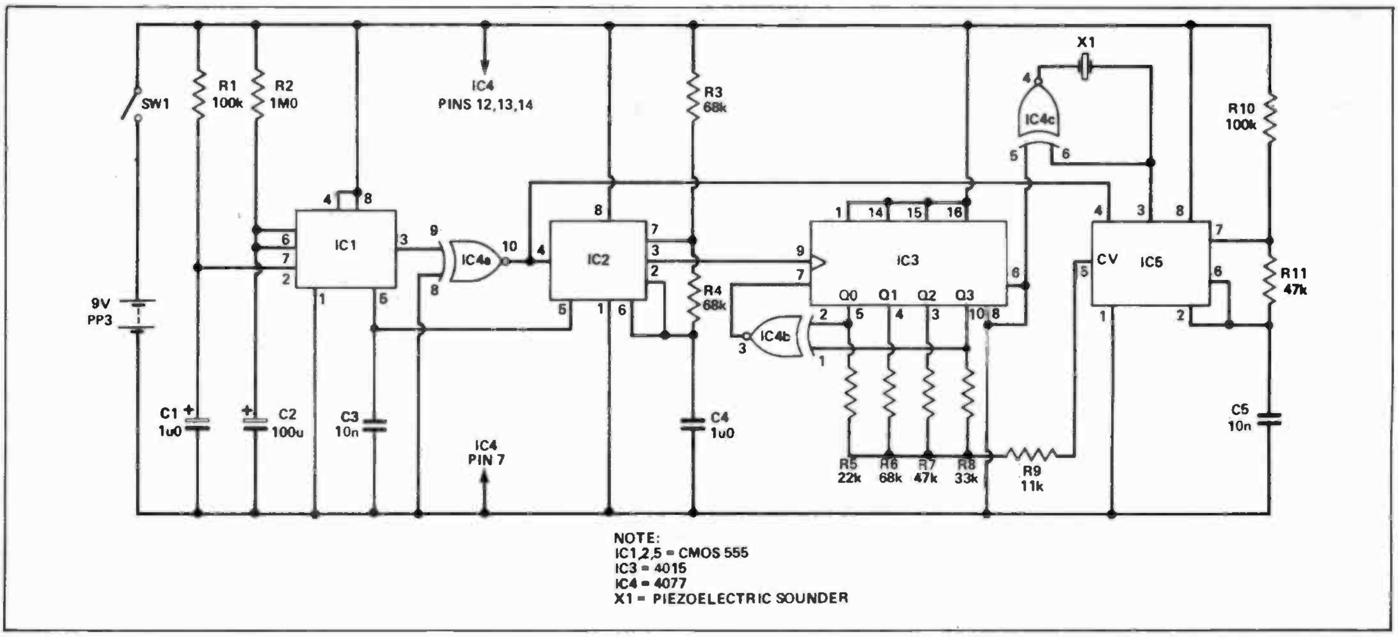
It is often useful to be able to measure the period of time for which a piece of mains-powered equipment has been in use, but the elapsed hour counters sold for this purpose are quite expensive. This circuit, which was originally designed for use with a central heating burner, uses a redundant calculator as the display and can be built very cheaply.

The circuit works by taking a 50Hz signal from the piece of equipment being monitored and divides this to drive the '+' key of a calculator. The calculator used must have the facility whereby an entered number, X, is incremented by each push of the '+' key to become 2X, 3X, 4X, etc. Most cheap calculators have this function.

The 50Hz signal is obtained from a small 6V transformer whose primary is connected in parallel with the mains supply to the equipment being monitored. The AC signal is rectified by D1 and then squared-off by the Schmitt trigger, IC1a. The resulting waveform is fed to the twelve stage ripple counter IC2, and the divided output then used to operate the bilateral switch, IC3. The switched output of this IC is connected across the '+' key of the calculator.

In use, the appropriate value of X for the readout required is keyed into the calculator and the 50Hz signal applied to the input. Values of X to give displays in hours, minutes and seconds are given in the table for various divider outputs.





Annoying Alarm

P. Cooper
London

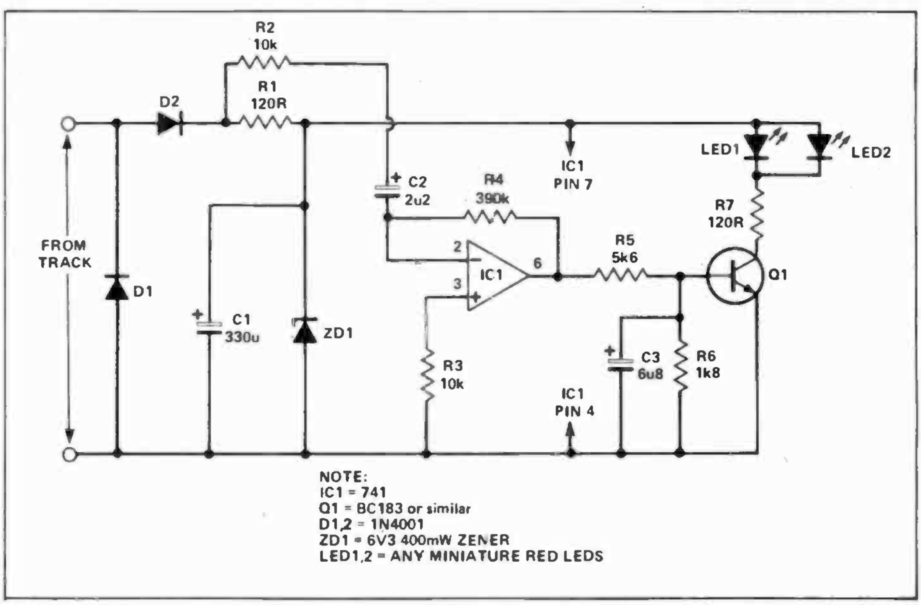
This circuit was designed to drive a computer maniac away from his machine in time for meals and emits an annoying pseudo-random sequence of tones about two minutes after being switched on. The prototype was arranged to be switched on by the removal of a jack plug so that it could not easily be disabled once activated.

A two minute delay is produced by monostable IC1, which is triggered by C1 when power is applied. IC1's output is inverted to give an active high enable signal which allows astables IC2 and IC5 to run after the delay. IC2 clocks a 4-bit shift register (IC3) at about 5 Hz while IC5 generates an audio tone whose frequendy is modulated by IC3's outputs and R1 to R5. The first and last outputs of the shift register are Exclusive-NOR'ed and the result is fed to the data input to produce the pseudo-random code. The two terminals of the piezoelectric buzzer are driven in antiphase to increase sound output.

The resulting alarm is very annoying, as people present during its development will testify!

Slot Car Brake Lights

M. Kendall
Fleet,
Hampshire



This circuit may be fitted to most small slot-type racing cars and drives two red LEDs mounted at the back of the car. The LEDs are automatically illuminated whenever the slot-car slows down, giving a realistic imitation of the action of car brake lights.

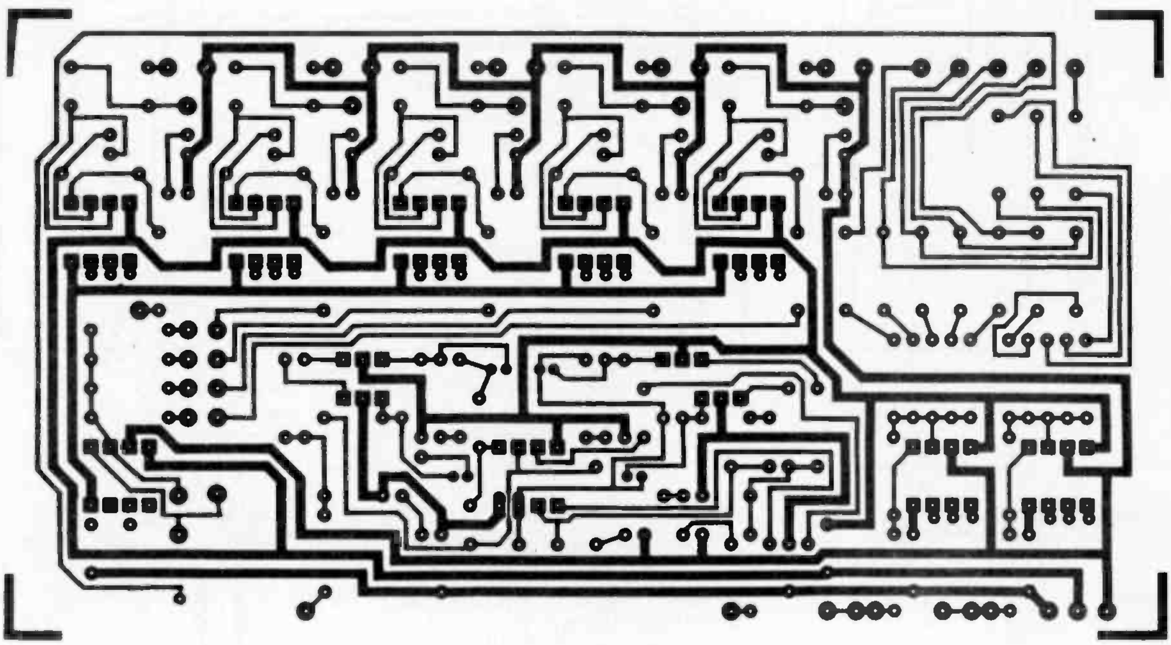
The circuit is based around IC1 which is connected as a differentiator. It monitors the voltage being supplied to the car and turns on Q1 as this falls. D2, ZD1, R1 and C1 provide a regulated supply for IC1. D1 removes any negative going spikes produced by the motor. With a constant voltage across the track the output of IC1 sits at about 2V DC, with a large AC content caused by spikes from the motor. R5 and R6 form a potential divider which holds Q1 just off under these conditions and C3 removes most of the AC. When the voltage across the track drops and the car slows down, the output of the IC rises to around 4V increase sound output.
and Q1 switches on, lighting the LEDs.

If the LEDs tend to flicker when driving at constant speed C3 can be usefully increased; size is the important consideration here, so use a tantalum capacitor.

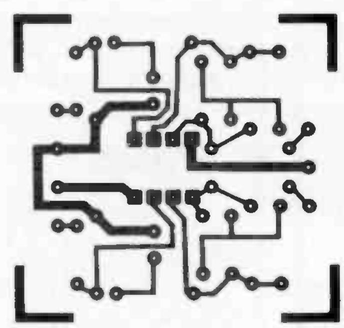
The circuit has been fitted in Scalextric rally cars and works well in practice.

ETI

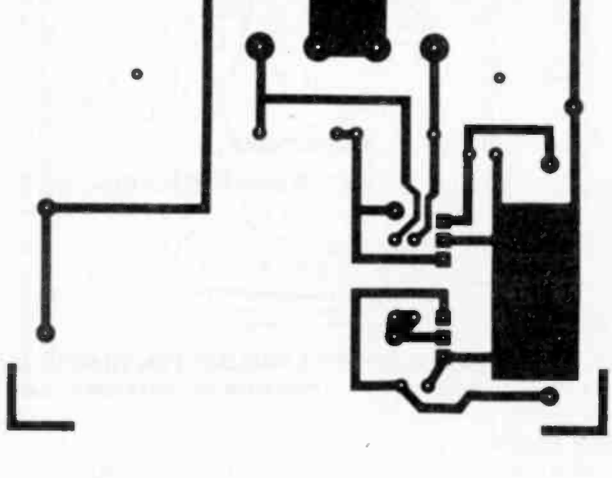
FOIL PATTERNS



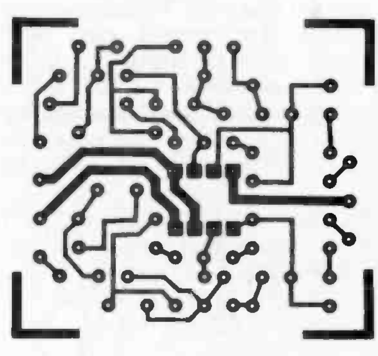
The pattern for the main board of the audio mixer.



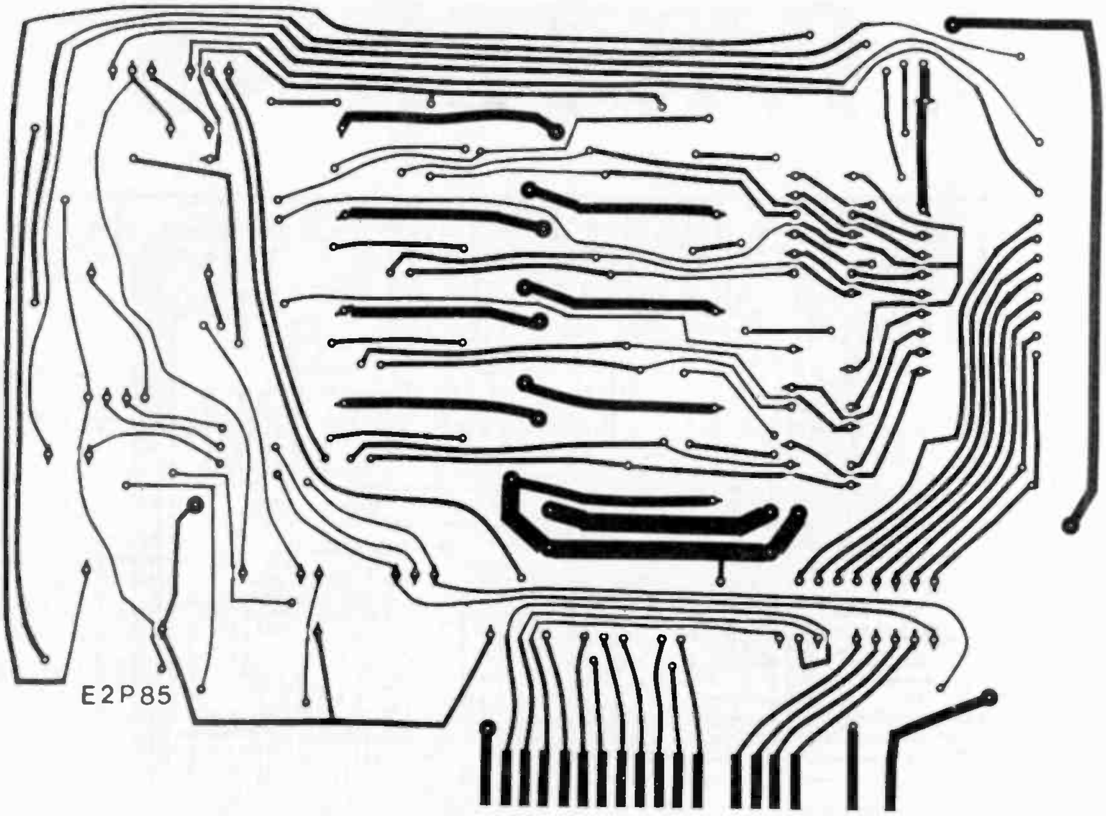
The audio mixer RIAA input stage board.



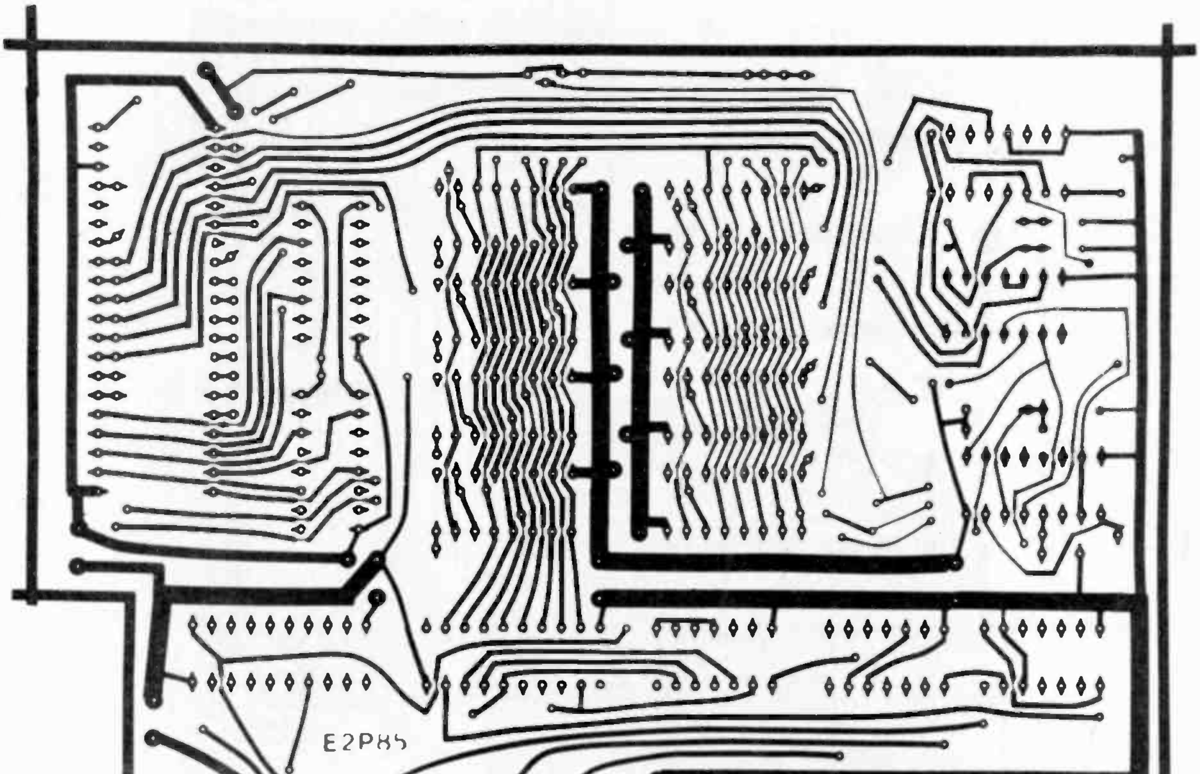
The power supply board for the audio mixer.

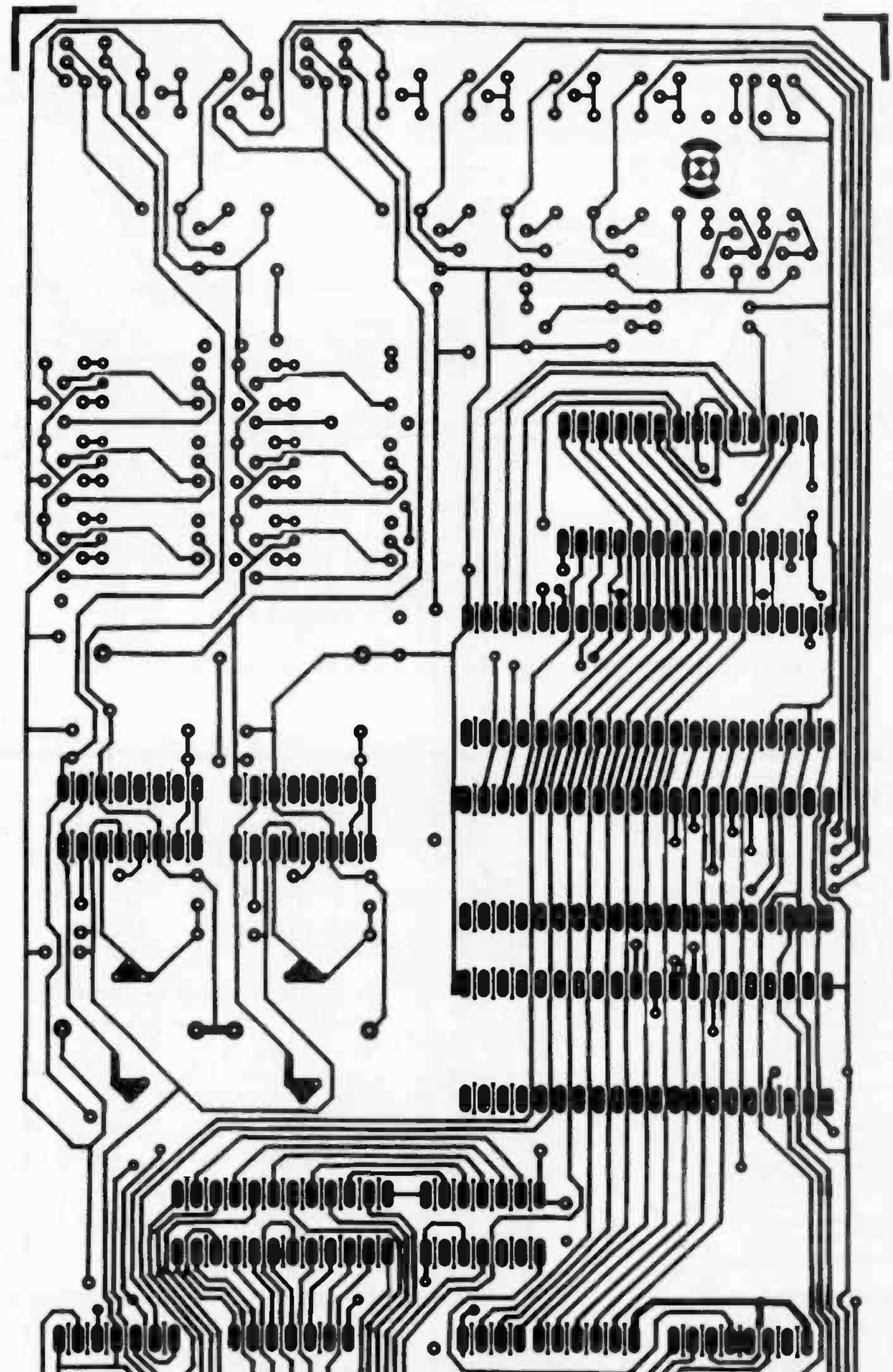


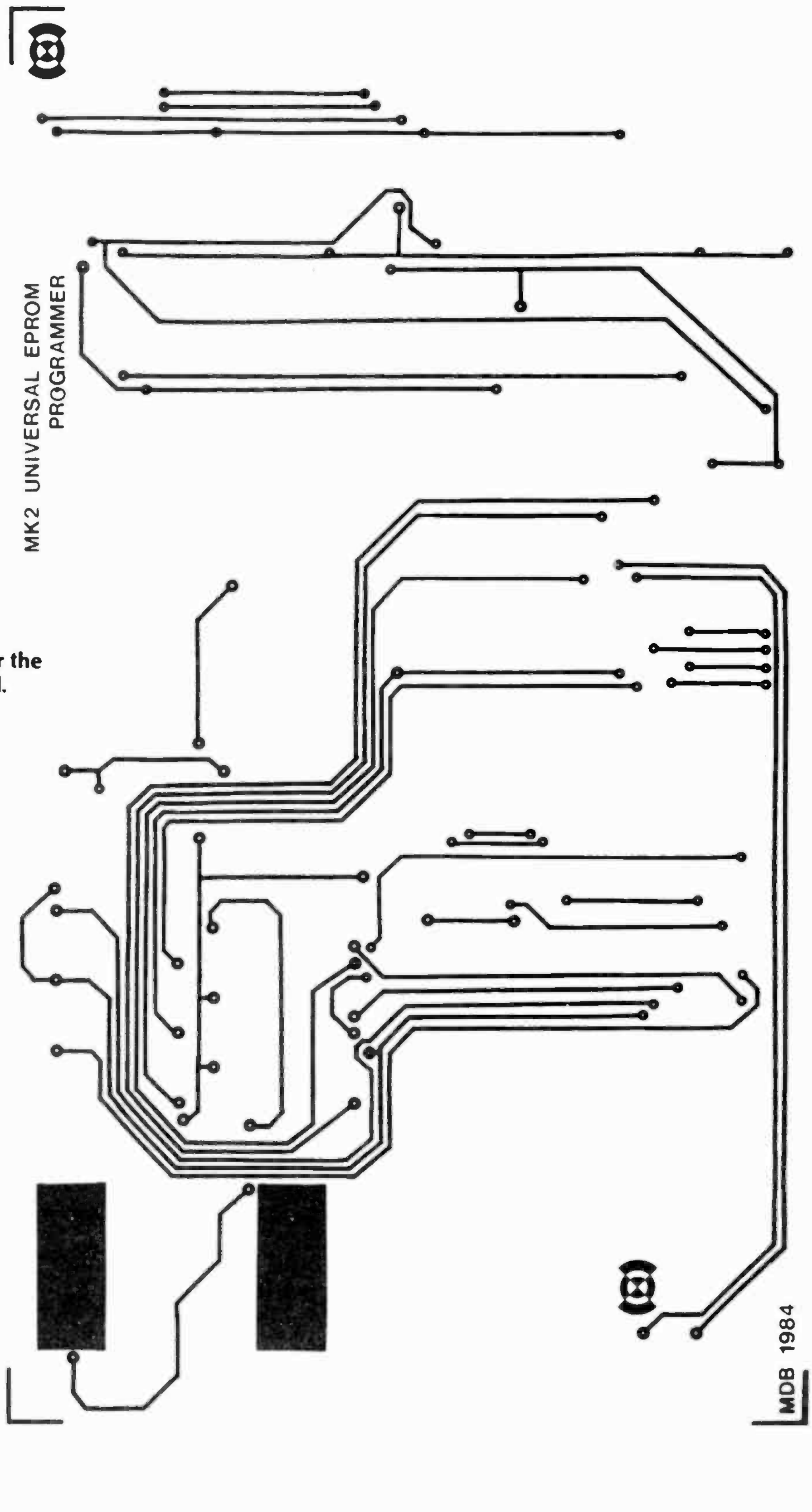
The optional tone control board for the audio mixer.



The top and bottom foils for the Electron Second Processor board.







The top and bottom foils for the EPROM Programmer board.

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In order to ensure that you get the correct board, you must quote the reference code when ordering. The code can also be used to identify the year and month in which a particular project appeared: the first two numbers are the year, the third and fourth are the month and the number after the hyphen indicates the particular project.

Note that these are all the boards that are available — if it isn't listed, we don't have it.

Our terms are strictly cash with order — we do not accept official orders. However, we can provide a pro-forma invoice for you to raise a cheque against, but we must stress that the goods will not be dispatched until after we receive payment.

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- ☐ E/8107-2 System A — Preamp.....5.95
- ☐ E/8107-3 Smart Battery Charger...2.27
- ☐ E/8108-5 Watchdog Home Security (2 boards)............6.11
- ☐ E/8109-1 Mains Audio Link (3 bds)...8.45
- ☐ E/8109-4 Laboratory PSU.........5.21
- ☐ E/8110-1 Enlarger Timer..........3.91
- ☐ E/8110-2 Sound Bender...........3.05
- ☐ E/8111-1 Voice Over Unit.........4.57
- ☐ E/8111-3 Phone Bell Shifter........3.40
- ☐ E/8112-4 Component Tester.......1.71

1982
- ☐ E/8202-2 Allez Cat Pest Repeller...1.93
- ☐ E/8202-5 Moving Magnet Stage....4.01
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REVIEWS

GATE ARRAYS: DESIGN AND APPLICATIONS

Book
John Reed (ed)

Collins Professional and Technical Publishers
8 Grafton Street
London W1

price: £20

This book is divided into nine sections, written by different authors from different companies on (presumably) their specialities. The first section, which lays out the background information and the basic technology, is written by the editor.

Gate Arrays are, typically, ICs with the interconnections between different parts not defined. A customer requiring a specific logic function can specify the interconnection pattern to meet his requirements, and thus can have a "semi custom IC" without having to start from scratch, with all the cost that entails. Even the provision of interconnect masks its not a cheap or simple business, however, so this technology is not for prototyping purposes.

Details of the device technology are provided, both for bipolar and MOS arrays. Analogue/linear arrays are also available (not a lot of people know that) and both bipolar and CMOS versions are discussed. Digital gate arrays are often known as uncommitted logic arrays, or ULAs.

Manufacturing a gate array is a complicated procedure in which a mis-step can be very costly, and computer aided design (CAD) is a big help. About forty pages are devoted to this important topic. Following this is a short section on manufacturing, in which the author comments 'whereas full custom circuits can frequently take up to a full year to implement, gate arrays. . . . can be produced in as little as three weeks from the time a logic diagram is received.' This cannot be cheap!

Once the design has been produced it must be tested. This is not as easy as it sounds, because it is not possible to place a logic probe at any convenient point in a complicated circuit. As the section covering this aspect points out, the design must be carried out so that the functioning of the circuit can be determined by access to the pins, and without having to take the circuit through every conceivable logic state.

After this are three sections on designing with and applying gate arrays. One example shown here is the Acorn Electron, in which most logic not connected with the microprocessor is carried out by a gate array. This includes video handling, sound generation and the cassette interface.

The book is primarily addressed to engineers and engineering management who are contemplating the use of gate arrays in their products. It deals with commercial and practical aspects as well as the technology, and rightly so in my view because many potential users of gate arrays must have no idea where the pitfalls lie. Given the rate of technological change, this book cannot give all the answers, but it pinpoints a lot of the important considerations in implementing a design in gate array form.

The electronics student is also liable to find this book useful, not least for the background information provided about semiconductor technology and devices. The home constructor will find little of relevance here, but those who are interested for interest's stake should give this informative book a look.

Andrew Armstrong

Received this month:

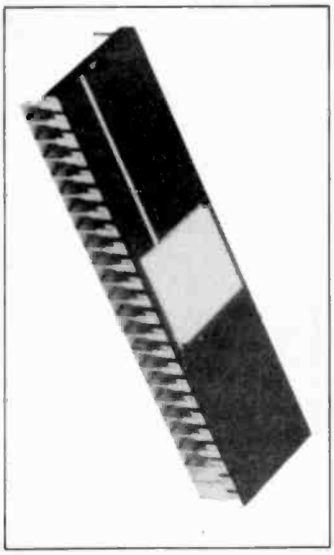
Microelectronics Systems 1 Checkbook
Microelectronics Systems 2 Checkbook
Microelectronics Systems 3 Checkbook
(R.E. Vears, Butterworths, London).

O-level and CSE Pass-cards, Electronics
(P. Clothier BSc, Letts, London)

LISP — The Language of Artificial Intelligence
(A.A. Berk, Collins, London)

These books will be reviewed next month.

Also next month, we will be reviewing the Microprofessor MPF 1/88 — an 8088-based development and training system from Flight Electronics, Southampton, and the Touchtech touch screen add-on for Microvitec monitors from Microvitec, Bradford.



DESIGNING MICRO PROCESSOR-BASED CIRCUITRY

Book

S.J. Cahill
Prentice-Hall International
66 Wood Lane End
Hemel Hempstead
Herts HP2 4RG

price: £9.95

Titling a book 'Designing Microprocessor-Based Digital Circuitry' is asking for trouble. Especially when the book in question carries a low price tag and is only a couple of hundred pages long. Dangerously so when the blurb claims that the book 'strips away the mystery surrounding microprocessors' and that it requires 'no prior knowledge of digital electronics and can be read by anyone with an appreciation of scientific method.'

The author, S. J. Cahill, works for the Department of Electronic and Electrical Engineering at the University of Ulster — pointedly described as being situated in 'N. Ireland, UK'. His own preface gives the lie to the blurb. The 'objective' of the book, he writes, is 'to strip off the mystery surrounding microprocessors as a digital device.' 'No great prior knowledge of electronics (is) assumed,' writes Cahill, and 'anyone with an appreciation of scientific method will benefit from the text.' The differences may be small but they are significant. The lesson we can learn is never to trust blurb-writers (or, for that matter, publishers).

That said, the text proper begins with a somewhat doubtful proposition. 'Electronics is defined as the art of processing information by electrical means,' writes the author. One wants to ask him, by whom is it so defined and what does it mean? Cahill has fallen into a trap before taking barely a step.

He has defined the subject of his study in order to fit the book, rather than writing a book which addresses the very real issues of how best to approach and understand microprocessor - based systems. This becomes clear as you move through the book, proceeding from an introduction to logic and digital circuits to a look at microprocesors finishing with the meat of the work — a project to build a 6802 controlled greenhouse thermometer.

This project forms well over half the book and ideas behind it are introduced as early as the first page of the text proper. My first question was, why build this particular project? This is a question that recurs throughout electronics and it's a question which Cahill makes some attempt to answer with, in my opinion, little success. My next question concerned Cahill's tendency to gloss over things that bear too little on the impending project. The book presumes a great deal and treats rather cursorily those aspects of electronics in general — and digital electronics in particular — which don't come within the author's purview.

There can be no doubt that the task Cahill has set himself is difficult. If he doesn't succeed gloriously he can be consoled by the fact that he has made a valiant attempt to take the ground. This is more than most writers on electronics ever do. Given its limitations, the book is well executed, readable and, at times, informative. Naturally, the project itself is handled with unimpeachable comprehensiveness. If you work through the book and construct the project (as suggested, on breadboard) there can be no doubt that you will end up with as good a working knowledge of 6802 MPU as can be had. This would be no small achievement, and no small return on the cost of the book. You would also be in a good position to develop a more general understanding of digital systems and microprocessors than could be guaranteed by any number of introductory texts. In that sense, Cahill's practical approach works — even if it doesn't quite attain his own or the blurb-writer's goal.

Gary Herman

TRAINS OF THOUGHT

Only three years ago if you said 'transistor' to the average railway modeller, he (or, rarely, she) paled visibly. If you said 'integrated circuit' he winced. And if you said 'computer' . . . well, you didn't because before you got that far he would have bolted from the room in blind panic.

A shame really, because the average railway modeller has quite an appreciation of electricity, of logic and of control. It's just that he is what he is because he likes to see things move. He's happy with switches by the bank, relays by the ream and rheostats by the kilowatt. But the the thought of electrons doing their thing out of sight inside black plastic cases where he can't get at them, well, that's contrary to all his instincts.

That was three years ago. Since then things have changed — and doubtless there are some who'll say, 'Not for the better'. Many railway modellers now are turning to electronics to solve some of their problems.

LEDs are now extensivley used as lamps (known, in the jargon, as *aspects)* in colour-light signals, an application for which they are far better suited than the traditional 'grain-of-wheat' bulbs. Train detection systems to tell the operator where his trains are — displaying the status, as like as not, on a mimic diagram — are no longer uncommon. And that's to say nothing of control systems of varying degress of sophistication, some of which generate simulated sound as well as giving the silkiest ever control of traction power.

Nor has the ubiquitous microcomputer left the railway modelling fraternity unscathed. Besides the miracles of four-bit processing that gave the world such command-control systems as Hornby's *Zero-1*, no exhibition railway layout is complete without a computerised display to tell the spectators what is supposed to be happening.

Many modellers have found their hands forced, if only because electronics offers the *only* feasible means to their end, the perfect reproduction in miniature of full-size railway practice. Readers of ETI, in contrast, need no convincing of the value of electronics. But you may perhaps be looking for some new avenue of application to challenge your expertise. If so, I urge you to consider railway modelling with an emphasis on such prototypical operations as multiple-aspect signalling and automatic train stop stems. In future issues I hope to give a selection of circuit ideas to show you some of the things that we modellers get up to in our lofts and attics and which I hope will set your trains of thought on the right lines!

Roger Amos

'AND FINALLY, I WISH TO PUBLICLY DENY ANY FINANCIAL INTERESTS IN FIRMS MANUFACTURING MICROPHONES AND STICKY TAPE'

OPEN CHANNEL

British Telecom takes pride of place this month with several items of news, the first being the recent announcement that it intends to provide telephone services to passengers flying on British Airways' 747 Jumbo jets. It makes British Rail's plans for phones on Inter City trains look positively mundane, doesn't it?

In a joint venture with Racal Decca, BT is going to develop a 'flying phone' system in three distinct stages. The first of these will be a technical evaluation exercise which will determine the best aerials, methods, and communications technologies etc, to provide an acceptable service. One of the main determining factors is the requirement that aircraft communications must be within the UHF L-band of frequencies, from about 0.4 GHz to 1.5 GHz with wavelengths from about 77 cm to 19 cm.

The next stage is a marketing evaluation exercise, to find out just who is likely to want to use in-flight telephones. During this stage it is intended that, wait for it, calls will be free. (Hello operator. What do you mean, I can only make a local call?)

The final stage will be the implementation of a commercial service, which should be available by 1987.

When X Equals Y

On another front — good old-fashioned land based phones — BT appears less sure of itself and its directions. Recently, a spokesman for BT was reported to have confirmed that software problems bugging the development of System X exchanges have been ironed out. The very first BT operated System X exchange at Baynard House in the City of London should, by the time you read this column, be in service. By the end of June, it is planned that 15 such exchanges will be operational in the UK network.

It would appear that all things are hunky dory for the contracted manufacturers of System X exchanges, and that profits must now at least show on their order books. However, the same manufacturers must be feeling somewhat peeved by the even more recent announcements that BT is reported to have asked for tenders for the manufacture of System Y exchanges — to operate alongside their System X counterparts. The System X makers must surely feel that several years' worth of design, development and manufacture of System X exchanges has been overridden by BT's apparent lack of commitment.

Satellite TV

The direct broadcast by satellite (DBS) debate seems to be reaching a head, with the 'Club of 21' (the consortium which is to operate Britain's DBS television service) baulking at the costs of the proposed satellite rentals.

Unisat, the satellite organisation comprising British Aerospace, GEC and — yes, you've guessed it — British Telecom, whose satellites the DBS organisation are presently bound to use, has priced the use of satellites too highly according to the Club of 21. Britsat, another satellite organisation, has offered satellite rentals to the Club of 21 at a much lower cost, for a longer time, and it promises services sooner.

The debate is compounded by news that foreign manufacturers are soon to produce cheap DBS television receivers. As one of the primary aims of DBS in the UK is to allow British companies to make DBS TVs for our own market, it stands to reason that plans for DBS services must soon be finalised so that they may do just that — before foreign competition does the job for them.

The Club of 21 is now playing a waiting game. They believe they can force the government's hand to allow a free choice of satellite rental services, thus providing a more economical solution. Unisat is also playing a waiting game — it believes Britsat's service is inferior.

It has not been, however, the government's general policy to wait in the sidelines for arguments to sort themselves out, and there is little likelihood it will do so now, in the light of the foreign competition. So, there really are only two routes it can take. One, it may allow the Club of 21 to choose its own satellite supplier, or two, it may disband the Club of 21 and create an alternative, contractually obliged to accept Unisat's services.

With the government's reputation on negotiating settlements agreeable to all sides (almost non-existent), I would advise the Club of 21 to seriously consider its stance.

Keith Brindley

Trains of Thought and Open Channel welcome letters and information on products and events to do with modelling and telecommunications respectively. Please address correspondence to the relevant column at ETI, ASP Ltd., 1 Golden Square, London W1R 3AB.

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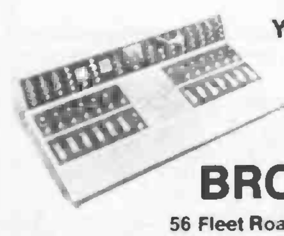

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SCRATCH PAD

by Flea-Byte

Now that STC have taken over ICL, poor old Robb Wilmot can't have much to do to fill his time. So, it's hardly surprising that the former ICL technical supremo has accepted a posting with Sir Clive Sinclair, the leading edge of the new technology. Wilmot will be looking after a new division of the Sinclair empire, formed to develop wafer-scale integrated circuits. Wafer-scale integration (WSI) means using a single wafer — or slice of silicon crystal (the biggest of which are 6 inches in diameter) to hold one enormously complicated circuit. The benefits in speed and energy consumption, when compared to circuits which have to wire up several chips, are obvious. So much so that two or three years ago, Gene Amdahl — former IBM whizz-kid and founder of Amdahl Computers — started up his Trilogy Corporation with the backing of six or seven of the world's leading computer manufacturers in an attempt to design and build a new computer based on WSI techniques. Some months, and many millions of dollars, later Amdahl gave up. The world, it would appear, was not ready for single circuits on a wafer — although it might be eager for a piece of cheese on a Ritz cracker. Sir Clive and his new partner Robb 'One Per Desk' Wilmot are not deterred. They have some money and they're going to spend it. Maybe all those customer complaints have finally got through to Sinclair. Since the object of WSI is faster processing time with a lower overhead, perhaps Sir Clive is thinking of a wafer scale circuit with a 28-day clock cycle (or your money back).

★ ★ ★

Another intriguing new hiring came to my attention recently. It seems that Robert Moog is now working for Kurzweil Music. Moog, you will recall, is the man who invented the synthesizer. Or, to be more precise, he realised that silicon components could be used to make flexible and virtually noise-free voltage controlled circuits which could then be patched together to produce complex waveform generating and wave shaping devices. Moog went on to design many of the now classic VCO, VCA and VCF circuits. He bundled several of them together with a piano-type keyboard and produced one of the very first analogue synthesizers. That was in the mid-sixties and, although he was once on the verge of joining the ranks of Biro, Hoover and Diesel — whose names have entered the language — his career took a nose-dive after reaching this peak. His company was bought out and, in his own words, Moog spent his remaining time there as 'window dressing'. Now he's moved across to join Ray Kurzweil, whose own career has been somewhat checkered. Kurzwell first came to public attention as the man behind optical character readers (OCRs) which can read text aloud, learn new typefaces and scan text for direct entry into databases. The company that produced the OCRs, Kurzweil Computer, was taken over by Xerox in 1980. It is said that Xerox were convinced by the Kurzweil charm that OCR's were about to become as common as photocopiers. It is also said that Xerox have been surprised to discover that this wasn't the case. Kurzweil himself made $6 million from the deal and went on to set up Kurzweil Music and produce the Kurzweil 250 — an electronic keyboard specifically designed to reproduce the complex tones of a grand piano as accurately as possible. The 250 does more than that, of course. At $11,000 a machine, it would have to. Kurzweil is very cagey about the technology used, revealing only that the 250 uses a combination of digital sound sampling and ROM-based algorithms. In order to distinguish the 250 from Fairlights, Synchlaviers, Emulators and other instruments, Kurzweil describes his technique as 'sound modelling'. The role that Moog played in developing the keyboard seems to have been minimal. According to Kurzweil, his major contribution was 'to settle our endless debates about whether we had got a sound right'. Moog himself says that 'the Kurzweil people understand my capabilites and are using them'. I don't know whether the Kurzweil 250 sounds like a grand piano or not, but I do know that it sounds like a hype.

★ ★ ★

Good news for those of you who can't afford a Sinclair C5. Designer Felice Campopiano has gone one better than the electric trike and produced an electric bike. The Pedelec's development has been funded by the Greater London Enterprise Board (to the tune of £76,000) and by Campopiano himself (£20,000). It will sell for £325 and have a maximum speed of 16 km/hr. We await with mounting excitement the announcement of an electric pedestrian.

★ ★ ★

Talking of which, more news from the Japanese robot front. The crafty blighters have produced a robot tea-lady which (who?) stops passers-by in their tracks by whispering — seductively, no doubt — 'I'm a vending robot, a tea sales girl. Let's talk.' Readers might like to submit the text of an ensuing conversation. I should point out, however, that ETI is staffed by editing robots and I am a writing robot. We're not noted for our sense of humour, but I'm sure if any of you succeed in making us laugh, I might persuade the subscription robots to send out a free subscription or a binder.

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