Australia $[illegible] New Zealand $1.75 Malaysia $[illegible]

PRACTICAL ELECTRONICS

JUNE 1984

90p

HYPERCHASER

TEST GEAR BUYERS GUIDE

OSCILLOSCOPES · PSU's

FUNCTION GENERATORS

FREE! LOGIC DESIGN CARD Nº4

PRACTICAL

ELECTRONICS

VOLUME 20 **No. 6** **JUNE 1984**

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL SUPPLEMENT

OUR JULY ISSUE WILL BE ON SALE FRIDAY, JUNE 1st, 1984
(for details of contents see page 16/6 of Micro-file)

WATFORD ELECTRONICS

33, CARDIFF ROAD, WATFORD, HERTS WD1 8ED, ENGLAND
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POLYESTER RADIAL LEAD CAPACITORS: 250V; 10n, 20n, 15n, 22n, 27n **6p**; 33n, 47n, 68n, 100n **8p**; 150n, 220n **10p**; 330n, 470n **15p**; 680n **19p**; 1µ **23p**; 1µ5 **40p**; 2µ2 **46p**.

ELECTROLYTIC CAPACITORS (Values in µF). **500V:** 10µF **52p**; 47 **78p**; **63V:** 0.47, 1.0, 1.5, 2.2, 3.3, **8p**; 4.7 **9p**; 10 **10p**; 15, 22 **12p**; 33 **15p**; 47 **12p**; 68 **16p**; 100 **19p**; 220 **26p**; 1000 **70p**; 2200 **99p**; **50V:** 68 **20p**; 100 **17p**; 220 **24p**; **40V:** 6.8 **15p**; 22 **9p**; 33 **12p**; 330, 470 **32p**; 1000 **46p**; 2200 **90p**; **25V:** 4.7, 10, 22, 47 **8p**; 100 **11p**; 150 **12p**; 220 **15p**; 330 **22p**; 470 **25p**; 680, 1000 **34p**; 1500 **42p**; 2200 **50p**; 3300 **76p**; 4700 **92p**; **16V:** 2.5, 40 **8p**; 47, 68, 100 **9p**; 125 **12p**; 220 **13p**; 330 **16p**; 470 **20p**; 680 **34p**; 1000 **27p**; 1500 **31p**; 2200 **36p**; 4700 **79p**.

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

POTENTIOMETERS: Carbon Track, 0.25W Log & Linear Values.

500Ω, 1K & 2K (LIN ONLY) Single	**35p**
5KΩ-2MΩ single gang	**36p**
5KΩ-2MΩ single gang D/P switch	**95p**
5KΩ-2MΩ dual gang stereo	**99p**

TANTALUM BEAD CAPACITORS:
35V: 0.1µ, 0.22, 0.33 **15p** 0.47, 0.68, 1.0, 1.5 **16p** 2.2, 3.3 **18p** 4.7, 6.8 **22p** 10 **28p** **16V:** 2.2, 3.3, **16p** 4.7, 6.8, 10 **18p** 15 **36p** 22 **36p** 33, 47 **50p** 100 **95p** 220 **100p** **10V:** 15, 22 **26p** 33, 47 **50p** 100 **75p**.

SLIDER POTENTIOMETERS
0.25W log and linear values 60mm track
5KΩ-500KΩ Single gang **80p**

SILVER MICA (pf)
2, 3.3, 4.7, 6.8, 8.2, 10, 12, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180 **15p**. 220, 250, 270, 330, 360, 390, 470, 600, 800 & 820pF **21p**. 1000, 1200, 1800 **30p each**. 3300, 4700 **60p each**

SIEMENS mulitlayer miniature capacitors.
250V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 8n2, 10n, 15n, 22n **7p**; 18n, 27n, 33n, 47n **8p**; 39n, 56n, 68n **9p**, 100nF **11p**.
100V: 100n, 120n, **10p**; 150n **11p**; 220n **13p**; 330n **18p**; 470n **23p**; 680n **30p**; 1µF **34p**; 2µ2 **50p**.

PRESET POTENTIOMETERS
0.1W 50Ω-2.2M Mini Vert. & Horiz **8p**
0.25W 220Ω-4M7 Vert. & Horiz **12p**

RESISTORS Hi-stab, Miniature, 5% Carbon.

	RANGE	Val.	1-99	100+
0.25W	2Ω2-4M7	E24	3p	1p
0.5W	2Ω2-4M7	E12	3p	1p
1W	2Ω2-10M	E12	6p	4p
1% Metal Film	51Ω-1M	E24	8p	6p

CERAMIC Capacitors: 50V
Range 1pF to 6800pF **4p**; 10nF, 15n, 33n, 47nF **5p**; 100nF/30V **7p**.

POLYSTYRENE Caps:
10pF to 1nF **8p**
1n5 to 12nF **10p**

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

TRANSISTORS

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AC127/8	35	BC308B	16	BFR98	105	TIP30C	37	2N914/5	32	2N5458/9	30
AC141/2	35	BC327/8	15	BFX29/84	35	TIP31A	38	2N918	40	2N5485	36
AC176	35	BC337/8	15	BFX84	35	TIP31C	45	2N930	20	2N5777	45
AC187/8	35	BC441	34	BFX85/86	35	TIP32A	43	2N1131/2	40	2N6027	32
AC188	35	BC461	34	BFX87/88	28	TIP32C	45	2N1303/4/5		2N6109	60
AD142	120	BC477/8	40	BFY50/51	30	TIP33A	70	2N1307/8	70	2N6290	70
AD149	79	BC516/7	40	BFY52	30	TIP33C	75	2N1613	30	2SA636	250
AD161/2	45	BC547/8	12	BFY53	30	TIP34A	85	2N1671B	160	2SA671	250
AF118	95	BC549C	15	BFY55	35	TIP34C	105	2N2160	325	2SA715	75
AF139	40	BC556/7	15	BFY56	35	TIP35A	120	2N2219A/20A/		2SC495/6	85
AF239	55	BC558/9	15	BFY64	40	TIP35C	130	21A/22A	25	2SC1061	250
BC107/8	14	BCY41/42	30	BFY90	80	TIP36A	130	2N2369A	18	2SC1096	85
BC107B	14	BCY70	18	BRY39	50	TIP36C	140	2N2646	45	2SC1162	45
BC108B	14	BCY71/2	20	BSX20	30	TIP41A	50	2N2846	80	2SC1172/3	125
BC108C	14	BCY72	25	BSX29	45	TIP41B	52	2N2904A/05A/		2SC1306	100
BC109	12	BCY78	30	BSY26	35	TIP42A	55	06A/07A	26	2SC1307	150
BC109B	14	BD131/2	65	BSY95	35	TIP42B	58	2N2926G	10	2SC1449	95
BC109C	14	BD133	60	BU105	180	TIP120	70	2N3053	25	2SC1679	190
BC114/5	30	BD135	45	BU205	190	TIP121	73	2N3054	55	2SC1678	140
BC117/8	25	BD136/7	45	BU206	200	TIP141	120	2N3055	50	2SC1923	65
BC140	38	BD138/9	40	BU208	200	TIP142	120	2N3442	140	2SC1945	225
BC142/3	38	BD140	40	MJ2955	90	TIP147	120	2N3615	199	2SC1953	90
BC147/8	12	BD158	68	MJE340	54	TIP2955	70	2N3663	20	2SC1957	90
BC147B	15	BD245	65	MJE371	100	TIP3055	70	2N3702/3	10	2SC1969	165
BC148C	10	BD434	70	MJE2955	99	TIS43	50	2N3704/5	10	2SC2028	85
BC149	12	BD695A	150	MJE3055	70	TIS44	45	2N3706/7	10	2SC2029	200
BC149C	15	BD696A	150	MPF102	40	TIS88A	50	2N3708/9	10	2SC2078	170
BC153/4	30	BF115	45	MPF103/4	30	TIS90	30	2N3710	10	2SC2091	85
BC157/8	14	BF154/8	30	MPF105	30	TIS91/93	32	2N3771	179	2SC2166	165
BC159	11	BF167	35	MPSA05	30	VK1010	98	2N3772	195	2SC2314	85
BC167A	14	BF173	35	MPSA06	25	VN10KM	70	2N3773	210	2SC2335	200
BC168C	12	BF177	35	MPSA08	30	VN46AF	95	2N3819	35	2SC2465	125
BC169C	12	BF178	35	MPSA12	32	VN66AF	110	2N3820	60	2SC2547	40
BC171/2	15	BF179	40	MPSA55	30	VN88AF	120	2N3822/3	60	2SC2612	200
BC173	15	BF194/5	12	MPSA56	30	VN89AF	120	2N3866	90	2SD234	75
BC177/8	16	BF198/9	18	MPSA70	40	ZTX107/8	12	2N3903/4	15	2SK45	90
BC179/81	20	BF200	30	MPSU02	58	ZTX109	12	2N3906/5	15	2SK288	225
BC181	30	BF224	40	MPSU05	60	ZTX212	28	2N4037	60	2SJ83	225
BC182/3	10	BF244A	28	MPSU06	60	ZTX300	13	2N4058	15	2SJ85	225
BC184	10	BF244B	29	MPSU52	65	ZTX301/2	16	2N4061/2	15	3N128	115
BC182L	10	BF245	50	MPSU55	60	ZTX303	25	2N4264	30	3N140	115
BC183L	10	BF256B	50	MPSU56	60	ZTX304	17	2N4286	25	40251	150
BC184L	10	BF257/8	32	OC23	170	ZTX320/26	30	2N4289	25	40311	60
BC186/7	28	BF259	40	OC28/36	220	ZTX500/1	14	2N4400	25	40313	130
BC212/3	12	BF394	40	OC41/42	75	ZTX502/3	18	2N4427	80	40361/62	70
BC212L	10	BF451	40	OC70	40	ZTX504	25	2N4859	78	40408	76
BC213L	12	BF494/5	40	OC72	50	ZTX531	25	2N5135	30	40412	90
BC214	10	BF594/5	30	OC75/76	55	ZTX550	25	2N5138	25	40467	130
BC214L	12	BFR39/40	25	OC76	50	2N696	30	2N5172	25	40468	85
BC237/8	15	BFR41/79	25	OC81/82	50	2N697	23	2N5180	45	40594	105
BC307B	15	BFR80/81	25	OC83/84	70	2N698	40	2N5191	75	40595	110
				TIP29A	32	2N699	48	2N5194	80	40603	110
				TIP29C	38	2N706A	25	2N5305	24	40673	70
				TIP30A	35	2N708	25	2N5457	30	40871/2	90

LINEAR IC's

Type	Price	Type	Price	Type	Price	Type	Price
555 CMOS	105	LM334Z	90	S566B	225	ZN419CE	180
702	75	LM335	135	SAB3209	425	ZN423E	130
709C 8 pin	35	LM337	00	SAB3210	325	ZN424E	130
710	48	LM339	40	SAB3271	485	ZN425E-8	345
741	16	LM348	60	SAB4209	695	ZN426E-8	300
747C 14 pin	70	LM349	125	SG3402	295	ZN427E-8	590
748C 8 pin	30	LM358	60	SL490	350	ZN428E	480
753 8 pin	185	LM377	215	SL924	00	ZN429E-8	210
810	159	LM379	495	SL6270	150	ZN459	290
9400CJ	375	LM380	90	SN76013N	350	ZN1034E	200
AY-1-1320	225	LM381N	175	SN76023N	350	ZN1040E	665
AY-1-5050	99	LM382	115	SN76033	350	ZNA234E	925
AY-1-5051	160	LM384	190	SN76488	480		
AY-1-6720	210	LM386	95	SP0256AL	799		
AY-3-1270	730	LM387	120	TA7120	140		
AY-3-8910	400	LM389	95	TA7130	125		
AY-3-8912	500	LM393	85	TA7204	150		
AY-5-1317A	630	LM394CH	395	TA7205	175		
CA3011	130	LM558	170	TA7222	150		
CA3012	175	LM725CN	300	TA7310	00		
CA3014	275	LM733	70	TAA900	395		
CA3018	86	LM1871	300	TAA621	296		
CA3019	80	LM1889	350	TAA661	190		
CA3020	210	LM2907	00	TAA700	275		
CA3023	210	LM2917	200	TAD100	159		
CA3028A	110	LM3900	50	TBA120S	70		
CA3035	255	LM3909	85	TBA540	275		
CA3036	270	LM3911	150	TBA550Q	330		
CA3043	275	LM3914	350	TBA641	290		
CA3045	365	LM3915	350	TBA651	190		
CA3046	70	LM3916	350	TBA800	80		
CA3048	220	LM13600	125	TBA810S	95		
CA3059	325	LS7220	280	TBA820	80		
CA3075	213	M51513L	230	TBA920Q	200		
CA3080E	70	M51515L	320	TBA990	350		
CA3081	190	M51516L	475	TCA270	350		
CA3085	00	M706B1	150	TCA280A	220		
CA3086	60	MB3712	200	TCA940	175		
CA3089E	200	MB3756	440	TCA950	00		
CA3090AQ	375	MC1204	250	TCA965	125		
CA3123	165	MC1301	90	TDA1004	350		
CA3130	90	MC1303	98	TDA1008	310		
CA3140	45	MC1304P	260	TDA1010	235		
CA3160	95	MC1310P	150	TDA1022	499		
CA3161E	160	MC1445	250	TDA1024	115		
CA3162	620	MC1455	50	TDA1034	350		
CA3189	275	MC1458	35	TDA1054	00		
CA3240	110	MC1469	300	TDA1490	350		
HA1366	175	MC1494	694	TDA2002	325		
HA1388	255	MC1495	350	TDA2003	250		
ICL7106	690	MC1496L	70	TDA2004	400		
ICL7107	975	MC1596	225	TDA2006	330		
ICL7611	99	MC1648	290	TDA2020	320		
ICL7660	248	MC3302	75	TDA2030	190		
ICL8038CC	300	MC3340	145	TDB0791	420		
ICL8211	350	MC3360	145	TL061CP	40		
ICM7205	1150	MC3401	50	TL062CP	60		
ICM7207	475	MC3403	65	TL064CN	98		
ICM7215	1050	MC3404	85	TL071CP	35		
ICM7216A	£22	MC3405	150	TL072CP	54		
ICM7217A	750	MC3442	00	TL074CN	100		
ICM7224	785	MC3423P	80	TL081CP	30		
ICM7240	300	MC3487	00	TL082CP	45		
ICM7555	105	MC4016	00	TL083CP	75		
ICM7556	150	MF10	350	TL084CP	90		
LA3350	250	MFC6040	75	TL091CP	55		
LA4031P	340	ML924	275	TL170	50		
LA4032	295	NE515	275	TL430C	90		
LA4400	350	NE529	225	TL507	110		
LA4422	320	NE531	140	TL509	110		
LC7120	300	NE543	225	UA2240	120		
LC7130	320	NE544	200	UA78540	230		
LC7137	350	NE555	20	UAA170	180		
LF347	150	NE556DB	45	UAA180	180		
LF351	48	NE558	170	ULN2003	75		
LF353	90	NE560	350	ULN2004	75		
LF355	95	NE562B	410	ULN2283	100		
LF356	99	NE564	420	UPC556	00		
LF357	110	NE565A	120	UPC575	275		
LF398	495	NE566	155	UPC1025H	375		
LM10	350	NE567	140	UPC1156H	295		
LM301A	25	NE570	410	UPC1181	00		
LM307	45	NE571	400	UPC1182	425		
LM308	95	NE5532	175	UPC1366	195		
LM311	65	NE5534	105	XR2206	375		
LM318	150	OM335	750	XR2207	400		
LM319	160	RC4136D	60	XR2211	575		
LM324	50	RC4558	60	XR2216	675		
				XR2266	360		
				ZN414	90		

COMPUTER IC's

Type	Price	Type	Price	Type	Price
2102L	160	8214	425	TMS9929	£16
2114	200	8216	130	TMS9980	£20
2147-3	425	8224	220	TMS9995	£12
2516	350	8226	250	ULN2003	75
2532-4	400	8228	270	UPD7002	425
25L32	450	8236	00	WD1691	£14
2564	700	8243	450	Z80CPU 2.5	299
27L08	450	8250	950	Z80ACPU4M	375
2716-5V	350	8251A	440	Z80ACTC	335
2732	450	8253	400	Z80B	£11
2764-250	650	8255	950	Z80DART	495
26501	75	8256A	£35	Z80ADART	820
27128/250n	£23	8257A	400	Z80ADMA	925
3242	590	8259	395	Z80DMA	795
4027	95	8271	00	Z80P10	325
4164-150	495	8272	£25	Z80AP10	350
4416-2	475	8279	440	Z80S10-1	850
4532-3	250	8282	450	Z80AS10	900
4816-100ns	300	8283	450	Z80AS10-2	£9
5514	250	8284	350	Z8002CPU	00
6116-150	550	8288	00		
6116L-120ns	650	8T26A	99		
6117-100n	490	8T27	150		
6167-6	795	8T28A	120		
6264L-15	£35	8T31	350		
6402	350	8T95N	90		
6502 CPU	325	8T97N	90		
6502A	490	9364AP	550		
6503	650	9602	220		
6504	600	AM26LS31C	125		
6505	650	AM26LS32A	125		
6520	175	AM26LS33	150		
6522 VIA	325	AY-3-1015	300		
6530 RRIOT	£11	AY-5-1013	300		
6532 RIOT	650	AY-5-1350	388		
6545 CRTC	899	AY-5-2376	600		
6551 ACIA	650	AY-5-3600	750		
6592	00	COM8017	275		
6800	220	COM8116	700		
6802	295	DM8131	275		
6803	850	DP8303	295		
6805	670	DP8304BN	250		
6808	520	DS3647	00		
6809	650	DS3691N	450		
6810	175	DS8820	110		
68B21	220	DS8830	110		
6821	190	DS8831	125		
6840	375	DS8832	250		
6843	00	DS88LS120	595		
6845	750	E9364	800		
6845SP	750	E9365	£35		
6846	625	FD1691	£15		
6847	650	FD1771	£15		
6850	175	FD1791	£22		
6852	250	FD1793	£23		
6854	650	FD1795	£28		
68B54	800	FD1797	£28		
6875	500	HD26501	75		
68000	£50	HM6845	756		
8035	600	IM6402	350		
8080A	250	INS8060N	1050		
8085A	550	MC1488	75		
8088	£18	MC1489	75		
81LS95/96	140	MC14411	675		
81LS97/98	140	MC14412	725		
8123	125	MC3242	590		
8131	275	MC3446	250		
8154	£9	MC3447P	315		
8155	495	MC3486	175		
8156	350	MC3487	175		
8202	£25	MK3886-2M	£7		
8212	300	MM5280D	695		
		MM5303	635		
		MM5307	1275		
		MM5387A	475		
		MM58174	700		
		RO-3-2513L	550		
		RO-3-2513U	650		
		SFF96364E	800		
		SP0256AL2	850		
		TMS2716-3	725		
		TMS4047	100		
		TMS4164-15	395		
		TMS4416-2	475		
		TMS4500	£14		
		TMS4532-3	350		
		TMS5100	600		
		TMS6011	500		
		TMS9927	£14		
		TMS9928	£20		

74S

Type	Price	Type	Price
74S00	45	74S283	00
74S02	45	74S287	225
74S03	45	74S288	210
74S04	60	74S289	200
74S05	60	74S299	540
74S08	60	74S301	350
74S09	60	74S365	250
74S10	40	74S373	400
74S11	50	74S374	365
74S15	60	74S412	380
74S20	40	74S470	325
74S22	50	74S471	620
74S30	40	74S472	1150
74S32	70	74S473	00
74S37	60	74S474	400
74S38	90	74S475	800
74S40	45	74S571	620
74S51	45	74S573	950
74S64	45		
74S65	45		
74S74	75		
74S85	295		
74S86	85		
74S112	90		
74S113	90		
74S114	80		
74S124	300		
74S132	110		
74S133	60		
74S134	60		
74S135	110		
74S138	100		
74S139	115		
74S140	60		
74S151	180		
74S153	182		
74S157	250		
74S158	195		
74S162	00		
74S163	300		
74S168	00		
74S169	00		
74S174	250		
74S175	320		
74S181	00		
74S182	00		
74S188	140		
74S189	140		
74S194	295		
74S195	275		
74S196	00		
74S197	400		
74S201	350		
74S225	500		
74S226	00		
74S240	300		
74S241	300		
74S244	290		
74S251	225		
74S257	225		
74S258	250		
74S260	70		
74S262	850		
74S274	00		
74S275	00		
74S280	00		
74S281	00		

75

Type	Price
75107/8/9	95
75110	90
75114	00
75121	00
75122	00
75150	125
75151	00
75154	195
75158	150
75159	140
75182/3	99
75188/9	75
75322	140
75324	00
75325	00
75353	00
75361	00
75365	00
75376	00
75450	86
75451/2	52
75454	70
75491/2	65

TTL 74

Type	Price	Type	Price	Type	Price
7400	20	7454	25	74197	50
7401	20	7460	25	74198	110
7402	20	7470	35	74199	110
7403	22	7472	35	74221	90
7404	35	7473	35	74246	120
74L04	00	7474	35	74247	120
7405	25	7475	60	74248	175
7406	125	7476	40	74249	120
7407	125	7480	55	74251	55
7408	25	7481	120	74259	150
7409	25	7482	100	74265	50
7410	25	7483	65	74273	170
7411	25	7484	90	74276	120
7412	25	7485	110	74278	120
7413	35	7486	40	74279	45
7414	50	7489	175	74283	65
7416	35	7490	40	74284	220
7417	35	7491	65	74285	180
7420	22	7492	45	74290	120
7421	22	7493	40	74293	75
7422	30	7494	80	74297	900
7423	30	7495	50	74298	100
7425	30	7496	60	74351	120
7426	45	7497	120	74365	60
7427	30	74100	100	74366	60
7428	30	74104	55	74367	60
7430	30	74105	55	74368	50
7432	60	74107	40	74376	90
7433	25	74109	50	74390	80
7437	30	74110	50	74393	120
7438	95	74111	60	74490	110
7440	25	74112	170		
7441	65	74116	100		
7442	55	74118	100		
7443	70	74119	105		
7444	65	74120	90		
7445	80	74121	40		
7446	78	74122	50		
7447	70	74123	80		
7448	75	74125	50		
7450	25	74126	50		
7451	25	74128	60		
7453	25	74132	60		
		74136	40		
		74141	75		
		74142	195		
		74143	200		
		74144	200		
		74145	80		
		74147	105		
		74148	105		
		74150	125		
		74151	50		
		74153	50		
		74154	100		
		74155	50		
		74156	50		
		74157	50		
		74159	130		
		74160	50		
		74161	50		
		74162	55		
		74163	55		
		74164	65		
		74165	65		
		74166	80		
		74167	200		
		74170	175		
		74172	280		
		74173	60		
		74174	100		
		74175	70		
		74176	50		
		74177	50		
		74178	80		
		74179	80		
		74180	50		
		74181	140		
		74182	55		
		74184	110		
		74185	110		
		74186	70		
		74188	75		
		74190	70		
		74191	75		
		74192	75		
		74193	60		
		74194	50		
		74195	50		
		74196	60		

74C

Type	Price
C244	195
C245	195
C373	240
C374	245
C922	570
C923	500
C925	698

74LS

Type	Price	Type	Price	Type	Price
LS00	30	LS91	60	LS327	290
LS01	18	LS92	35	LS347	65
LS02	18	LS93	35	LS348	125
LS03	18	LS95	40	LS352	65
LS04	45	LS96	80	LS353	65
LS05	18	LS107	40	LS356	180
LS08	40	LS109	40	LS363	175
LS09	18	LS112	40	LS365	45
LS10	30	LS113	35	LS366	45
LS11	25	LS114	35	LS367	45
LS12	20	LS122	60	LS368	45
LS13	30	LS123	120	LS373	180
LS14	45	LS124	150	LS374	180
LS15	25	LS125	45	LS375	50
LS19	00	LS126	45	LS377	120
LS20	30	LS132	40	LS378	85
LS21	25	LS133	40	LS379	106
LS22	25	LS135	28	LS384	475
LS24	50	LS136	30	LS385	180
LS26	25	LS138	60	LS386	50
LS27	30	LS139	60	LS390	60
LS28	20	LS145	80	LS393	120
LS30	35	LS147	120	LS395	85
LS32	50	LS148	100	LS396	300
LS33	25	LS151	50	LS398	120
LS37	25	LS153	50	LS399	100
LS38	60	LS154	150	LS445	125
LS40	25	LS155	35	LS447	50
LS42	40	LS156	35	LS465	140
LS47	50	LS157	45	LS467	120
LS48	50	LS158	35	LS490	110
LS49	60	LS160	50	LS540	100
LS51	25	LS161	50	LS541	120
LS52	25	LS162	50	LS624	150
LS54	25	LS163	85	LS629	150
LS55	25	LS164	65	LS640	200
LS63	55	LS165	65	LS641	200
LS73	50	LS166	120	LS645	200
LS74	60	LS168	140	LS668	60
LS75	40	LS169	90	LS669	60
LS76	30	LS170	100	LS670	120
LS78	40	LS173	100	LS673	950
LS83	45	LS174	60	LS674	800
LS85	70	LS175	90	LS682	250
LS86	34	LS181	110		
LS90	30	LS183	110		
		LS190	55		
		LS191	50		
		LS192	55		
		LS193	55		
		LS194	45		
		LS195	45		
		LS196	55		
		LS197	55		
		LS221	90		
		LS240	120		
		LS241	100		
		LS242	75		
		LS243	75		
		LS244	250		
		LS245	250		
		LS247	65		
		LS248	65		
		LS249	65		
		LS251	45		
		LS253	40		
		LS256	175		
		LS257	45		
		LS258	40		
		LS259	120		
		LS260	35		
		LS261	150		
		LS266	30		
		LS273	120		
		LS275	80		
		LS279	45		
		LS280	175		
		LS283	45		
		LS290	45		
		LS292	900		
		LS293	45		
		LS294	999		
		LS295	70		
		LS298	70		
		LS299	160		
		LS320	180		
		LS323	185		
		LS324	150		
		LS325	150		
		LS326	290		

CMOS

Type	Price	Type	Price	Type	Price
4000	20	4045	110	4532	65
4001	20	4046	60	4534	400
4002	22	4047	60	4536	275
4006	65	4048	55	4538	80
4007	22	4049	38	4539	90
4008	48	4050	35	4541	95
4009	33	4051	45	4543	70
4010	33	4052	60	4544	150
4011	22	4053	60	4549	400
4012	25	4054	85	4553	245
4013	60	4055	85	4554	180
4014	60	4056	85	4555	35
4015	60	4057	£10	4556	55
4016	40	4059	435	4557	250
4017	60	4060	68	4558	120
4018	60	4061	£5	4559	395
4019	58	4062	995	4560	160
4020	90	4063	85	4561	104
4021	58	4066	45	4562	350
4022	67	4067	245	4566	165
4023	30	4068	25	4568	250
4024	50	4069	25	4569	175
4025	22	4070	25	4572	45
4026	90	4071	25	4580	255
4027	48	4072	25	4581	125
4028	45	4073	26	4582	99
4029	60	4075	25	4583	100
4030	35	4076	68	4584	48
4031	130	4077	25	4585	70
4032	70	4078	25	4599	155
4033	130	4081	25	40097	45
4034	140	4082	25	40098	42
4035	70	4085	60	40100	215
4036	275	4086	60	40101	130
4037	115	4089	125	40102	140
4038	75	4093	37	40103	412
4039	280	4094	70	40104	120
4040	60	4095	95	40105	220
4041	57	4096	100	40106	38
4042	50	4097	275	40107	38
4043	42	4098	80	40108	198
4044	50	4099	75	40109	100
		4160	95	40110	175
		4161	99	40114	240
		4162	99	40161	194
		4163	99	40163	50
		4174	99	40174	45
		4175	105	40175	50
		4194	105	40181	220
		4408	850	40192	75
		4409	850	40193	95
		4410	725	40194	90
		4411	750	40195	80
		4412	805	40244	195
		4415	590	40245	195
		4419	280	40257	198
		4422	770	40373	240
		4433	770	40374	245
		4435	850		
		4440	999		
		4450	350		
		4490	450		
		4500	395		
		4501	38		
		4502	60		
		4503	40		
		4504	99		
		4505	385		
		4506	100		
		4507	45		
		4508	130		
		4510	55		
		4511	55		
		4512	55		
		4513	150		
		4514	115		
		4515	125		
		4516	65		
		4517	275		
		4518	48		
		4519	32		
		4520	53		
		4521	115		
		4522	125		
		4526	60		
		4527	65		
		4528	50		
		4529	150		
		4530	90		
		4531	130		

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

SPEAKERS

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

DIODES

AA119	15
AA129	20
AAY30	15
BA100	15
BAX13	20
BY100	24
BY126	12
BY127	14
CR033	250
OA9	40
OA47	12
OA70	12
OA79	15
OA81	20
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	15
1N5404	16
1N5406	17
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

BRIDGE RECTIFIERS

(plastic case)

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	396
BY164	56
VM18	50

ZENERS

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

VARICAPS

MVAM2	166
BA102	30
BB105B	40
BB106	40

TRIACS

3A/100V	48
3A/400V	56
3A/800V	85
8A/100V	60
8A/400V	69
8A/800V	115
12A/100V	78
12A/400V	82
12A/800V	135
16A/100V	103
16A/400V	105
16A/800V	220
25A/400V	185
25A/800V	295
25A/1000V	480
30A/400V	525
T2800D	125

SCR's Thyristors

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

DIAC

ST2 25

SOLDERCON PINS

100 75p
500 370p

OPTO

LEDS price includes Clips

TIL209 Red 3mm	10
TIL211 Green 3mm	14
TIL212 Yellow	14
TIL220 .2" Red	12
0.2" Yel, Grn, Amber	14
Rectangular LEDs with two part clip. R, G & Y	45
Rectangl. Stackable LEDS	18
Triangular LEDs R&G	18
0.2" Flashing LED Red	56
0.2" Bi colour LEDs Red/Green	65
Green/Yellow	80
0.2" Tri colour LEDs Red/Green/Yellow	85
0.2" Red High Bright	59
High Bright Green or Yellow	65
LD271 Infra Red (emit)	46
TIL32 Infra Red (emit)	52
SFH205 (detector)	118
TIL78 (detector)	55
TIL38	50
TIL81 82; TIL100	90

0.5" LCD DISPLAYS

3½ digit	495
4 digit	530
6 digit	625
BPX25	250
BPW21	320
BPX65	320
ILD74	115
ILQ74	220
ILCT6 Darlington Isolator	135
TIL111	70
OCP71	120
ORP12	78
2N5777	50
4N33	135
Pin diode	720
Schmitt Receiver	715

OPTO SWITCH

Reflective TIL139 225
Slotted similar to RS 186

7 Segment Displays

TIL321 .5" C.An	140
TIL322 .5" C.th	140
DL704 .3" C.Cth	125
DL707 .3" C.Anod	125
FND357 or 500	130
.3" Green C.A	140
±1 .3" Red or Green	150
Bargraph 10 seg. Red	275
Bargraph NSM3914	500

ALUM. BOXES

4×2½×2"	100
4×2½×2½"	103
4×4×2½"	120
5×4×2"	105
5×2½×1½"	90
5×2½×2½"	130
5×4×1½"	99
5×4×2½"	120
6×4×2"	120
6×4×3"	150
7×5×3"	180
8×6×3"	210
10×4½×3"	240
10×7×3"	275
12×5×3"	260
12×8×3"	295

FERRIC CHLORIDE

Crystals 1lb
195p + 50p p&p

DALO ETCH RESIST

Pen plus spare tip 100p

COPPER CLAD BOARDS

	Single-sided	Double-sided	SRBP 9.5"×8.5"
Fibre Glass 6"×6"	100p	125p	110p
6"×12"	175p	225p	

VEROBOARDS 0.1"

	Clad	Plain		
2½×3⅞"	95	—	'VQ' Board	180
2½×5"	110	—	'DIP' Board	395
3¾×3⅞"	110	—	Vero Strip	144
3¾×5"	125	95p	**PROTO-DECs**	
3¾×17"	420	275p	Veroblock	480
4¾×18"	590	—	S-Dec	395
Pkt. of 100 pins	55p		Eurobreadboard	590
Spot Face Cutter	150p		Bimboard 1	695
Pin Insertion Tool	185p		Superstrip SS2	£13

VERO WIRING PEN and Spool 350p

Spare Wire (Spool) 75p; Combs 6p ea.
Wire Wrapping Stakes 100 250p

VOLTAGE REGULATORS

1A T0220 Plastic Casing

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

100mA T092 Plastic Casing

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

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

SWITCHES

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

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

PUSH BUTTON
Spring loaded
Latching or Momentary 6A
SPDT c/over 150
DPDT c/over 200

SUB-MIN TOGGLE 2 amp
SP changeover 64
SPST on off 58
SPDT c/off 85
SPDT Biased 105
DPDT 6 tags 80
DPDT C/OFF 68
DPDT on/on/on 185
DPDT Biased 145
4-pole 2 way 220

MINIATURE
Non Locking
Push to make 15p
Push break 25p

ROTARY: (Adjustable Stop Type)
1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way 48p

ROTARY: Mains 250V AC, 4 Amp 64p

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

AMPHENOL PLUGS

	IDC	Solder
24 way IEEE	475p	470p
36 way Centronix	450p	475p
24 way Female	525p	490p

ASTEC UHF MODULATORS

6MHz Standard 325p
8MHz Wideband 450p

DIL SOCKETS

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

ZIF DIL SOCKET

24 way 565p
28 way 750p
40 way 845p

DIL PLUGS (Headers)

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

RIBBON CABLE

(price per foot)

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

'D' CONNECTORS:

Pins	9 way	15 way	25 way	37 way
MALE				
Solder	80p	110p	160p	240p
Angle	150p	210p	250p	355p
Strait	170p	180p	220p	310p
FEMALE				
Solder	105p	160p	200p	338p
Angle	165p	215p	290p	440p
Strait	175p	200p	300p	420p
COVERS	80p	75p	75p	90p

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

SIL Sockets

0.1"
20 way 65p
32 way 95p

EDGE CONNECTORS

.1"

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

SPECTRUM 32K UPGRADE

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

IDC CONNECTORS (Speed block type)

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

EURO CONNECTORS

Gold flashed contacts

	FEMALE SOCKETS Strt.	Angle	MALE PLUGS Strt.	Angle
DIN 41617 31 way	170p	—	—	175p
DIN 41612 2×32 way	275p	320p	220p	285p
DIN 41612 2.3×32 way	295p	340p	240p	300p
DIN 41612 3×32 way	360p	385p	260p	395p

TRANSFORMERS (mains Prim. 220-240V)

3-0-3V, 6-0-6V 100mA; 9-0-9V 75mA; 12-0-12V 75mA; 15-0-15V 75mA 98p
6VA: 2x6V-5A; 2x9V-4A; 2x12V-0.3A; 2x15V-.25A 250p
12VA: 2x4V5-1.3A; 2x6V-1.2A; 2x12V-.5A; 2x15V-.4A 345p (35p p&p)
24VA: 6V-1.5A 6V-1.5A; 9V-1.2A 9V-1.2A; 12V-1A 12V-1A; 15-.8A 15-.8A; 20V-.6A 20V-.6A 385p (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-2A; 2x30V-0.8A 520p (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x30V-1.5A; 2x40V-1.25A; 2x50V-1A 965p (60p p&p)

JUMPER LEADS Ribbon Cable Assembly

DIL Plug (Headers)
Single Ended Lead, 24" long

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

IDC FEMALE RECEPTACLE Jumper Leads 36"

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

COMPUTER CORNER

- **SEIKOSHA GP100A** – Unihammer Printer, normal & double width characters, dot resolution graphics 10" Tractor feed, parallel interface standard. **£144**
- **SEIKOSHA GP 250X** Printer **£199**
- **EPSON FX80 PRINTER** 160 CPS, 11×9 matrix, proportional spacing, superscript, subscript, dot addressable graphics, Normal, Italic & Elite characters. Up to 256 user definable characters. Down loadable character set. Condensed and double width printing. 4 user define margin positions. Tractor and Friction feed. 10" maximum width, Bi-directional, logic seeking. Centronix Interface standard. **£345**
- **EPSON RX80 PRINTER** **£235**
- **EPSON RX80 FT PRINTER** **£259**
- **KAGA – RGB** 12 inch medium resolution colour monitors **£199**
- **ZENITH 12" Hi-RES**, Green Monitor 40/80 column select switch, value for money. **£75**
- **MICROVITEC 14"** colour monitor. RGB input. Lead incl. **£195**
- **MICROVITEC 1451** Hi-res 14" Monitor incl. Lead **£319**
- **TEX EPROM ERASER.** Erases up to 32 ICs in 15-30 min. **£33**
- **Spare** 'UV lamp bulbs **£9**
- **4 × 4 matrix keypad** (reed switch assembly) **£4**
- **C12 COMPUTER Grade BASF Cassettes** in Library Cases **40p**
- **8½" or 9½" Fan fold paper** (1000 sheets) **£7 (150p)**
- **Teleprinter Roll** (no VAT) **£3.50**

MANY MORE PRINTERS, MONITORS, INTERFACES, AVAILABLE. CALL IN AT OUR SHOP FOR DEMONSTRATION OR WRITE IN FOR OUR DESCRIPTIVE LEAFLET.

(P&P on some of the above items is extra)
Call in at our shop for demonstration of any of the above items. Be satisfied before you buy.

BROTHER HR-15 DAISEY-WHEEL PRINTER/

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C15W	510p	Spare bits	85p
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CRYSTALS

32.768KHz	100
100KHz	235
200KHz	268
455KHz	370
1MHz	275
1.008M	275
1.28MHz	392
1.5MHz	420
1.6MHz	395
1.8MHz	515
1.8432M	250
2.0MHz	225
2.4576M	200
2.5MHz	225
2.56250M	220
3.2768M	150
3.57954M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.194304M	200
4.433619M	100
4.608MHz	200
4.80MHz	200
5.0MHz	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	200
7.0MHz	150
7.168MHz	250
7.68MHz	200
8.0MHz	150
8.08333M	395
8.867237M	220
9.00MHz	200
9.375MHz	350
10.0MHz	175
10.5MHz	250
10.7MHz	150
10.24MHz	200
12.0MHz	175
12.528MHz	300
14.31818M	170
14.7456M	175
14.765MHz	250
15.0MHz	240
16.0MHz	220
18.0MHz	180
18.432M	150
19.968MHz	150
20.0MHz	200
24.0MHz	170
24.930MHz	325
29.695MHz	150
26.670MHz	325
27.125MHz	295
27.145M	190
27.648MHz	300
38.66667M	240
48.0MHz	240
55.5MHz	400
100MHz	295
116.0MHz	300
145.8MHz	225

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Low-price robots from POWERTRAN

– hydraulically powered
– microprocessor controlled

The UK-designed and manufactured range of Genesis general purpose robots provides a first-rate introduction to robotics for both education and industry.

GENESIS P101

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

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

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

GENESIS P102

Cortex 16 bit microcomputer

HEBOT II Turtle-type robot

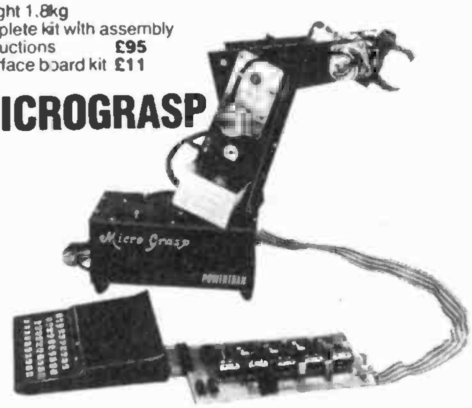
For a little over £100, Herbot II takes programming off the VDU and into the real world. Each wheel is independently controlled by a computer, enabling the robot to perform an almost infinite number of moves. It has blinking eyes, a two-tone bleep and a solenoid-operated pen to chart its moves. Touch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

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

HEBOT II

Weight 1.8kg
complete kit with assembly instructions **£95**
Interface board kit **£11**

MICROGRASP



A real programmable robot for under £300! Micrograsp has an articulated arm jointed at shoulder, elbow and wrist positions. The entire arm rotates about its base and there is a motor driven gripper. All five axes are motor driven and four of these are servo controlled giving positive positioning. The robot can be controlled by any microcomputer with an expansion bus – the Sinclair ZX81 being particularly suitable.

MICROGRASP

Weight 8.7kg, max. lifting capacity 100g
Robot kit with power supply **£215.00**

Universal computer interface board kit **£57.00**
23 way edge connector **£3.00**
ZX81 peripheral/RAM pack splitter board **£3.50**

GENESIS P101

Weight 34kg, max lifting capacity 1.8kg
6-axis model (kit form) **£750**
6-axis complete system (kit form) **£1050**

GENESIS P102

Weight 36kg, max lifting capacity 2kg
6-axis system (kit form) **£1476**

Powertran Cortex microcomputer self-assembly kit **£295.00**

Goods subject to availability. All prices exclusive of V.A.T. and correct at time of going to press.

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PE VOLUME 20 No. 6 JUNE 1984

TECHNOLOGY AND UNEMPLOYMENT

THIS issue carries a feature which describes a development of significance to all householders; a development which would not be possible without modern technology; a development which will probably mean a reduction in jobs; a development which could save us all money. The feature to which we are referring is *Spot-Pricing Needs Electronics.* No mention is made in the article of job losses, but we believe total introduction of such a system could result in the need for fewer employees in the electricity supply industry. This leads to the question of job losses caused by the introduction of new technology and automation in general.

Of course the question has been posed over many years and some commentators have suggested that increased sales, resulting from automation reducing product prices, will mean similar or even greater staffing levels. It is now becoming clear that, so far, this has not proved to be the case. A few years ago most companies were optimistic about the effects of new technology on employment but a recent survey by the Policy Studies Institute suggests that about 30,000 jobs will be lost in the next two years because of the use of microelectronics. Perhaps this is one reason why unemployment figures continue to rise in the face of a gradual economic recovery.

Spot-pricing could save us all money but this could well be partially achieved as a result of job losses. Does this mean that we should not introduce new technology? If we don't our industry will soon become out of step with the rest of the world and not only will we need import restrictions to compete in the UK but we will lose our export market on which we depend for much of our prosperity. Surely it means that we must find ways of spreading employment to keep everyone in a worthwhile, paying job.

RESPONSIBILITY

Since electronics must carry the responsibility for many of the lost jobs should the electronics industry start to put things right by introducing a lower retirement age and a shorter working week? While this sounds wonderful on paper, in practice it leads to a number of problems, not the least being the lack of qualified, experienced electronic engineers. This lack of skilled personnel will only be solved gradually with the aid of our educational system. It must gear itself to produce workers to fill the demands of industry not simply to educate for the sake of education.

However, there are areas where something could be done now to make room for qualified unemployed personnel, for instance we find it unbelievable that doctors are able to work into their seventies and eighties when young qualified doctors cannot get jobs. A compulsory retirement age for all would start to sort out the problem and a gradual reduction of that age would possibly help in the future.

The lead to a better future for all must be set by government, not by the industry that spawns the developments from which the problems start. Surely it is better to pay a pension than unemployment benefit?

Technical *and editorial queries and letters (see note below) to:*
Practical Electronics Editorial,
Westover House,
West Quay Road, Poole,
Dorset BH15 1JG

Phone: *Editorial* Poole 671191
We regret that lengthy technical enquiries cannot be answered over the telephone

Queries and letters concerning advertisements *to:*
Practical Electronics Advertisements,
King's Reach Tower,
Stamford Street, London SE1 9LS
Telex: 915748 MAGDIV-G

Letters and Queries
We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in PE. All letters requiring a reply should be accompanied by a stamped, self addressed envelope, or addressed envelope and international reply coupons, and each letter should relate to **one published project only.**

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

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

Binders for PE are available from the same address as back numbers at £5·50 each to UK or overseas addresses, including postage, packing and VAT where appropriate. State year and volume required.

Subscriptions
Copies of Practical Electronics are available by post, inland for £13, overseas for £14 per 12 issues, from: Practical Electronics, Subscription Department, IPC Magazines Ltd., Room 2816, King's Reach Tower, Stamford Street, London SE1 9LS. Cheques, postal orders and international money orders should be made payable to IPC Magazines Limited. Payment for subscriptions can also be made using any credit card and orders placed via Teledata. Tel. 01-200 0200.

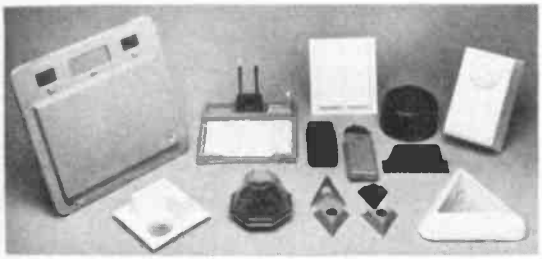
Items mentioned are available through normal retail outlets, unless otherwise specified. Prices correct at time of going to press.

TOP OF THE FORM

Most of us at one time or another would like to see our projects housed in a more professional manner. Now we can do just that with a one-off vacuum forming service from Origin Products. A heated thermoplastic sheet is sucked over a wooden pattern forming a 'shell' facsimile of the original.

All the items shown here were vacuum formed using the Formech range of machines. Two machines are available from the company—the 300 and the 450. The 300 has a maximum material handling size of 300mm square and 10mm deep, and is a bench-top model. The 450 is somewhat larger and is freestanding, its maximum capabilities are 450mm square and 250mm deep. Both these machines can be used directly from a standard 13A supply. The maximum size of mouldings available from the one-off service are the same as those stated for the Formech 450 machine.

The materials used include high-impact Polystyrene, ABS, PVC, Polycarbonate and perspex. Many different colours and textures are available, 'clear' being a further option. Origin will produce a mould from a customer's own pattern, which must fulfil a few basic requirements such as allowances for release angles, etc. A detailed advice sheet giving simple tips will be supplied by the company on receipt of a s.a.e.



Typical prices for one-off mouldings in 1mm thick styrene are 150mm x 150mm—£3.00, 300mm x 300mm—£4.50, and 450mm x 450mm—£6.00. The machines, however, cost £950 for the 300 and £1450 for the 450. Details from Origin Products Ltd, 10 Lambton Place, Westbourne Grove, London W11 2SH (01-221 4121).

TRACK REPORT

A range of self-adhesive copper foil strips has been launched by Copperfoil Enterprises. As well as for p.c.b. track repairs and modifications the foil will be of great value in prototype applications.

The soldering-proof adhesive bonds the strip monolithically to all insulating surfaces including paper. The strip conforms to BS safety regulations and has an a.c./d.c. voltage rating of 24V, current 5A. Being almost pure copper (99·999%) excellent heat dissipation can be expected. Present uses include alarm systems, proximity switches, moisture detection, level detection and capacitive applications etc, etc.

Copperfoil is available in four widths: 4mm, 4·75mm, 6mm, and 8mm; prices per 33 metre roll are £2.95, £3.35, £3.95 and £4.25 respectively, includes VAT and p&p. Copperfoil Enterprises, 141 Lyndhurst Drv, Hornchurch, Essex. (04020 56697).

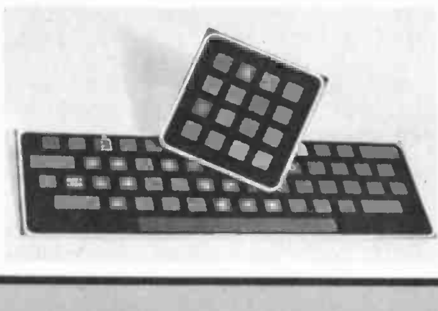
KEYBOARDS

Membrane QWERTY keyboards 350mm x 100mm x 2mm and 16-way 0-9 plus A-F keyboards 100mm x 100mm x 2mm are available from Semiconductor Supplies.

These very thin keyboards consist of glass fibre PCB's faced with a tough, attractively colour-printed polycarbonate film. A light touch on the film makes a silver-plated contact.

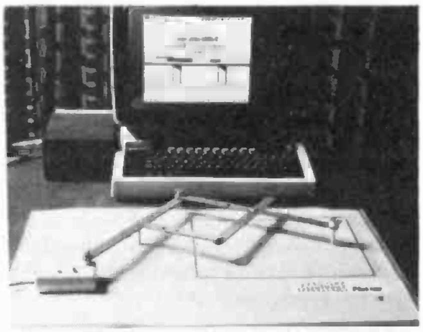
The full-size 55 key non-encoded QWERTY keyboard has a matrix output via a 16-pin DIL socket. On the 16-way board connections are via 17 pins (one common).

Prices: £17.75 and £7.90 inc VAT and p&p. For further details contact Mr. Dennis Cresswell, Semiconductor Supplies, Sutton. (01-643 1126).



PANTOGRAPHIC PLOTTER

The Reekie Technology Co is launching a versatile drawing aid for BBC model B micro's. Software is available on disc



or cassette. Software is presently being written for the Commodore 64, Spectrum and the IBM/PC.

The Image Plotter allows the reproduction of diagrams, maps and charts etc with great precision. Even the most irregular and complex shapes can be enlarged or reduced in vivid colour. Using a printer, disc or cassette these diagrams can then be saved for future use.

The plotter costs £49.45 inc VAT and p&p. It comes complete with calibration sheet, detailed handbook and software (state disc or cassette). It is only available through mail-order at the moment, from Reekie Technology Company, Beaufort Road, Off Richmond Road, East Twickenham, Middx. TW1 2PH. (01-892 2877).

FORTH FIRST

In our February edition we reported on a multitasking FORTH ROM for the ZX81, by David Husband (now Skywave Software). Not surprisingly, this product has been a success and has allowed a move to larger premises. Work in progress now includes a multitasking FORTH I/O cartridge for the Spectrum.

Prompted by the release of the new FORTH-83 standard by the FORTH Standards team, David Husband has brought forward the release of his Multi-FORTH 83 for the BBC Micro, which, naturally, includes multitasking. The product is purposely priced only a few pounds above the old 8K version associated with the early BBC Micros, whilst featuring a performance far exceeding those old versions. Skywave Software, 73 Curzon Road, Boscombe, Bournemouth BH1 4PW. (0202 302385).

MARKET PLACE

POINTS ARISING...

STARDESK January/February '84

TR27–34 are shown correctly for the devices used in the original unit. However, most other manufacturers have the pinouts in the reverse fashion. Constructors should check the pinout for the manufacturer they use.

Diodes D62–69 are shown the wrong way round on the component layout.

Through board link not shown (above R121).

R169 not marked on overlay and is between S7 and S8.

The pin layout for the small signal transistors given at the top right of the layout diagram should read "all transistors except TR27–34".

To get the correct relationship between slider and switches heights, the sliders are mounted on top of the board and soldered to short lengths of 1·2mm/18s.w.g. tinned copper wire which itself occupies the p.c. holes.

C34 is incorrectly shown in the parts list as 2μ2. It *is* shown correctly on the circuit as 22μ.

The tinned copper wire reinforcement mentioned in the text should bridge the *live* bus which is on the back of the board, not the neutral as stated. The reinforcement is best applied at the junctions of the triac terminal pins and C13/16, C35/42 with sleeving between. This avoids the need to remove the solder resist, and prevents fouling of the GRP backing strip by the wire.

Note: The 1N4148 diodes supplied with the kit have a yellow band as polarity marker (+ve or cathode). The grey band should be ignored.

COMPUTER TERMINAL Feb/March '84

Some readers may wish to know that the AY-5-2376 keyboard encoder referred to in the article is now obsolete. The article assumes the use of a keyboard incorporating its own encoder, in conjunction with the Computer Terminal p.c.b. However, a constructor wishing to either build his own keyboard encoder section, or replace an AY-5-2376 already found on an old keyboard assembly, can use the pin-compatible SNC KR2376, supplied by Campbell Collins of Stevenage. ✆0438 69466. The i.c. costs around £10.

Briefly...

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

Membership for UK and Eire members is £5.50, overseas £7.00 (£8.50 air-mail). For details contact: The BAEC Hon. Sec. Mr Margetts, 113 South Rd, Horndean, Hants PO8 0ER.

• • • •

The long-awaited breakthrough has finally been made. Using the latest silicon technology, over one million transistors can be crammed into one chip.

At the International Solid-State Circuits Conference in San Francisco 1-Mbit dynamic RAMs were on display. Made by Hitachi Ltd, these chips are organised as 1M by 1 bit and can be squeezed into an 18-pin package.

Silicon News Corner

Motorola ➧ Fast new HMOS 16K-bit static RAM (16K × 1) is the MCM2167H.

➧ Fast new 16K-bit static RAM (2048 × 8) is the MCM2016H.

➧ Extensive new line of RF power MOSFETs (5W–125W @ 150MHz) using TMOS. Designated MRF134, MRF136, MRF171, MRF172 and MRF174.

➧ MC3412/3512 is a high speed 12-bit DAC which minimises external adjustments.

➧ New series plastic Schottky rectifiers to 240A. These are: MBR20035CT and MBR20045CT.

➧ New 8-bit HCMOS μP incorporating EEPROM and ADC. Type MC68HC11.

➧ New 8-bit μP has 96 bytes RAM, 2K ROM plus EEPROM, called MC6805K2.

➧ New CMOS 8-bit ADC is the MC14442, μP compatible.

➧ 400V transistor opto-couplers MOC8204, MOC8205 and MOC8206.

➧ Three-volume data book set, covers all CMOS devices.

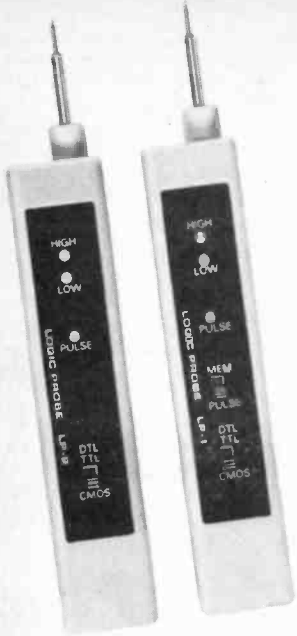
Motorola Ltd., European Literature Centre, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP.

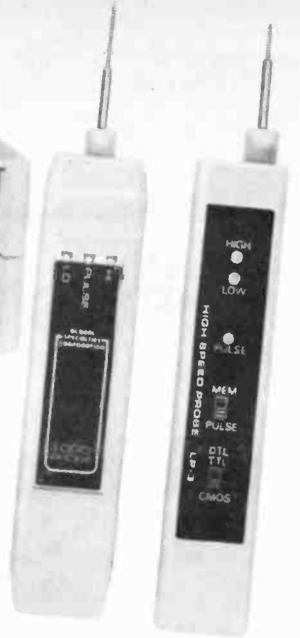
Countdown...

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to Mike Abbott.

Biotech Europe May 15–17. Wembley Conf. Cntr., London. O
DEC User May 15–17. Cunard Int. Hotel, Hammersmith, London. Q1
Micro City May 15–17. Exhibition Complex, Bristol. F3
EXPO 84 (West Midlands) May 26–June 3. N.E.C. J4
Energy Management & Control May 29–31. W3
Scotelex June 5–7. Royal Highland Exhibition Halls, Ingliston, Edinburgh. O5
IBM System User Show June 12–14. Wembley Conf. Cntr., London. O
Computer Fair June 14–17. Earls Court. K2
Qualex June 19–21. Corn Exchange, Brighton. D4
Compec North June 19–21. Belle Vue, Manchester. K2
Surface Treatment & Finishing Show June 25–29. Birmingham. M
Office Automation Show June. Barbican, London. T1
Leeds Electronics July 3–5. University. E
Networks July 3–5. Wembley Conf. Cntr., London. O
Cable July 10–12. Wembley Conf. Cntr., London. O
Laboratory Sept. 4–6. Barbican, London. E
Testmex Sept. 11–13. Grosvenor Ho. Pk. Lane, London. E
Personal Computer World Show Sept. 19–23. Olympia 2, London. M
Building & Home Improvement Sept. 25–30. Earls Court, London. M
Computer Graphics Oct. 9–11. Wembley Conf. Cntr., London. O
Software Expo Oct. 16–18. Wembley Conf. Cntr., London. O
Drives, Motors & Controls Oct. 24–26. Harrogate Exhibition Cntr. E
Computers In The City Nov. 20–22. Barbican, London. O
Data Security Nov. 20–22. Barbican, London. O

D4	Network ✆ 0280 815226
E	Evan Steadman ✆ 0799 26699
F3	Tomorrow's World ✆ 0272 292156
J4	N.E.C. Birmingham ✆ 021-780 4141
K2	Reed Exhibitions, Sutton, Surrey
M	Montbuild ✆ 01-486 1951
O	Online ✆ 01-868 4466
O5	Institute of Electronics ✆ 0706 43661
Q1	W.P. Association ✆ 01-242 8697
T1	Cahners ✆ 0483 38085
W3	MCM Publishing ✆ 01-231 1481





The GSC range of logic probes have been designed to simplify the troubleshooting of digital circuits. All four probes shown here are powered from the circuit under test. The **LP1** probe combines the functions of a level detector, pulse detector, pulse stretcher and pulse memory. The unit responds to 50nsec pulses at up to 10MHz. The **LP2** is a basic probe for applications where high speed and memory are not required. The **LP3** is for high speed troubleshooting and is capable of capturing pulses as narrow as 10nsec or pulse trains over 50MHz. The **LPK1** is a kit probe which is suitable for lower speed logic systems. The **4001** pulse generator can drive up to 40 TTL loads and has four modes: run, triggered, gated and one shot. Prices: LP1 £39·67, LP2 £24·15, LP3 £61·52, LPK1 £16·67, 4001 £184. **GSC (UK) Ltd,** Unit 1, Shire Hill Industrial Estate, Saffron Walden, Essex. (0799 21682).

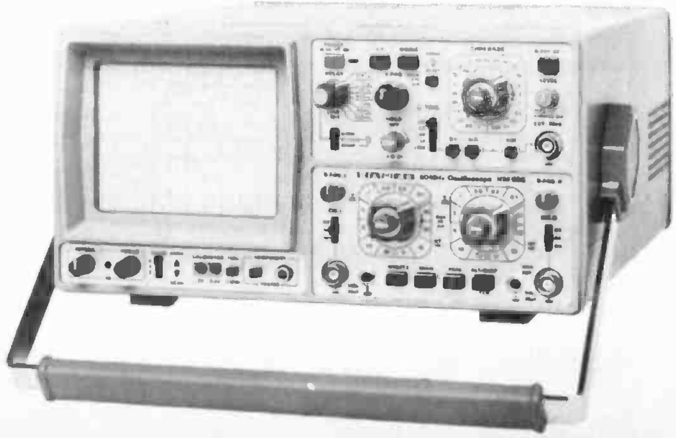
TEST INSTRUMENTS buyer's guide

At some time during the building or testing of an electronic circuit there will always be a need for test equipment. Whether it is just a simple logic probe or an oscilloscope, test equipment can make the troubleshooting of circuits both easier and more interesting.

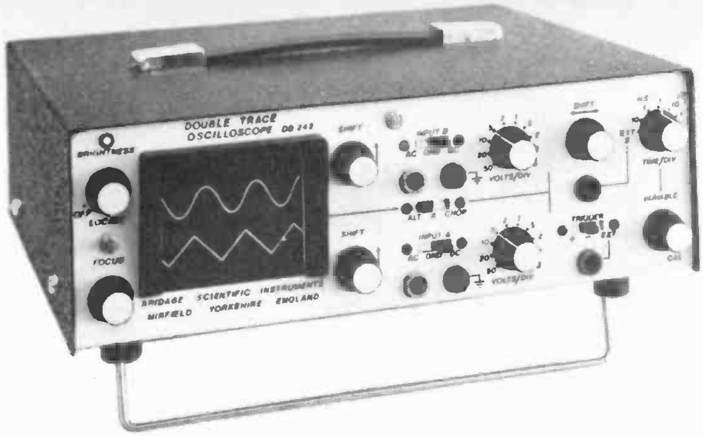
In this buyer's guide we have chosen an interesting cross section of instruments to cover most applications.

Further information and complete specifications on all models mentioned can be obtained from the addresses shown. Please note that all the prices shown include VAT but not p&p or carriage.

The **TG 105** from Thandar is a 5Hz to 5MHz pulse generator. The unit operates over 6 overlapping decade ranges with a separate vernier providing continuously variable control within each range. Run, gated, triggered, squarewave, complement or one shot modes are available and the output amplitude is switch selected over two variable ranges (0·1V to 1V and 1V to 10V). The TG 105 is priced at £120·75. **Audio Electronics,** 301 Edgware Road, London. (01-724 3564).

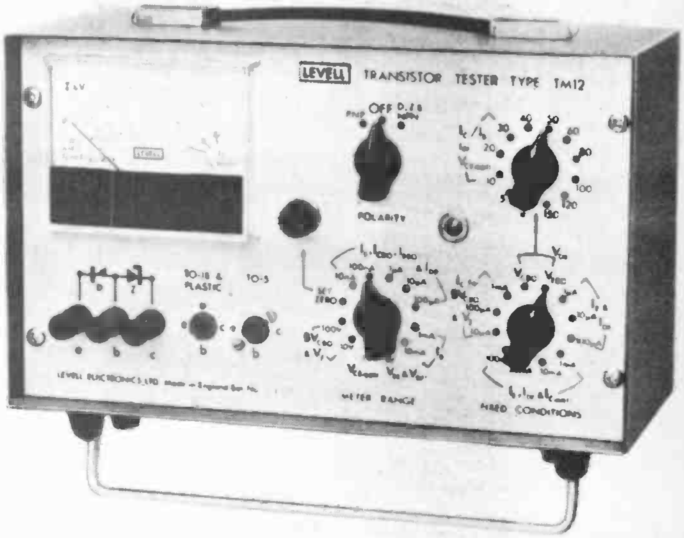


The **Hameg 605** is a dual trace 60MHz oscilloscope with a built-in component tester for checking either single components or for in-circuit testing. Triggering is possible up to 80MHz and it is possible to display two unrelated time signals at one time. Small sections of signals can be analysed using a sweep delay feature which allows 'X' expansion of 1000 or more. A built in delay line permits viewing of the trigger leading edge. The HM 605 is priced at £560·00 and is available from **Hameg Ltd.,** 74–78 Collington Street, Luton, Beds. (0582 413174).



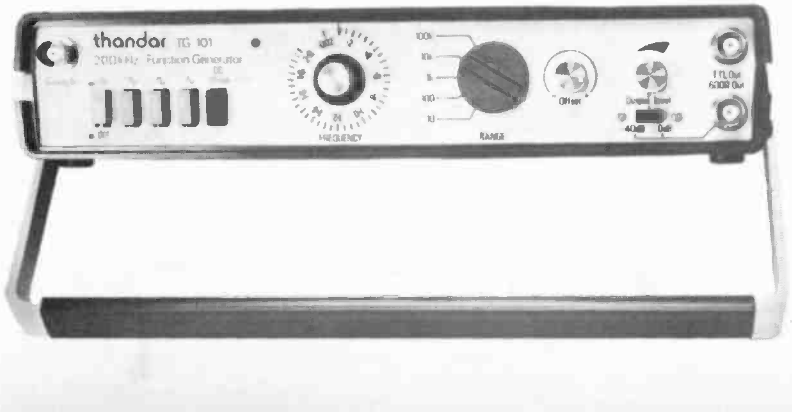
The **DB242** general purpose oscilloscope is a portable unit which has been designed for educational, service and hobby use. Sensitivity can be varied from 50mV/cm and sweep speeds varied between 1µs/cm and 0·2s/cm using calibrated switch positions. A cheaper single trace version, the Bridage **SB121** is also available and its general specification is similar to the DB242 but without the twin channel facility. The DB242 is priced at £258·75 and the SB121 at £224·25. **Bridage Scientific Instruments Ltd.,** 63/65 High Street, Skipton, North Yorkshire. (0756 69511).

The **PFM 200A** is a pocket sized counter with an 8-digit l.e.d. display covering a frequency range from 20Hz to 200MHz using two ranges. Resolution for the unit is down to 0·1Hz and the sensitivity is typically 10mV r.m.s. Battery life, depending upon range and display, is around 10 hours. Two prescalers (up to 600MHz and 1GHz) are available as optional accessories. The PFM 200A is priced at £79·93 and is available from **Audio Electronics,** 301 Edgware Road, London. (01-724 3564).



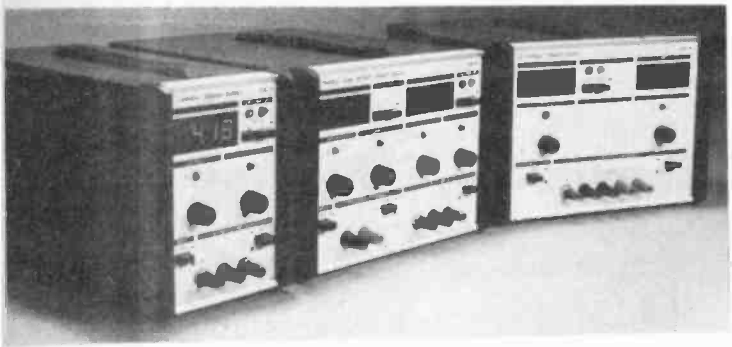
The **TM12** measures the characteristics of bipolar transistors, diodes and Zeners. Current gains are checked at collector currents from 1µA to 100mA. Breakdown voltages up to 100V are measured at currents of 10µA, 100mA and 1mA. Leakage currents down to 0·5nA are measured from 2V to 150V. The collector to emitter saturation voltage of the transistor is measured at collector currents of 1mA, 10mA, 30mA and 100mA for Ic/Ib ratios of 10, 20 and 30. The instrument is powered by a 9V battery. The TM12 is priced at £207·00 and is available from **Levell Electronics Ltd.,** Moxon Street, Barnet, Herts. (01-440 8686).

The **TG303** function generator produces sine, square, triangle, pulse, sawtooth ramp and asymmetrical sine waveforms over the frequency range of 0·02Hz to 2MHz. A d.c. offset can be superimposed on the output signal. The TTL output is a fixed amplitude square or pulse waveform with a fast rise time able to drive up to 20 TTL loads. The unit has a 6-digit frequency counter that can be switched to measure the frequency of the generator or an external source up to 10MHz. A CMOS output variable from 5 to 15V is also available. The TG303 is priced at £224·00 and is available from **Levell Electronics Ltd.,** Moxon Street, Barnet, Herts. (01-440 8686).



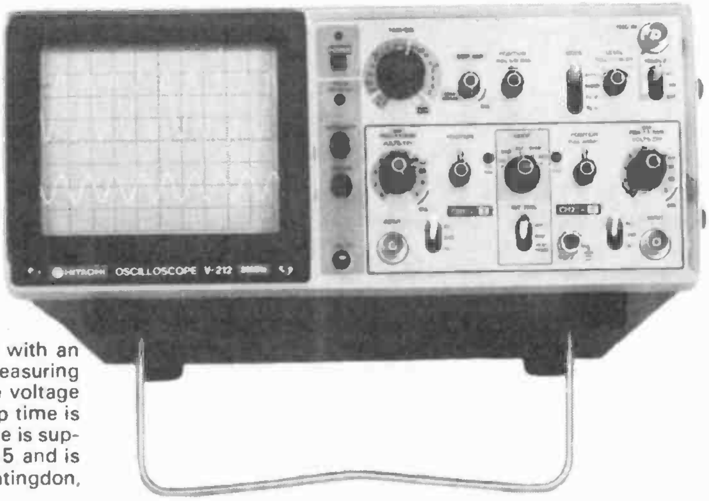
The **TG101** function generator covers the frequency range 0·02Hz to 200kHz in five overlapping decade ranges with a vernier fine adjustment. The input impedance is 10kΩ. The output level of the three operating modes: sine, square and triangular, is adjustable from 0 to 5 volts pk-pk into 600 ohms. There is also a TTL output which is capable of driving up to 20 standard TTL loads. Priced at £120·75 the TG101 is available from **Audio Electronics,** 301 Edgware Road, London. (01-724 3564).

TEST INSTRUMENTS buyer's guide



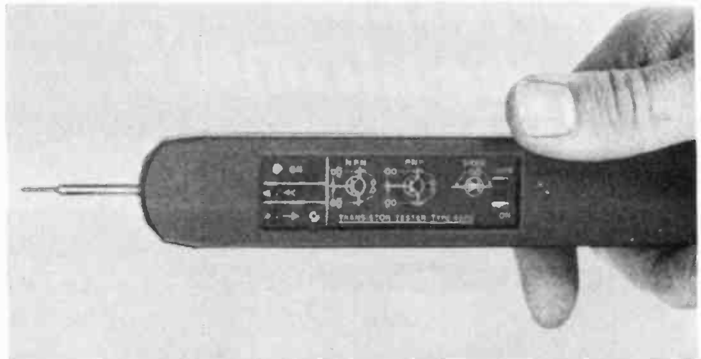
The **Soar FC-841** Frequency Counter is capable of measuring frequencies from 10Hz to 50 MHz. The instrument has a 4 digit 10mm l.e.d. display and is battery powered. A feature of this unit is the range switch, which allows up to a 7 digit accuracy. Input impedance is 1Mohm plus stray capacity, input sensitivity being 60mV. Oscillator stability is 1·5p.p.m. (0·0015%). Supplied with batteries this counter is priced at £49·90 and is available from **Maplin Electronic Supplies Ltd,** 159–161 Kings Street, Hammersmith, London W6 (01-748 0926).

The **D Range** of power supplies from Farnell includes: the **D30-2** a 30V(2A) single output unit, the **D30-2T** a 30V(2A) dual output unit, the **D30-4** a 30V(4A) single output unit, and the **D100-1** 100V(1A) single output unit. Output voltages on all the models are variable from zero. Current control is continuously variable from 1% to 100% of maximum rated output. These models will measure external voltages (39·99V) max on 30V units and 399·9V max on 100V units). Prices, respectively are: £159·85, £313·95, £289·80 and £284·05. From **Farnell Instruments Ltd,** Sandbeck Way, Wetherby, West Yorkshire LS22 4DH (0937 61961).



The **Hitachi V-212** 20MHz oscilloscope is a dual trace unit with an internal graticule to eliminate parallax errors when measuring waveforms. The output of channel one is provided to enable voltage measurement using an external frequency counter. The sweep time is from 0·2µs/div to 0·2s/div in 19 calibrated steps and the scope is supplied with two probes (x10). The V-212 is priced at £339·25 and is available from **Thurlby-Reltech**, New Road, St. Ives, Huntingdon, Cambs. PE17 48G (0480 63570).

The **ALT-AI PP241** is a regulated variable power supply unit with overload protection. Simple switching enables the meter to read either voltage or current. There are two voltage ranges 0V – 12V and 12V – 24V, stability is within 0·75%. Two versions of this unit are available with different output ratings: the PP241 (1A) and the **PP243** (3A), they cost £32·20 and £48·30 respectively. Available from **Semiconductor Supplies International Ltd.,** Dawson House, 128/130 Carshalton Road, Sutton, Surrey (01-643 1126).

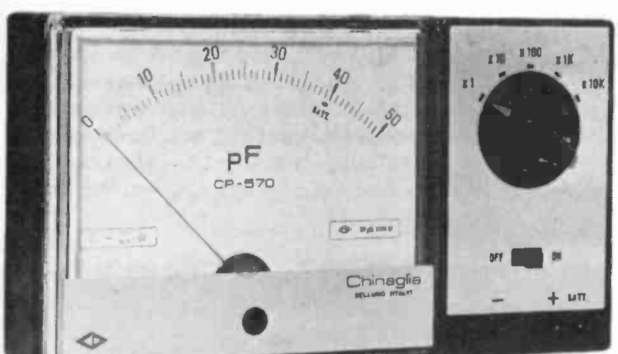


The **4500** transistor tester simplifies and speeds up the task of checking the p.n. junctions of discrete semiconductors, in or out of circuit. This lightweight hand held device features a series of l.e.d.s, which indicate the junction status. PNP or NPN transistors, diodes and open or short circuit junctions can be identified with parallel circuit values as high as 270 ohms or 33 microfarads. Price £18·40 from **Osborne Electronics,** Binstead Road, Ryde, Isle of Wight (0983 63622).

Global's 3002 Auto-ranging Capacitance Meter provides direct readings from 1pF to 19,999µF. A dual threshold measurement technique eliminates reading errors due to dielectric absorption. Capacitance in cables, switches and other electric components can be measured by using d.c. charging characteristics to determine true capacitance. Priced at £165·60. From **Global Specialties Corporation (UK) Ltd.,** Shire Hill Ind Est, Unit 1 & 2, Saffron Walden, Essex CB11 3AQ (0799 21682).

The **Global 1301** is a fully regulated triple-output power supply. Features include a fixed 5V (1A) output and two independently variable 5V–18V (0·5A) outputs. It is possible to link the outputs to increase the output range. Built-in current limiting circuitry protects against short circuits. The front panel meters allow current monitoring up to 1A and voltage up to 20V. Price £182·85, from **Global Specialties Corporation (UK) Ltd.,** Shire Hill Ind Est, Saffron Walden, Essex CB11 3AQ. (0799 21682).

The **PR 651** is a regulated power supply, 0V to 18V at 1·5A. Both voltage and current can be read at the same time. The unit features circuit protection to minimise constant current/voltage output drift. Also available is the **PR 653,** this is a 0 to 35V at 1·5A supply with the same characteristics and features. Prices respectively are £212·75 and £228·85. From **House of Instruments,** Clifton Chambers, 62 High Street, Saffron Walden, Essex CB10 1EE (0799 24922).



The **Chinaglia CP570** capacitance meter can accurately identify any capacitor within its range. An up to date meter suspension system is incorporated along with a shockproof ABS case. Both the test probes and the sockets in which they engage are designed to reduce contact resistance and wear. Five ranges can be set from 0 to 0·5µF, accuracy is within 3% of reading. The CP570 is priced at £51 and is available from **Alcon Instruments Ltd.,** 19 Mulberry Walk, London SW3 6DZ (01-352 1897).

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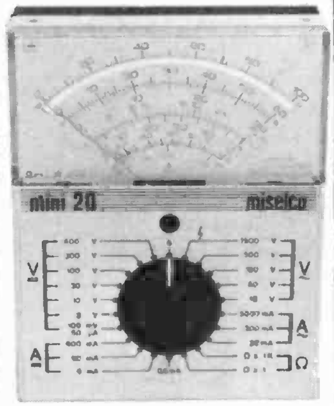

Accuracy: 2% d.c. and resistance, 3% a.c.
28 ranges: d.c. V 100mV, 3V, 10V, 30V, 100V, 300V, 600V. d.c. 150μA, 600μA, 6mA, 600mA. a.c. V 15V, 50V, 150V, 500V, 1500V. a.c. 130mA, 300mA, 3.0A. Ohms 0–2kΩ, 0–2MΩ. dB from −10 to +62 in 6 ranges.
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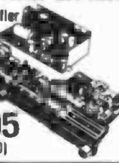

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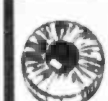

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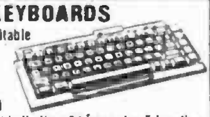

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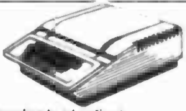

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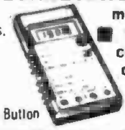

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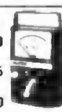

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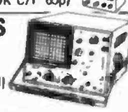

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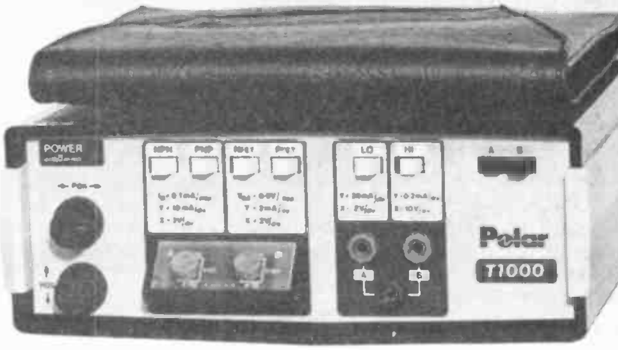
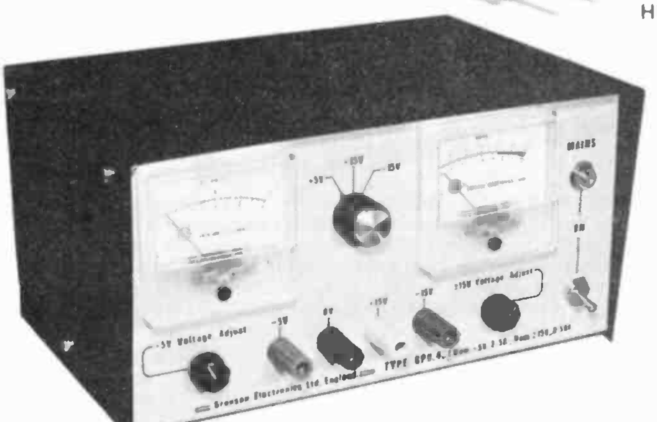


Polar T1000 converts a standard oscilloscope into an in-circuit component tester/curve tracer. It features automatic plotting and comparison of semiconductor characteristics. Produces a Lissajous signature for any combination of component elements, be they capacitive, inductive, and/or resistive. Allows swift comparisons and trouble shooting of unpowered boards, possibly without knowledge of the circuit. Usage is as much an art as a science, with applications yet to be discovered. Oscilloscope must have timebase switch-off with X input. Price £373·75. Available from **Antron.** (0428 54541). Note: Antron is offering a £50 discount on submission of a "Bazaar" coupon as proof of PE readership.

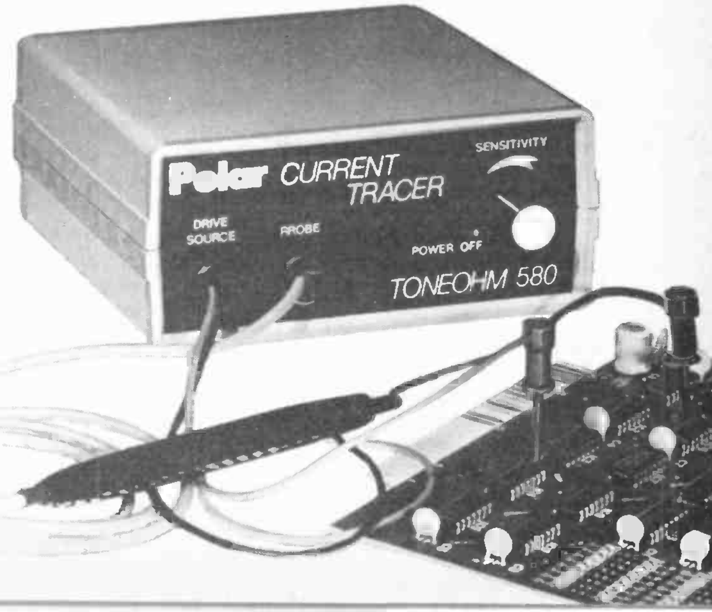
Hy-Trak 100D high resolution digital meter for p.c.b. short circuit location and measurement of resistances below the range of standard multimeters (20mΩ l.s.d.). Audio tone or meter reading indicates the position of the short. Has d.c. injection facility to prevent decoupling capacitors from introducing a "false short," and the Hy-Trak range ensures that shorts between voltage planes are detected. Price £249·17 (£224·25 c.w.o.). Available from **Omnitest Ltd.,** Highcliffe House, 411–413 Lymington Rd., Highcliffe, Christchurch, Dorset BH23 5EN. (04252 77731)

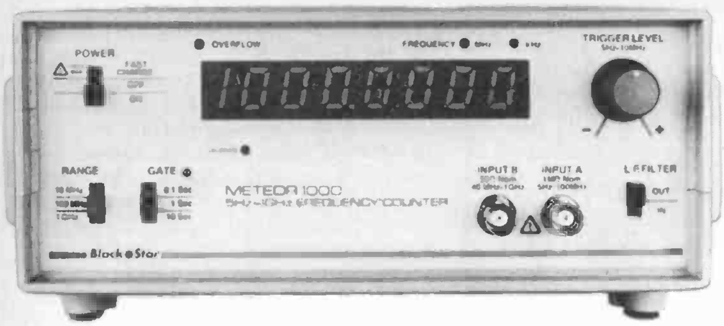


Grenson BPU-4 bench power supply has three variable outputs: +3 to +8V @ 2·5A +8 to +16V @ 500mA and −8 to −16V @ 500mA. Outputs are highly stabilised and fully protected against long term overload, short circuits and the injection of an external voltage. Voltage and current are independently monitored. Price £59 kit (£98 assembled). Available from **Grenson Electronics Ltd.,** High March, Daventry, Northants N11 4HQ. (0327 705521)

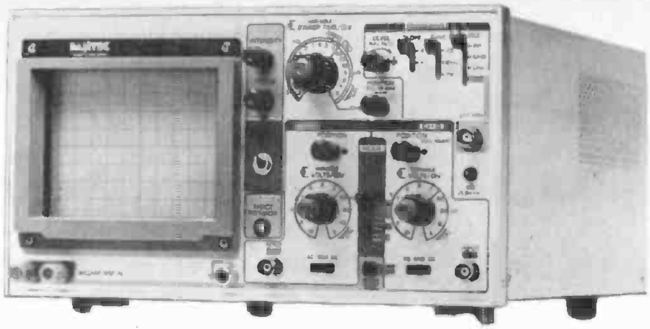
Digimax 500 series frequency counters offer an accuracy of 1 p.p.m. Measuring only 135 × 128 × 40mm separate models cover ranges of 10Hz to 512MHz and 50Hz to 1GHz with resolutions of 1Hz and 10Hz respectively. Powered by rechargeable battery pack or mains adaptor. Input sensitivities of 15 to 50mV at input impedance of 50Ω. Price £217·35 (model D-510 shown). Available from **Aspen Electronics Ltd.,** 2–3 Kildare Close, Eastcote, Ruislip, Middlesex HA4 9UR. (01-868 1188)

Polar Toneohm 580 is a sensitivity adjustable current tracer which can "sniff" out short circuits and partial shorts (up to 200Ω) with a non-contact probe. Source and sink clips introduce a safe current path through the populated, but unpowered board under test. A pitch variable whistle gives audible indication of the short's proximity. The 580 can also isolate faulty i.c.s. Price £193·20. Available from **Antron Electronics,** Hamilton House, 39 Kings Rd., Haslemere, Surrey GU27 2QA. (0428 54541). Note: Antron is offering a £25 discount on submission of a "Bazaar" coupon as proof of PE readership.





Meteor 1000X 5Hz to 1GHz precision frequency counter has temperature compensated crystal. Sensitivity is <50mV at 1GHz. Stability is ±0·5 p.p.m. at −10°C to 40°C with aging at ±1 p.p.m. per year, and stability of ±0·2 p.p.m. Battery or mains powered. Trigger level control. Three gate times: 0·1 sec, 1 sec and 10 sec. Price £258·75. Available from **Black Star Ltd.,** 9A Crown St., St. Ives, Huntingdon, Cambs PE17 4EB. (0480 62440)



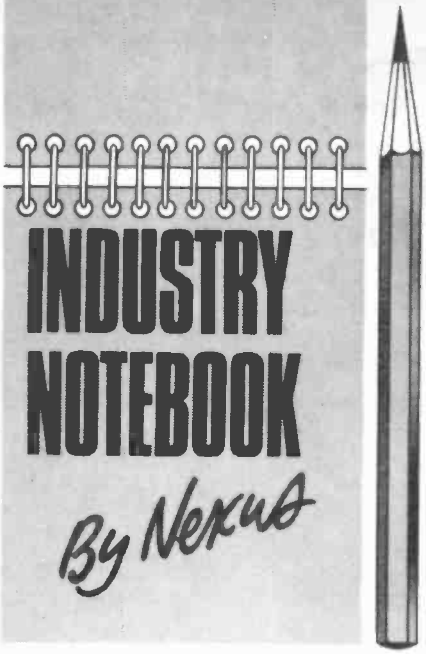
Pantec PAN8022 is a 20MHz dual trace oscilloscope with built-in component tester. Incorporates add and invert, alternate or chop (@ 200kHz). There are 12 ranges in 1–2–5 steps with fine control. Maximum input voltage of 300V. Timebase linearity better than 3%, with X5 magnifier. Ranges from 0·2μs/div to 0·5s/div on 20 ranges. Includes intensity modulation. Component tester generates 9V a.c. at 2mA max. (source resistance 4k7). Price £447·35. Available from Pantec Divn., **Carlo Gavazzi (UK) Ltd.,** 162–164 Upper Richmond Rd., Putney, London SW15 2SL. (01-785 9022)

Linstead S3 HT/LT bench PSU has 0–300V (@ 60mA) and 0–30V d.c. (ripple = 100mA). Also incorporates two isolated 6·3V @ 2A heater supplies. The PSU is fully protected against overload and short circuit by a variable trip. Voltage outputs monitored by switched meter. Price £140·30. Available from **Supercat Electronics Ltd.,** PO Box 201, St. Albans, Herts AL1 4EN. (0727 62171)

Levell TG302 function generator can generate triangle, square, sine, pulse and ramp waveforms from 0·02Hz to 2MHz in 7 ranges. It provides 20V p.p. from a 50Ω source with variable offset. TTL output. External sweep over three decades. Built-in frequency counter to 10MHz. Price £155·25. Available from **Levell Electronics Ltd.,** Moxon St., Barnet, Herts EN5 5SD. (01-440 8686)

Crotech 3132 oscilloscope incorporates a semiconductor and passive component tester and component comparator for checking against known standards. This dual trace (Alt or Chop) oscilloscope can also check complete circuits using signature techniques. It includes a mini PSU: +12V, −12V @ 200mA and 5V @ 1A. Basic scope bandwidth is d.c. to 20MHz with a maximum speed of 40ns/div. Price £325·45. Available from **Crotech Instruments,** 5 Nimrod Way, Elgar Rd., Reading, Berks RG2 0EB. (0734 866945)

Altai PP154 variable stabilised PSU with overload protection, ranges from 5–15V d.c. output at 4A. Stability is 0·1% with ripple confined to 5mV. Meter reads voltage or current (switched). Price £46. Available from **Semiconductor Supplies International Ltd.,** Dawson House, 128/130 Carshalton Rd., Sutton, Surrey SM1 4RS. (01-643 1126)



Productivity

I remember some years back, when hand-held digital multimeters were just becoming popular, being amazed to find on a factory visit that the production line was just two girls and three youths. The two girls 'stuffed' the p.c.b.s with components. The assembled p.c.b.s then went off to a flow-soldering machine and returned to the three youths who tested, calibrated and cased the instruments. Throughput was 100 instruments per 8-hour shift with a then retail value of about £100; so we might estimate an ex-factory unit value of £50, or £5,000 per shift, giving £25,000 per 5-day single shift week, say £1·2 million per working year.

The 'secret' of the low labour-cost was in clever design by production engineers. As well as being simple to make, the work was also de-skilled. The girls were guided by light beam where to mount each component, the technicians testers aided by automatic test equipment. Since those early days a number of look-alikes have appeared forcing the price down to less than half. As they became more popular so volume would have increased, making automatic component insertion economically viable.

I was reminded of this experience by what I confess is only a third-hand (via a friend of a friend) report of a visit to Japan where the itinerary included a visit to a large factory devoted to the manufacture of video recorders. The figures are hard to believe and may have been distorted in the telling. Throughput of this factory was 500,000 units a month. There were 250 production engineers beavering away in offices on the periphery of the production area, where only 17 operators handled the whole production which, one must assume, was as fully automated as modern technology would allow.

This, however, is not the end of the story. Production engineers, ever in search of lower assembly costs, are pushing hard for an emerging technique called surface mounting. This calls for component with lead forms which contact solder pads on the track side of a p.c.b., making through-holes unnecessary. Similarly, the multi-way connectors may be surface-mounted and designed to be clamped or soldered to the p.c.b. tracks, the clamp design permitting separable connection without de-soldering. The hold-up at the moment is that the whole range of components is not yet available for surface mounting, but few doubt that it must come. *This technique was featured in the article SO/SMD's, by M. Abbott, in the May '84 issue of PE.*

Another promising new production technique is to switch from conventional laminated p.c.b.s to injection-moulded substrates using polymides as a material which has the necessary mechanical, chemical and electrical characteristics. Among its advantages are that all holes can be moulded in, thus eliminating all drilling, the ability to mould-in three-dimensional features such as structural ribs or stand-off pillars, and no scrap material because scrap can be melted and re-processed. Because of the high tooling costs, production runs should ideally be at least 100,000 units, but cost savings could amount to 30 per cent.

Robots

Britain's robot population increased by over 50 per cent in 1983, according to statistics from the British Robot Association. At the year end the number was 1,753, but the predicted growth in use of robots is for at least 3,000 by May next year. Even so, Britain still lags behind the USA, Japan, West Germany, Sweden, France and Italy.

The most popular applications are in injection-moulding, spot-welding and arc-welding, but with increasing sophistication the number employed on assembly work is increasing. Biggest impact of the robot revolution is in the automotive industry, where robots have had a significant effect on the number of people employed on production lines.

Experience in the electronics industry in the USA is that few people, if any, have been displaced by robots, although those at work have been re-allocated to new tasks in the factories. This is most probably because the electronics market is still growing, whereas the automotive market is near saturation. Applications in electronics have been mainly in highly repetitive jobs which are boring to human operators, particularly in some stages of p.c.b. manufacture. Robots for electronics assembly are still in the research stage, but we may expect them soon to be on production lines loading components, handling loaded boards, soldering, and final testing.

Reports from leading electronics companies in the USA are that robots are providing productivity gains of up to 300 per cent with improved quality of product. And, whereas to remain competitive some companies had to farm out some operations to cheap labour areas in the Far East, such work can now return to in-house in the home country.

Tartan Spring

Hard on the heels of Scotland winning the Triple Crown (for overseas readers it is a Rugby Football honour last won by Scotland 46 years ago) came news that National Semiconductors were to back Scotland with a further £100 million of investment which, with existing investment by other electronics companies, makes Scotland one of the fastest growing sunrise industry areas in Europe. What is especially welcome is that National's plan is not for just another off-shore assembly plant but a pioneer in use of the 6-inch wafer and all that goes with it. The only pity is that of the 1,000 new jobs to be created, very few are suitable for the horny-handed workers being laid-off in nearby shipyards.

In the Edinburgh area, Hewlett-Packard are expanding with a new microwave facility on top of the big expansion at South Queensferry last year. H-P has doubled turnover since 1980 in UK-based operations, and productivity measured in sales per employee is running at over £83,000. Present plans forecast an increase in the labour force of 700 in the foreseeable future.

Sweethearts

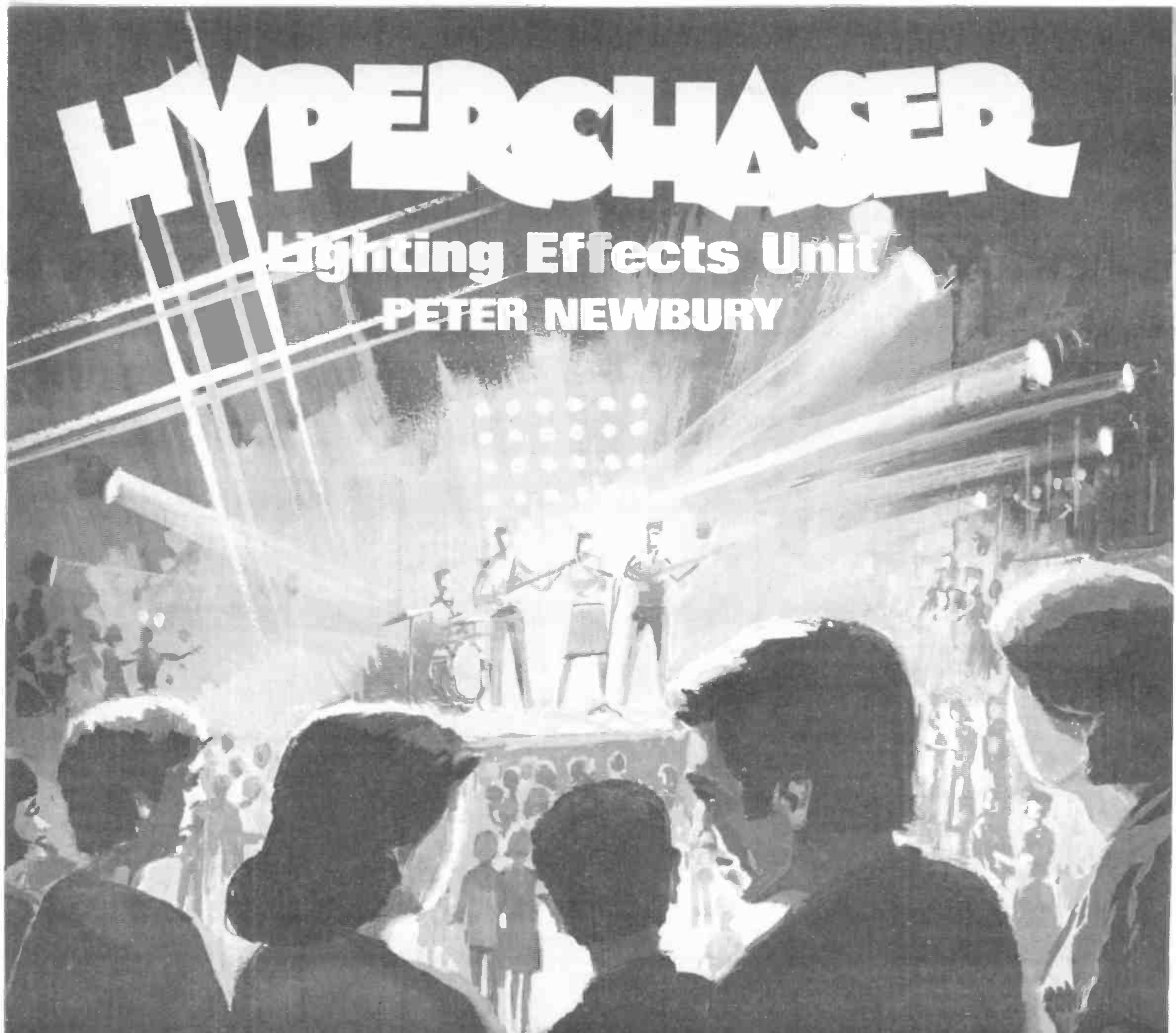
Since I last mentioned the role of trade unions we have had the GCHQ rumpus which quickly faded from the scene as the miners sprang into militant action.

What has passed almost unnoticed during the torrents of press and TV coverage is the continuing emergence of what have been dubbed sweetheart deals, an agreement for no strikes freely entered into between management and unions.

For this new development we have to thank the Japanese, who as part of the bargain for setting up plants in the UK, notably in South Wales, insisted on a single union rather than a multiplicity to represent the workers. With declining membership and influence the unions are all too anxious to move into new enterprises, and union rivalry provides an element of competition which results in union concessions with winner takes all.

Experience so far indicates that a single-union workforce makes for a happier environment. If nothing else, it cuts out inter-union squabbles over who does what and for how much. The first purely British company in the electronics industry to adopt a single-union policy is probably Inmos. I have heard of no other so far. At the old Philips factory at Lowestoft, now taken over by Sanyo, the former seven unions have been replaced by one, and it seems to work. There is much greater flexibility in work practices, greater co-operation between management and labour, greater harmony and more understanding.

Spearheading the new movement is the electricians' union, a progressive body interested more in members' welfare than in grabbing headlines and TV coverage. Togetherness, in their view, is preferable to futile confrontation which helps nobody.



HYPERCHASER

Lighting Effects Unit

PETER NEWBURY

IN the early days of discotheques a lighting control unit meant, more often than not, a simple unit, usually three channels at most, that responded with varying degrees of efficiency to separate sections of the audio frequency spectrum. For a three channel unit this would be bass, middle and treble with the channel separation often somewhat dubious. For lesser units operation was on a loudest takes precedence basis. As discotheques became established, more complicated and versatile units entered the market place, but before the advent of TTL at sensible prices, any form of sequence effect entailed relatively complex circuitry.

As TTL i.c.s became established there was a trend to four channel operation. The extra lamp meant that serious consideration could be given to endowing units with a number of different chase programmes. The trouble with a group of three lights is the limited number of variations that can be achieved. There is also the added question as to whether such programmes, if they can be generated, are of sufficient interest to those on the dance floor. However, whereas a three channel system offers only 8 choices (including all the lamps off) a four channel unit provides double this. That, and the extra step required to traverse the display, give a significant subjective advantage in favour of the four channel controller.

USING EPROMS

As EPROMs became available at reasonable prices the job of designing a four channel controller which would offer a number of programmes, rather than just forward and reverse chase, became much easier. A circuit that once contained two or three counters, plus scores of diodes and/or gates for routing purposes, multipole switches and large expensive printed circuit boards was reduced overnight to a counter plus an EPROM.

The PE Hyperchaser does not use a microprocessor. Nevertheless, in terms of the end result achieved it could reasonably claim to be intelligent. The Hyperchaser is not just a chaser: it is a lighting controller, and as such can be used to control inductive loads as well as resistive loads, although still providing an interference free dimming function, and at the same time will control strobes. It has a sound operated facility, and is capable of sequence operation on four, three, two or even one channels.

The controller is of compact size, being $5\frac{1}{4}''$ high, in keeping with standard rack practice. It is less than the standard 19" wide for those who are not rack mounting equipment but can obviously still be rack mounted if the occasion demands. It is particularly slim, only $2\frac{1}{4}''$ behind the front panel, and the front panel layout is simple, with a single row of keyboard switches, two rotary controls, and a mains on/off switch. Power handling on normal resistive loads, including tungsten lamps, which are the most common, is 750W/channel, limited by the mains capability for a 13A plug. This should be derated to 500W/channel for tungsten halogen lamps, which have much lower cold resistances and similarly for inductive loads where dV/dT considerations exist.

There are ten keyboard switches in all, some having double functions. Starting with the righthand four switches, these provide, in the absence of the operation of other switches, a manual flash function. The operator can depress any or all of these switches to provide a momentary or sustained flash on the channels in question. Incorporated at the top of each switch is a l.e.d. channel output indicator. The flash switches override the sequence. The sequence itself is controlled by the top of the two rotary controls. At the lowest setting the sequence is disabled. Rotating the control clockwise brings the sequence effect into being with increasing speed as the control is rotated. This "Sequence Disabled" setting allows the unit to be used purely for ambient lighting control, if so desired.

HOLD AND DIM

To the left of the manual flash switches are the hold and dim switches. If the hold switch is depressed at the same time as a channel switch or switches, the channel/s in question are switched on permanently, or at least until the process is repeated. If the manual flash button is depressed on its own whilst that channel is in the hold mode, the channel will flash off, rather than on as before—a useful effect. When any channel is placed on hold, the memory is informed accordingly and selects a suitable group of programmes from its repertoire for the remaining channels. Thus, no matter whether one, two, or for that matter, three channels are on hold, the remaining channels present programme information that makes visual sense. The memory holds sixteen 4 channel programmes, 8 three channel programmes, four two channel programmes and two rates of flash for single channel operation. Used thus, the controller can provide ambient lighting, can work into other than four channel display configurations and is generally pretty flexible. The dimming function has been nicknamed "Shimmer Dimmer". With today's discos using a variety of light sources such as pinspots which, using a low voltage lamp, incorporate a transformer, any truly versatile controller must be able to work into inductive loads. Since a transformer is decidedly unhappy when presented with d.c., it is important to ensure that a proper a.c. waveform leaves the controller. This affects output stage design as will be discussed later in the article, and also means that a popular method of dimming, that of blocking alternate half-cycles, is definitely not on. The Hyperchaser dimmer works by allowing every other complete cycle of power to leave the unit, presenting any transformers that comprise the load, or part of the load, with a.c., albeit interrupted a.c. As with the half-wave method, a degree of flicker is introduced. This is actually quite pleasant when used as part of a kinetic effect, and is useful to balance lamps of unequal brilliance, or simply to *tone-down* the overall brightness of a display.

Anyway, the Shimmer Dimmer function works as for the hold function. Holding down the dimmer switch and simultaneously depressing any of the channel switches will dim that channel. Repeating the process will restore the channel to full output.

To the left of the Hold and Dimmer switches are the Manual and Auto Programme selection switches. These are self explanatory, the Manual switch advancing to the next programme when depressed, and the Auto switch when operated, making the change at the end of each programme run.

Carrying on to the left is the audio switch. The audio input is very sensitive, less than 100mV, and can thus be run direct from a mixer. It will however handle the output voltage of amplifiers up to 200 watts quite happily. Rather than the normal audio chase effect where the pulses derived from the beat of the music are used to trigger the sequence along, necessitating that the initial sequence speed be set fairly low, the audio effect on the Hyperchaser is called audio halt. As the name implies, the beat derived pulses are used to *stop* the sequence clock in its tracks. This has two advantages over the conventional method. Firstly, there is no need to adjust the sequence speed every time the audio effect is selected, or, for that matter, to incorporate circuitry to remove control of speed from the operator whenever the audio switch is depressed, reverting to a preselected speed. Secondly, the sudden arresting of the sequence in time with the beat of the music is very effective, if the pun may be pardoned, and certainly subjectively better than the other option.

CIRCUIT DESCRIPTION

The unit was designed around the 2716 single rail 16K memory. At the time of writing the article I was warned that this device was being phased out in favour of the 2732, which has twice the capacity. There is no problem using the 2732 instead, and, at present, the 2716 is still cheaper than the 2732.

PSU, CLOCK AND CIRCUITRY

This includes the 25Hz signal which is derived for the dimming function and the zero-voltage pulse circuitry (see Fig. 1). The power supply is a simple bi-phase arrangement, using D1 and D2. However, instead of feeding the output of these two diodes directly to the 5 volt regulator, IC1 (7805), the 100Hz waveform is fed to the smoothing capacitors, C1 and C2, through D3 *and* fed to TR2. This results in a positive pulse at the collector of TR1 every time the input to D1 or D2 drops below about 1 volt. When the collector of TR2 goes negative again, TR3 is biased hard off for a very short period decided by the combination of R31 and C9, again producing a positive pulse but this time much narrower and better defined. This pulse is used to clock IC17a, half of a 4027 dual JK flipflop, producing a 50Hz output from the 100Hz input. That output is again divided by the second half of IC17, resulting in a 25Hz waveform. The output of TR3 also switches TR4, when on for that brief period, pulls a 47k resistor connected to pin 5 of the 555 timer, IC19, to ground potential. This has the effect of reducing the threshold voltage of the timer for that instant. Figs. 2a, b, and c show the waveforms at the rectifiers, TR2 and TR3 respectively, whilst Fig. 2d shows the threshold voltage of IC19 superimposed on the timer capacitor waveform. The waveform shown corresponds to the highest sequence speed attainable on the unit, with the speed control at maximum and

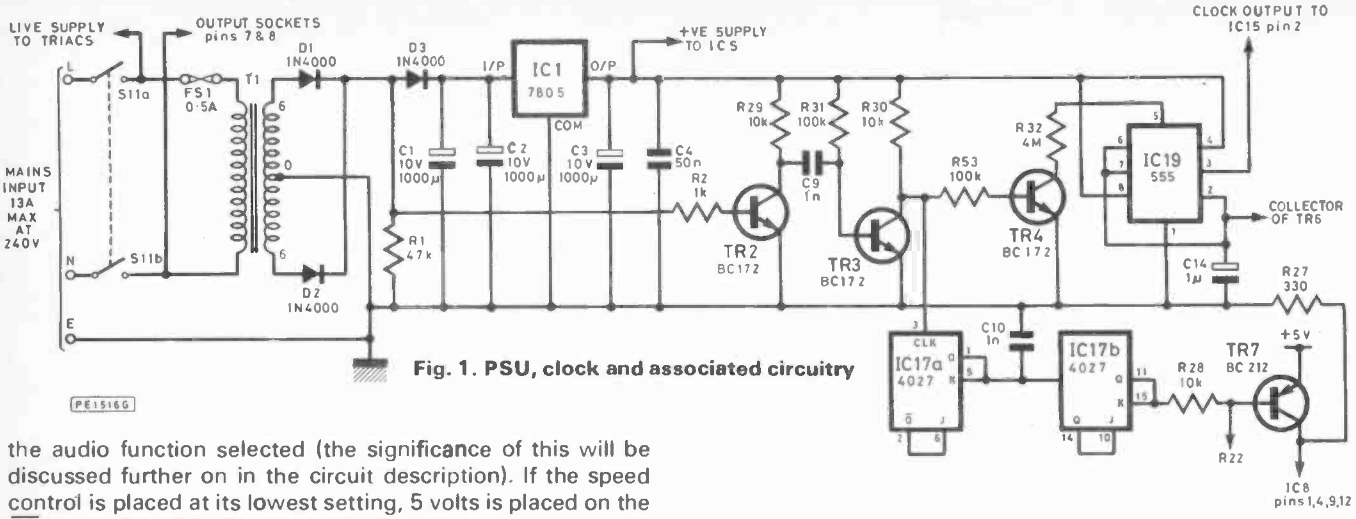
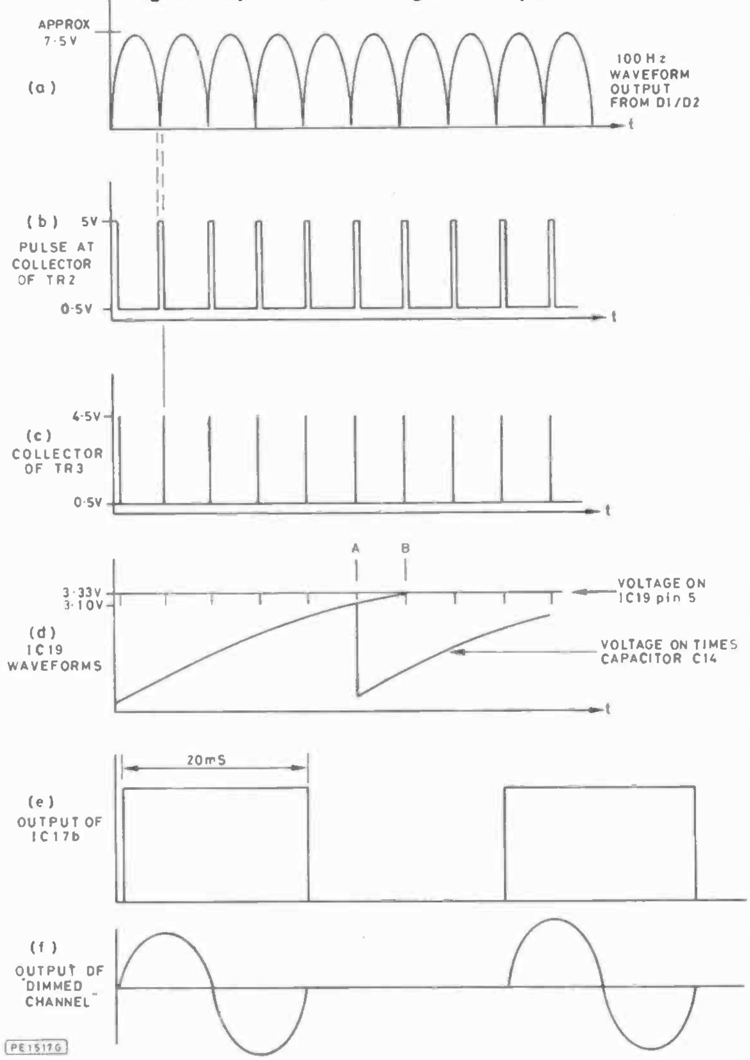


Fig. 1. PSU, clock and associated circuitry

the audio function selected (the significance of this will be discussed further on in the circuit description). If the speed control is placed at its lowest setting, 5 volts is placed on the $\overline{OE}$ input of the 2716 and this disables the sequence, leaving the flash, hold and dim functions unaffected. Because the internal potential divider deciding the 555's threshold voltage consists of three 5k resistors in series, with the junction of the top and middle resistors defining the threshold voltage; e.g. normally 2/3 the supply voltage, the effect of the 47k resistor R32 being grounded is to lower the threshold voltage by about 7%, ignoring the saturation voltage of TR4. If the voltage on the timing capacitor C14 is sufficiently high that within the next half cycle of the mains input it would reach the threshold voltage and trigger pulse at the output, thus changing the state of the counter and, further along the line, the memory, then it is also high enough to exceed the short term reduced threshold voltage that corresponds with the pulse from TR3. Thus, the timer will only produce an output pulse and the output stage will only change state at the nominal zero crossing point. I say nominal, because this point is in truth after the zero crossing point, but in practice not so far that it causes even the least hint of interference problems. If the purist wished, he could include a capacitor on the base of TR2, to ground, add a preset potentiometer (say 10k) in series with R2, reduce R1 to 1k and then set the unit up with an oscilloscope to give truly accurate zero-crossing switching, at the end of the half cycle, but whether this is worthwhile is highly debatable.

The output of the second JK flipflop is fed to TR7 which acts as a buffer, supplying the 25Hz square wave to IC8. An override signal from the strobe selection switch circuitry also connects to TR7's base. Again, more in a moment, but suffice it to say that the dimming function must be cancelled when the strobe function is selected in order to preclude a series of pulses, rather than one pulse, being fed to the strobe outputs with each change of state of the output.

Fig. 2. Graphs of zero voltage circuitry etc.



FLASH, HOLD, INVERT AND DIM FUNCTIONS

We will deal with channel one as an example, since all four channels are identical (see Fig. 3). All i.c. sections are numbered and reference to the component layout, Fig. 5, will simplify identification of the physical route through the unit of a particular channel.

Taking the output stage first, this consists of a buffered NAND gate, IC18a (7437). This sinks enough current for the MOC3020 opto triac that isolates the low voltage circuitry from the output stage and also for the indicator l.e.d. D4. A further feed from the output of IC18a goes to the strobe output NOR gate IC16c, but since this is a 74C02 and therefore a CMOS device its input requirements may be ignored. The anode of the opto triac IC23 (MOC3020) is returned to supply, in common with its three counterparts IC20-22, via TR1. TR1 is switched off by operation of the Strobe switch, thus disabling the output stage, and extinguishing all lights except the strobes. For an output from channel 1, both inputs of the NAND gate must be high. One input derives from the dimming circuitry and the other from the signal path.

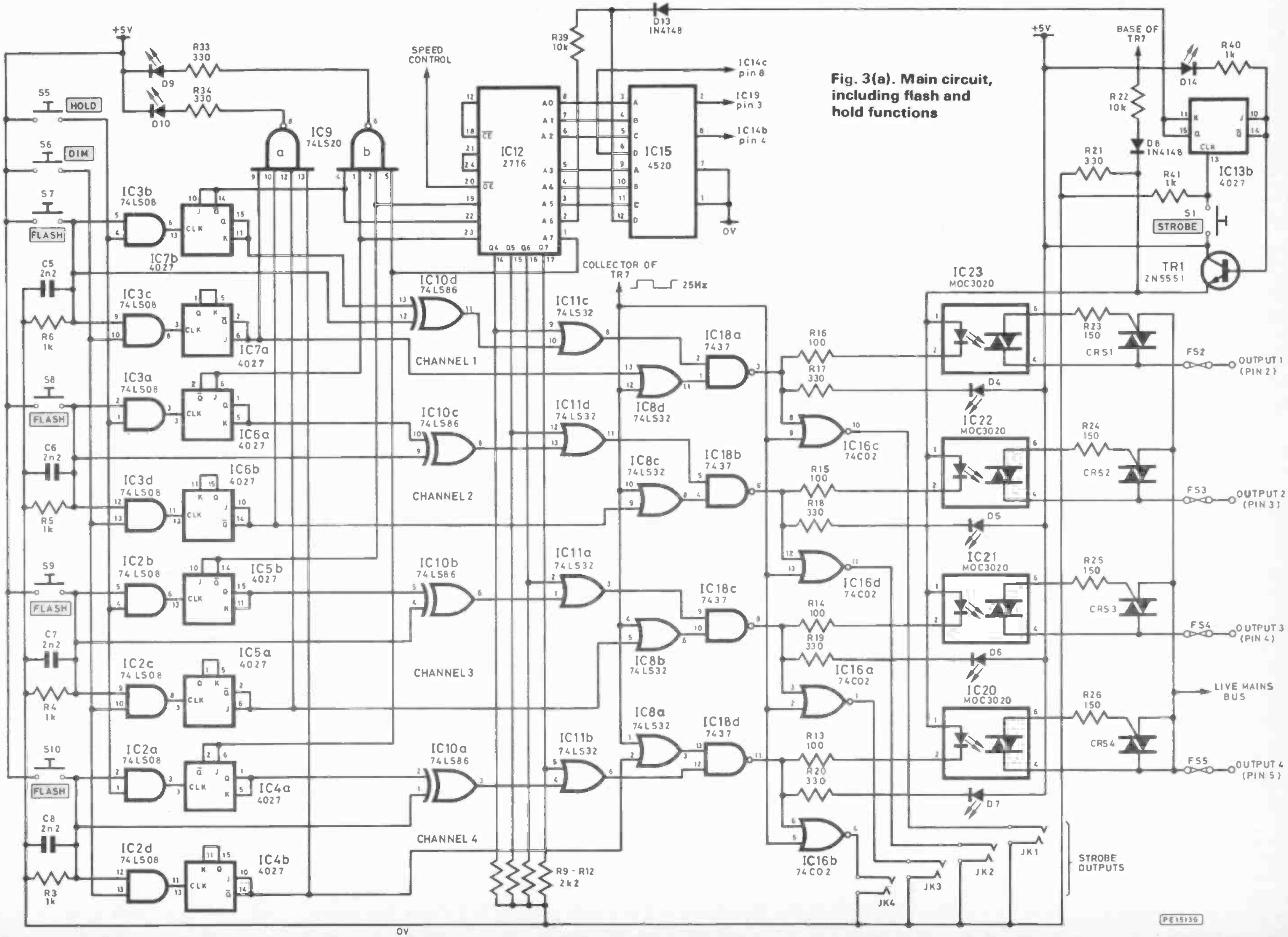


Fig. 3(a). Main circuit, including flash and hold functions

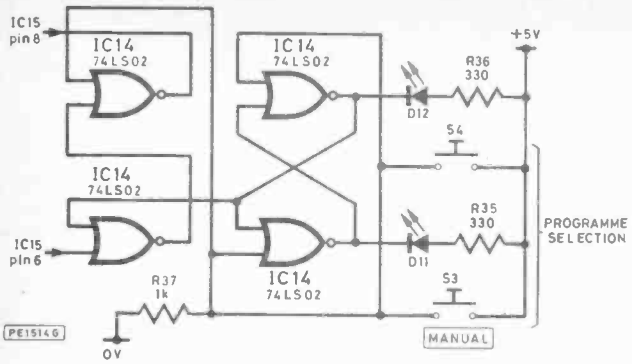


Fig. 3(b). Programme selection

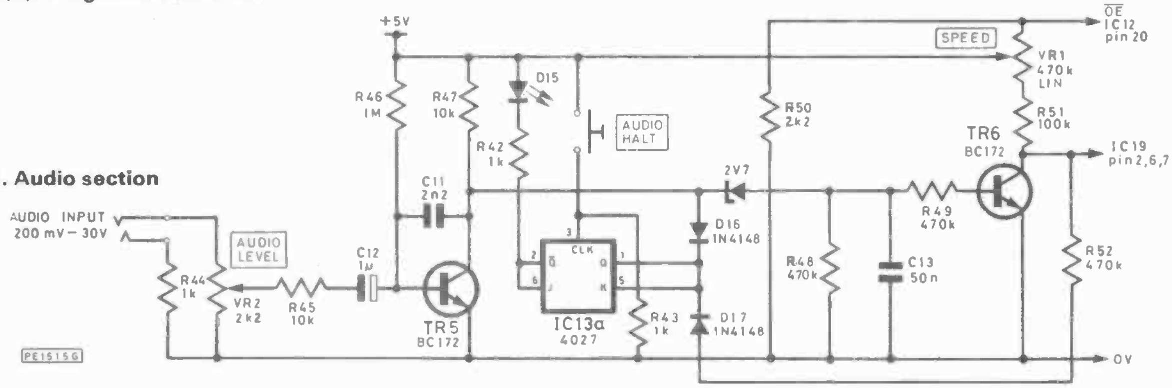


Fig. 4. Audio section

Proceeding to the beginning of the circuitry for channel 1, the Flash/Hold/Dim switch, S7 connects to one gate each of the two input AND gates IC3b and IC3c, and also to the input of an EXOR gate IC10d (74LS86). The remaining inputs of the AND gate are commoned to their neighbours on the other three channels and taken to the Hold and Dim switches respectively. If the Hold switch is depressed at the same time as the channel 1 button, then the output of the AND gate IC3b goes high, and IC7b, half of a 4027 JK flip-flop, changes state. The '1' output is fed to the other input of the EXOR gate. With the switches released, the output of the EXOR gate is high and this is fed via the 2 input OR gate IC11c (74LS32) to the NAND buffer mentioned above. At the same time, the $\overline{Q}$ output of IC7b is taken to one input of the four input NAND gate IC9b (74LS20) whose output promptly goes high and is used to provide an indication that the Hold function has been selected. The $\overline{Q}$ output also goes to an input on the 2716 memory to instruct it that channel 1 is on hold and to produce, forthwith, a selection of three channel programmes based on channels 2, 3 and 4. There is no particular reason that the $\overline{Q}$, rather than the Q, output is used to perform this task, simply that the NAND gate driving the Hold indicator is located close by and circuit layout is thus simplified by the omission of four extra pieces of track. A word on the indicator drivers. The published spec of an LS gate will show its sourcing capability, i.e. its High output current only guaranteed to be 400µA. This is however the current for correct logic high level output; the output capability is much greater when the output voltage is not critical, such as when used to drive an l.e.d.

As for channel 1, the $\overline{Q}$ outputs of the Hold flip-flops are taken to the memory, occupying in all the A7-A10 inputs. These four inputs are used to select programs for the channels remaining, whatever the number of channels. Although there are 16 four channel programs the choices for 3, 2 and 1 channel operation are limited and thus 8, 4 and 2 programs respectively are incorporated.

With the channel not on hold, the EXOR gate will have a '0' on both inputs and operation of the channel button on its own will result in a high output from the EXOR gate and corresponding switching of the NAND buffer. When the Hold function is selected, there is already a '1' on one input of the gate; operating the channel button will result in a '1' on both inputs of the EXOR and thus a '0' on the output. In this manner the channel can be made to flash off when on Hold, providing the Invert Flash function.

If the Dim button and the channel button are depressed, the output of IC3c, the second AND gate, goes high and clocks IC7a, the second half of the 4027. The $\overline{Q}$ output of IC7a had been high and was therefore keeping the output of the OR gate IC8d, high, allowing IC18a, the NAND buffer, to be wholly dependent on what appeared at its other input. When the $\overline{Q}$ output of IC7a goes low, the output of IC8d will now follow the 25Hz waveform from the collector of TR7 and in turn, IC18a will only be able to operate the indicator and opto-triac every other complete cycle, thus accomplishing the effect described earlier in the article. The same $\overline{Q}$ output drives the Dim indicator via IC9b (74LS20).

STROBE FUNCTION

As previously mentioned, this facility disables the main outputs, and puts a positive signal for each stage of the sequence on the appropriate output jack. When the strobe mode is selected, the dim function must be overridden to prevent a series of pulses appearing at these outputs when the dim function is selected. The strobe mode is selected by S1 and IC13b, the final 4027 in the unit, the other half of which is used for the audio selection. When the strobe mode is invoked, the Q output goes high, placing logic '1' on the A6 input of the 2716 memory, via D13. This address input is one of four used to give a total choice of 16 programmes. The arrangement of the programmes is such that every other programme is suitable for strobe work, i.e. it does not consist of fill and empty type routines that would be ineffective when used with a strobe. Overriding the A6 input thus restricts the programme range to 8 rather than 16 programmes (in the 4 channel mode) and ensures that all of these 8 programmes are the correct type for strobe use. The same applies for three and two channel operation.

A further noteworthy point is that the maximum speed of pulses to the strobe outputs is limited by the clock and audio circuitry design to well below the critical speed that has caused so much controversy with local authorities in the past. It is more or less agreed that under the correct circumstances, epileptic fits can be induced, viz in an epileptic sufferer by the operation of strobes at frequencies in the order of just over 16Hz. The risk of such a happenstance is not so clearly defined, but in any case, the effect of direct strobe light at this rate of flash on a non-epileptic is to cause breaking up of the vision and is not to be recommended.

AUDIO SECTION

Audio inputs from below 100mV to 40V r.m.s. are fed into J5 (see Fig. 4). If the sound system is stereo, it is only necessary to use one channel as the audio halt circuitry is basically bass orientated and such signals should be present on both channels of a stereo system. TR5 is biased directly from the supply via R46, rather than feedback being taken from its collector. Thus the collector voltage is low and is, provided the transistor is up to spec., below 1 volt. Negative going half cycles of the audio input will produce positive pulses on the collector of TR5, with a bass emphasis provided by the capacitor C11, which causes the stage to roll off above 100Hz. If the audio effect is not selected, the Q output of IC13a is low and the signal at the collector of TR5 cannot rise above about 1 volt, due to the clamping effect of D16. When the audio effect is selected, D16 becomes reverse biased and whenever the collector voltage of TR5 rises above the rated voltage of ZD1, C13 starts charging. When sufficient energy is available, such as with the bass notes, as the input level is set high enough, C13 will charge sufficiently high enough and for long enough to keep TR6 held on, thus stopping the clock (IC19). R49 allows the discharge through the base emitter junction of TR6 to be gradual, rather than immediate, when there would be less or no effect on the clock. R48 limits the time constant without which the time constant would vary, as the reducing voltage approached the knee voltage of that junction, according to the gain of TR6.

With the effect selected, if the speed control were to be reduced, the effect would be more and more reduced as the speed was lowered. To avoid this, regardless of the speed setting prior to selecting the audio halt effect, the Q output of IC13a also places R52, via D17, in parallel with the speed control. This has the result of narrowing the range of the speed control and restricting that range to the higher speeds so that, whatever the speed setting before the audio effect is switched in, the effect will not be lost.

CONSTRUCTION

As mentioned earlier, the whole unit is slimline in appearance. All components are mounted on a single rectangular double sided p.c.b. which fits inside a purpose designed case. The output sockets, which are the standard 8 pin Bulgin P552 type, used on many commercial units, are mounted on the rear panel and hard wired to the p.c.b. Approximately 2/3 of the back of the case is removable, and the front panel need only be screwed in place after the unit is finished and tested, thus accessibility to all components is good. Fig. 5 shows the component layout looking at the front of the unit, with rear mounted components such as triacs shown in dotted lines. The printed circuit board is

COMPONENTS . . .

Resistors

R1, 32	47k (2 off)
R2–6, 37, 38, 40–44	1k (12 off)
R7, 8, 17–21, 27, 33–36	330 (12 off)
R9–12, 50	2k2 (5 off)
R13–16	100 (4 off)
R22, 28–30, 39, 45–47	10k (8 off)
R23–26	150 (4 off)
R31, 51, 53	100k (3 off)
R46	1M
R48, 49, 52	470k (3 off)
All resistors ¼W 5%	

Potentiometers

VR1	470k lin. through-board mounting (Radiohm)
VR2	2k2 log. through-board mounting (Radiohm)

Capacitors

C1–3	1000µ 10V axial elect. (3 off)
C4, 13	50n ceramic or mylar type (2 off)
C5–8, 11	2n2 ,, ,, ,, (5 off)
C9, 10	1n ,, ,, ,, (2 off)
C12, 14	1µ radial elect. or tant. bead (2 off)

Transistors & Diodes

TR1	2N5551 (or BFX 84 etc)
TR2–6	BC172 (5 off)
TR7	BC212
D1–3	1N4000 (3 off)
D4–7, 9–12, 14, 15	3mm red l.e.d.—must be splayed leg type 0·1" spacing (10 off)
D8,13,16,17	1N4148 (4 off)
D18	2V7 400 mW Zener

Integrated Circuits

IC1	7805
IC2,3	74LS08 (2 off)
IC4–7,13,17	4027 (6 off)
IC8,11	74LS32 (2 off)
IC9	74LS20
IC10	74LS86
IC12	2716(5V)*
IC14	74LS02
IC16	74C02
IC18	7437
IC19	555
IC20–23	MOC3020 (4 off)
CSR1–4	TXAL228B isolated tab triac (4 off)
J1–5	Mono p.c. jack
F1	20 x 5mm 0·5A
F2–5	20 x 5mm 3A HRC
S1–10	TRS keyboard switch set comprising switch, fingerpad and l.e.d. holder
T1	Transformer 7–0–7 volts 6VA

DPDT rocker switch; 2 knobs to suit pots; 2 Bulgin P552 sockets; double sided p.c.b.; case, front panel, back panel, and heatsink spreader

Constructors' Note

A full set of parts, including printed facia, case, p.c.b., and transformer may be obtained from:
Bensham Recording Ltd., 327 Whitehorse Road, Croydon, Surrey CR0 2HS. (01) 684 8007. Price £78.50 inc VAT & P.P.
The kit may be purchased whole or in sets of resistors etc. Board, case etc available separately.
*EPROM listing available from PE (Poole Office). Send 10 x 7in. S.A.E.

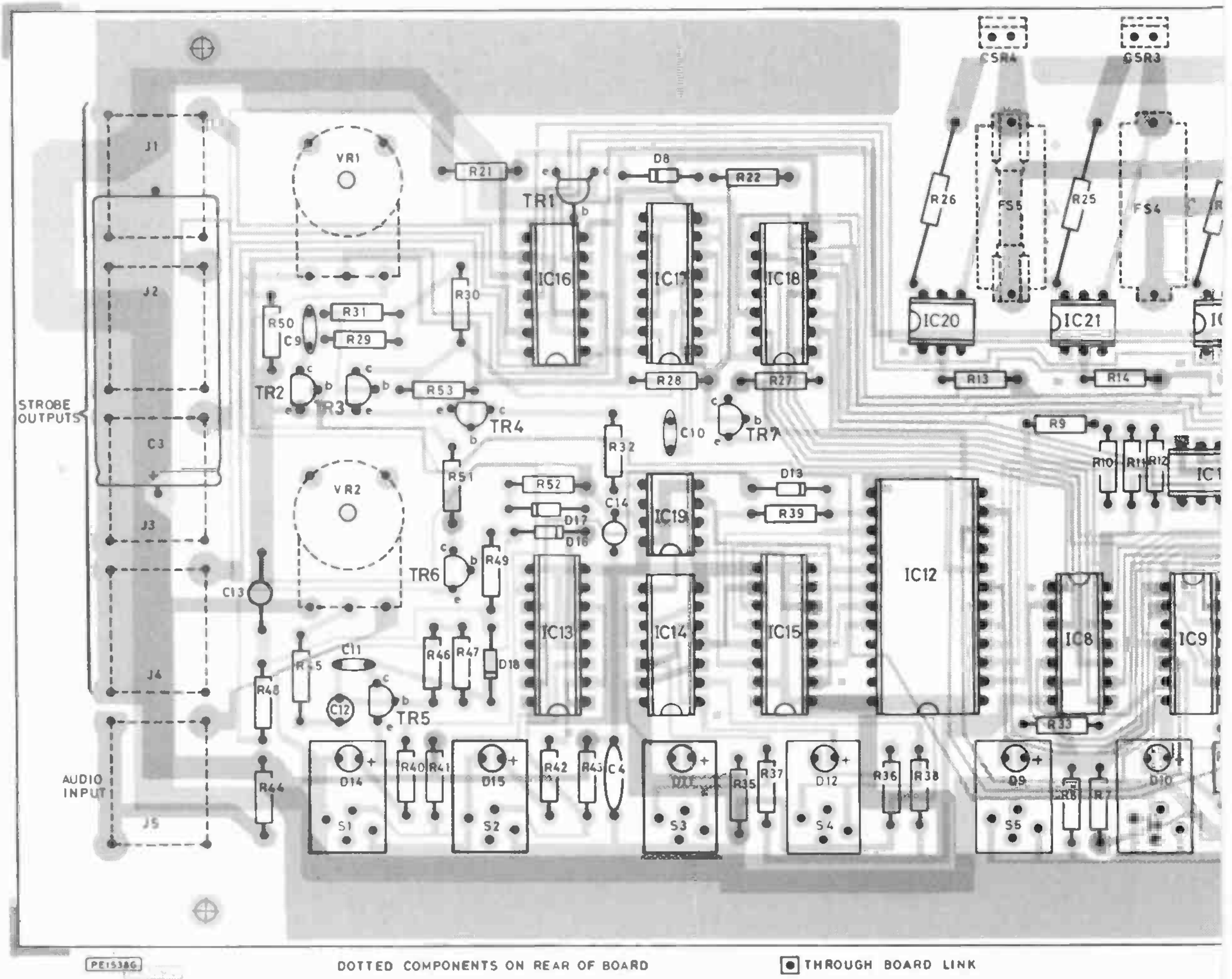
solder resisted both sides for ease of assembly, the case is plated and the front panel painted and printed.

When assembling, leave the switches and larger components until last, fitting resistors, etc, first. There are half a dozen through board links that should be inserted at the beginning, lest they be forgotten later, especially since two of them are located between C1 and C2 and could easily be missed later on during assembly. There are a good few top-side connections on both i.c.s and resistors. Neglect these at your peril. These are necessary in such a compact unit and preclude the need for wire links and consequently even more cramping in the layout. The disadvantage of such connections only becomes apparent when an i.c. is inserted wrongly and has to be removed. So, unless you are an expert with a solder-sucker, take care! Some components, particularly the capacitors, may need to be bent over to clear the front panel. Alternatively, such items, C4 as an instance, could be rear mounted if the constructor so desired. The switch assemblies should ideally be made up all at once and inserted in one fell swoop to avoid slip-ups. For convenience, the board was laid out with the positive lead of the l.e.d.s to the right of the unit. Take care when deciding the positive lead; most are indicated by the longest lead, but this is not always the case, as the author has found to his chagrin in the past. Fit the transformer last, and before the Bulgin sockets are fitted, slide the board into the case from the back, inserting it at the left hand end, gently bending it slightly to clear the transformer past the flange on the part of the back of the case that is permanent. Screw the board into place, and also the triacs. These mount against the top of the case via an aluminium thermal "spreader". Use thermal compound liberally here. It is probably wise to delay soldering the triacs until they are screwed down, in order to avoid stressing the leads.

Before fitting the Bulgin sockets, of which more later, fit the mains input lead, securing well and leaving about 3 inches stripped and tinned for connection to the switch. Also solder two flying wires into the board as shown in Fig. 9 for connection also to the switch. Both the mains input and the flying leads should be of sufficient current rating to cope with the full output of the unit, viz 13A. For the time being link the two pairs of wires in a piece of terminal block so that the unit can be tested without the front panel being in the way.

The easiest way to fit the Bulgin sockets is as follows: cut, for each socket, seven pieces of 16g tinned copper wire, varying in length from 5cm to 10cm. Solder these, in ascending order of size around the tags on the socket, leaving out tag number 6. Starting with the socket nearest the mains input, and with the flat on the centre section towards the top of the unit, locate the wires, one by one, starting with the longest. When all the wires on the first socket are in place, push the socket all the way home and screw or pop-rivet in place. Solder the wires to the pcb, feeding the iron through the nearest appropriate hole. Note that some wires

Fig. 5. Component layout



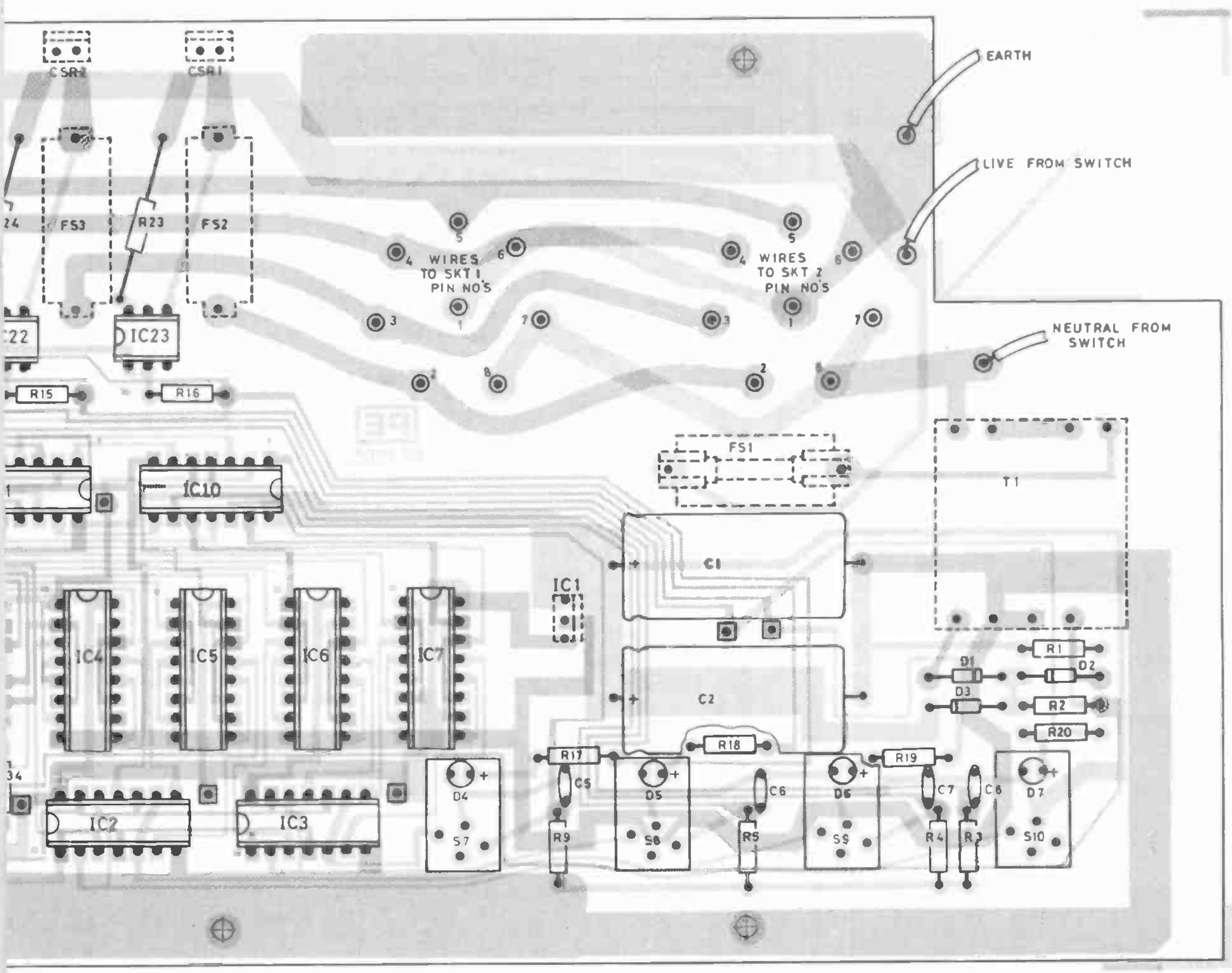
PE1538G DOTTED COMPONENTS ON REAR OF BOARD ■ THROUGH BOARD LINK are also soldered above the board. Repeat the process for the second sockets. The Hyperchaser should now be ready for testing.

TESTING

Connect the output to a set of lamps, preferably all the same colour (for the test only) and preferably fairly low power, unless they are mounted behind a diffuser. The output connections for the Bulgin socket are: Channel 1—pin 2, Channel 2—pin 3, Channel 3—pin 4, Channel 4—pin 5, Common neutral return from lamps—pins 7/8, Earth—pin 1 (centre). This follows the accepted standard for these connectors. Before connecting the mains supply (and remember when testing that there is live mains on parts of the unit) check the supply lines for shorts and also for continuity around the board. Connect the supply, and switch on, immediately checking for 5 volts output on IC1. The manual switch should be illuminated, but no others. If the strobe or audio functions switches are illuminated, switch them off by simply depressing the fingerpads. A 4027 will normally come on with the Q output low, but no fail safe circuitry is incorporated to ensure this. Thus occasionally one may encounter a recalcitrant i.c. that will need to be manually set after switch-on. Turn the speed control to minimum, thus disabling the memory, and then check the flash buttons in turn. Next try the hold function and then the dim effect. With the dim function invoked, operate the strobe button, which should illuminate. The output l.e.d. indicators which should have been operated at a reduced brilliance showing a degree of flicker should be restored to full brilliance until the strobe button is pressed again. There will also be an amount of flicker on the load lamps, but not so significant as the l.e.d.s due to the thermal inertia of the lamps. Take all of the channels off Dim and Hold (in that order, since monitoring correct switch operation is easier in this fashion) and advance the sequence speed control and observe the display.

The unit should now perform a sequence. Advance the programme by pressing the Manual button and check that each of the 16 programmes are being selected correctly, i.e. that all outputs of the 4520 are getting to the 2716. Place each channel in turn on Hold and check the three channel programmes that result. This is a long winded process if you do the whole bit, going through every permutation of channels, and checking every programme, and is really only to ascertain that the memory is in fact correctly programmed. Since all the programming devices I have encountered throw up a clear warning if the programming sequence has gone awry, it is perhaps enough to confine this stage of the testing to checking that the operation of each hold button is having the desired effect and that it is therefore connected properly.

To check the strobe function, a simple indicator may be made from four l.e.d.s each in series with a 1k resistor and the positive of each l.e.d. connected to a strobe output. ★



Space Watch...

LA PALMA OBSERVATORY

It is not always appreciated that the level of precision engineering required for modern telescopes is exceptionally high. Over the last three decades almost every aspect of looking at and seeking to understand what exists outside the Earth on which we live, has undergone change. The telescopes at La Palma continue this trend.

Aids for use with optical telescopes have reached a high standard also. There will be the Image Photon Counting System. This consists of a special television camera with an image intensifier. This also has a computer device which helps to sharpen the image by 'freezing' the 'snow' on the picture. This is particularly useful for studying spectra.

For direct pictures of small areas of the sky a charge coupled device (CCD) will be used. This consists of a large silicon chip which is sensitive to light. The CCD is about thirty times more sensitive than the best photographic emulsion. It is therefore possible for the exposure time to be cut from hours to a few minutes, thus cutting the exposure time of each observation and also getting more reliable data at a greatly increased rate.

Other facilities available will be 'speckle interferometry' which will enable images to be reliably photographed. This method enabled astronomers to show that the planet Pluto consisted of two bodies separated by only a short distance. The density also was much lower than had been previously thought.

These new techniques are very useful especially when false colour is used to model very faint and distant objects like the recently discovered 'black hole'.

Although there will always be resident astronomers at the La Palma observatory British astronomers will be able to control the three main telescopes from the Royal Greenwich Observatory at Herstmonceux in Sussex. This is the remote operation which will be made by telephone; from the control room they will be able to look through to the telescopes via their television screens. This will save time and money and enable those in the observatory to watch the screens at Herstmonceux, even collectively, if anything specially interesting is found.

WHY LA PALMA?

With the emphasis moving from the bright stars to distant faint objects some of the original objectives have been revised and by the time that the Isaac Newton 100 inch mirror telescope had been fully available the emphasis in astronomy had moved to the investigation of faint objects. It was this new area of astronomical research that led to the choice of La Palma as the final site for this telescope.

In 1969 a committee was set up to decide upon the best site for a telescope and observatory to be known as the Northern Hemisphere Observatory. It needed to be able to provide clear 'seeing' free from dust in the atmosphere. The images were not to be of such a nature that there was turbulence which would spread and distort the image. There had to be a very dark sky, far from man made sources of interference. In 1971 a team tested places in Italy, the South mainland of Spain, the Cape Verde Islands, Madeira, Hawaii, Tenerife and La Palma. The sites were narrowed down to a choice between Hawaii and La Palma. It was decided that there would be difficulties at Hawaii because of the altitude and so La Palma was chosen. Hawaii however is more suitable for infra-red and millimetre astronomy.

The peak of La Palma, which is on the edge of its volcanic caldera, is 2,400 metres high. It is elevated enough to be a suitable site but it is not inconveniently high. Its great advantage is that it is above the clouds for most of the time and above the inversion layer which keeps down the water vapour and the dust in the lower atmosphere. The air above comes in a steady stream from over the Atlantic. The sea temperature alters less between day and night than land temperatures. So this is favourable and light is less likely to blur the images of the stars and faint objects. It is likely that this will be a successful venture for the Northern Hemisphere and future source of research and new discovery.

VENUS

It is well established now that there are indications of vulcanism on Venus though there may not be direct and short term eruptions. Better methods have been developed over the last few years of gathering details. A great deal of the credit for this must go to the Russian spacecraft and probes. Peter Cattermole of Sheffield University is very active in this field and Anglo - Australian research, particularly in the infra-red, has led to greater accuracy in mapping the dark side of this planet.

Be that as it may the news recently from America suggests that there are signs of eruptions every 5 to 10 years. The last one, it is suggested, was in 1976. This was thought to be as catastrophic as Krakatoa. There are two regions, thousands of kilometres apart, that are suggested as being the main places of activity. There seems to be great structural differences between Venus and the Earth, though they came into being at the same time some 4,000 million years ago.

In February this year three American astronomers released information about the results of their findings using data from NASA's Ames Research Centre. The three researchers were H. Masursky of the US Geological Survey, L. Esposito from the

Frank Wilsenham Hyde

FRANK Wilsenham Hyde, author of *Spacewatch*, died on March 22, aged 75. A respected and admired contributor well known to readers of Practical Electronics for his enlightening monthly commentary on extra terrestrial exploratory matters, Frank was also, to those who knew him personally, a kindly and unassuming individual though always capable of provoking deep thought and discussion in many subjects. Indeed his scientific and engineering knowledge and experience encompassed many disciplines. However it was to radio astronomy that Frank was especially devoted for most of his life. This interest commenced in his teens, for it was while an engineering apprentice with Crompton-Parkinson at Chelmsford he first began pioneer investigations in radio physics.

In 1950 he began serious work in radio astronomy and set up at Little Claston, in Essex, what was the largest privately owned radio observatory in the world. He worked with Cambridge and Jodrell Bank and had a special assignment when the first earth satellite was launched and made certain discoveries regarding the ionosphere. Also at this time he was engaged in the special electrical Meeting of Jupiter which was later funded by the National Aeronautics and Space Administration of America (NASA). Some of the experiments on Pioneer 10 and 11 were the direct sequel to this work. He continued to work in collaboration with Cambridge in the study of the Crab Nebula, Quasars and the Solar Wind.

The unique experience of working closely with leading academics in this young branch of science, and being associated with major discoveries in space, made Frank Hyde the ideal choice as commentator for Practical Electronics on this emergent field in which electronics played a vital part. The first Spacewatch appeared in October 1967, and for two years was bi-monthly until March 1969 when increasing activity in the space sciences made a regular monthly article imperative.

Spacewatch soon became compulsive reading even for those who had no special interest in satellites or space exploration in general, for it frequently contained snippets of information of even wider interest and potential application—the so-called spin-offs from space technology. Frank was often the first into print with such technical titbits.

Frank Hyde's story seems to confirm the view that there is intellectual or philosophical reward in the study of space; that it unshackles the mind from earthly prejudices and limited vision. Right up to his death Frank actively pursued a number of interests, with dedication. These included some less than conventional "fringe" topics such as paraphysics and he also became a keen advocate for the revival of the airship as a commercially viable form of transport, particularly for bulky loads to not easily accessible places.

Frank was the author of two books on radio astronomy and he contributed articles to various magazines. He was an accomplished lecturer, delivering lucid accounts of radio astronomy techniques to Societies, Schools and Universities. He appeared in a number of television programmes and had also been interviewed on radio in connection with space matters. He was a Fellow of the Society of Engineers, Fellow of the Society of Professional Engineers, and Past President of both. He was a founder member of the Airship Association and a Fellow of the Royal Astronomical Society. Awards were made by several learned societies to Frank Hyde for his contributions to radio astronomy.

Fred Bennett

University of Colorado and F. Scarf of the Aerospace Company TRW Inc. The news was unexpected and startling.

The story begins with an eruption on Earth: in 1982 the volcano El Chichon in Mexico erupted. A small spacecraft operating under the control of Esposito's group detected large amounts of sulphur dioxide in the Earth's atmosphere and this led to the examination of previous records. He examined the data from spectrometer reading of Pioneer Venus. He found that the records showed that a large injection of sulphur dioxide had been noted a few months *before* Pioneer Venus began collecting data in 1978. The levels were about 50 times higher during that time. Since then the readings have been declining. From the rate of decline it was apparent that the level must have been much higher than would have been expected from El Chichon. Indeed it was so powerful that the injection came up through the dense atmosphere of Venus (more than 100 times that of the Earth), to rise some 70 kilometres from the surface of the planet.

Masursky's map had helped to show that the volcanoes on Venus were situated in two regions. One of these is called Beta Regio. It runs North/South for at least 2,000 km. It is thought that there are two shield volcanoes. The other volcano is called Atla Regio and is on the Eastern coast of a large continent, Aphrodita Terra.

There is evidence of gravitational anomalies about the regions. The areas are young from the geological point of view, being probably less than one million years old. This is supported by findings on Earth, the gravity anomaly being a factor of all young volcanoes. These anomalies are caused by underlying regions being uneven. Those of Venus were sufficient for the spacecraft to register the stress.

The contribution of the third participant in this discovery (F. Scarf) was the data culled from the lightning phenomena from which he has been collecting data since 1976. He detected continual lightning bolts occurring in the areas of the two volcanoes, the Beta and Atla regions. Of course there are others who dispute this. However the evidence of Esposito supports his views.

A fascinating picture emerges from these findings. For instance it may be that Venus is unable to rid itself of internal heat in the way that the Earth does. It may be that the water that Venus once had and what remains is in the atmosphere and that this has left no 'breathing' mechanism and so since Venus does not seem to have a techtonic plate system the solid mass is heating up causing the planet to erupt in order to reduce stresses. It would certainly seem that the present conditions and those that are expected will preclude a man landing in the foreseeable future. Is it not the case that there are changes in direction in scientific endeavour? Now emphasis has turned again to near *and* very far objects for study; at a meeting at the Royal Society jointly held with the RAS, the Solar system was the subject of much new-wave thinking.

Frank W. Hyde

Ingenuity Unlimited

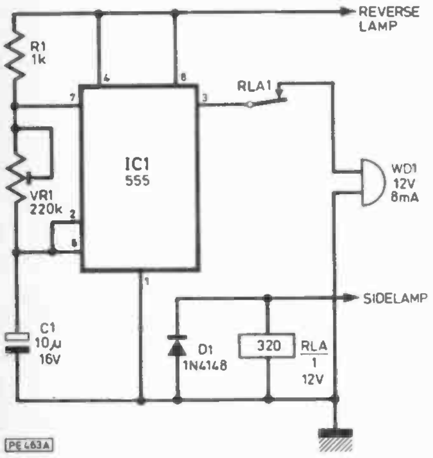
A selection of readers' original circuit ideas.

Why not submit *your* idea? Any idea published will be awarded payment according to its merits.

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

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not in the text.

AUDIBLE REVERSING ALARM



THIS circuit was designed to produce a low cost "car reversing alarm," which is already compulsory in some European countries. In this circuit a 555 Timer is used to drive a piezo electric buzzer at a frequency set by VR1, whenever the reversing lights are operated during the daytime. To eliminate any noise nuisance at night a relay RLA1 is wired to operate when the side lights are on, thus disconnecting the buzzer.

If the circuit is mounted in the boot, then the sound output can easily be heard (80dB). The unit costs about £5 which is cheaper than most other varieties already available on the market.

J. McPherson,
Houston,
Renfrewshire.

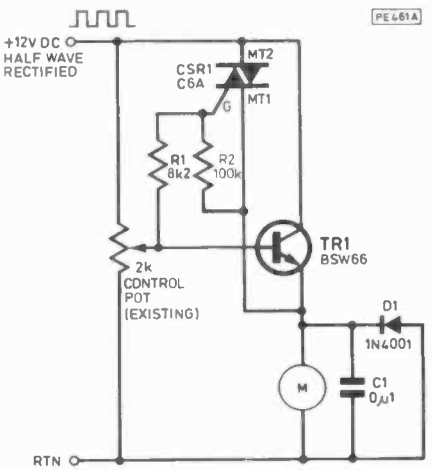
SCALECTRIX MOTOR CONTROL

THIS circuit was designed to improve and prolong the use of the hand-held Scalectrix controller. The circuit utilises the existing 2K slider pot and all the components easily fit into the controller case.

In normal use the slider potentiometer is prone to burn out, so an emitter follower TR1 was introduced to reduce the current flow. During tests, however, erratic start up, stiction and current hysteresis were problems that were solved by the inclusion of a silicon-controlled rectifier CSR1.

As the wiper is moved towards the supply line, CSR1 will fire, giving maximum current through the motor. This pulsed current gets the motor going and produces the usual back e.m.f. to give subsequent smooth linear speed control. Suppression components D1 and C1 were included to give protection to TR1.

A. Cook,
Burgess Hill,
West Sussex.



PE micro~file

R.W.Coles

FILESHEET 16 16032

DURING the last two file articles we have focused the spotlight on National Semiconductor and two of its most popular processors, the 8073 and the NSC 800. We have found that National, while being indisputably the largest semiconductor manufacturer in Silicon Valley, and despite having been involved in the microprocessor scene from its early days, has nevertheless managed to come fourth in what is essentially a four horse race.

This rather mediocre performance has not been ignored in the National boardroom, and the obvious success of upstarts like Intel and Zilog was not to be left unchallenged for long. The National response has now arrived, in the form of the NS16000 microprocessor family, and for once the whole industry has had to stop and take stock in the face of what can only be described as a massive onslaught from a company that hitherto had been considered to be a rank outsider!

It is the sheer *scale* of the National response which takes one's breath away. Having seen Intel's 8086 architectural problems caused by 8080 compatibility, Zilog's Z8000 failure caused by a messy instruction set and lack of an 8 bit bus version, and Motorola's lateness in providing a proper family of peripheral devices for its 68000, National decided to take on the whole bunch with a processor family which would suffer from none of these drawbacks. Easy to say, of course, but actually pulling it off was a mammoth task. It involved introducing a complete new family of microprocessors and peripherals all within the space of about twelve months, which would be a remarkable achievement for anyone, if, indeed, it could be done at all.

The first family member, the NS16032 16 bit processor described here, arrived in late 1982, and, keyed to an unprecedented barrage of marketing ballyhoo which kept potential designers saturated with relevant facts and figures, the other family members arrived as if fired from a machine gun. Now, not much more than a year later, we find ourselves able to choose from a compatible family which includes the basic NS16032, the 8 bit bus NS16008 and the 32 bit NS32032, and able also to select the NS16081 floating point math unit and the NS16082 memory manager to complement them if needed. From being the last to introduce a modern 16 bit processor, National now find themselves the first into 32 bits, a quite extraordinary situation.

It is tempting to think that such a rapid evolution must have resulted in a lot of rough edges and shortcomings in the National designs, but this does not appear to be the case. The basic family architecture is at least as elegant as that of last year's "Miss-Microprocessor", the 68000, and yet it offers higher performance and better intra-family compatibility.

It is difficult to judge just how well any new device is actually supported, because what is promised in the ads is not always fulfilled in practice, but one thing National *have* managed to convince me of is their on-going *commitment* to the new family, a feature often sadly lacking or short-lived in their earlier efforts. Certainly, National have had to work twice as hard as their competition to convince doubting designers of their sincerity, thanks mainly to their rather unimpressive track record!

The basic 16032 processor is most easily compared with the 68000, because like that Motorola processor, it uses 32 bit internal data pathways and registers and has a simple, regular, instruction set which supports a wide range of addressing modes and data types. Unlike the basic 68000 though, the 16032 and all its cousins support virtual memory operations directly, making it competitive not just with earlier mini-computers such as the PDP 11 but also with full blown 32 bit midi-computers such as the ubiquitous VAX.

A major aim of the National designers was to make their architecture as compatible as possible with the data structures and concepts used in modern high level languages such as Pascal so that compiled code would run as efficiently as assembled code without suffering the speed penalties usually encountered (particularly with 8 bit machines) in trying to force the high level language "square-peg" into the processor "round-hole". I think they have succeeded in this aim, and I doubt whether many users, even those designing fast real-time controllers, will ever have to bother with the tedium of assembly language when using a member of the 16000 family.

REGISTERS

The 16032 register set is similar in many respects to that available on the 68000. Most registers are 32 bits long to provide immediate compatibility with the 32032 processor and a potential address space of 4 Gigabytes, 16 Megabytes of which are directly implemented by the 16032.

The set is organised into two main groups consisting of eight general purpose data or address registers and eight special purpose registers. The general purpose registers are all 32 bits long and can be used for high speed access to data or address information. The registers in this group will store bytes, words, double words, or (in pairs) quad words, and can be used as accumulators, data registers, or as address pointers; any instruction can use them without restriction. Another eight general registers are made available externally when the 16081 Floating Point Unit (FPU) is added to a system.

The special purpose group contains six 32 bit registers which are reduced in the 16032 to 24 bits (the width of the address bus) by having the high order 8 bits set to zero. In addition there are two 16 bit special purpose registers, making eight in all. The individual members of this group are described below:

Interrupt Base Register; this register holds the base address of the interrupt vector table (called the dispatch table by National) which can be located anywhere in the 16 M byte address range. A single external 16202 Interrupt Control Unit (ICU) can provide up to 16 separate interrupt vectors, expandable to a maximum of 256 levels with additional ICUs. Each entry in the despatch table is 32 bits long.

Static Base Register; this points to the base address for address calculations used to access the global variables of a particular software module. All procedures within a module access any common module variables relative to the base address stored in this register. The provision of this feature is particularly valuable in supporting the modular code produced as a natural consequence of using high level languages such as Pascal.

Frame Pointer; while the SBR is used as a base address for module-wide *global* variables, the Frame Pointer performs a similar function but provides a base pointer for a frame of *local* variables and parameters which are relevant only to the currently executing procedure. This register is therefore reloaded for each new procedure within a module, whereas the SBR is only reloaded on the commencement of a new module, which may itself contain many procedures.

16032 REFERENCE FILE SHEET

GENERAL

With a poor record for being disloyal to users of its previous microprocessor designs, National has had to go all-out with its marketing effort for the 16032. Although this processor is probably the best 16 bit device available, and despite Nationals creditable efforts in providing a high level of hardware and software support, the late arrival of this chip has virtually precluded it from achieving a leading position. This situation may change with the early introduction of the compatible 32 bit 32032, since it will be the first mainline 32 bit device to become available and this will undoubtedly boost sales of the whole family.

REGISTERS

THE 16032 HAS A USEFUL SET OF DEDICATED AND GENERAL PURPOSE REGISTERS, MOST OF WHICH ARE 32 BITS WIDE.

31–23	23–0		
'0'	INTERRUPT BASE REG	INTBASE	
'0'	STATIC BASE REG	SB	
'0'	FRAME POINTER	FP	EIGHT
'0'	USER STACK POINTER	SP1	SPECIAL
'0'	INTERRUPT STACK POINTER	SPO	PURPOSE
'0'	PROGRAM COUNTER	PC	REGISTERS
	PROGRAM STATUS (bits 15–0)	PSR	
	MODULE (bits 15–0)	MOD	

31 … 0		
	R0	EIGHT GENERAL REGISTERS
	R1	
	R2	
	R3	
	R4	
	R5	
	R6	
	R7	

3			0	
C	M	F	I	CFG — 4 BIT CONFIGURATION REGISTER

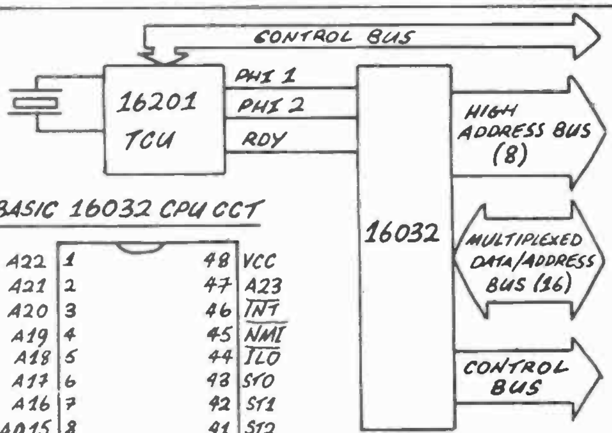
FLAGS

15 SUPERVISOR ONLY 8 | 7 USER & SUPERVISOR 0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
X	X	X	X	I	P	S	U	Z	F	X	X	X	L	T	Cy

INSTRUCTION SET AND SOFTWARE

With a 16 M byte linear address space, virtual memory capability and a powerful two address instruction set optimised for high level language compilation, the 16032 will probably appeal to all data processing fans. National have put together a useful software development environment which includes UNIX and CP/M operating systems and most of the popular languages. Until someone introduces a popular 16032 based PC, however, application software will remain a problem.



BASIC 16032 CPU CCT

		16032		
A22	1		48	VCC
A21	2		47	A23
A20	3		46	$\overline{INT}$
A19	4		45	$\overline{NMI}$
A18	5		44	$\overline{ILO}$
A17	6		43	ST0
A16	7		42	ST1
AD15	8		41	ST2
AD14	9		40	ST3
AD13	10		39	$\overline{PFS}$
AD12	11	16032	38	$\overline{DDIN}$
AD11	12		37	$\overline{ADS}$
AD10	13		36	U/$\overline{S}$
AD9	14		35	AT/$\overline{SPC}$
AD8	15		34	$\overline{RST/ABT}$
AD7	16		33	$\overline{DS}$/$\overline{FLT}$
AD6	17		32	$\overline{HBE}$
AD5	18		31	$\overline{HLDA}$
AD4	19		30	$\overline{HOLD}$
AD3	20		29	BBG
AD2	21		28	RDY
AD1	22		27	PHI2
AD0	23		26	PHI1
GNDL	24		25	GNDB

OTHER FAMILY MEMBERS

- 16008 — 16032 WITH 8 BIT EXTERNAL DATA BUS. 48 PIN PACKAGE.
- 32032 — 16032 WITH FULL 32 BIT EXTERNAL DATA BUS. USES 68 PIN L.C.C. PACKAGE.

PERFORMANCE DATA

	16032
MEMORY ADDRESS RANGE :-	16M byte
I/O ADDRESS RANGE :-	(MEMORY MAPPED)
CLOCK FREQUENCY :-	6MHz*
POWER SUPPLIES :-	5V
INTERRUPTS :-	$\overline{INT}$, $\overline{NMI}$

*10MHz ALSO AVAILABLE

BENCHMARKS	16032
ADD REG TO REG	0.67µs
O/P REG TO PORT	2.7µs
MOVE FROM MEMORY TO MEMORY (16 BIT DATA, ABSOLUTE ADDRESSING)	4.7µs

MANUFACTURERS

ORIGINATOR :- NATIONAL SEMICONDUCTOR

2ND SOURCE :- FAIRCHILD

SUPPORT CHIPS

THE 16032 NEEDS AN EXTERNAL TIMING CONTROL UNIT (TCU) TO ACT AS CLOCK AND WAIT STATE GENERATOR AND HAS A USEFUL, GROWING, FAMILY OF POWERFUL PERIPHERAL CIRCUITS SUCH AS THE 16081 FLOATING POINT MATH UNIT, THE 16082 MEMORY MANAGEMENT UNIT AND THE 16202 INTERRUPT CONTROL UNIT.

Module Register; all NS16000 programs are organized as modules, and each module consists of three components, namely the program code, the static data, and a link table which contains entries describing any variables or procedures which may be needed but happen to be resident in other modules. Also provided is a Module Table which must be set up in low memory to contain a Module Descriptor for each module used by a program. There are three 32 bit entries in each Module Table comprising a Static Base address (to load into the SBR), a Link Base address, which points to the start of the module's Link Table, and a Program Base address which points to the start of the code. The 16 bit Module Register is used to hold the base address to the Module Descriptor for the current module. (Phew!)

PC, SPO, SP1 and PSR; the remaining four dedicated registers are fairly conventional, and consist of a 24 bit program counter (PC), two 24 bit stack pointers (SPO and SP1) and a 16 bit flag or status register (PSR).

Also worthy of note is the four bit Configuration Register (CFG) which lives within the control section of the CPU architecture. This register can only be modified via the special SET CFG instruction, and it is used by the programmer to declare the presence of various external peripheral devices. The I bit informs the processor that an external vectored interrupt controller (e.g. the NS 16202) is present, and that a vector will be provided. The F, M, and C bits perform a similar function for the floating point arithmetic unit (NS-16081), the memory management unit (NS16082), and any presently unspecified "Custom Slave Processors".

Before leaving the subject of the sophisticated register set of the NS16000 series, it is also interesting to note that the register addressing scheme used actually supports the use of additional registers *outside* the CPU chip itself. For example the NS16081 provides another eight general purpose registers and one special, all of which can be treated as though they are part of the basic CPU set. This is an extremely useful facility and provides a lot of "stretch" potential to the current architecture.

INSTRUCTION SET

The instruction set of the 16000 series of processors will bring tears of joy to the eyes of system software writers, because it is so symmetrical and efficient, and because it comes closer than any I have seen to the ideal for use with high level language compilers.

Instructions can be used with any of nine addressing modes, any of the byte, word, and double word data types, and can employ any of the general purpose registers. In addition, the instructions can all specify at least two operands, and in some cases up to five. Each basic instruction consists of between one and three bytes of code which may be optionally extended depending on the instruction type and addressing modes selected as follows:—

OPTIONAL					BASIC		
IMPLIED IMMEDIATE OPERAND(S)	DISP. 2 / IMM 2	DISP. 1 / IMM 1	INDEX BYTE 2	INDEX BYTE 1	GEN. ADDR. MODE 1	GEN. ADDR. MODE 2	OPCODE

There are over 100 basic instruction types as shown in the listing. Four standard addressing modes are provided as follows:—

REGISTER Used to specify an operand located in one of eight *internal* general purpose registers, or in the case of certain slave processor instructions, one of eight *external* general purpose registers.

IMMEDIATE Used to specify an operand encoded with the instruction (as usual).

ABSOLUTE Used to specify an absolute memory address, although in this case the "absolute" value is really a displacement from a base register.

REGISTER RELATIVE used to form a register-indirect address computed from the contents of a general purpose register and a displacement value issued with the instruction.

And in addition a group of five so-called high-level-language modes are provided to satisfy the needs of compiler writers:—

MEMORY MODE This mode is similar to Register Relative, but in this case a dedicated register is used.

MEMORY RELATIVE This mode allows the direct use of address pointers stored in main memory without the need to first load the pointer value into a CPU register. This is useful for rapid access to tables of data or records in RAM.

EXTERNAL This mode is unique to the NS16000 series and provides support for the "software-module" approach (mentioned in the register section) by providing a means to access operands that do not reside in the currently executing module.

TOP OF STACK Another NS16000 family special, this mode provides push and pop access to operands on the stack for *all* instructions, not just those provided specifically for the purpose as in most other processors. This is particularly useful for arithmetic procedures.

SCALED INDEX This mode provides "smart" indexed addressing to allow access to arrays of data organised on a byte, word, double word, or quad word, basis. A general purpose register value is used as the index, and this is automatically multiplied by one, two, four or eight to achieve the correct stepping increment for the particular array data type involved. Thus a single register increment operation can be used to step through arrays of data organised to contain 64 bit entries.

No doubt many readers (including, it must be admitted, the author!) will find the above addressing modes rather daunting and beyond past experience or recognised need. Fortunately, the only people who really need to come to grips with these fancy features are the system software and compiler writers. This is because, as mentioned earlier, ordinary mortals like us will only need to write code for the NS16000 in a high level language such as Pascal, where all these sophisticated capabilities only become obvious when we notice that our program runs very fast indeed and uses very little memory. What a relief!

Trying to summarise the instruction types available is also a daunting task. Suffice to say that everything you are likely to need is there in abundance including multiply and divide, BCD arithmetic, string handling and bit manipulation. If there *is* anything missing, however, it can always be provided via a "custom slave" processor since the instruction set provides direct access to this facility. In a similar vein, a complete set of floating point math and memory management instructions are included for use on systems containing the 16081 and 16082 devices. This is a great deal simpler than the load/unload operations often required by other microprocessors to gain access to their dedicated slaves.

VIRTUAL MEMORY

One of the most important features of the NS16032 and its cousins is that they support the concept of "Virtual Memory". Since this National family is the first we have covered in the Microfile series to feature this useful capability, it is necessary to have a look at the concept and the way that NS16032 handles it, in more detail.

With the size of software modules growing ever larger, and with the need for multiple programs to "time-share" the CPU resources, then even with the low cost of today's dynamic RAM chips, system designers find it difficult to provide a sufficiently large physical memory space to allow all programs and users sufficient space.

One way to overcome this problem which is supported by many disc BASICs, is to use an overlay mechanism by which the programmer, realising that his code is becoming too large to fit comfortably in memory, can divide his program into a number of overlay segments, only one of which is loaded from disc into RAM at any one time. The trouble with this technique is that the programmer must make the overlay decisions himself while writing the program and on multi-user systems it is virtually impossible to decide in advance just how much memory will be available at run time.

A much neater technique would be to let the programmer use as much memory space as he needs, without the need to worry about overlays, and then let the *system* decide at run time how much physical memory can be allocated. This is just what the Virtual Memory concept provides, but a processor using it has a problem on its hands which can only be solved by additional chip complexity. If the operating system allocates 4K bytes, for example, and the program happens to be 40K bytes long, then when the processor attempts to fetch the (4K + 1)th code byte, it must be able to recognise its "mistake", abort the current instruction, and ensure that the operating system is informed so that another chunk of code can be loaded from disc into the allotted space, and execution resumed without the loss of a single instruction. This is obviously a neat trick if you can pull it off, and fortunately for us, the NS16000 family can!

When mated with an NS16082 MMU the NS16032's 16M byte *logical* address space is effectively divided into 32,768 pages, each of a fixed size of 512 bytes, which may (or may not) be represented in *physical* memory. Each program or task can make use of an apparent 16M bytes of memory, although in fact, the MMU relocates the addresses it receives by mapping them into the actual physical memory available. Programs and data are swopped in and out of memory in units of a page, in an operation transparent to the programmer (other than by its effect on execution time), stage managed by the MMU and processor working together under the control of an appropriate virtual memory operating system software package.

The MMU uses an address table stored in RAM to map from *logical* to *physical* space, and in addition to address information, table entries include five bits which provide the MMU with information about the status of the page concerned, as follows:—

> **V**=Valid Bit, which indicates whether the page is actually present in memory. **R**=Referenced Bit, which indicates whether the page has been accessed. **M**=Modified Bit which indicates whether the page has been written into. **PL**=Protection Level field (2 bits) which indicates whether the page can be used for Read Only or Read/Write operations.

These status bits provide all the necessary information for the proper implementation of a Virtual Memory operating system and its page swopping algorithms.

When the MMU receives an address for translation, it checks the Valid Bit in the page entry to see whether the required page is actually resident in physical memory. If it is not, then the MMU detects a "page fault" and generates an ABORT signal which causes the processor to halt execution of the current instruction.

In effect the ABORT signal is like an interrupt, and causes the processor to restore register information to its status *before* the current instruction was attempted, and then to call the operating system to sort the whole mess out. Horrific and tangled though the job may seem to *us*, the NS16032 (with the aid of suitable system software) is able to find a suitable page space, store the code already resident there onto the disc, load the next page from disc into RAM, and get the whole thing up and running again in next to no time.

Needless to say, the availability of a Virtual Memory operating system on a desk top microprocessor will endow that humble system with capabilities which are currently far above its status. Such systems will no doubt become available quite soon, thanks not only to the NS16000 family, but also to the availability of capacious, cheap and fast access Winchester hard-disc drives.

SOFTWARE

The Achilles heel of all radically new microprocessors is to be found in the level of software support that they enjoy. With the NS16032 National have had to start from scratch, but despite this fundamental obstacle, they have managed to produce (with the help of third party software houses) a creditable array of software tools which includes about five operating systems and thirteen languages!

Included among the operating systems are old favourites like UNIX (employing Virtual Memory), and CP/M in its Concurrent CP/M form from Digital Research.

All of this is very encouraging, but what counts in the end will be the availability of applications packages such as spread-sheets, word-processors, and payroll ledgers, and these are traditionally supplied by a lower echelon of third party software houses over which National can have no control.

What National have to do, and they know it, is to keep up such a barrage of ballyhoo that the World will finally succumb and generate a demand for such software. If they stop now, regardless of how wonderful their new processor family may be, the whole thing will fizzle out like a damp squid.

INTERFACING

There seems to be little point in delving too deeply into the hardware interfacing of such a mighty machine, because it will be some time before the average hobbyist will pluck up the courage to tackle a project based upon the NS16032! Not that there is anything especially *difficult* about designing and building such a system, the problem in this case lies in developing the software to do the system justice. With the availability of easy-to-interface memory and peripheral chips we enjoy today, the assembly of an NS16032 system would probably be a lot simpler than building one of those "8080A and 4K of dynamic RAM" systems of yesteryear.

Suffice to say that, as we have come to expect, the 16032 uses a form of NMOS technology, operates from a five volt supply, and provides all the necessary bus signals to make interfacing straightforward. About the only surprising thing concerning this device, in fact, is that it does require a separate clock generator and controller chip, the NS16201, which uses a 24 pin package.

APPLICATIONS

There can be little doubt that the NS16032 is the most powerful and capable 16 bit microprocessor yet developed, and if there is any justice in this world, it should go on to establish a star-studded career for itself in the data processing system market.

At present, however, it is difficult to imagine how such a device can be used to advantage in a small home computer application unless it is provided with at least one Winchester disc drive to act as a backing store. An NS16032 saddled with only a cassette port would be rather like a Porsche deprived of its wheels: lots of fun revving the engine but it won't actually be able to *go* anywhere!

Fortunately for us, Winchester disc drives are getting cheaper, and even Sir Clive will be offering one as an optional peripheral with his new QL machine so perhaps we won't have too long to wait before we can all tap the power of National's behemoth. One system which may be first in line for an NS16032 upgrade is the BBC micro, for which such a facility has been planned since before the original launch, while the NS16000 family was still just a twinkle in National's eye.

One thing is for sure though, this device is *not* the thing to use for your doorbell or central heating controller!

INSTRUCTION SET SUMMARY

MNEMONIC	DESCRIPTION	MNEMONIC	DESCRIPTION
MOVES		**LOGICAL AND BOOLEAN**	
MOVi	Move a value.	ANDi	Logical AND.
MOVQi	Extend and move a 4-bit constant.	ORi	Logical OR.
MOVMi	Move Multiple: disp bytes.	BICi	Clear selected bits.
MOVZBW	Move with zero extension.	XORi	Logical Exclusive OR.
MOVZiD	Move with zero extension.	COMi	Complement all bits.
MOVXBW	Move with sign extension.	NOTi	Boolean complement: LSB only.
MOVXiD	Move with sign extension.	Scondi	Save condition code (cond) as a Boolean variable of size i.
ADDR	Move Effective Address.		

INTEGER ARITHMETIC

ADDi	Add.
ADDQi	Add 4-bit constant.
ADDCi	Add with carry.
SUBi	Subtract.
SUBCi	Subtract with carry (borrow).
NEGi	Negate (2's complement).
ABSi	Take absolute value.
MULi	Multiply.
QUOi	Divide, rounding toward zero.
REMi	Remainder from QUO.
DIVi	Divide, rounding down.
MODi	Remainder from DIV (Modulus).
MEIi	Multiply to Extended Integer.
DEIi	Divide Extended Integer.

INTEGER COMPARISON

CMPi	Compare.
CMPQi	Compare to 4-bit constant.
CMPMi	Compare Multiple: disp bytes.

PACKED DECIMAL (BCD)

ADDPi	Add Packed.
SUBPi	Subtract Packed.

FLOATING POINT

MOVf	Move a Floating Point value.
MOVLF	Move and shorten a Long value to Standard.
MOVFL	Move and lengthen a Standard value to Long.
MOVif	Convert any integer to Standard or Long Floating.
ROUNDfi	Convert to integer by rounding.
TRUNCfi	Convert to integer by truncating, toward zero.
FLOORfi	Convert to largest integer less than or equal to value.
ADDf	Add.
SUBf	Subtract.
MULf	Multiply.
DIVf	Divide.
CMPf	Compare.
NEGf	Negate.
ABSf	Take absolute value.
LFSR	Load FSR.
SFSR	Store FSR.

SHIFTS

LSHi	Logical Shift, left or right.
ASHi	Arithmetic Shift, left or right.
ROTi	Rotate, left or right.

BITS

TBITi	Test bit.
SBITi	Test and set bit.
SBITIi	Test and set bit, interlocked.
CBITi	Test and clear bit.
CBITIi	Test and clear bit, interlocked.
IBITi	Test and invert bit.
FFSi	Find first set bit.

JUMPS AND LINKAGE

JUMP	Jump.
BR	Branch (PC Relative).
Bcond	Conditional branch.
CASEi	Multiway branch.
ACBi	Add 4-bit constant and branch if non-zero.
JSR	Jump to subroutine.
BSR	Branch to subroutine.
CXP	Call external procedure.
CXPD	Call external procedure using descriptor.
SVC	Supervisor Call.
FLAG	Flag Trap.
BPT	Breakpoint Trap.
ENTER	Save registers and allocate stack frame.
EXIT	Restore registers and reclaim stack frame.
RET	Return from subroutine.
RXP	Return from external procedure call.
RETT	Return from trap. (Privileged)
RETI	Return from interrupt. (Privileged).

CPU REGISTER MANIPULATION

SAVE	Save General Purpose Registers.
RESTORE	Restore General Purpose Registers.
LPRi	Load Dedicated Register.
SPRi	Store Dedicated Register.
ADJSPi	Adjust Stack Pointer.
BISPSRi	Set selected bits in PSR.
BICPSRi	Clear selected bits in PSR.
SETCFG	Set Configuration Register.

MEMORY MANAGEMENT

LMR	Load Memory Management Register. (Privileged)
SMR	Store Memory Management Register. (Privileged)
RDVAL	Validate address for reading. (Privileged)
WRVAL	Validate address for writing. (Privileged)
MOVSUi	Move a value from Supervisor Space to User Space. (Privileged)
MOVUSi	Move a value from User Space to Supervisor Space. (Privileged)

ARRAYS

CHECKi	Index bounds check.
INDEXi	Recursive indexing step for multiple-dimensional arrays.

MISCELLANEOUS

NOP	No Operation.
WAIT	Wait for interrupt.
DIA	Diagnose. Single-byte.

CUSTOM SLAVE

CCAL0c CCAL1c CCAL2c CCAL3c	Custom Calculate.
CMOV0c CMOV1c CMOV2c	Custom Move.
CCMPc	Custom Compare.
CCV0ci CCV1ci CCV2ci CCV3ic CCV4DQ CCV5QD	Custom Convert.
LCSR	Load Custom Status Register.
SCSR	Store Custom Status Register.
CATST0	Custom Address/Test. (Privileged)
CATST1	(Privileged)
LCR	Load Custom Register. (Privileged)
SCR	Store Custom Register. (Privileged)

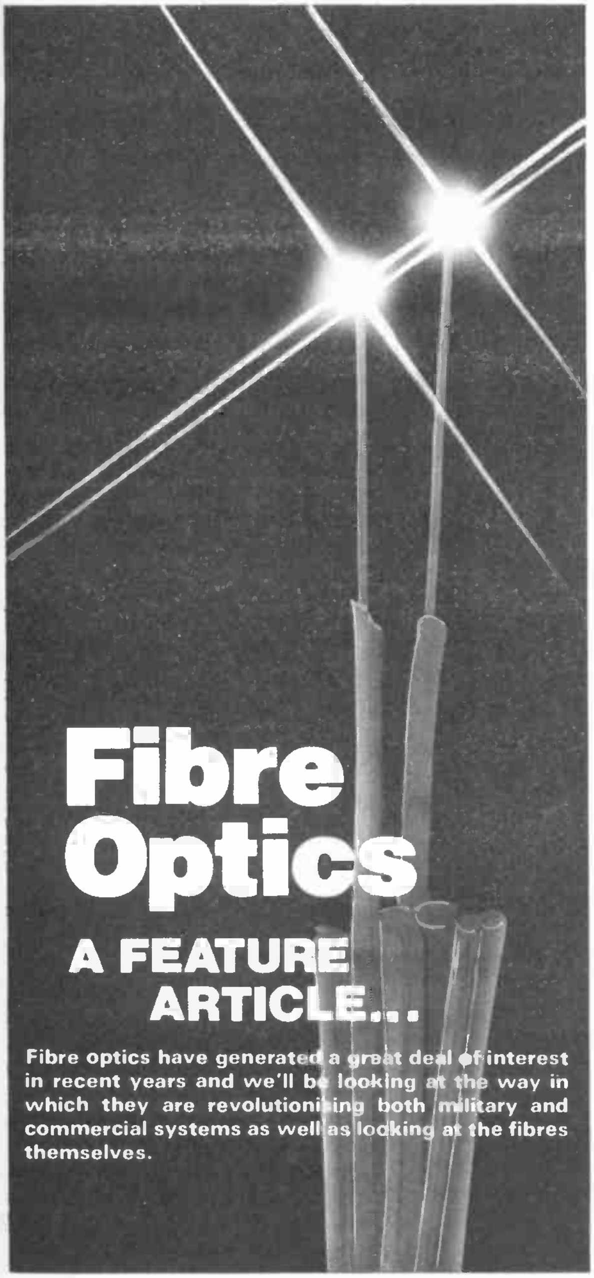
STRINGS

MOVSi	Move String 1 to String 2.
MOVST	Move string, translating bytes.
CMPSi	Compare String 1 to String 2.
CMPST	Compare, translating String 1 bytes.
SKPSi	Skip over String 1 entries.
SKPST	Skip, translating bytes for Until/While.

BIT FIELDS

EXTi	Extract bit field(array oriented).
INSi	Insert bit field (array oriented).
EXTSi	Extract bit field (short form).
INSSi	Insert bit field (short form).
CVTP	Convert to Bit Field Pointer.

all in your JULY issue!



SIMPLE LOGIC ANALYSER

With four address, and two data displays this simple micro' debugging tool can reveal memory contents, look for preset data and generate an oscilloscope trigger pulse at the required time.

SLIDE DISSOLVE CONTROL

Ideal for the budding audio-visual enthusiast this dissolve unit allows two projectors to be coupled together to give a slide dissolve with automatic slide change on the dimmed projector.

Also...

ADD ON SUB-WOOFER

PRACTICAL

ELECTRONICS

THE JULY ISSUE IS ON SALE FRIDAY, JUNE 1ST

Spot Pricing needs Electronics!

T.W. BERRIE Consultant

THE advent of cheap reliable small micro-computers, micro-processors and micro-controllers should usher in an era of spot-pricing for energy and public utility services which means cheaper energy and public utilities for all. To keep up the momentum, electronics experts must continue the good work by rising to the challenge, studying spot-pricing systems and putting the hardware and software elements of such systems together so that they work efficiently.

INTRODUCTION

The energy and public utilities sectors will have to depend a great deal for their future viability on electronic systems. Such sectors are desperate to get their prices down following the oil price rises of the 1970s, but to achieve this some drastic re-thinking and restructuring of their methods of planning and operation is needed. Fortunately today technology can cope with such re-thinking and restructuring by encouraging spot-pricing of these services, using the widest range of electronic systems now available. Massive savings could be achieved by using an interactive supply/demand spot-pricing system.

£200M per annum could be saved by remote meter reading for instance. It is further estimated that £600-£700M might be saved from oil burning power stations if this type of control scheme were introduced.

The forecasting of demand is all important and an interactive control system could save another £500M here. Stand-by stations and peak-time power availability could be optimised. In all then savings in these sectors could reach £1400M+ per annum.

At present the planning of energy and public utilities' sectors is much complicated by the fact that it takes many years, possibly ten, to construct a project in them. The traditional planning process therefore tends to play safe by building up a margin of spare equipment in case, in the event, demand for energy or the services is greater than was forecast and/or more plant providing these services is out of commission than was forecast. Such margins of spare equipment can amount to 35% or more compared with planned requirements and they are very costly to provide. For operational planning, e.g. next week, month or year, smaller margins of spare equipment are planned for.

SPOT-PRICING

Spot-pricing eliminates this traditional "playing safe" in planning and operation because it ensures that the demand for the

Costs (at 1979/80 price levels)	Stage 1 1983	Stage 2 1984	Stage 3 1985	Stage 4 1986	Stage 5 1987	Stage 6 1988
1 Cumulative savings possible in England and Wales (see Part 1)	£100m	£350m	£650m	£900m	£1,100m	£1,400m
2 Savings per year equals capital charges per annum allowable in equipment for spot-pricing (per year)	£100m	£250m	£300m	£250m	£200m	£300m
3 Capital costs of equipment for spot-pricing (using 10% annuity factor) allowable (per year)	£1,000m	£2,500m	£3,000m	£2,500m	£2,000m	£3,000m
4 Number of consumers changed over to spot-pricing (per year)	50,000	150,000	500,000	5 million	10 million	5 million
5 Capital costs of equipment for spot-pricing allowable per consumer (3 ÷ 4)	£20,000	£16,500	£6,000	£500	£200	£600
6 Allowable cost of microprocessors, activating devices and communications channel (per consumer)	£15,000	£12,500	£4,000	£300	£150	£350
7 Allowable cost of experimentation and consumer education (per consumer)	£5,000	£4,000	£2,000	£200	£50	£250
8 Main thrust of implementation Note: Consumer apparatus economy of scale reached (stage 1) at end of 1984; stage 2 at end of 1986.	Large industrial and large commercial: initial stage	Large industrial & commercial: Follow-on stage	Medium industrial and medium commercial	Small commercial and residential: initial stage	Small commercial and residential: Follow-on stage	Residential: Final stage

Fig. 1. Implementation programme for interactive control with spot-pricing

energy or service in question in the event never exceeds the supply. It does this by:

(i) charging short-run marginal cost prices.

(ii) providing virtually instantaneous communication between supplier and consumer by electronic hardware and software systems which not only transmit information to ensure that supply and demand always balance but also control the joint producers/consumers systems to operate in an optimum manner, in real time if necessary.

ECONOMY

Economists are satisfied that spot-pricing jointly optimises the "welfare" (overall intrinsic benefits) of producers and consumers at any instant in time; this must be an improvement on the present pricing systems which are designed to optimise on a hypothetical situation expected to occur in the energy or public utility sectors at some point on the planning horizon. The spot-price for energy or a public utility service is the short-run variable costs, in the electricity case mainly fuel costs at any particular instant in time, except on those rare occasions when demand is trying to run ahead of supply, when a surcharge must be added to bring supply and demand back into line. There are no capital charges, fixed charges etc., because investment is part of a related but quite separate process to pricing. Investment will have a much more entrepreneural nature. Spot-pricing enables *all* producers of energy or suppliers of the service, part-time or full-time, private of public, to fully play a part in supplying the total need, not as is the case today when part-time electricity generators, for example, do not get a fair price for their product.

IMPLEMENTATION OF SPOT-PRICING

Fig. 1 gives an illustration of the kind of stages of implementation of a spot-pricing scheme and of the costs and cost savings that might be involved. Such an implementation table must eventually be drawn up for all energy and public utilities sectors for every country in the world. Implementation may well be carried out first in the developing countries because these countries have most proportionally to gain from the savings made by spot-pricing, especially the oil-importing developing countries where both investment capital and fuels are in short supply.

The equipment needed for implementing spot-pricing is illustrated in Fig. 2 and Fig. 3. This equipment, especially when used in the industrial sectors, must allow data and information to pass accurately and instantaneously between producers and consumers and vice-versa. The equipment can be broken down into three broad categories:

(i) Producer control and data/information, supplier/receiver apparatus.

(ii) Consumer control and data/information, supplier/receiver apparatus.

(iii) Transmission hardware and software systems between producers and consumers.

Fig. 4 (overleaf) shows this in greater detail.

Producers' and consumers' control apparatus has been under development for many years, e.g. to cater for the needs of load management control in the energy and electricity sectors, especially for industrial users. One such system has been devised by the South Eastern Electricity Board (Fig. 5). It incorporates microprocessor based Credit and Load Management Units (CALMU's). These units would replace present meters and their associated equipment. This system is in its infancy and at present is undergoing tests. What is needed after these tests is a hard look at how to make such apparatus as reliable and as cheap as possible, and to make any improvements in the other apparatus listed.

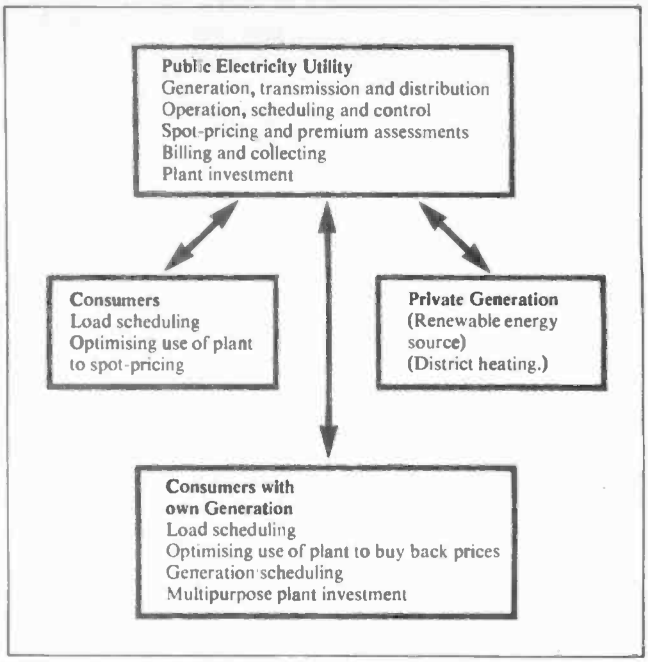


Fig. 2. The market place and institutional framework with full interactive control

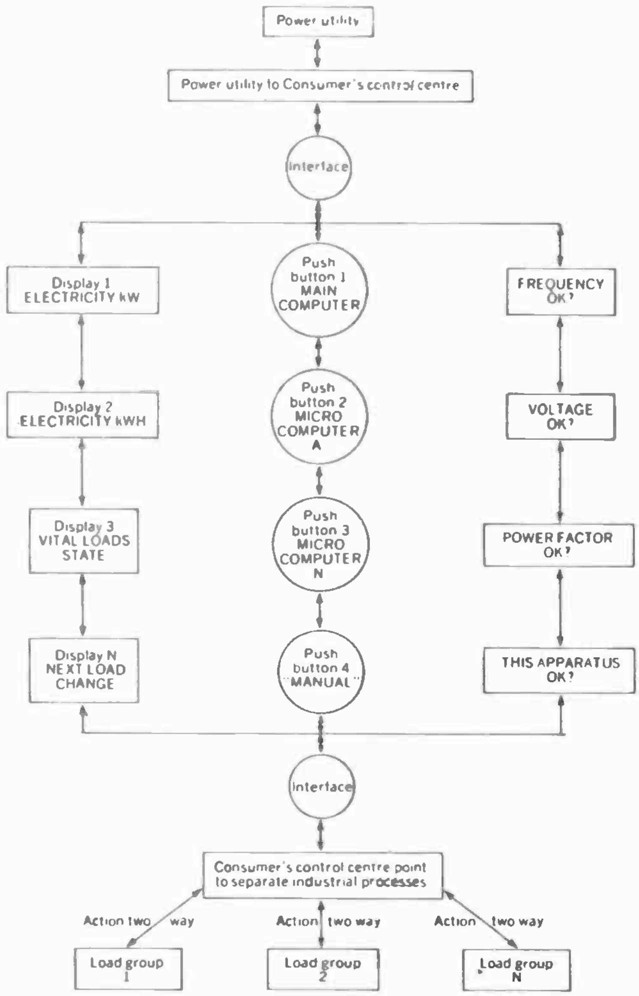


Fig. 3. Basic elements of an industrial consumer's interactive load control unit

Electricity Producers (full-time or part-time)
- Automatic generator control
- Automatic system control
- Automatic data collection, storage and processing
- Data and information systems
- Data transmission systems (internal)
- Management information systems
- Producers/consumers interfaces

Data Transmission
- Electricity, mains-borne
- Public radio, private radio, transmission and reception
- Public telecommunications network

Electricity Consumers (Industrial)
- Micro-computers and micro-processors
- Micro-controllers for industrial processes
- Data and information systems
- Data transmission systems (internal)
- Management information systems
- Consumers/producers interfaces

Electricity Consumers (Commercial and Domestic)
- Micro-computers
- Mini-controllers for energy and energy related systems
- Management information systems
- Consumers/producers interfaces

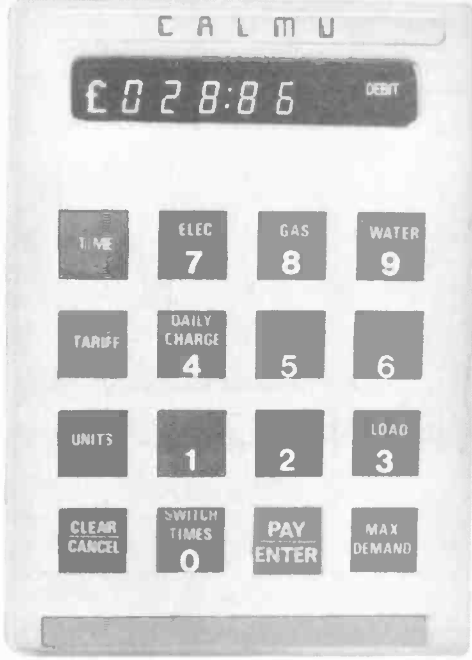
Other applications
- Remote reading of electricity, gas, water and telephone usage
- Payment of accounts for public utility and other services
- Consumer relations with producers
- Fault recording

Fig. 4. Opportunities for equipment manufacturers and contractors with energy spot-pricing

TRANSMISSION HARDWARE AND SOFTWARE SYSTEMS

Fig. 5 shows the three modes for data/information transmission:

(i) Using the public utilities' own system of wires/pipes, etc.
(ii) Using radio.
(iii) Using the public telecommunications network (PTN).



Credit and Load Management Unit (CALMU). This microprocessor controlled consumer unit will interact with the electricity board, optimising tariff rates and replacing the old meter system

These three modes, and especially the first two, have undergone extensive testing over many years and must be counted as technologically proven. However, there is still room for improvement and reductions in cost.

OPENING FOR ELECTRONICS

The author believes that spot-pricing of all energy and public utilities' services in every country in the world is inevitable and will be completed over the next 25 years. This includes a number of sectors: coal, oil, gas, electricity, water supply, telephones, roads, railways, shipping, airways, and probably banking and wholesale/retail marketing. The amount of cheap, reliable, small, efficient, plentiful electronic hardware and software equipment that will be required is truly immense, and it is up to the electronics industry as a whole to make it, sell it, supply it, test it, install it, and maintain it. ★

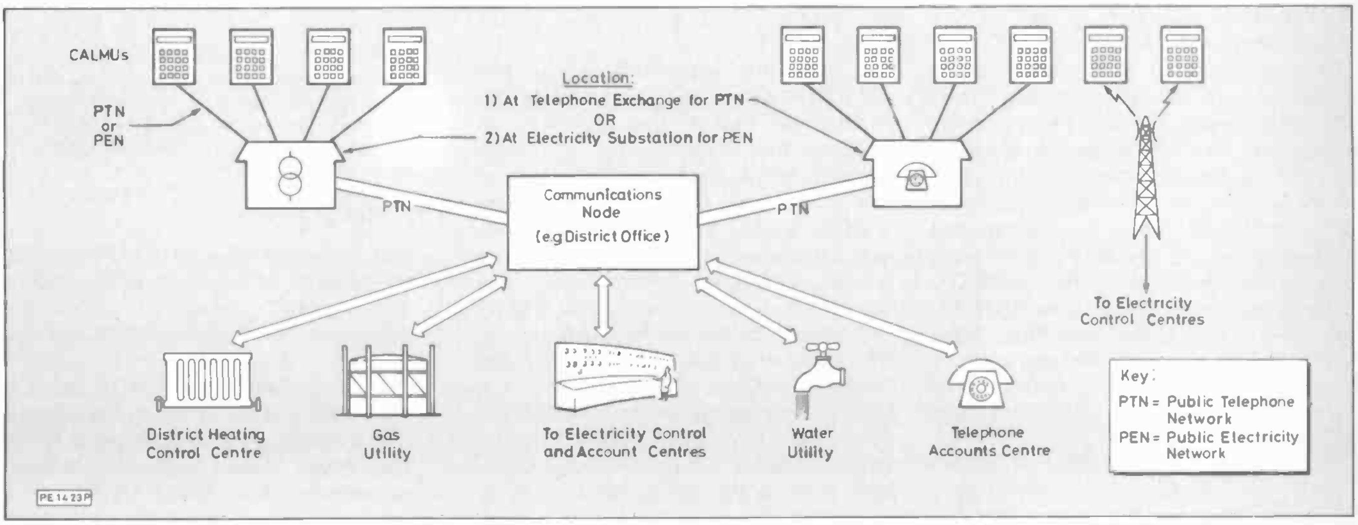


Fig. 5. SEEBoard CALMU interactive control communications network

INTRODUCTION TO DIGITAL ELECTRONICS

MICHAEL TOOLEY BA DAVID WHITFIELD MA MSc CEng MIEE

O & A Level CMOS

In this series so far we have used TTL gates to illustrate many of the basic principles of digital electronics. We also mentioned in Part One that these basic principles apply equally to logic families other than TTL, and in this last part of the series we will be looking to see how well the theory works in practice. As an alternative to the TTL family, we have chosen CMOS, a logic family which is fast emerging as a rival to TTL. We will start, therefore, by looking at some of the background to this emergence of CMOS as a popular general purpose logic family.

HISTORY OF CMOS

Until 1962 the only monolithic integrated circuits which were available used bipolar transistors as their basic active elements. In that year RCA developed the first i.c.s to use field effect transistors (FETs) as their basic elements. Since then, quite a number of ranges of digital i.c.s based on FET technology have been produced, and these have been given the general classification of MOS (metal-oxide-silicon) devices. Many of them actually now use a technology which has moved on beyond the basic FET, and usually now involves insulated gate FET types (IGFETs), but the general name remains. Some MOS digital logic uses only p-channel (PMOS) IGFETs, and some uses only n-channel (NMOS) IGFETs. The Complementary MOS (CMOS) logic family, however, uses a combination of both p-channel and n-channel IGFETs in its basic gate circuit.

Single-channel PMOS, developed from 1962 onwards, has been widely used in complex digital systems. Its use, however, has been largely confined to custom-designed devices. PMOS is easily recognised because of its negative supply rail, and is commercially much easier to produce than NMOS. Even so, only a few off-the-shelf PMOS i.c. families have appeared from more than one manufacturer, and consequently there has been little support for PMOS as a general purpose logic family.

With CMOS, however, the story has been rather different. The first commercial CMOS logic circuits (the CD4000 series) were produced by RCA in 1968. Although successful in their own way, the real breakthrough came in 1971 with the introduction of the much improved CD4000A series. This was due in no small part to the simultaneous production of the first "COS/MOS Integrated Circuit Manual". This designer's handbook has since achieved the same sort of following as TI's legendary "TTL Data Book", and is required reading for any CMOS designer.

Since the introduction of the CD4000A series, the range and performance of CMOS has steadily improved, and CMOS i.c.s are now offered by a significant number of manufacturers. The current standard CMOS range, the CD4000B series, was introduced in 1976 and represents a very significant improvement over the earlier A-series. Meanwhile, CMOS technology continues to advance, and the latest high-speed CMOS has the speed and drive capability to match LSTTL. This brings the story of CMOS up to date and identifies the B-series as the designer's current standard. It is now time, therefore, for us to look at the technology behind the name: "What *is* CMOS?"

BASIC PRINCIPLES OF CMOS

We will begin our study of CMOS by looking at some of the basic characteristics of the most popular CMOS logic range. The essential features of the CMOS 4000B series are summarised in Table 1. We would point out that the supply connections in CMOS are referred to as V_{DD} and V_{SS}, where the 'D' and 'S' refer to the drain and source of an n-channel FET, respectively.

The circuits work over a very wide power supply voltage range, typically from +3 to +15 volts.
The output changes from 0 to 1 at exactly halfway between V_{DD} and V_{SS}, giving good noise immunity.
Operating current is extremely low, particularly at low switching frequencies. CMOS circuits consequently run very cool.
The inputs to gates behave almost as if they are open circuits, and are thus very easy to drive.
The unloaded output logic swing goes from V_{SS} to V_{DD}.
The output stages do not generate large current spikes on the power lines, and thus CMOS circuits generate little noise of their own.
The output transition times are usually longer than the gate delay times. This means that gates tend to swallow glitches and system noise.

Table 1. Essential features of CMOS logic

The simplest of all CMOS gates is the inverter, and the internal circuit of a typical CMOS inverter is shown in Fig. 1. The circuit shows how an n-channel pull-down driver device (TR2), and a p-channel load device (TR1) are used in a complementary configuration. When

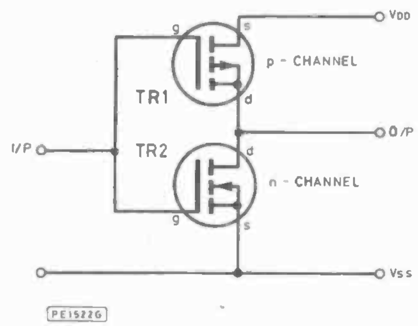


Fig. 1. **Internal circuit of a CMOS inverter**

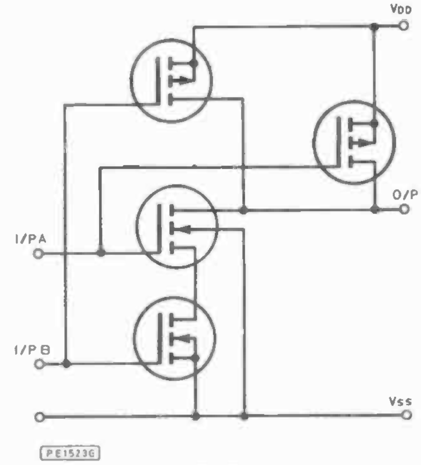


Fig. 2. CMOS NAND gate circuit

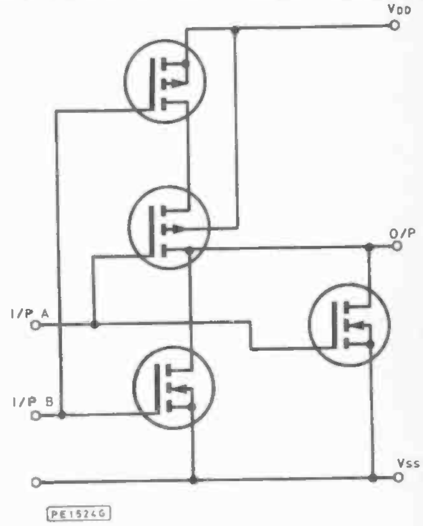


Fig. 3. CMOS NOR gate circuit

the output is at either logic 0 or logic 1, the gate draws only an extremely low (leakage) current from the supply. The only significant power dissipation therefore occurs during transitions of the input signal. This causes power dissipation in a CMOS circuit to depend primarily on the frequency of signal changes. The quiescent consumption is simply the product of supply voltage and the (very low) leakage current. This is in significant contrast to, say, TTL where the power dissipation is essentially constant.

The internal circuits for CMOS NAND and NOR gates are shown in Fig. 2 and Fig. 3, respectively. One of the things we notice when comparing these circuits with their TTL counterparts is the lack of an equivalent to the multi-emitter transistor which is characteristic of TTL gates. The FETs in the input circuit are distinct devices, rather than being part of any multigate FET arrangement. The end result, however, is little different since the advantages of FET technology remove the need for such a device; no overall advantage would be gained.

In practice, the complete circuits for these gates are rather more complex than those shown because, for clarity, we have omitted the diode clamp protection circuits which are usually found on the gate inputs. The breakdown voltage of the MOS gate oxide is about 100V, and although this may seem a lot, the very high resistance and low capacitance of the gate inputs mean that this voltage can easily be exceeded by static electricity. As may be imagined, this caused many problems with the handling of the early MOS circuits, and input clamp circuits are now usually to be found on each CMOS input. The input clamp circuits found in CMOS i.c.s are usually similar to the one shown in Fig. 4.

The internal circuits shown so far relate to the original A-series CMOS gates. The B-series was introduced in 1976 to overcome some of the shortcomings of the earlier CMOS devices. Internal buffers, usually consisting of a pair of inverters, were added to all outputs. The difference between the A- and B-series devices can be seen by looking at the internal circuit of a B-series NOR gate shown in Fig. 5. The equivalent logic arrangement for this circuit is shown in Fig. 6.

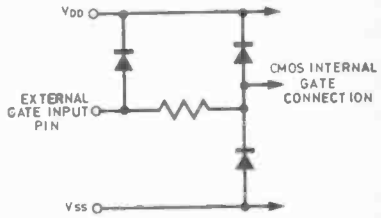


Fig. 4. Input clamp circuit

Fig. 6. Equivalent circuit for B-series NOR gate

These buffers equalise the output drive in both directions, equalise the signal rise and fall times, and improve the gate speed. In addition, the B-series generally puts right a number of 'undesirable' characteristics which found their way into some of the earlier A-series devices.

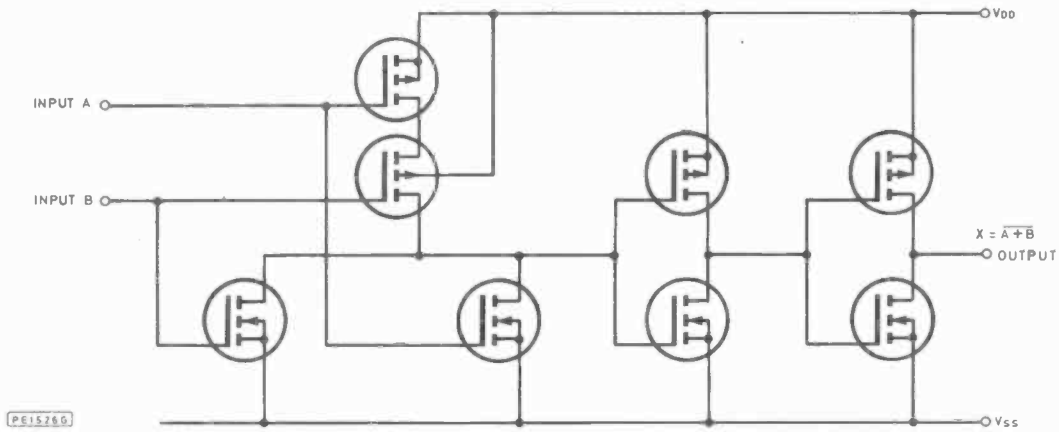


Fig. 5. B-series CMOS NOR gate

A more recent development in CMOS is based on the B-series. The UB-series is similar to the B-series, but the gates have no output buffers, resulting in a reduced propagation delay, and hence increased speed. Generally speaking, the B-series devices have now completely replaced the A-series CMOS devices, and for the remainder of this article we will concern ourselves only with the B-series.

The transfer function for a CMOS inverter is shown in Fig. 7, and is significantly different from the com-

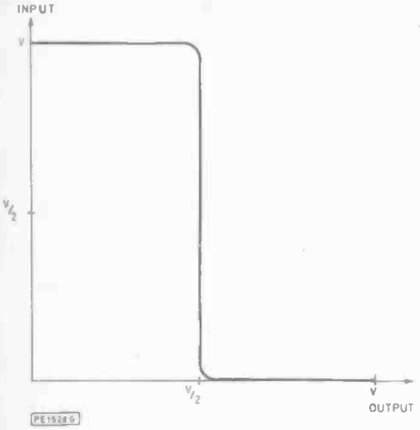


Fig. 7. Transfer function for a CMOS inverter

parable TTL characteristic. The output of a CMOS gate changes state exactly halfway between the two extremes of the power supply voltage limits V_{DD} and V_{SS}, usually the +ve and ground rails, respectively. This type of transfer function gives CMOS the best possible noise immunity. The actual logic thresholds for CMOS gates are given in Table 2, where we note that the thresholds are specified in terms of V_{DD} and V_{SS}, rather than absolute voltages. This is a reflection also of the wide range of supply voltages over which CMOS can operate.

Input Logic Thresholds	
Logic 0:	70% to 100% of V_{DD}
Logic 1:	V_{SS} to 30% of V_{DD}

Table 2. CMOS logic input thresholds

POWER SUPPLIES

CMOS is basically a low power logic family, and one which can operate from a wide range of supplies. The two supply rails for CMOS, V_{SS} and V_{DD}, are usually arranged so that V_{SS} is at 0 volts and V_{DD} is at +ve volts. This, however, is not always the case, and the supply rails could for example run at −5/+5 volts, respectively. For the remainder of this discussion, however, we will assume the normal supply configuration.

CMOS will operate from any supply in the range +3 to +18 volts, and is reasonably tolerant of voltage ripple and line regulation. The optimum supply voltage, however, is in the range +9 to +12 volts, where fast operation, good noise immunity and high drive capability is available. At +5 volts, we find that these factors are degraded by a factor of about two. On the other hand, running CMOS at much above +12 volts does not provide any significant improvements in performance, and can lead to overheating problems.

Although CMOS is much more tolerant than TTL, it is still always good practice to pay due attention to proper supply decoupling and distribution. To this end, we can apply much the same rules to CMOS as we have been using for power supply distribution and decoupling in TTL circuits. If we follow the guidelines used for TTL, we will usually end up with a 'safe' design. In general, the current required from the power supply will be significantly less than a TTL circuit of comparable size. For example, a +12 volt, 200mA supply should be adequate for all but the largest CMOS circuits. We should always remember, however, that non-logic loads (such as l.e.d.s) require the same amount of power, irrespective of the logic family in use. This is an easy point to overlook. As always, it is better to play safe when designing the power supply and its distribution, rather than have to go back later and do it again properly.

Working out the expected power dissipation for a CMOS circuit is a little more involved than it was for TTL. This is due mainly to the fact that the supply current for a CMOS gate depends on switching frequency, in a manner

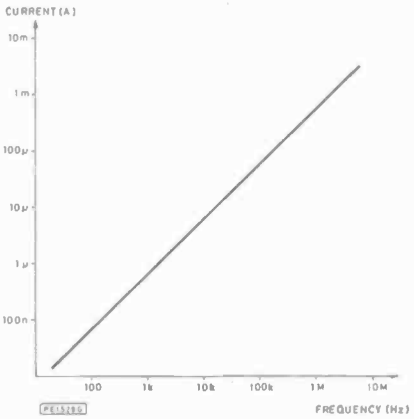


Fig. 8. Supply current variation with frequency

typically as shown in Fig. 8. In practice, i.c. supply current figures are usually quoted at one or more operating frequencies, and often for more than one supply voltage. Typically supply currents are quoted at 1MHz and at +5/+10/+15 volts. For intermediate conditions, we can calculate the corresponding figures from the fact that doubling/halving the frequency has the effect of exactly doubling/halving the supply current, respectively. Similarly, doubling/halving the supply voltage will double/halve the supply current.

As an example, a CD4000B NOR/inverter connected to a +10 volt supply will typically draw a quiescent current of around 10nA (0·00001mA). Operating at 1MHz, however, the supply current will typically rise to 0·6mA. Reducing the supply voltage to +5 volts, on the other hand, will cause the supply current to fall to 0·3mA. By reducing the frequency to 500kHz, the current will be further reduced to 0·15mA. For comparison, the supply current for a TTL 7400 gate is around 8 mA at a 50% duty cycle, and is substantially independent of frequency.

UNUSED INPUTS

CMOS logic gates are intended to be used in digital mode, with their inputs at either V_{SS} or V_{DD}, and under these circumstances we have seen that almost no supply current is drawn. If, however, an input is left to float, it can cause the gate to stray from its digital region into the linear (active) region. One effect of this change of operating mode will be to significantly increase the supply current being drawn. This rise in supply current will be in addition to the effect we encountered with TTL, and which applies equally to CMOS, whereby any floating input can cause the circuit to behave randomly.

Unlike TTL, a CMOS gate input cannot be assumed to take up any particular default state. Some positive action must therefore be taken to condition all unused gates/inputs in order to prevent unexpected circuit behaviour. In TTL, we are only normally concerned with unused inputs on gates actually being used in the circuit (e.g. the unused fourth input of a 4-input NAND gate). With CMOS, however, we must consider *all* of the gates in any i.c. which is connected to the power supply rails. If we forget about these otherwise unused gates, they may still consume considerable amounts of power. Since this rise in supply current is often very difficult to track down, our basic rule should be to disable all unused gates when they are *first* put into the circuit. This will avoid many problems later.

We can disable CMOS inputs by connecting them directly to one of the supply rails, although which one is used will depend on the type of gate involved. One input of an AND/NAND gate connected to V_{SS} (logic 0) will disable the whole gate, whereas $+V_{DD}$ (logic 1) should be used for OR/NOR gates. Either of the supply rails may be used to disable buffers and inverters. As with TTL gates, unused inputs on multi-input gates may be tied to a used input in order to disable it and prevent unwanted circuit behaviour.

REAL CMOS GATES

Readers will by now probably have become familiar with the device numbers of at least a few of the more common TTL devices. As time passes, the pin numbers even start to spring readily (if not always correctly!) to mind—if in doubt always check with the PE Logic Design Cards. One of the problems often encountered when starting to use a new logic family is a feeling of being 'lost'. None of the familiar numbers apply any more, and the temptation is to return to TTL as 'the devil we know'. However, CMOS offers significant advantages over TTL in a number of areas, and even a limited study can pay substantial dividends. We will proceed, therefore, by trying to fill in some of the missing practical background by looking at some of the currently available CMOS devices.

Table 3 lists a selection of CMOS i.c.s from the 4000B series, together with typical figures for supply current when operating from a +5 volt supply at 1MHz. The gates are all available in standard 14-pin or 16-pin d.i.l. packages which are identical in outline to those we described for TTL devices.

Device Number	Function	Package Current	No of Pins
NOR/NAND			
4002	Dual 4-input NOR	0·4mA	14
4012	Dual 4-input NAND	0·4mA	14
4025	Triple 3-input NOR	1·2mA	14
4023	Triple 3-input NAND	0·6mA	14
4001	Quad 2-input NOR	0·4mA	14
4011	Quad 2-input NAND	0·4mA	14
4078	8-input NOR	0·4mA	14
4068	8-input NAND	0·5mA	14
4000	Dual 3-input NOR plus inverter	0·3mA	14
4077	Quad Ex-NOR	0·2mA	14
4093	Quad 2-input NAND Schmitt	0·4mA	14
OR/AND			
4072	Dual 4-input OR	0·5mA	14
4082	Dual 4-input AND	0·5mA	14
4075	Triple 3-input OR	0·5mA	14
4073	Triple 3-input AND	0·5mA	14
4071	Quad 2-input OR	0·5mA	14
4081	Quad 2-input AND	0·5mA	14
4070	Quad Ex-OR	0·2mA	14
Buffers/Inverters			
4069	Hex inverter	0·5mA	14
4502	Hex inverter/driver 3–S	3·0mA	16
4049	Hex inverter/TTL translator	0·8mA	16*
4050	Hex buffer/TTL translator	0·8mA	16*
4041	Quad inverter/ buffer	1·6mA	14
Flip-Flops			
4013	Dual D-type	0·8mA	14
4027	Dual J–K	0·4mA	16
4043	Quad R–S NOR	1·0mA	16
4044	Quad R–S NAND	1·0mA	16
Monostables			
4047	Single monostable		14
4098	Dual monostable		16

*V_{SS} = pin 8 and $+V_{CC}$ = pin 1
All other devices have: V_{SS} = pin 7/8
V_{DD} = pin 14/16

Table 3. A selection of CMOS devices

Although CMOS devices are now much more robust than the early types, it is still advisable to observe some simple handling rules. The main problem, as we mentioned earlier, is that CMOS inputs represent a very high input resistance and a low capacitance. This means that a relatively small static charge can raise the voltage at the gate input to quite significant levels, and in extreme cases this can still damage the i.c.s, despite the input clamp circuits. The only safe way to store CMOS i.c.s, therefore, is with all of the pins connected together in some way. This prevents any voltage difference between the gate input(s) and the rest of the i.c. The easiest methods of storing i.c.s in this way is to wrap them in aluminium foil, use black conducting foam (loaded with carbon particles), or keep them in anti-static i.c. carriers.

While in circuit, it is a wise precaution to ensure that any gate input which goes off the circuit board is never left completely unconnected and floating. A 1MΩ resistor between the gate input and ground will avoid this problem, but without affecting normal circuit operation. The resistor provides a discharge path for the static, but without upsetting the logic levels.

PE LOGIC TUTOR WITH CMOS

Now that we are familiar with some of the basic principles, we can look at how the PE Logic Tutor can be used for developing CMOS circuits. In fact this turns out to be almost as easy as for TTL. No modifications, other than a few simple additions, are required in order to use the Logic Tutor with CMOS, so long as a +5 volt supply rail is adequate for the circuit in question. This will only actually be a limitation where high speed CMOS applications are involved.

This said, there are a number of factors which we *should* consider when using CMOS with the PE Logic Tutor, and which arise because it is basically a TTL unit. We hope to use the discussion of these points to demonstrate some of the techniques involved in interfacing CMOS to TTL. We begin by looking at the interface requirements and the buffer i.c.s which are available specifically for converting between CMOS and TTL.

INTERFACING CMOS AND TTL

The basic principle involved in interfacing between logic families is to make logic signals from one family appear as if they could have come from the other family, and vice versa. If we can do this for CMOS and TTL, we should then be able to connect CMOS and TTL circuits together and take advantage of the special features of both types of logic. As we might guess, the i.c. manufacturers have anticipated our needs in this area, and most of them provide a range of devices to simplify the interfacing task. Before looking at these i.c.s, however, we will first look at what is actually required to interface between TTL and CMOS. When discussing CMOS/TTL interfacing, we have limited the discussions which follow to the most common situation of CMOS operating from the same +5 volt supply as the TTL circuits.

TTL TO CMOS

At the input of a CMOS gate, the logic levels should ideally be kept as close as possible to 0V and +5V, for logic 0 and logic 1, respectively. In extreme cases these levels can be allowed to rise/fall to +1·5V and +3·5V, respectively. In practice, however, it is generally recommended that the input signals should keep logic 0 below 1V and logic 1 above 4V. Looking back to TTL's output specifications, we recall that logic 0 is below 0·8V, and logic 1 is above 2·4V. A TTL logic 0, therefore, represents no problem at a CMOS input, but something must be done, however, to guarantee that the logic 1 level provided by a TTL gate (still marginal at typically +3·5V) is correctly recognised by a CMOS gate. What we need to do is to pull the logic 1 level closer to the positive supply rail, while leaving the logic 0 level unaffected.

The usual method of interfacing a TTL output to a CMOS input is shown in Fig. 9, and this arrangement works

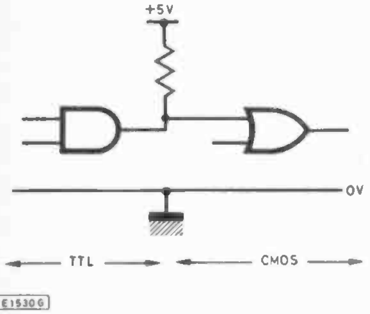


Fig. 9. Driving CMOS from TTL

equally well for any of the TTL subfamilies. Because CMOS inputs behave almost like open circuits, and require only around 100nA each, there is no problem obtaining the necessary drive current from a TTL gate. A single TTL gate can then drive almost any number of CMOS gates, and the usual practical limit of around 50 is due more to the extra capacitance represented by each additional gate connected, than any inherent drive limitation.

CMOS TO TTL

At the output of a CMOS gate, we find that the voltages used for logic 0 and 1 present no problems for TTL gates. The problem, instead, is with the available drive current—just the opposite of the situation at a CMOS input! A B-series CMOS gate is able to sink approximately 0·44mA at logic 0, and source approximately 0·16mA at logic 1. This compares with the current requirement of 1·6mA per standard TTL load at logic 0. There *is*, however, sufficient drive available for a standard B-series CMOS output to drive *one* (and only one) LS TTL gate. This has the additional benefit of allowing us to use an LS TTL gate as a high drive CMOS buffer.

To allow CMOS circuits to drive more than one LS TTL load, or any standard TTL loads at all, we must provide additional current-driving capability. The simplest way of doing this is to use one of the CMOS-to-TTL converters, the most common of which are the 4049 and 4050 hex inverters and buffers, respectively. These are each able to drive up to two standard or four LS TTL loads, or any other equivalent load requiring up to 3·2mA of current sinking capability. These devices are extremely useful in all types of interfacing applications, and we will now look at how they can be used to help CMOS circuit development with the PE Logic Tutor.

THE 4050 AND 4049 TTL BUFFERS

The internal arrangement of the 4050 hex non-inverting buffer and TTL driver is shown in Fig. 10. We note in

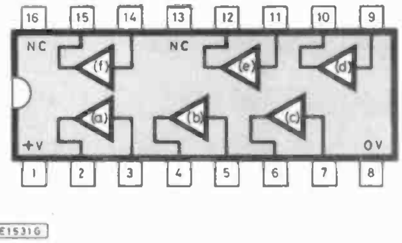


Fig. 10. The 4050 non-inverting CMOS/TTL buffer

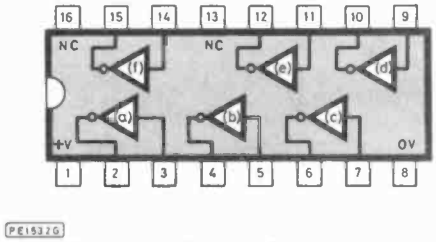


Fig. 11. The 4049 inverting CMOS/TTL buffer

passing that the CMOS/TTL buffers are among the few i.c.s in the B-series which do *not* follow the standard arrangement of power supply pin numbering. The six buffers in the package are all electrically identical, and each can drive up to two standard TTL loads, or their equivalent. The 4049 is the inverting version of the 4050, and is otherwise similar in all respects. The internal arrangement of the 4049 is shown in Fig. 11. Both the 4049 and the 4050 can operate from power supplies in the range 3V to 15V, but must be used from a +5V supply when used with TTL.

In order to use the PE Logic Tutor to full effect with CMOS, we should ideally buffer some of its facilities. The logic state indicators in particular should be buffered for reliable operation, although in many cases they will not adversely affect the circuit if this is not done. We suggest that a 4050 non-inverting buffer is used between the CMOS circuit and the indicators D1 to D4. This may be wired up in a convenient socket, and then used for all future CMOS circuit development. The modified logic state indicator circuit then becomes as shown in Fig. 12. We

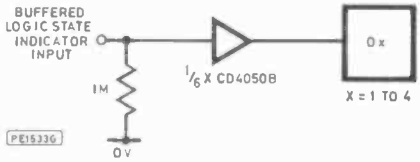


Fig. 12. Logic state indicators modified for CMOS

have included 1MΩ pull-down resistors in order to protect the floating logic state indicator inputs. The two unused buffers in the package must also be disabled to prevent excessive current drain.

The preferred method of wiring up the modified indicator circuits (or any other CMOS circuit) is to install the wiring first, and only *then* insert any i.c.s; this minimises the possibility of any static-induced damage. The links required for a 4050 in socket B are as follows:

B3 to 0V (via 1MΩ) . . . New D1 i/p
B2 to D1
B5 to 0V (via 1MΩ) . . . New D2 i/p
B4 to D2
B12 to 0V (via 1MΩ) . . . New D3 i/p
B11 to D3
B15 to 0V (via 1MΩ) . . . New D4 i/p
B14 to D4
B7 to 0V (Unused gate i/p)
B9 to 0V (Unused gate i/p)
B1 to +5V(Supply)
B8 to 0V (Supply)

With the circuit above completed, the logic state indicators D1/D2/D3/D4 now have their inputs at pins B3/B5/B12/B15, respectively.

In order to ensure that the logic level generators S1/S2/S3/S4 and the CLOCK all produce CMOS-compatible logic levels, we must add five 2·2kΩ pull-up resistors at the signal outputs. Each should be connected between one of the S1/S2/S3/S4/CLOCK connectors, and a convenient +5V point. The generators/clock sources may then be used as for TTL.

Now that we have optimised the Logic Tutor for CMOS, we can conclude this final part of the series by looking at a few examples of practical CMOS circuits. Rather than repeat any of the ideas used for TTL, which for the most part will work just as well in CMOS, we will concentrate on applications which are special to CMOS.

TOUCH SENSITIVE SWITCHES

Touch sensitive switches are an increasingly common part of everyday life. They have come into widespread use mainly as a result of the development of MOS technology, which allows them to be produced easily at low cost. We can actually make a touch sensitive switch from standard CMOS logic gates, although in many applications custom-designed multiple-switch i.c.s are used. Whichever implementation is chosen, the basic principles remain the same.

Touch sensitive switch circuits all have one feature in common; they have a very high input impedance. We have seen, however, that this is also true of a CMOS gate input, which typically has an input impedance in excess of 100MΩ. The problem facing us as designers is how to use this property to produce a touch sensitive switch? We know that the high impedance/low capacitance of a CMOS input means that only a very low charge is required to influence the voltage at the input. The human body acts as a quite reasonable aerial when it comes to picking up 50Hz hum from the electrical field produced by the mains distribution system. Thus contact with the hand can be used to trigger a suitable high impedance switch.

The circuit shown in Fig. 13 is based on the 'human aerial' effect. The figure shows the complete circuit, including

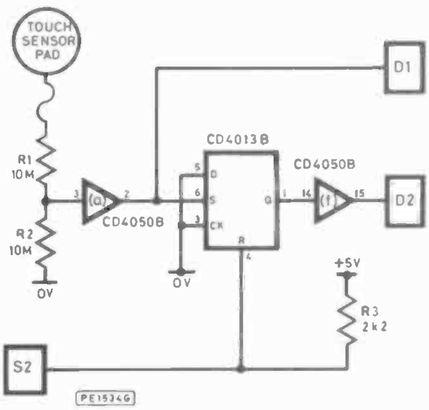


Fig. 13. Touch sensitive switch circuit

all of the necessary interfacing between CMOS and the Logic Tutor. The sensor pad is connected to R1, and can take any convenient form, e.g. a small circular piece of foil or copper laminate. For initial tests, the lead of R1 itself is quite adequate. Large sensors should, however, be avoided because they tend to act as aerials in their own right, and thus reduce the sensitivity of the switch. If we experiment with ever-larger pieces of foil, there eventually comes a point when the switch is always on. The switch circuit works most reliably if it has a good earth, but it will *usually* work quite adequately without any additional earthing.

The sensor pad is connected via R1 to the input of one of the CMOS/TTL translators in a 4050. R2 is included in the circuit to tie the input to ground when no signal is present; the switch behaviour is otherwise indeterminate. The combination of R1 and R2 sets the sensitivity of the switch, which should be kept as low as possible. Reducing R1 or increasing R2 increases the sensitivity, but be warned that a high sensitivity makes the circuit more liable to static damage and/or false switching caused by power transients, etc. The output of the gate is connected to the Set input of a 4013 D-type latch (similar to the TTL 7474, but with non-inverted Set/Reset inputs). This latch is set whenever the switch is activated, and remains in this state until reset by pressing S2 (whose output is pulled up by R3). The output state of the switching gate is shown by D1, while the output of the overall switch (i.e. the Q output of the latch) is shown by D2.

The circuit is built on the Logic Tutor by inserting a 4050 into socket B (pin 1 in B1), and a 4013 into socket F (pin 1 in F1), and adding the following links:

B3	to 10MΩ	(R1: to touch sensor)
B3	to 10MΩ	(R2: other end to 0V)
B2	to D1	(Switch o/p display)
B2	to F6	(Switch o/p to latch)
F5	to 0V	(Disable D i/p)
F3	to 0V	(Disable CK i/p)
S2	to 2 2kΩ	(R3: other end to +5V)
S2	to F4	(Reset i/p)
F1	to B14	(Latch o/p)
B15	to D2	(Latch o/p display)
B5	to 0V	(Disable i/p)
B7	to 0V	(Disable i/p)
B9	to 0V	(Disable i/p)
B11	to 0V	(Disable i/p)
F10	to 0V	(Disable i/p)
F11	to 0V	(Disable i/p)
F12	to 0V	(Disable i/p)
F13	to 0V	(Disable i/p)
B1	to +5V	(Supply)
B8	to 0V	(Supply)
F16	to +5V	(Supply)
F7	to 0V	(Supply)

As a final thought on touch switches, we invite readers to extend our simple switch circuit for use as an intruder alarm. Adding a single 4000 i.c. should make it possible to cause the switch to trigger a pair of alternately flashing lights whenever the sensor is touched. As a suggestion, use the inverter in the 4000 to produce anti-phase CLOCK signals to apply to the two OR gates, use the $\overline{Q}$ output from the latch to drive both OR gates, two 4050 buffers to interface the OR gate outputs to D3/D4, and don't forget the unused OR gate inputs! The whole circuit should still be reset by pressing S2. The internal circuit and pin configuration for the 4000 dual 3-input NOR gate plus inverter is shown in Fig. 14.

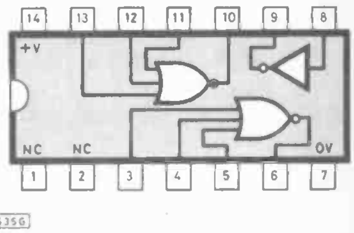


Fig. 14. The 4000 dual 3-input NOR plus inverter

LIQUID DETECTORS

Touch switches are not the only way we can take advantage of the high input impedance of CMOS gates. Liquid level detectors are another interesting application area, and here we use the conductivity of the liquid itself to activate a CMOS switch. Liquids are usually considered to be poor conductors, representing high impedances to the flow of electrical current. In CMOS terms, however, liquids must be viewed in a rather different light. The conductance of many liquids is actually enough to allow simple fluid detector circuits to be easily constructed.

The circuit of Fig. 15 shows a simple liquid level detector. The liquid sensors can be any convenient conductors, such as two lengths of bared wire, or a pair of Veroboard tracks. Using two tinned wires 10mm apart, D1 is illuminated when they just touch the surface of a glass of water. A damp sponge has a similar effect, and the sensitivity of the switch can be varied by changing the spacing of the sensors or the value of R1. These simple sensors are suitable for a wide range of applications, and due to their low cost, a

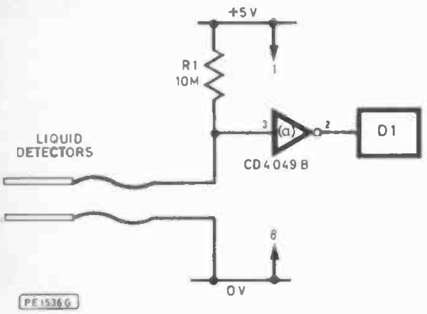


Fig. 15. Liquid level detector circuit

large number can easily be used to give accurate monitoring. It is an interesting experiment to try different sensors and adjust the switch sensitivity to allow the ultimate in gardening luxury—automatic garden watering! The idea is to detect the falling conductivity of soil as the moisture content of the soil falls, and then turn on the sprinklers.

These few examples give an idea of the versatility of CMOS, and indicate that it is a logic family with which it is fun to experiment. It obeys all the laws of standard logic, but has a number of added advantages, not least of which is very low power consumption. When used in conjunction with TTL, the designer has perhaps the best of both worlds.

We hope this brief look at CMOS will give readers the confidence to experiment with this 'new-fangled' logic family. Good luck!

74C00 SERIES

As a final note, we feel it necessary to mention the existence of one other rather interesting CMOS family. The 74C00 series is a pin-for-pin, function-for-function equivalent to the various 7400 TTL sub-families. All of the 74C00 series devices are compatible with low power TTL, and their outputs are each capable of driving one LS TTL load. As such, the family can provide a very convenient way of converting an application from TTL to CMOS with the minimum of circuit modification. It is perhaps worth considering the 74C00 series as a possible alternative introduction to CMOS. ★

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I.C.'s for sale TMS 4030 40 off @ 50p. 8279 3 off @ £2. 8755 8 off @ £2. 2516 @ £1. 08833 4503. Mr. G. Heath, 103 Pollards Oak Road, Oxtèd, Surrey RH8 0JE. Tel: Oxted 4503.

TANDY DMP100 Graphics printer par/serial interface. As new with lead, manual, paper. Cost £299. Now £185. Derek Kennedy, 12 Herries Road, Glasgow G41. Tel: 041 423 2115.

WANTED broken Spectrum for bits. Dave Stewart. Tel: 0772 634897 Mr. D.I. Stewart, 22 Blenheim Drive. Warton, Lancs. PR4 1DH.

ULTIMUM mother board (working) in case with all psu's. Also chips for 16K Ram board £50. Mr. J. Stevens, 18 The Harrage, Romsey, Hants. Tel: (0794) 515884.

DATA dynamics 390 teletype. Includes printer, keyboard, punch, reader, pedestal, and RS232 interface. £50. Tel: Horndean 592036 M. Droney.

WANTED UK 101 Memory expansion board, eg magnum electronics type. Have one already and need further 8–16K. C. F. Bashford, 12 Swansholme Gardens, Sandy, Beds. Tel. (0767) 80860.

BI Directional printer RS323/Centronics interfaces. Can be seen working or s.a.e. for print out. Phone Southampton (0703) 788278. £125. R.H. Pearce, 8 Holly Oak Road, Coxford, Southampton SO1 6GD.

ELECTRONIC ignition. Capacitive discharge for negative or positive earth (no data). £6.50. Write or phone. T.C. Sheridan, 46 Seymour Court, Whitehall Road, North Chingford, London E4 6DZ. Tel: 01-529 0612.

WANTED Add On RAM for 8K UK101, 32K if possible. T.E.D. White, The Gate, Llandinam, Powys. Tel: Caersws 630.

TEKTRONIX 502A Scope. User Manual and or Circuit Schematic wanted. J. Bartle, 28 High Street, Bishopton, Stockton-on-Tees, Cleveland TS21 1HA. Tel: 0740 30512.

CLEARING out mixed bags transistors, capacitors, resistors. 100+ items £2.50. Pots 22K LIN 10 £1. (List s.a.e.). D. Martin, 29 St. Johns Close, Leatherhead, Surrey.

PC1500, Printer, 4K Rampack, power supply, manuals, case, all user-magazines and machine code details. £200. Dave Jackson, Liverpool. Tel: 051-489 9842.

WANTED Television magazine 1976–1981. Must be complete. Also 8 amp Variac. Must be v.g.c. Brian Ward, Burnley. Tel: (0282) 50574.

COLLINS mechanical filters 455kHz, 3·1kHz, 1·5kHz BW. Mullard crystal filter 455kHz, 600Hz BW. £6 ea. Chelmsford 59033. J. H. Gooday, 53 Lawn Lane, Chelmsford, Essex.

I need back numbers of Practical Electronics in 1982 and 1983 years. Ali Reza Mahabadi, 121 Emam Mousa Sadr Street, Rey Avenue, Tehran 11797, Iran.

TEST equipment HP5245L counter £75. HP606A H.F. generator £50. Advance HI audio generator £10. Chelmsford 59033. J. H. Gooday, 53 Lawn Lane, Chelmsford, Essex.

TWO Mullard fast valve testers with cards £35; Avo valve tester and analyser with manual £28. Mr. A. Mabrouk, 21 Redington House, Rodney Street, London N1 9QQ. Tel: 01-278 4806.

TRIO TR2300 £100. New 4CX250B plus base and chimney £60. Kenwood DM81 DIP-Meter £25. C. Leyson, 56 Park Road, Whitchurch, Cardiff. CF4 7BR. Tel: (0222) 626466.

WANTED: Ohio 610 Board and DOS 65D3.3 or Vortex + FDC. Ockier Jan, MGR Christiaensstraat 16, 8880 Tielt, Belgium.

8" disk drive, with interface for the UK101. Power supply, leads, manuals and operating software. £220. D. Fellows, 26 Westbourne Avenue, Emsworth, Hants. PO10 7QU. Tel: (02434) 5548.

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PE BAZAAR JUNE '84

VERNON TRENT *at Large!*

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

YOU can safely bet your last copper coin that whenever some new kind of human activity crops up—for business or pleasure—its emergence will be followed in a trice by a flurry of publications devoted to its interests.

So, if you should be so clever one of these days as to launch, say, some new sport on the world—like indoor marathon running or bingo on ice—you can be as sure as tomorrow's sunrise that some smart publisher will rapidly be in there doing his stuff. Doing it, by the way, not only for the running and bingo buffs, but also for the suppliers of the appropriate goods and services. Fair enough, perhaps, for it's the gold they spend on advertising space that makes the whole project possible.

The electronics industry has never been short of its attendant publications. Some of them have been first-class and have gone from strength to strength. Others have not been so good, but have nevertheless managed to scratch a living. A few, because they ought never to have been born in the first place, have inevitably gone the way of all flesh.

The marked element of chance in this sort of venture, however, has never been a deterrent. New organs pop up like mushrooms in the dawn. The pace has quickened in recent times with the phenomenal growth of computers and microprocessors. Enough papers are published in a month in this field to stuff a cushion. And it's a sign of the times that one of the latest magazines in the technological field is called 'Satellite & Cable TV News'. This is one, I think, that cannot fail. It is likely to have enough material at its disposal to last a lifetime. Unless, that is, SCTV itself goes down the drain. And, in spite of the sorting out that still has to be done, I don't reckon that's on the cards.

There is one outstanding pioneer in the electronics publishing business which, without fundamentally changing its approach or its basic policy and format, has not only withstood the ravages of environmental change and increasing competition, but steadfastly holds a leading position. I am not referring to *PE* (though I might well have been doing so) but to 'Electronics Weekly'.

I was talking recently to 36-year-old Mick Elliott, its engaging Cockney editor. We were seated in his office at the HQ of Business Press International, the publishers, at Quadrant House, Sutton, in suburban Surrey. One wry wit who used to work for *EW* described the place as 'a plastic Lubianka'. I don't know about that, but there's nothing wrong with its central heating.

As the editor of what was Britain's first weekly newspaper for a technical readership, Mick is, quite properly, well-versed in its origins. He reminded me that *EW* was sired by a monthly called 'British Communications & Electronics', and was launched in 1960 by Heywood & Co. Its ownership underwent several convulsions over the years, involving Odhams, Newnes, the Daily Mirror Group and IPC. Geographically, it moved around a bit as well. From Russell Street off Drury Lane to Fleet Street. From Bowling Green Lane in historic Clerkenwell to Dorset House, that imposing memorial to grandiose architecture within puffing distance of Waterloo Station. And thence a few years ago to Sutton. "But," said Mick, "in other directions there has been a good deal of consistency. In 24 years the paper has known only three Editors: Cyril Gee (who never held the title of Editor, but that of Managing Editor), John Wilson (arguably one of the best writers in the electronics business who did an eminently sensible thing and semi-retired to the Cardigan coast—an area said to be highly-conducive to literary creation), Roger Woolnough (now successfully freelancing) and myself.

"Only three editors in twenty-four years"

"From the start, *EW* adopted the unique policy of staff specialisation. Few, if any, journals have it. Mike Payne, for example, has been dealing for years with avionics and defence. David Manners is exclusively concerned with the wide-ranging field of components. And there are other specialist correspondents handling computers and communications. These are all key areas. And we have other staff covering finance, non-specific technology and sundry news items. *EW*'s policy has always been to cater—in the news, features and comment senses—for people professionally concerned with electronics who need information about current developments in an easily assimilated form—and fast. This can only be achieved by weekly newspaper techniques. In this respect, if none other, *EW* has proved a trail-blazer."

A major change in the paper's philosophy was when it went over to controlled circulation. This, for the uninitiated, means that it is mailed automatically to a selected readership, free of charge, instead of being sold on the news-stands. Finance comes entirely from advertising.

"Requested readership alone," said Mick, "already stands at 35,000 and the call is growing fast. I wouldn't say we're all the way we want to go yet, but we're certainly moving in the right direction. We think we've got our editorial just right and, more importantly, we're bringing into the readership field many more of the younger engineers and designers upon whose flair, talent and innovative ability the future of the industry depends."

Mick himself is no stranger to or enemy of change. He studied journalism at the City Literary Institute. He could have gone on from there to a local newspaper. But, as he says: "It would have to have been in a sports capacity (he's a mad-keen footballer), and you can't be a player and a reporter at the same time." So instead he worked on journals as diverse as 'Point of Sale News' and 'Electronics Manufacturer' before joining 'Electronics Weekly' as a sub-editor. He reckons that the latter four-year stint was invaluable in giving him an insight into the complexities of the products and policies of the electronics industry.

How does he see *EW* in 20 years from now? "I can't really see any drastic changes in the newspaper itself. Its appearance isn't likely to change much. I'm sure it will never become a magazine. Or what's worse, a hybrid. And if management and financial support continues at its present level, we shall go on leading the field in weekly electronics industry journalism.

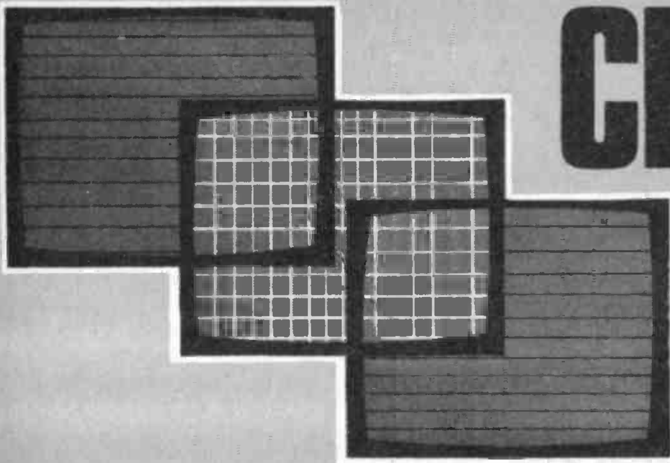
"One thing I would like to see over the next couple of decades is a greater use by us, as a newspaper, of electronics techniques. So far as production is concerned, this is at present restricted to the telephone and facsimile machine. In the current state of the art this seems to be the optimum. After all, when your printer is 54 miles away there isn't much opportunity to make use of such techniques as direct input of copy. Maybe this will come. I don't know. In an industry that moves as swiftly as ours anything can happen and there is no such thing as surprise."

* * *

The electronics industry, especially where components are concerned, is ill-placed when it comes to displaying its wares to the general public. Consumer items, like TV receivers, music centres, VCRs and the like, tend to lend themselves to attractive display in shop windows. They're tangible things that John Citizen can easily be attracted to and appraise. But how do you whip up visual enthusiasm about resistors, capacitors and all the rest of the vital guts which hobbyists in their thousands use?

Most, of course, base their purchases on the non-pictorial advertisements and on manufacturer-reputations and past experience. But isn't there a case for component manufacturers putting a bit of zip into their sales promotions?

How about transistors, tastefully laid on a bed of ice and marked: 'Were diffusing yesterday'? Or picture tubes bearing the popular label: 'As seen on TV'? Or, taking a leaf out of the wonderful world of Woolies, offering baskets of passives on the pick 'n' mix principle of selection? And what about tuners in family packs of half-a-dozen? Or is this just plain heresy?



CROSSHATCH GENERATOR

R. A. PENFOLD

AS its name implies, a cross-hatch generator merely produces a pattern of horizontal and vertical lines on a t.v. screen. The principal use of a cross-hatch generator is as an aid to making colour television dynamic convergence adjustments, but a device of this type can also be used when adjusting horizontal and vertical picture linearity, and it can be useful as a video signal generator for general test purposes.

The cross-hatch generator has been made as simple as possible without resorting to the use of expensive or difficult to obtain components. It simply feeds into the aerial socket of the television set and the use of a ready-made u.h.f. modulator makes the unit very easy to set up ready for use. Power is obtained from an internal 9 volt battery so that the unit is self-contained and fully portable. The display produced has 12 vertical lines by 8 horizontal lines.

THE SYSTEM

The circuit has to provide four basic signals which are mixed and then applied to the u.h.f. modulator, and the block diagram of Fig. 1 helps to explain how this is achieved. A clock oscillator and divider chain are used to provide outputs at the four frequencies required, and in this design a single integrated circuit is used as the basis of the clock and divider circuit. This will be discussed in more detail shortly. The two important frequencies are the 50Hz frame synchronisation signal and the 15·625kHz line synchronisation signal. A t.v. picture is made up from 625 lines, but these are transmitted as two frames of 312·5 lines each, with the two frames interlacing to produce a complete picture. Twenty five pictures per second are transmitted so that the 50Hz frame frequency and the 15·625kHz (50Hz × 312·5) line frequency mentioned above are obtained. The line synchronisation pulse is only about 4µs in duration but the field synchronisation pulse is much longer at about 300µs. Two monostable multivibrators are used to give pulses of appropriate durations.

The vertical lines are produced by a number of pulses during each line scan which generate a series of evenly spaced dots on every line of the picture. These dots must occur at the same points on each line scan so that they are vertically aligned and produce neat, properly vertical lines. The pulses must be very brief in order to give reasonably narrow lines, and they must be at a much higher frequency than the line frequency in order to give a reasonable number of vertical lines. The number of lines generated is simply equal to the pulse frequency divided by the 15·625kHz line frequency, but some of the lines will effectively be off the edges of the screen and the number actually displayed is somewhat less than the calculated figure. In this design a simple pulse shaper is used to process the squarewave output signal from the divider chain to give the required brief pulses.

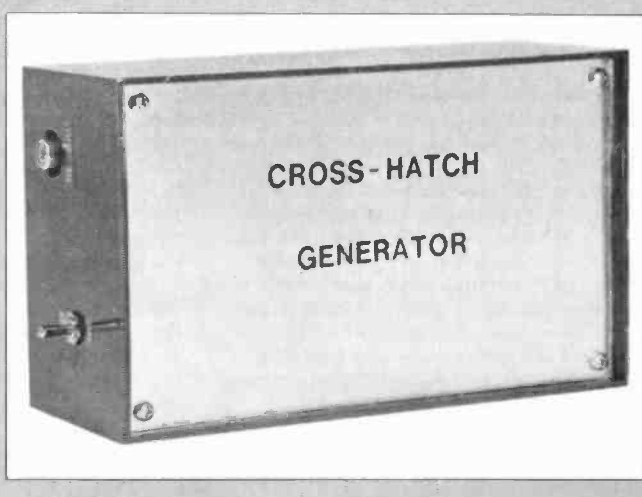
In order to produce the horizontal lines it is necessary to provide a modulation signal which is equal in length to one or more line scans, and timed to coincide with line scans. Gaps of suitable length between these pulses space the lines down the screen as required. The number of lines produced is equal to the pulse frequency divided by the 50Hz frame frequency, but like the vertical lines, some of those that are generated are not displayed on the screen. Two monostable circuits are used to ensure that the pulses appear at the appropriate times and are of the correct length. Without the delay provided by the first monostable the lines would commence in the middle of scans and not at the beginning.

A mixer stage is used to combine the four signals before they are applied to the modulator, and this circuit must be arranged so that the synchronisation signals blank the modulation signals. Note that the synchronisation pulses are negative whereas the modulation pulses must be positive in order to generate a conventional display having white lines on a dark background.

DIVIDER CHAIN

The clock oscillator and divider chain are based on a CMOS 4060BE device which is a 14 stage binary divider and oscillator. This is used in the manner shown in Fig. 2.

A clock frequency of 250kHz is used, and this undivided signal is used to provide the vertical lines. The first four stages of the divider chain give a divide-by-sixteen action

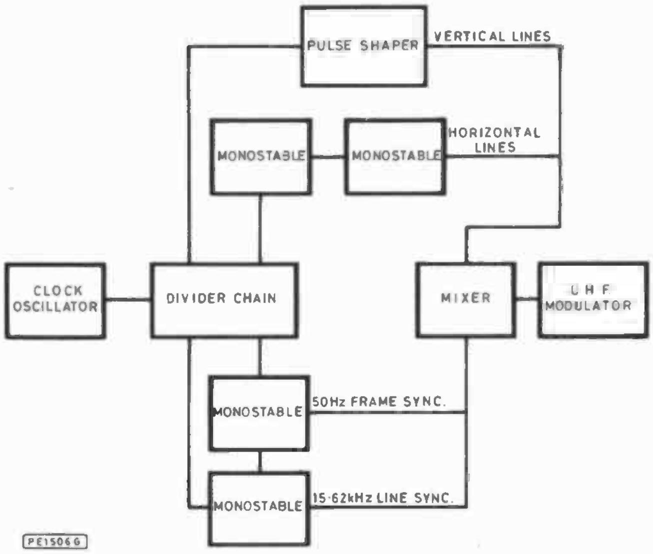


and give the 15·625kHz line synchronisation frequency. The output from stage nine of the divider gives a further reduction in frequency by a factor of 32 and produces an output frequency of about 488Hz which is used to give the horizontal lines.

A five input AND gate is used to reset the counter when the Q4, Q7, Q8, Q9 and Q13 outputs of the divider are at logic 1, and this effectively gives a divide-by-625 action to the 31·25kHz output from the third stage of the divider. This gives the 50Hz field synchronisation signal.

Using a single divider chain in this way is obviously rather limiting in that it is not possible to obtain any desired number of horizontal or vertical lines. However, in practice a 12 by 8 display is perfectly satisfactory. An advantage of this system is that it enables a very simple and inexpensive circuit to be used, and it also ensures that the signals are all properly synchronised so that a "rolling" picture is avoided.

Fig. 1. Block diagram



THE CIRCUIT

Fig. 3 shows the full circuit diagram of the cross-hatch generator.

It is possible to use the oscillator of the 4060 (IC1) as either a crystal or a C-R type. In this circuit the C-R option is used as it is cheaper and provides adequate performances. Also, a 250kHz crystal could be difficult to obtain. C1 enables the frequency of operation to be trimmed to the correct figure.

Resistor R5 plus D1 to D5 form a simple AND gate which provides the reset signal to inverter TR1 via C3. The 50Hz frame synchronisation signal is obtained from this gate and is used to trigger a simple CMOS monostable circuit formed from two gates of IC2. The other two gates of IC2 are used to form the line synchronisation monostable, and this is triggered by the 15·625kHz output of IC1. These two monostables produce positive output pulses, but these are mixed by R8–R9 and then inverted by TR2 before being applied to the input of the modulator.

TR3 is used to buffer the output of the clock oscillator before it is fed to the simple pulse shaper which comprises C6, R15 and D6. The latter ensures that only positive pulses are applied to the modulator by the pulse shaper, and that no blanking of the horizontal lines is produced by this signal.

C9 couples the 488Hz output of IC1 to the series of two monostables. These use the two sections of 556 device IC3 (this is a dual 555 timer). IC3b provides a delay and IC3a gives a pulse which is equal to one line scan in duration. Due

Fig. 2. Simple divider arrangement

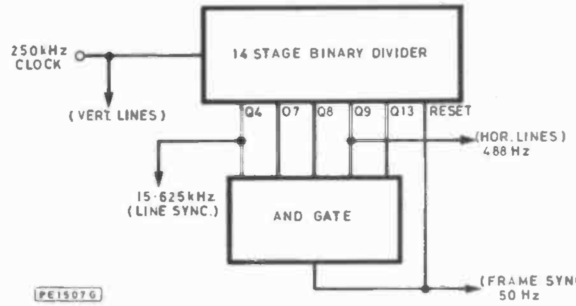
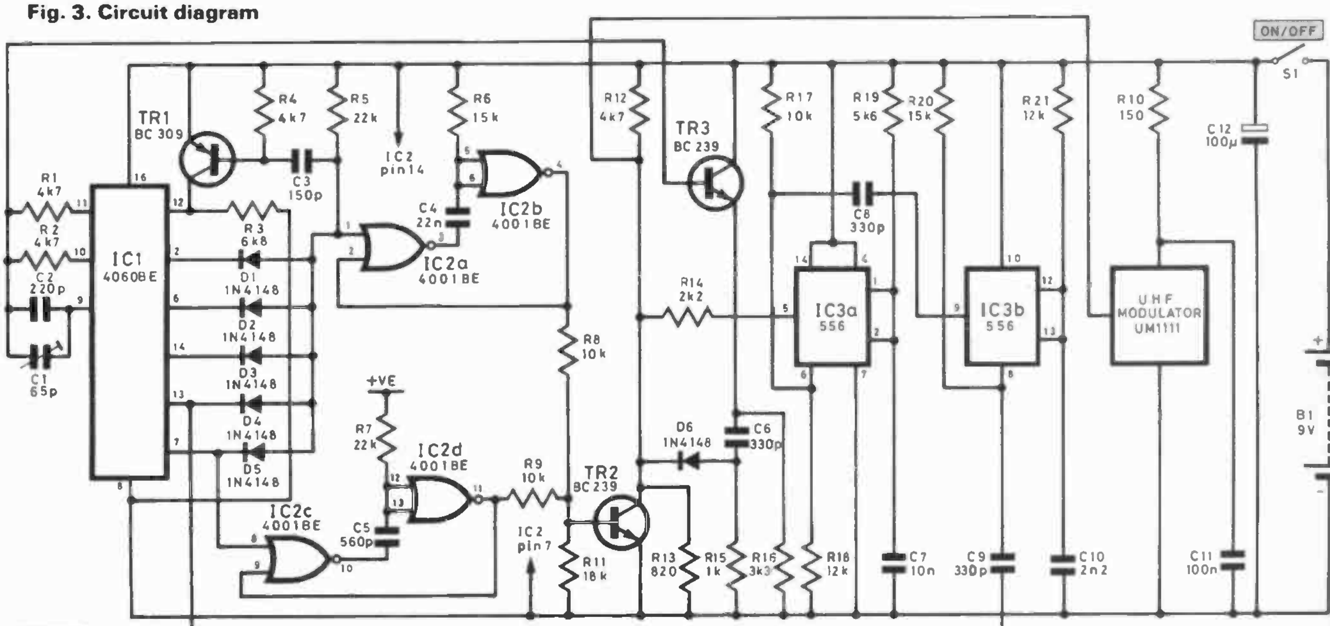


Fig. 3. Circuit diagram



COMPONENTS . . .

Resistors

R1,2,4,12	4k7 (4 off)
R3	6k8
R5,7	22k (2 off)
R6,20	15k (2 off)
R8,9,17	10k (3 off)
R10	150
R11	18k
R13	820
R14	2k2
R15	1k
R16	3k3
R18,21	12k (2 off)
R19	5k6

All resistors 5% 0·25W carbon

Capacitors

C1	65p miniature film dielectric trimmer
C2	220p ceramic plate 2%
C3	150p ceramic plate
C4	22n carbonate 5%
C5	560p ceramic plate 2%
C6,8,9	330p ceramic plate (3 off)
C7	10n carbonate 5%
C10	2n2 carbonate 5%
C11	100n polyester
C12	100µ 10V radial elect

Semiconductors

IC1	4060BE
IC2	4001BE or 4001UBE
IC3	NE556
TR1	BC309
TR2,3	BC239 (2 off)
D1 to D6	1N4148 (6 off)

Miscellaneous

S1	SPST miniature toggle type
B1	9 volt battery (e.g. 6 x HP7s in plastic holder)

Modulator Astek type UM111E36 (6MHz)
16 pin DIL socket
14 pin DIL socket (2 off)
Printed circuit board (155 x 60mm)
Metal/plastic case about 156·5 x 91·5 x 50mm
PP3 type battery connector
6BA fixings, wire, etc.

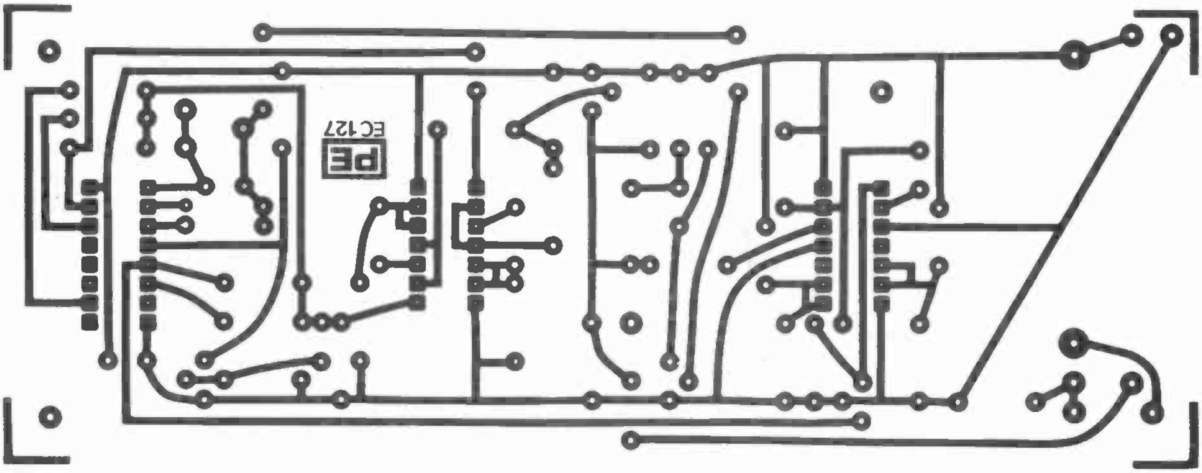


Fig. 4. P.c.b. layout (actual size)

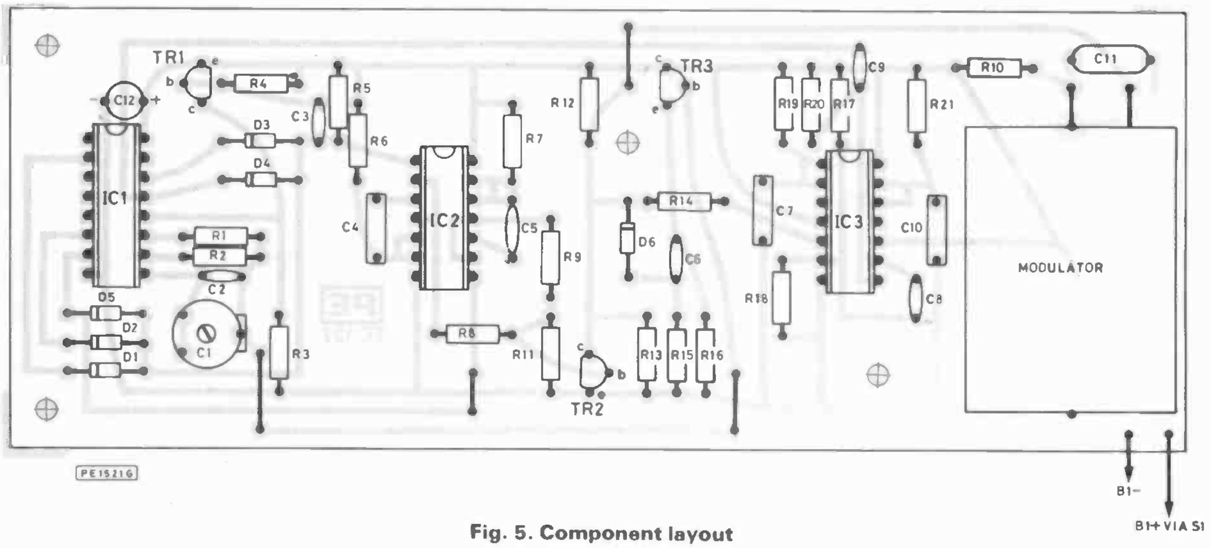
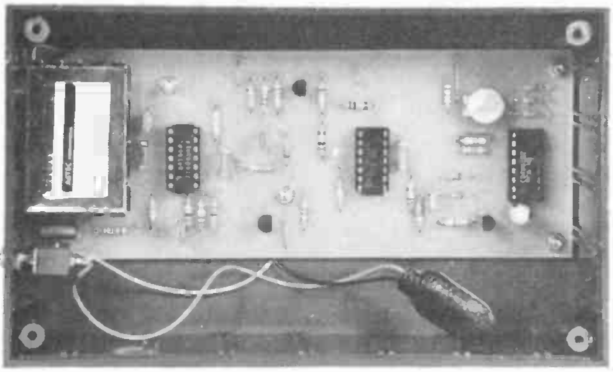
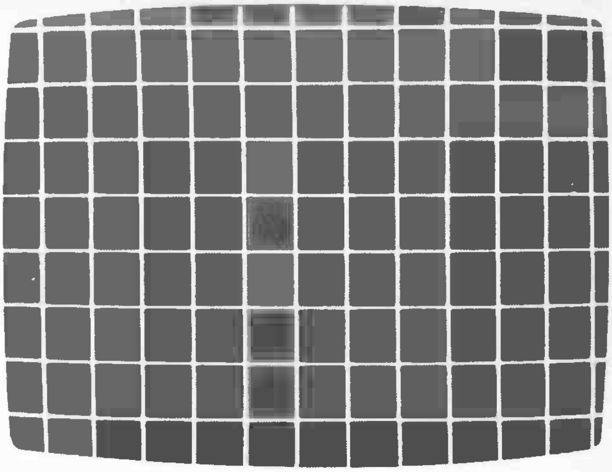


Fig. 5. Component layout





to the interlacing this gives two scans per horizontal line. The values in the pulse shaper have been chosen to give vertical lines of approximately the same width. If desired broader lines can be obtained by raising the values of R15 and R19.

When TR1 is switched on by a frame or line synchronisation pulse it has such a low collector to emitter impedance that the required blanking of the modulation signals is obtained.

CONSTRUCTION

With the only exceptions of the on/off switch and battery the components all fit onto the printed circuit board. Details of this board are shown in Figs. 4 and 5.

IC1 and IC2 should be fitted in i.c. sockets as these are both CMOS devices, and the other normal CMOS handling precautions should be taken. C1 must be the specified miniature foil trimmer if it is to fit onto the printed circuit board without the need for any modifications to the design. Any type having a maximum value of about 65p is electrically suitable. Similarly, it is advisable to use the specified Astek modulator as this will fit onto the printed circuit without difficulty, and this particular type is also quite inexpensive and easy to obtain.

A plastic box having a metal lid and approximate outside dimensions of 156·5 by 91·5 by 50mm will accommodate all the components, but this is about the smallest type that is suitable. The printed circuit board is mounted on the base panel of the case using 6BA fixings, and a hole about 12·5mm in diameter is made in the case at the appropriate point so that access to the phono output socket of the modulator is possible. The on/off switch can conveniently be mounted at this end of the case.

As the current consumption of the circuit is about 24 milliamps it is advisable to power the unit from a fairly large 9 volt battery such as a PP7 size, or six HP7 cells mounted in a plastic battery holder. If this second method is used connection to the battery holder is by way of an ordinary PP3 style battery connector.

The completed unit is connected to the t.v. set using a standard phono to coaxial cable of the type used with video games machines and home computers. The only adjustment which the finished unit requires is to set C1 to give an output frequency of 50Hz from pin 4 of IC2. Most t.v. sets will synchronise properly over a fairly wide frequency range, but if possible the unit should be accurately set up so that the possibility of picture distortion due to poor frame frequency accuracy is avoided. The output of the modulator is preset at around channel 36 by the manufacturer, and this component should not need any adjustment. ★

Continuity Checker

CHRIS LARE

THE normal method of measuring resistance is to use a multimeter. With cheaper meters the lowest resistance measurable can be in the order of several ohms which is not always useful, particularly when the item to be measured has a natural resistance of that order. Furthermore, even cheap multimeters are far too expensive to leave lying around in a garage or the home. More expensive meters will resolve the lower resistance ranges but the cost of accidental damage results in a much greater reluctance to allow them to leave the work bench. In view of this there is a requirement for a cheap and robust resistance measuring unit for low values of resistance typically found around the car and home. In most cases in this application the exact value of the resistance is not important and it is sufficient to know that a resistance is, or is not, present.

The unit works by comparing the resistance between the probes with a preset value. If the probe resistance is lower than the preset value an l.e.d. lights and a tone sounds allowing the checker to be used in awkward and dark corners. The prototype unit was built with five preset values, 1 ohm, 10 ohms, 50 ohms, 100 ohms and 1 kilohm and although these may be altered it has been found that this set offers the most flexibility. The unit is battery powered and quite compact.

BALANCING OP-AMP AND COMPARATOR INPUTS

There are some applications of op-amps and comparators where high accuracy and matching between the two inputs is required. Typically this will be most critical where low levels of signals are envisaged of which the circuit described here is an application. It is not really possible to make op-amps and comparators with very accurate input stages at a reasonable cost due to production tolerances during the actual manufacture of the silicon chip and so many parts allow the end user some means of nulling-out any errors. Obviously accurate parts are made but these will be specially selected and trimmed during the final chip assembly stages and are thus very expensive.

Theoretically any device should give a balanced output (half supply rail) when the inputs are joined together and grounded through a resistor. If this is done it will be noticed that the output of the device is usually hard over in one direction and a small voltage appears on the inputs even though they are supposedly grounded. The device output sitting at one of the rails is caused by a small voltage mismatch in the actual comparator circuit, whereas the small voltage seen is a result of the inputs themselves sourcing a small current. This voltage is called the 'offset' voltage. As the source impedance becomes larger the effect of this offset becomes worse because the current flow from the input is essentially constant. Fig. 1 shows a typical device with source impedances. Even if both resistors are the same, differences in the two currents will result in error. The method adopted by the device designer is to allow the user to slightly vary the input stage currents by providing two extra pins on the device which give access to the input stage balancing network. The user may allow current to flow into

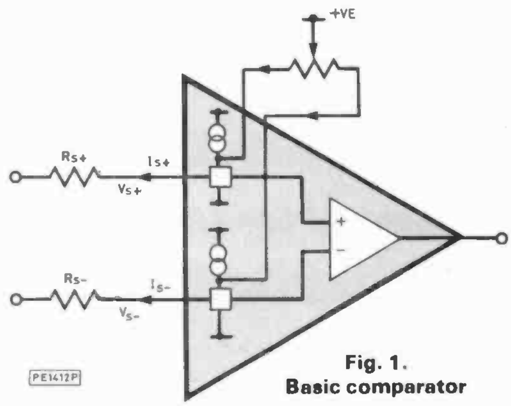


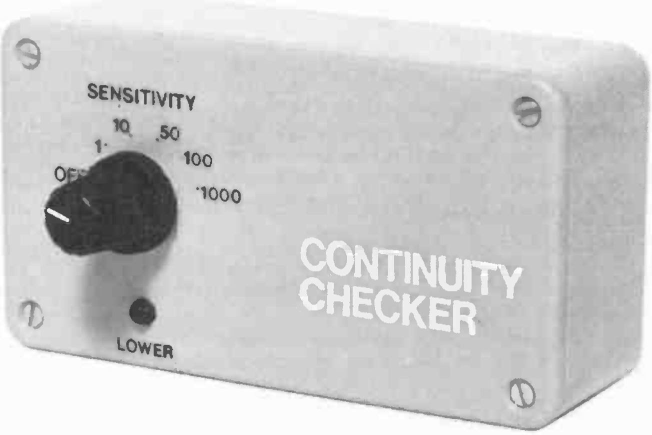
Fig. 1. Basic comparator

these pins to cancel out the actual device error.

The most simple way of doing this is illustrated where a potentiometer has been connected between the two correction pins. When the wiper is in mid position the current injected into both input stages will be equal and thus the adjustment has no overall effect. As soon as the wiper is moved different amounts of current are injected which can be used to cancel out any imbalances in the input stages. It is worth noting that this technique will also cancel out effects through the source resistors not being properly matched, although severe mismatch will be outside the adjustment range.

In actual practice a resistor is connected in series with the potentiometer wiper to limit the current if it is set fully over to one end which would allow large, and potentially damaging, currents to flow into the device. A capacitor can be connected between the ends of the potentiometer to help prevent oscillation when a comparator is used but this is not too common for op-amps. It is also possible to use one of the adjustment pins to add hysteresis to the comparator by making use of offset errors.

Although Fig. 1 shows the offset adjustment connected to the positive supply care should always be taken to ascertain which supply should be used since many devices use the negative rail for this form of correction. The device pins will be labelled 'balance' or 'offset null'.



CIRCUIT

The resistance sensing part of the circuit is built around a traditional balanced resistor bridge. Consider the effect of switch S1 being set to the '1' position. This will give rise to a voltage at point A. If the probes are connected across a one ohm resistor as well, the voltage at point B will be equal to that at point A and the bridge will be balanced. If the resistance across the probes is slightly less than one ohm the voltage at point B will increase very slightly, a condition which is fairly easy to detect with a voltage comparator. The voltages are fed to the comparator, an LM311, through two equal resistors R10 and R11. These are included for two reasons: firstly they provide a defined input impedance for the comparator allowing offsets to be nulled-out and secondly, together with D3–D6, they limit the comparator input differential voltage if the probes are accidentally connected to something unpleasant. The diodes play no normal part in the operation of the circuit. Now, in the case above where point B is higher than point A the inverting input of the comparator will be higher than the non-inverting and so the comparator output will go low which will light the l.e.d., D7.

Possibly the most important trimming fitted is the supply voltage derivation for the bridge circuit. Normally the bridge is connected directly across the supply but this would imply that the comparator was required to operate within millivolts of its supply which it will not do effectively. To avoid this the bridge is fed with 3·7 volts which sets the comparator inputs at almost half supply rail which is the best point. This scheme also gives the advantage that the bridge supply is very well decoupled from the main battery supply and is thus fairly immune to noise created by other parts of the circuit, in particular the tone generator. The actual value of the supply to the bridge is not important since it is fed to both sides of the balancing network and so it was derived from a 4·3 volt Zener. D2 drops this voltage a further 600mV but is mainly intended to prevent damage to the Zener should a high voltage be applied to the probes. The supply is well decoupled by C1.

The preset resistances are selected by a rotary switch, S1. The 50 ohm setting is obviously not absolutely accurate but it was felt that it was good enough for the intended application. Obviously more precise 1% resistors could be used instead of the 5% ones specified but the value of this is again open to debate.

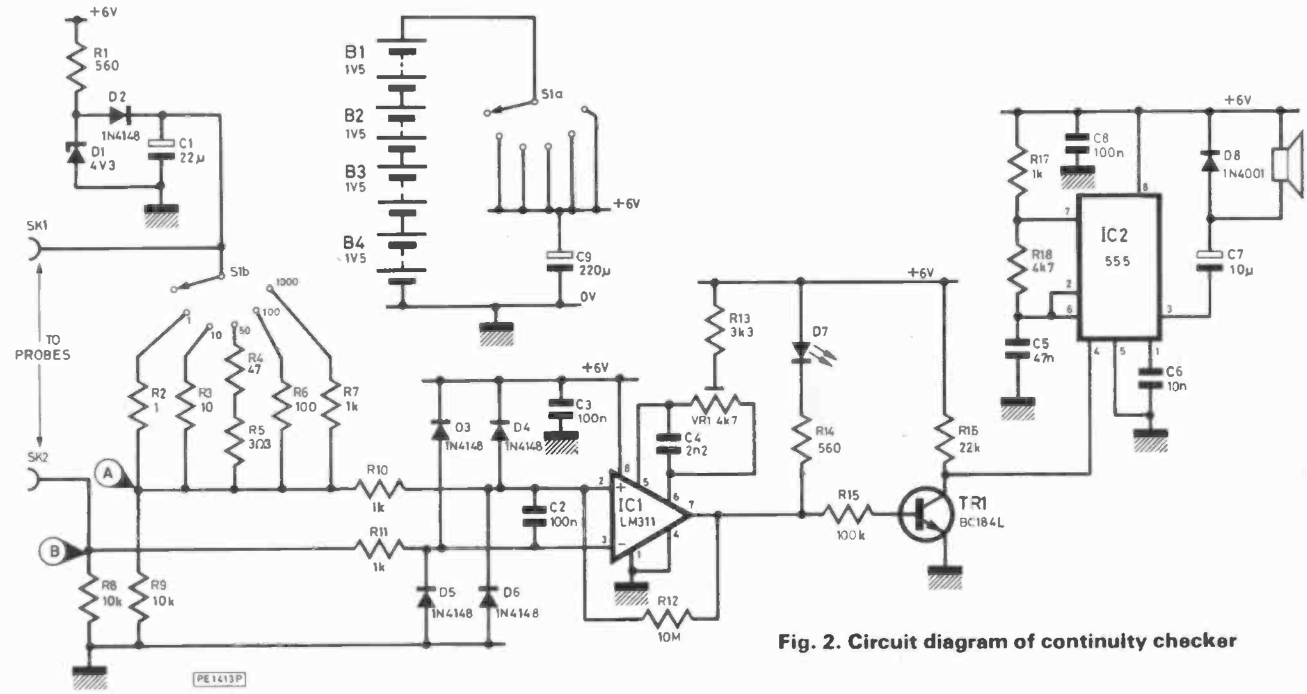


Fig. 2. Circuit diagram of continuity checker

Several circuit trimmings are required to make this work as intended. Firstly comparator circuits of this type tend to oscillate when the theoretical switching point is reached. This is caused by a variety of reasons, all due to the fact that the comparator is a very high gain device. The tendency to oscillate can be removed by small amounts of positive feedback which is supplied by R12. It is important that R12 is not made any smaller (which would be better for the circuit) because the hysteresis effect thus created would swamp any small input voltage changes. The reduction of oscillation is continued by the addition of C2 which effectively lowers the a.c. input differential and C3 which acts as a decoupling capacitor very close to the comparator.

The offset null adjustment circuit as previously mentioned consisting of VR1, R13 and C4 allows the circuit to be properly balanced.

The tone generator consists of a standard 555 timer astable circuit running at 400Hz. When the comparator output goes low TR1 turns off which allows the reset pin (4) of the 555 to be pulled high by R16 thus enabling the tone. An 8 ohm speaker was used in the prototype which gave sufficient volume. C7 blocks any d.c. current flow when the tone is not sounding (the 555 output will be low) and also acts as a series impedance when the tone is sounding to limit the current flow through the speaker. The 555 is decoupled with a 100n C8 close to it and the usual control voltage input decoupling capacitor C6.

The entire circuit is decoupled by a 220µF electrolytic which although larger than usual is probably a good idea for a circuit as sensitive as this. The checker is switched by the other pole of S1 which simply connects the battery to the rest of the circuit when any of the resistance values are set. The current consumption is about 14mA standing, which rises to some 36mA when the l.e.d. and tone are operational.

CONSTRUCTION

The complete unit was designed to fit into a small plastic box and only requires 5 holes to be drilled for the switch, l.e.d., speaker and terminals.

The holes for the l.e.d. and S1 should be marked as follows: S1 and the l.e.d. are on a centre line 33mm from the left hand side of the lid, switch S1 being centred 32mm from the top of the lid and the l.e.d. 54mm from the top of the lid. The hole for the l.e.d. is 5mm diameter and the switch 9·5mm diameter. Since these components are p.c.b. mounted it is very important to make accurate measurements. The p.c.b. is held in place solely by the switch retaining nut.

The two holes for the 4mm terminals should be drilled so that they fit above the speaker but do not interfere with the p.c.b. A 10mm hole should be drilled for the speaker in the bottom of the box and covered with a small piece of cloth. After glueing down the speaker, the terminals should be fitted and the flying leads attached to both the speaker and the terminals.

Assemble the circuit board which should be used in preference to Veroboard. Fit all the components in any order although the l.e.d. is probably best left until last. The rotary switch specified is supplied with tag (ends) which should be cut off. Insert the switch with care and solder only two pins in before checking it is flush with the board and soldering the other pins in. The l.e.d. should be fitted so that its rim is level with the top of the switch so that it will appear through the lid of the box in final assembly.

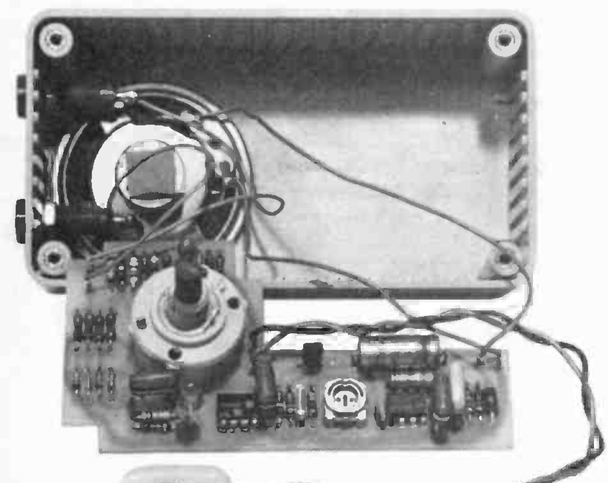


Fig. 3. Complete assembly of continuity checker

Testing the board should be very simple, although it should be mentioned that the loading of an average multimeter will upset the bridge operation. Check firstly the operation of the on/off switch wafer and check that the battery voltage appears on the circuit and that the current consumption does not exceed 17mA. Set the resistance switch to 1 and join the probe sockets together whereupon the l.e.d. should light and the tone sound. Check that all the other settings work as well and then set up the offset adjustment. This is most easily done by firmly joining points A and B (not the terminals) and adjusting the preset until the l.e.d. just comes on and then turning it back very very slightly to counteract the hysteresis effect. It may happen that the circuit will just oscillate but this is not of any consequence. The l.e.d. should not go out at this stage. Finally test the unit by connecting known resistances between the probes, remembering that the contact resistance can be in the order of a few ohms and so soldered connections are recommended for testing.

Complete the final assembly by fixing the circuit board into the box lid (using a washer to space it if necessary) and then connecting the flying leads and the battery clip to the relevant terminals. Give the unit a final check and fit the lid onto the box. ★

COMPONENTS . . .

Resistors

R1, R14	560 (2 off)
R2*	1
R3*	10
R4*	47
R5*	3Ω3
R6*	100
R7*, R10, R11, R17	1k (4 off)
R8, R9	10k
R12	10M
R13	3k3
R15	100k
R16	22k
R18	4k7

All 5% ¼W unless greater accuracy is required when *items should be replaced by 1% types

Potentiometer

VR1	4k7 miniature horizontal preset

Capacitors

C1	22µ 10V tantalum
C2, C3, C8	100n C280 type polyester (3 off)
C4	2n2 polyester block 0·3in pitch
C5	47n C280 type
C6	10n disc ceramic
C7	10µ 10V elect.
C9	220µ 10V elect.

Semiconductors

D1	4V3 400mW Zener
D2, D3, D4, D5, D6	1N4148 (5 off)
D7	Green l.e.d.
D8	1N4001
TR1	BC184L
IC1	LM311
IC2	NE555

Miscellaneous

Plastic box 120 x 45 x 60mm
Printed circuit board
Suitable knob and pointer
Terminal pins
S1 — 2 pole 6-way switch (Lorlin 'Wavechange' type)
Battery clip, holder for four HP7 in square format
B1–4 — HP7 batteries (4 off)
2 of 4mm terminal sockets, test probes
LS1 — Miniature 8 ohm 2 inch speaker
Speaker cloth, connecting wire, small piece of paxolin, washer for switch
Letraset to suit

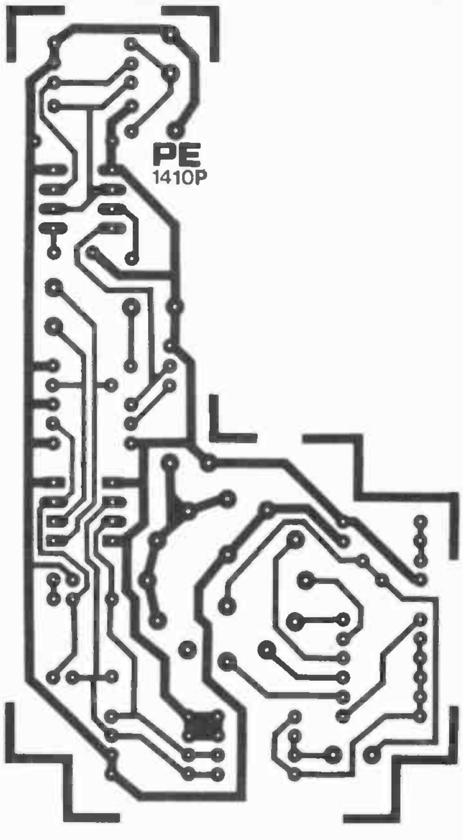


Fig. 4. Printed circuit board layout (actual size)

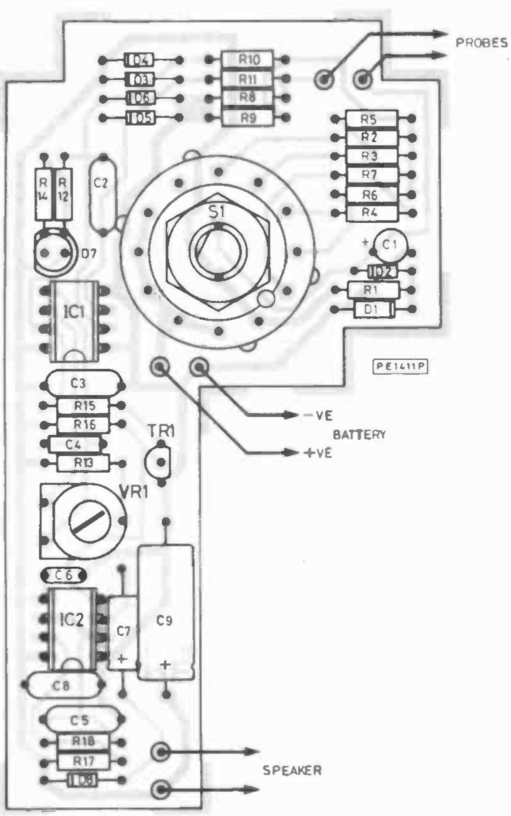


Fig. 5. Component layout

MICRO-BUS

and MICROPROMPT

Appearing every month, Micro-Bus now presents ideas, applications and programs for the most popular microcomputers and all micro-related projects so far published in PE. Ideas must be original, and payment will be made for any contribution featured.

UK101 M/C TRACE

The Trace facility of PE April 1983 was most interesting but unfortunately it does not give a complete trace, in fact only interrupting instructions of two clock cycles in length. 6502 microprocessor instructions vary from two to six cycles of the 1MHz clock and therefore some additional refinements would have to be incorporated to display the addresses of all instructions.

The 6502 microprocessor has certain conditions to be fulfilled before initiating an interrupt sequence. Essentially the IRQ or NMI lines must go low and remain low for at least two clock cycles to be recognised. In addition the IRQ line must remain low until the end of the current instruction sequence to be recognised. If an IRQ interrupt is to be used to drive a Trace facility and be driven from the sync pin of the 6502 then a method must be found to "stretch" the sync pulse until the interrupt is recognised. This stretched pulse must then be terminated on completion of the IRQ routine or the microprocessor will, on returning to the main program, immediately repeat the interrupt. One way of doing this is to provide a latch which will be set by the sync pulse and be reset on completion of the interrupt loop by a pulse derived from "ANDing" the sync pulse with a decoded RTI instruction from the data bus. Fig. 1 shows a simple circuit to implement this which can be built on a piece of stripboard.

IC1 partially decodes the data bus and the decoding is completed by IC2a. In order to ensure that the data on the bus is stable the Ø2 clock pulse used to trigger the latch IC3 is delayed some 100ns by IC2b. To allow for stray capacitances some adjustment may be required to the value of the capacitor. IC3 is set by a sync pulse but reset when a sync pulse occurs in conjunction with the RTI instruction.

D0 to D7 can be connected to the spare connecting pads to the left of IC14. (On the UK101 D0 is nearest the keyboard.) Ø2 can be connected to W6. Ground and Vcc can be connected to pins 1 and 12 respectively of IC14. IRQ and SYNC are connected to the 6502 pins 4 and 7. There is no need to disconnect R11 as the circuit will operate in the wired-OR configuration. Mr Beckett's software will now print out at the top of the screen the current address of the operation code being performed.

For those who have fitted the WEMON monitor the Trace machine code shown here will provide much more information. This program will print out on the top, normally non-printing line, of the screen the contents of all the registers namely program counter, flags, stack pointer, accumulator, X and Y registers. It should be noted that the data shown in the registers is that existing before the instruction to be found in the program counter is executed. Wemon uses locations 0241 to 0247 to store this information and this program uses the sub-routine at F98F to print it out. An additional facility provided by the program is that the Trace will wait in the interrupt loop until the left-hand shift key is pressed. This allows the user to "single step" through a program, viewing the contents of all the registers at each step, a most useful feature in de-bugging.

If Trace is being used to step through a BASIC program then "MEMORY SIZE?" should be answered by 8115. The WEMON IRQ vector is set to point to the correct location by POKE561,76: POKE562,184: POKE563,31 and this should be placed at the start of the program. The Trace speed is set by a poke to 8191, 1 for fast, 0 for slow and 127 for medium. The IRQ mask is cleared by POKE11,182: POKE12,31: X=USR(X). The switch is used to turn Trace on and off.

J. H. Howarth,
W. Lothian.

Trace program for use with WEMON monitor

1FB6	58	CLI		Clear interrupt mask
1FB7	6Ø	RTS		and return to program
1FB8	8E46Ø2	STX	$Ø246	Store X register in Wemon store
1FBB	8C47Ø2	STY	$Ø247	Store Y register in Wemon store
1FBE	68	PLA		Pull status off stack and
1FBF	8D43Ø2	STA	$Ø243	store
1FC2	68	PLA		Pull program counter hi- byte
1FC3	8D42Ø2	STA	$Ø242	off stack and store
1FC6	68	PLA		Pull program counter lo- byte off
1FC7	8D41Ø2	STA	$Ø241	stack and store
1FCA	BA	TSX		Transfer stack pointer to X register
1FCB	8E44Ø2	STX	$Ø244	and store
1FCE	2Ø8FF9	JSR	$F98F	Print contents of Wemon stored registers
1FD1	A9FE	LDA	£$FE	Address row which contains the l.h.
1FD3	8DØØDF	STA	$DFØØ	shift key in the keyboard latch
1FD6	A9Ø5	LDA	£$Ø5	Address column in keyboard to see
1FD8	2CØØDF	BIT	$DFØØ	if l.h. shift has been pressed
1FDB	DØF4	BNE	$1FD1	Shift not pressed go back & try again
1FDD	AEFF1F	LDX	$1FFF	Shift pressed. Continue via
1FEØ	ACFF1F	LDY	$1FFF	the delay stored in address 1FFF
1FE3	88	DEY		
1FE4	DØFD	BNE	$1FE3	
1FE6	CA	DEX		
1FE7	DØFA	BNE	$1FE3	Delay incomplete. Return again
1FE9	AD41Ø2	LDA	$Ø241	Fetch program counter lo- byte
1FEC	48	PHA		and push on the stack
1FED	AD42Ø2	LDA	$Ø242	Fetch program counter hi- byte
1FFØ	48	PHA		and push on the stack
1FF1	AD43Ø2	LDA	$Ø243	Fetch status and
1FF4	48	PHA		push on the stack
1FF5	AD45Ø2	LDA	$Ø245	Reload original value of accumulator
1FF8	AE46Ø2	LDX	$Ø246	Reload original value of X register
1FFB	AC47Ø2	LDY	$Ø247	Reload original value of Y register
1FFE	4Ø	RTI		Return from interrupt routine
1FFF	ØØ	BRK		Space reserved for delay counter

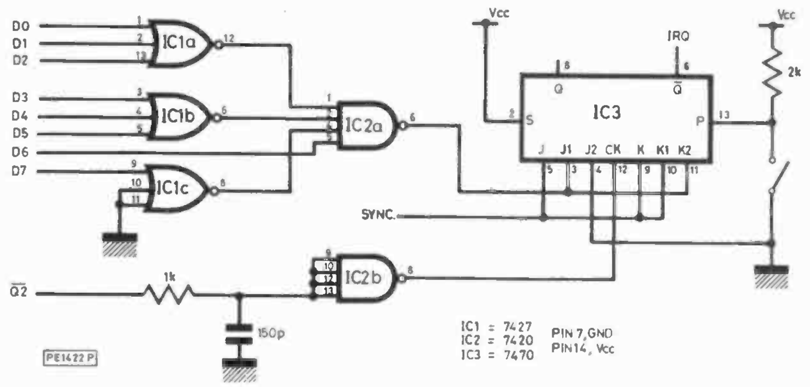


Fig. 1. Hardware for Machine Code Trace

It is emphasised that material presented in Micro-Bus has not necessarily been proved by us. Neither can compatibility with *all generations* of the computer equipment to which it relates be guaranteed.

Software and hardware designs submitted should be accompanied by a declaration to the effect that it is the original work of the undersigned, and that it has not been accepted for publication elsewhere.

RESONANCE

Sir—I have been reading your magazine for the past eighteen years and think it's about time I made a contribution. The adjacent program was written for the Dragon 32 computer and should run on any machine, without too much alteration, as only text is used. The program will calculate values of capacitance, inductance and frequency at the resonant frequency of a parallel or series connected coil and capacitor combination.

The computer will first ask which of the three variables needs to be calculated and will then request the other two. All the usual denominations are taken care of, i.e. Hz, kHz, pF, mH, etc., and all the answers are presented in the same form.

I hope that this program will interest some of your readers and perhaps inspire someone to tackle the problem of coil construction. Who knows? I might come up with something within the next eighteen years!

Mr. A. D. Flower,
Staffordshire.

```
10 PI=3.1415926
20 CLS:PRINT @107,"RESONANCE (23
   spaces) *********"
30 PRINT @233,"BY A.D.FLOWER."
40 PRINT @362,"MARCH 1983"
50 FOR T=1 TO 4000:NEXT T:CLS
60 PRINT @132,"DO YOU WISH
   CAPACITANCE,(8 spaces)INDUC-
   TANCE OR FREQUENCY (11
   spaces)TO BE CALCULATED ?"
70 PRINT @357,"PRESS KEY
   'C','I'OR'F'"
80 A$=INKEY$
90 IF A$="C" THEN 130
100 IF A$="I" THEN 260
110 IF A$="F" THEN 410
120 GOTO 80
130 CLS:PRINT @42,"CAPACITANCE
    (21 spaces) ————————————
    —"
140 PRINT @97,"PLEASE ENTER IN-
    DUCTANCE VALUE (3 spaces)AND
    (WHEN REQUESTED) ITS (8 spaces)
    DENOMINATION. (19 spaces) DO
    LIKEWISE FOR THE FRE-
    QUENCY."
150 GOSUB 560:GOSUB 590:GOSUB 650
160 IF F=0 OR L=0 THEN 140
170 C=((1/(2*PI*F)) ↑2)/L
180 C=C*1E06:REM C=MICROFARADS
190 IF C>999.99 THEN GOSUB 750
200 IF C<0.0005 THEN 220
210 PRINT:PRINT" CAPACITANCE =
    ";:PRINT
    USING"# # #.# # # #";C;:PRINT
    "UF":GOTO 50
220 C=C*1E06:REM C=PICOFARADS
230 IF C<0.5 THEN GOSUB 740
240 PRINT:PRINT" CAPACITANCE =
    ";:PRINT
    USING"# # #.#";C;:PRINT "PF"
250 GOTO 50
260 CLS:PRINT @43,"INDUCTANCE (22
    spaces) ————————————"
270 PRINT @97,"PLEASE ENTER
    CAPACITANCE VALUE (2 spaces)
    AND (WHEN REQUESTED) ITS (8
    spaces) DENOMINATION.(19 spaces)
    DO LIKEWISE FOR THE FRE-
    QUENCY."
280 GOSUB 620:GOSUB 590:GOSUB 650
290 IF F=0 OR C=0 THEN 270
300 L=((1/(2*PI*F)) ↑2)/C
310 L=L*1E06:REM L=MICROHENRYS
320 IF L>999.99 THEN 350
330 IF L<0.05 THEN GOSUB 740
340 PRINT:PRINT" INDUCTANCE =
    ";:PRINT
    USING"# # #.# #";L;:PRINT
    "UH":GOTO 50
350 L=L*1E-03:REM
    L=MILLIHENRYS
360 IF L>999.99 THEN 380
370 PRINT:PRINT" INDUCTANCE
    =";:PRINT
    USING"# # #.# #";L;:PRINT
    "MH":GOTO 50
380 L=L*1E-03:REM L=HENRYS
390 IF L>999.99 THEN GOSUB 750
400 PRINT:PRINT" INDUCTANCE =
    ";:PRINT
    USING"# # #.# #";L;:PRINT
    "H":GOTO 50
410 CLS:PRINT @43,"FREQUENCY (23
    spaces) ————————————"
420 PRINT @96,"PLEASE ENTER IN-
    DUCTANCE VALUE (3 spaces) AND
    (WHEN REQUESTED) ITS (8 spaces)
    DENOMINATION. (19 spaces) DO
    LIKEWISE FOR THE
    CAPACITANCE."
430 GOSUB 560:GOSUB 620:GOSUB 650
440 IF L=0 OR C=0 THEN 420
450 F=1/((2*PI)*SQR(L*C))
460 REM F=HERTZ
470 IF F>999.99 THEN 500
480 IF F<1 THEN GOSUB 770
490 PRINT:PRINT" FREQUENCY =
    ";:PRINT
    USING"# # #.# #";F:;PRINT
    "HZ":GOTO 50
500 F=F*1E-03:REM F=KILOHERTZ
510 IF F>999.99 THEN 530
520 PRINT:PRINT" FREQUENCY =
    ";:PRINT
    USING"# # #.# #";F;:PRINT
    "KHZ":GOTO 50
530 F=F*1E-03:REM F=MEGAHERTZ
540 IF F>999.99 THEN GOSUB 760
550 PRINT:PRINT" FREQUENCY =
    ";:PRINT
    USING"# # #.# #";F;:PRINT
    "MHZ":GOTO 50
560 PRINT:INPUT" INDUCTANCE ";L
570 INPUT"(4 spaces) H:MH:UH ";DI$
580 RETURN
590 PRINT:INPUT"(2 spaces) FRE-
    QUENCY ";F
600 INPUT" HZ:KHZ:MHZ ";DF$
610 RETURN
620 PRINT:INPUT" CAPACITANCE";C
630 INPUT"(6 spaces) UF:PF ";DC$
640 RETURN
650 IF DI$ ="H" THEN L=L
660 IF DI$ ="MH" THEN L=L*1E—03
670 IF DI$ ="UH" THEN L=L*1E—06
680 IF DF$ ="HZ" THEN F=F
690 IF DF$ ="KHZ" THEN F=F*1E03
700 IF DF$ ="MHZ" THEN F=F*1E06
710 IF DC$ ="UF" THEN C=C*1E—06
720 IF DC$ ="PF" THEN C=C*1E—12
730 RETURN
740 PRINT @449,"VALUE TOO
    SMALL":RETURN
750 PRINT @449,"VALUE TOO
    LARGE":RETURN
760 PRINT @449,"FREQUENCY TOO
    HIGH":RETURN
770 PRINT @449,"FREQUENCY TOO
    LOW":RETURN
```

SEMICONDUCTOR CIRCUITS

TOM GASKELL BA(Hons) AMIEE

TOUCH TUNERS (SAS 580 and SAS 590)

MANY integrated circuits are specifically designed to fulfil well defined roles. Indeed, most of the i.c.s featured in Semiconductor Circuits to date fall into this category, being specifically intended for use as door chimes, combination locks, audio preamplifiers, l.e.d. bargraphs, etc. It is often interesting to apply some lateral thinking to the way in which these i.c.s are used; this can often result in unusual designs of considerable effectiveness and simplicity which are very different to the original intentions of the i.c. manufacturers. The Siemens SAS 580 and SAS 590 are perfect examples of this. They were designed as touch tuning amplifiers for television and radio tuners, but in practice they offer marvellous facilities for use in a whole host of switching and controlling applications.

The basic intention of the i.c.s is to provide a tuning voltage for varicap diodes. This tuning voltage alters the capacitance of the diode, which in turn causes the radio or television receiver to tune in to the appropriate station. Four different analogue voltages can be fed into the i.c., and four switches are provided to allow the relevant voltage to be switched through to the diode. If each analogue voltage represents the tuning voltage for a different station, the switches enable instantaneous selection of any of these four different stations. Furthermore, four load driving outputs are provided, suitable for driving lamps, l.e.d.s, relays, or waveband selection circuitry as required.

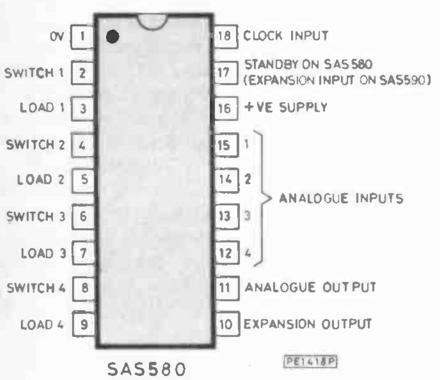
INGENIOUS FACILITIES

Although the basic description of i.c. operation seems simple enough, numerous more complex extra facilities are provided. Full interlocking is arranged such that only one input is switched to the output at any one time, except when two control inputs are deliberately turned on together as a momentary action. The control inputs themselves (switch 1, switch 2, switch 3, and switch 4) have been made touch sensitive, so that either non-moving touch plates or conventional switches may be used as the switch input device.

A clock input is provided so that the stations can be switched in sequence to 'scan' through the available stations automatically, and the system can be expanded in blocks of four channels at a time, almost without limit. Even more subtle features will become evident as the detailed operation of the i.c.s is considered!

BLOCK OPERATION

The SAS 580 and SAS 590 are both 18 pin bipolar i.c.s with pinout and specifications shown in Fig. 1 and a block diagram shown in Fig. 2. Four RS type flip-flops control the switching in such a way that the 'setting' of any flip-flop causes the resetting of all others in the circuit. This is the means by which interlocking of the switches is provided. The flip-flops can be set either by a clock input (pin 18) or by individual switch inputs (pins 2, 4, 6 and 8). Whenever the clock input is pulsed to logic 1 (a high level) the next flip-flop along the



SAS580 (& SAS590)

Characteristic	Notes	Min	Typically	Max	Units
Supply voltage	All specs measured at +30V supply	10		36	V
Quiescent current		2·9	7	9·5	mA
Temperature range		0		+70	°C
Analogue input voltage	Pins 15, 14, 13, 12	0·3		(+ve supply −2)	V
Analogue offset voltage	Between pins 15, 14, 13, or 12, and pin 11			±100	mV
Temperature drift	20°C to 50°C, at pin 11			5	mV
Analogue input current	Pins 15, 14, 13, 12		150	300	nA
Analogue output impedance	Pin 11		3		k
Switch input threshold	Pins 2, 4, 6, 8		5·5		V
Switch input current	Pins 2, 4, 6, 8	20	80	200	nA
Clock frequency				10	kHz
Driver load current	Pins 3, 5, 7, 9			55	mA
Saturation voltage	Pins 3, 5, 7, 9 1k load		0·8	1·5	V
	Pins 3, 5, 7, 9 30k load		30	60	mV
Reverse voltage	Pins 3, 5, 7, 9 5μA to 100μA current	50			V
Reset to channel 1	(Pin 18) Pulse duration	70			μs
	(Pin 18) Pulse rise time			1	μs
Clock to next channel	(Pin 18) Pulse duration		2·5		μs
	(Pin 18) Pulse rise time			1	μs
Zener voltage	Pin 16 (at typically 10mA)	34		39	V
Supply current	Via resistor, when using Zener			15	mA

Fig. 1. Pinout and specifications for the SAS 580 and SAS 590

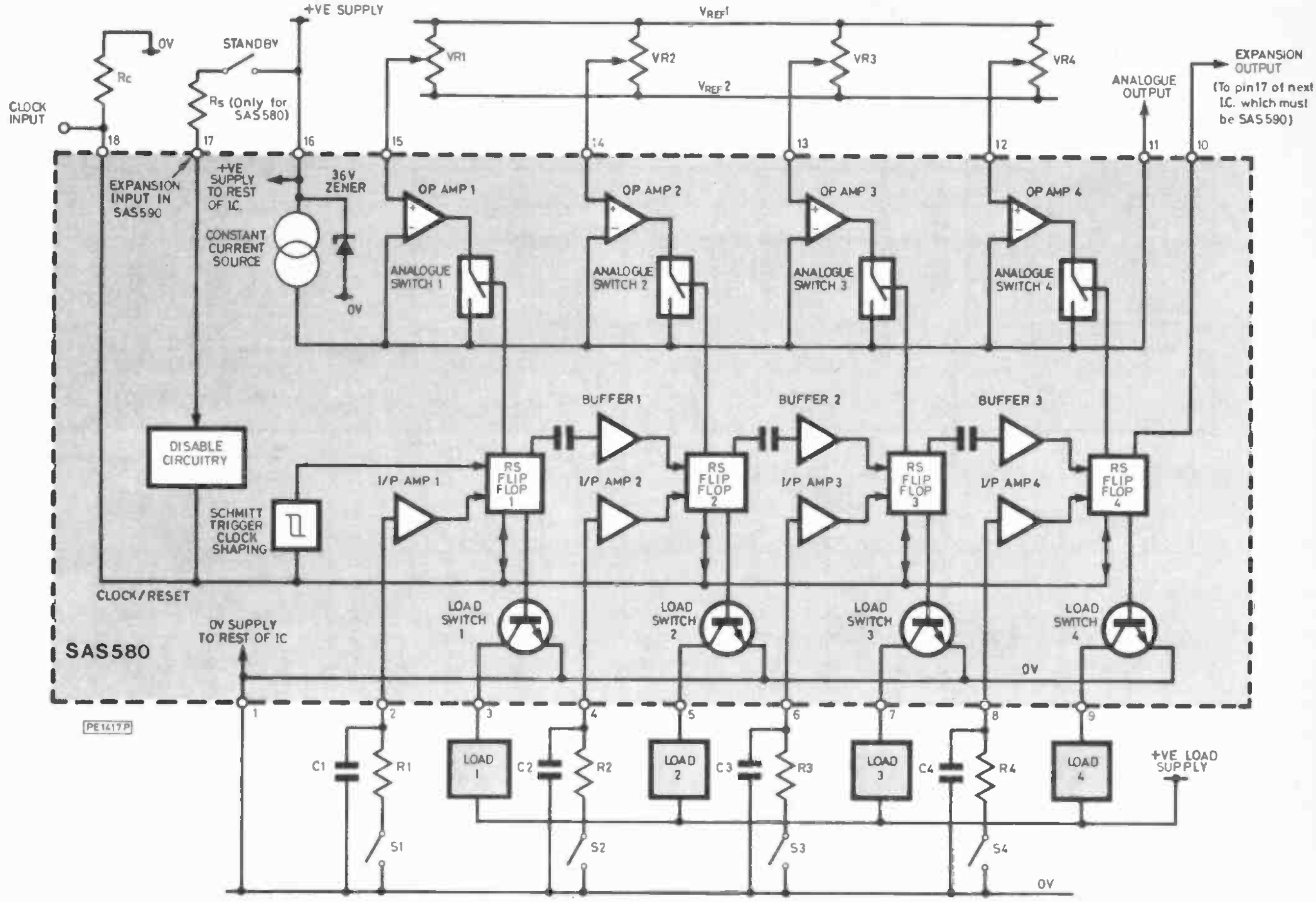


Fig. 2. Block diagram of the SAS 580 and 590

chain turns on, i.e. is set with all others turning off, i.e. reset. Hence, if flip-flop 1 is turned on, then the clock pulsed, 1 turns off as 2 turns on. On the next pulse, 2 turns off as 3 turns on, etc. At any time the individual switch inputs can override the clocking, turning on only the flip-flop required, and the clocking will start from any given flip-flop being on; 1, 2, 3 or 4.

Each flip-flop controls a load switch, which is basically an open collector *npn* transistor which can sink up to 55mA of current to 0 volts when turned on. This can be used to light an indicator, for example, to show the channel selected. The flip-flop also turns on an analogue switch around the feedback loop of a voltage following op-amp. When turned on, this switch completes the feedback loop of that op-amp, allowing the relevant analogue input voltage to be accurately reproduced, with unity gain, at pin 11 of the i.c. This can be any voltage within the limits of the specification, of course, which frees the i.c.s for use in many different applications other than varicap diode control. A constant current source provides suitable loading and biasing of the op-amp outputs.

The 'standby' facility is only provided on the SAS 580, not on the SAS 590. When R_s, normally 100k, is taken to the positive supply rail, the action is normal, but when disconnected from the positive supply the voltage at pin 17 drops to less than 0·5 volts, causing the currently selected channel to remain selected irrespective of any switch or clock action. The i.c. is nominally rated at up to +36V supply. If higher supply voltages are to be used then adding a suitable resistor in series with the positive supply allows the internal Zener diode to regulate the voltage to between 34 and 39 volts. (This is quite safe for the i.c., even though potentially higher than the specified +36V.) Typically 13mA, and certainly no more than 15mA, should be arranged to flow into pin 16 when using this Zener facility.

INPUTS AND OUTPUTS

The switch inputs to the i.c.s, pins 2, 4, 6 and 8, are very high impedance inputs suitable for use both in touch sensitive and mechanically switched applications. The inputs are activated by momentarily connecting them to 0 volts via a large value resistor; typically 1M for mechanical switches, and 10M for touch switches. In the latter case, the switches should consist of two metal pads spaced apart by a small gap. The finger should bridge this gap to turn the input on. As with all touch controlled circuitry, great care must be taken if the equipment has a mains derived power supply, with the 0 volts supply line, and all metalwork, connected to mains earth. To provide a measure of interference rejection, capacitors should normally be connected between pins 2, 4, 6 and 8, and 0 volts. These should all be typically around 10nF, with the exception of C1 on the SAS 580 only, which should be a little larger; typically 22nF. Note that more than one channel can be selected at once if several inputs are connected to 0 volts simultaneously. This condition only lasts until the inputs are disconnected from 0 volts, but if it causes problems then mechanical switches with electrical interlocking should be used to prevent more than one input being active at any time.

The analogue inputs and output are fairly self-explanatory. The minimum voltage that can accurately be switched is 0·3V, and the maximum is 2 volts less than the supply voltage at pin 16. Inputs as low as 0 volts or as high as the pin 16 voltage will not cause damage, but cannot be reproduced at pin 11. The output impedance at pin 11 is typically 3k, so a buffer amplifier should be provided if driving into anything other than a high impedance. The clock input, pin 18, provides both clocking and reset functions. If a positive going (high level) pulse of typically 2·5µs is fed to pin 18 it will 'clock the channels along' by one position, e.g. if channel 2 is turned on before the pulse, channel 3 will be turned on after it. If the pulse is longer than 70µs, however, the i.c. will be reset, causing channel 1 to be selected automatically irrespective of the number of i.c.s in the system. Resetting to channel 1 will also occur when power is first applied.

EXPANSION

The first i.c. in any 'chain' of devices must be an SAS 580. After that, SAS 590s must

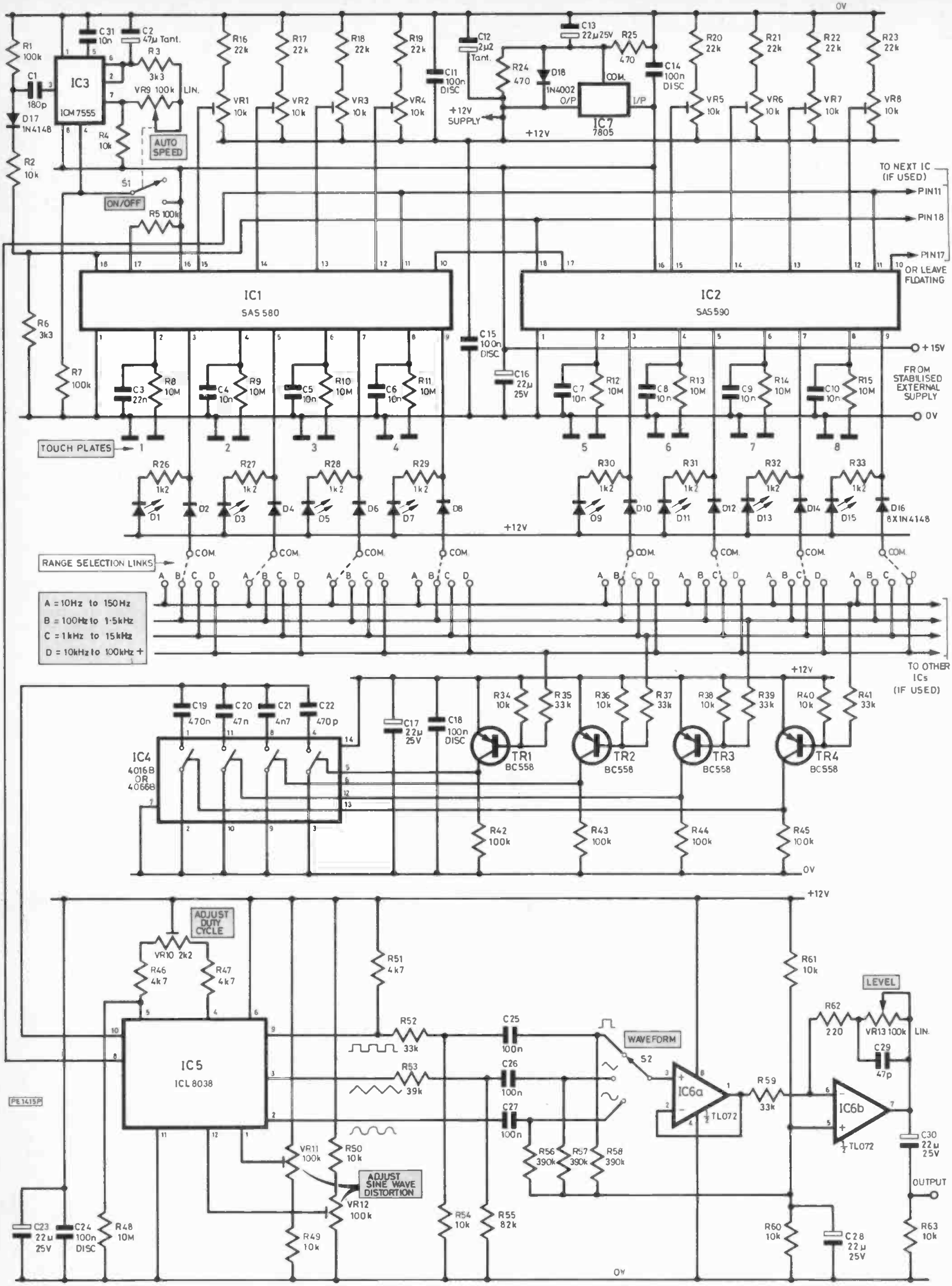


Fig. 3. Circuit diagram of the Spot Frequency Oscillator

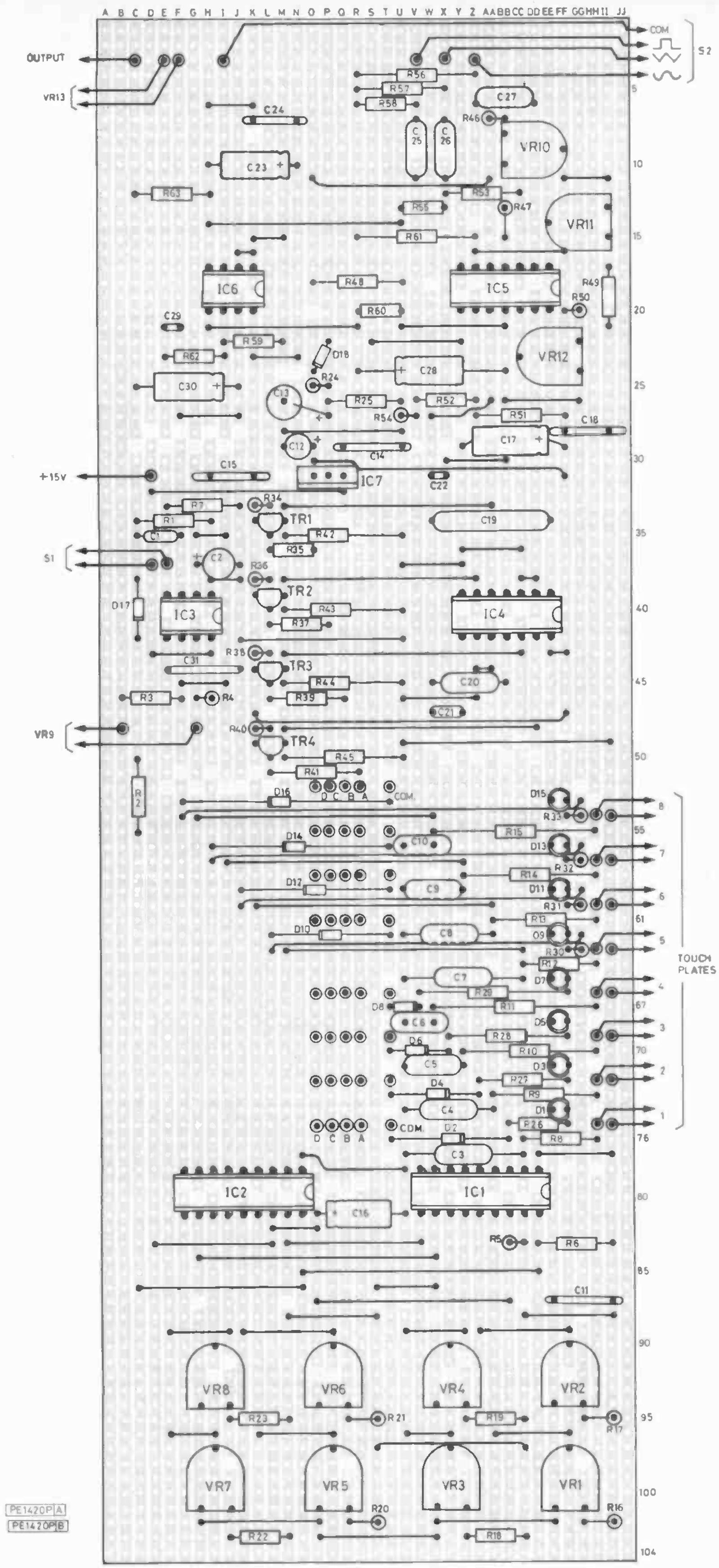


Fig. 4. Veroboard design

be used to add four channels at a time to the system. There is no limit to the number of SAS 590s which can be cascaded in this way. For all i.c.s, both 580 and 590, pins 18 should be commoned, as should all pins 11. Pin 10 of the first i.c. should connect to pin 17 of the second, then pin 10 of the second should be connected to pin 17 of the third, etc, etc, all down the line. See Fig. 3 for a simple example of this. (The 'standby' facility, and R_s, are only used on the SAS 580.) A really clever touch is that the i.c.s can detect how many devices have been connected in the chain! If only one i.c. is provided, then when clocked the sequence is 1-2-3-4-1-2-3-4-1-2 etc. If two are connected the system counts 1-2-3-4-5-6-7-8-1-2-3-4-5-6 etc. Hence, the circuit will always count round the maximum number of channels provided, without requiring special links or circuitry.

APPLICATIONS CIRCUIT

Fig. 3 shows the circuit diagram of a spot frequency oscillator, used as a 'quick check' instrument for simple audio systems. Eight different frequencies can be generated, each one variable from 10Hz to 100kHz in four bands. The switching can be manual, via touch plates, or automatic with a variable change rate.

The circuit is based around one SAS 580, one SAS 590, and a voltage controlled oscillator, the popular ICL 8038. Square, triangular, and sine waves of different amplitudes are produced by the 8038, and these are adjusted to be approximately equal in amplitude by R52, R53, R54, and R55. S2 selects the output waveform required, and IC6 with associated components provides a variable level a.c. coupled output from the circuit. The maximum output voltage is approximately 9V pk/pk, and the minimum is around 20mV, although different output amplifier configurations could extend this range further. Four frequency bands have been provided: 10Hz to 150Hz, 100Hz to 1·5kHz, 1kHz to 15kHz, and 10kHz to 100kHz or more. The range selection is implemented by a CMOS analogue switch i.c., IC4, which connects timing capacitors C19, C20, C21, or C22 from pin 10 of IC5 to 0 volts. Wire links on the Veroboard layout shown in Fig. 4 are used to select the range chosen for each channel of the system, with TR1, TR2, TR3, and TR4 inverting and buffering the control signals from the links to IC4.

Clocking is provided by IC3, a 7555 CMOS timer connected as a low frequency oscillator. C1, R1, D17, R2, and R6 ensure that pin 18 of IC1 and IC2 receives a pulse of approximately 2·5μs duration, to clock it without danger of resetting it to channel 1. VR9 is a switched potentiometer, switch S1 ensuring that the oscillator is turned off when the potentiometer is in the extreme anti-clockwise position. IC5 requires a wide range of voltages to allow the maximum possible sweep of output frequencies. Ideally, the voltage at pin 8 of IC5 should be allowed to reach right up to the positive supply voltage. Unfortunately, the maximum output from IC1 or IC2 is 2 volts less than their positive supply. To avoid this problem, IC1, IC2, and IC3 are run from a higher supply than the rest of the circuitry; this should be a +15V regulated supply. IC7 is a +5V regulator with R24 and R25 connected in such a way that it actually provides a +12V supply to the rest of the circuitry.

In use, the range selection link for each channel should be soldered to the appropriate p.c.b. tags, and the relevant preset should be tuned to give the required output frequency. VR10 should be adjusted to give an output waveform duty cycle of exactly 50% (equivalent to a 1:1 square wave mark/space ratio). VR11 and VR12 should be adjusted for minimum distortion on the sine wave output, either visually or using a distortion analyser.

Both the SAS 580 and the SAS 590 can be obtained from **Cricklewood Electronics Ltd.,** 40 Cricklewood Broadway, London NW2 3ET. (01-452 0161).

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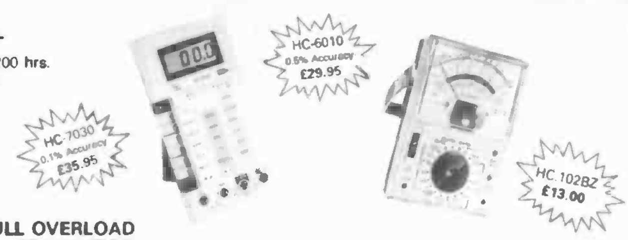

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6.8 35V 21p
10 16V 18p
10 35V 27p
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2.2	63	9p
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2.2	350	30p
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3.3	40	11p
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4.7	16	8p
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4.7	100	14p
10	25	8p
10	40	12p
10	63	14p
10	100	16p
10	350	55p
22	25	11p
22	40	14p
22	63	16p
22	100	21p
47	25	14p
47	40	17p
47	63	26p
47	100	28p
100	16	14p
100	25	16p
100	40	22p
100	63	25p
100	100	30p
220	10	16p
220	16	18p
220	25	22p
220	40	25p
220	63	30p
220	100	40p
470	16	22p
470	25	28p
470	40	33p
470	63	43p
470	100	60p
1000	16	30p
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100	10	9p
100	16	9p
220	10	11p
220	16	12p
470	10	17p
470	16	18p
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1000	16	24p
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2N3711 10p
2N3712 2.00
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2N4909 2.90
2N5089 37p
2N5190 68p
2N5191 70p
2N5193 90p
2N5194 79p
2N5245 37p
2N5246 40p
2N5247 45p
2N5248 46p
2N5249 48p
2N5266 2.88
2N5293 98p
2N5294 1.28
2N5295 1.37
2N5401 35p
2N5415 1.10
2N5416 1.54
2N5447 16p
2N5448 19p
2N5449 21p
2N5450 23p
2N5451 23p
2N5457 29p
2N5458 29p
2N5459 29p
2N5460 72p
2N5551 37p
2N5884 5.95
2N5886 5.95
2N6121 57p
2N6122 59p
2N6123 65p
2N6124 65p
2N6125 65p
2N6126 75p
2N6129 75p
2N6130 93p
2N6131 98p
2N6132 83p
2N6133 1.14
2N6134 1.30
2N6253 1.45
2N6254 1.55
2SC1306 95p
2SC2078 1.70
2SJ49 3.95
2SJ50 4.50
2SJ82 4.75
2SK134 3.95
2SK135 4.50
2SK226 4.75
3N128 1.12
3N140 1.07
3N200 6.93
3N201 2.98
40360 60p
40361 67p
40362 67p
40363 2.95
40406 1.39
40407 75p
40408 1.59
40410 1.80
40411 3.95

40412 90p
40673 70p
40822 1.80
40871 1.00
40872 1.00
AC125 49p
AC126 32p
AC127 32p
AC128 35p
AC132 68p
AC141K 28p
AC142K 28p
AC151 51p
AC152 45p
AC153 55p
AC153K 64p
AC176 27p
AC176K 27p
AC187 25p
AC187K 28p
AC188 26p
AC188K 40p
AF239 55p
AF240 1.00
BC107 10p
BC107A 12p
BC107B 12p
BC108 10p
BC108A 12p
BC108B 12p
BC108C 12p
BC109 10p
BC109B 12p
BC109C 12p
BC140 29p
BC141 37p
BC142 29p
BC143 30p
BC147 10p
BC147A 10p
BC147B 10p
BC147C 20p
BC148 10p
BC148A 12p
BC148B 13p
BC148C 13p
BC149 10p
BC149B 12p
BC149C 13p
BC152 35p
BC153 23p
BC154 27p
BC157 11p
BC157A 12p
BC157B 13p
BC158 10p
BC158A 12p
BC158B 12p
BC159 11p
BC159A 12p
BC159B 12p
BC159C 18p
BC160 48p
BC161 48p
BC167 10p
BC167A 10p
BC167B 10p
BC168 10p
BC168B 10p
BC168C 10p
BC169 10p
BC169B 10p
BC169C 10p
BC177 16p
BC177A 25p
BC177B 26p
BC178 20p
BC178A 24p
BC178B 25p
BC179 20p
BC179A 25p
BC179B 25p
BC179C 27p
BC182 10p
BC182A 12p
BC182B 13p
BC182L 10p
BC182LA 12p
BC182LB 13p
BC183 10p
BC183A 11p
BC183B 12p
BC183C 12p
BC183L 10p
BC183LA 13p
BC183LB 13p
BC183LC 14p
BC184 10p
BC184B 12p
BC184C 13p
BC184L 10p
BC184LB 13p
BC184LC 14p
BC186 24p
BC187 24p
BC212 10p
BC212A 12p
BC212B 13p
BC212L 10p
BC212LA 13p
BC212LB 14p
BC213 10p
BC213A 11p
BC213B 12p
BC213C 13p
BC213L 10p
BC213LA 13p
BC213LB 14p
BC213LC 14p
BC214 10p
BC214B 12p
BC214C 13p
BC214L 11p
BC214LB 13p
BC214LC 14p
BC237 15p
BC237A 16p
BC237B 17p
BC237C 18p
BC238 15p
BC238A 16p
BC238B 17p
BC238C 18p
BC239 15p
BC239A 16p
BC239B 17p
BC239C 18p
BC300 44p
BC301 44p
BC302 43p
BC303 47p
BC327 14p
BC328 14p
BC337 15p

BC338 15p
BC440 32p
BC441 49p
BC460 32p
BC461 33p
BC516 40p
BC517 40p
BC546B 15p
BC547 13p
BC556B 15p
BC547A 14p
BC547B 14p
BC548 12p
BC548A 14p
BC548B 14p
BC548C 14p
BC549 13p
BC549B 14p
BC549C 15p
BC550 16p
BC550C 25p
BC557 15p
BC557A 16p
BC557B 16p
BC558 15p
BC558A 15p
BC558B 16p
BC558C 17p
BC559 15p
BC559B 16p
BC559C 17p
BC560 25p
BC560C 25p
BC650 45p
BC651 46p
BCY70 16p
BCY71 16p
BCY72 19p
BD131 44p
BD132 44p
BD135 35p
BD136 35p
BD137 35p
BD138 37p
BD139 38p
BD140 38p
BD237 98p
BD238 98p
BD239A 57p
BD239C 64p
BD240A 59p
BD240C 73p
BD241A 61p
BD241C 67p
BD242A 65p
BD242C 70p
BD243A 72p
BD143C 85p
BD244A 82p
BC244C 1.00
BD245A 1.14
BD245C 1.30
BD246A 1.20
BD246C 1.50
BD249A 2.00
BD249C 2.31
BD250A 2.11
BD250C 2.46
BD419 1.29p
BD420 1.37
BD437 88p
BD438 88p
BD439 90p
BD440 91p
BD441 91p
BD442 93p
BD529 1.50
BD530 1.50
BD535 75p
BD536 75p
BD537 80p
BD538 80p
BD539 80p
BD539C 1.10
BD540 85p
BD540C 1.20
BD675 78p
BD676 78p
BD677 78p
BD678 83p
BD711 1.32
BD712 1.32
BDX32 3.47
BDX66B 5.95
BDX67B 5.95
BDY54 1.70
BDY55 1.75
BDY56 2.25
BDY57 5.25
BDY58 6.15
BF194 12p
BF195 12p
BF196 12p
BF197 12p
BF198 15p
BF199 15p
BF200 75p
BF224J 32p
BF225J 35p
BF244A 55p
BF244B 55p
BF245A 55p
BF245B 65p
BF246 70p
BF246A 70p
BF246B 75p
BF247A 75p
BF247B 75p
BF254 39p
BF255 39p
BF256A 58p
BF256B 58p
BF256C 65p
BF257 30p
BF258 32p
BF259 35p
BF457 36p
BF458 56p
BF459 62p
BF469 86p
BF470 86p
BFR39 25p
BFR40 25p
BFR41 25p
BFR79 25p
BFR80 25p
BFR81 25p
BFR90 2.11
BFS28 2.95
BFS61 1.00
BFS98 1.10
BFX29 36p
BFX30 36p

BFY50 36p
BFY51 36p
BFY52 36p
BFY53 31p
BSX19 24p
BSX20 24p
BSX21 40p
BU104 2.22
BU105 1.70
BU108 3.95
BU109 3.29
BU126 1.47
BU204 2.25
BU205 1.75
BU206 1.89
BU208 1.98
BU226 4.95
BU326S 2.35
BU406 1.45
BU407 1.45
BU408 1.35
BU500 2.95
BUY18S 3.95
F430 5.95
J300 70p
J310 70p
MJ802 3.99
MJ900 2.90
MJ901 3.10
MJ1000 2.50
MJ1001 3.00
MJ1800 3.60
MJ2500 2.19
MJ2501 2.25
MJ2955 1.00
MJ3000 2.19
MJ3001 2.25
MJ4502 3.99
MJ15003 4.85
MJ14004 5.55
MJ15015 2.45
MJ15016 3.34
MJE340 53p
MJE350 1.50
MJE2955 1.95
MJE3055 1.25
MJE2955T 99p
MJE3055T 69p
MPSA05 25p
MPSA06 25p
MPSA10 28p
MPSA12 32p
MPSA13 48p
MPSA14 48p
MPSA16 30p
MPSA18 65p
MPSA20 48p
MPSA42 49p
MPSA43 49p
MPSA55 28p
MPSA56 30p
MPSA65 40p
MPSA66 47p
MPSA70 45p
MPSA92 39p
MPSA93 39p
MPSL01 46p
MPSL51 49p
MPSU01 84p
MPSU04 1.32
MPSU05 55p
MPSU06 56p
MPSU07 75p
MPSU51 88p
MPSU55 58p
MPSU56 59p
MPSU57 1.20
NE5534A 1.66
TIP29A 29p
TIP29C 38p
TIP30A 35p
TIP30C 36p
TIP31A 33p
TIP31C 34p
TIP32A 38p
TIP32C 42p
TIP33A 65p
TIP33C 78p
TIP34A 74p
TIP34C 88p
TIP35A 1.09
TIP35C 1.28
TIP36A 1.29
TIP36C 1.39
TIP41A 49p
TIP41C 55p
TIP42A 55p
TIP42C 56p
TIP49 1.20
TIP50 1.40
TIP53 1.57
TIP54 1.59
TIP110 74p
TIP112 90p
TIP115 81p
TIP117 96p
TIP120 69p
TIP122 73p
TIP125 84p
TIP127 93p
TIP130 93p
TIP132 93p
TIP135 99p
TIP137 99p
TIP140 1.04
TIP142 1.04
TIP145 1.15
TIP147 1.15
TIP2955 4.95
TIP2955 77p
TIP3055 70p
TIS43 58p
TIS88A 60p
VN10KM 80p
VN46AF 95p
VN66AF 99p
ZTX107 10p
ZTX108 10p
ZTX109 12p
ZTX300 13p
ZTX301 14p
ZTX302 15p
ZTX303 23p
ZTX304 15p
ZTX310 15p
ZTX311 25p
ZTX312 35p
ZTX313 36p
ZTX314 24p
ZTX330 25p
ZTX341 35p
ZTX450 39p

ZTX500 14p
ZTX501 14p
ZTX502 14p
ZTX503 17p
ZTX504 24p
ZTX510 24p
ZTX530 24p
ZTX531 25p
ZTX650 45p

DIODES

1N34A 30p
1N821 70p
1N823 92p
1N914 4p
1N916 6p
1N4001 4p
1N4002 4½p
1N4003 5p
1N4004 5½p
1N4005 6p
1N4006 6½p
1N4007 7p
1N4009 20p
1N4148 3p
1N4150 18p
1N4448 22p
1N5400 12p
1N5401 13p
1N5402 14p
1N5404 16p
1N5406 18p
1N5407 19p
1N5408 20p
1N5024 52p
1S44 10p
BA102 25p
BA115 25p
BA133 40p
BA138 30p
BA142 20p
BA155 15p
BA156 38p
BA157 25p
BA158 30p
BA150 25p
BA182 40p
BA201 18p
BA202 26p
BA316 25p
BA317 25p
BA318 30p
BAV10 16p
BAV19 15p
BAV20 15p
BAX13 10p
BB109G 65p
BY126 11p
BY127 12p

SCR's TRIACS DIACS

THYRISTORS
4, 8 & 12 Amps Texas TO220
Suffix A = 100V
B = 200V
C = 300V
D = 400V
M = 600V
TIC 104A 46p
TIC 106B 47p
TIC 106C 48p
4A
TIC 106D 49p
TIC 106M 68p
TIC 116A 66p
TIC 116B 68p
8A
TIC 116C 71p
TIC 116D 73p
TIC 116M 80p
TIC 126A 72p
TIC 126B 72p
12A
TIC 126C 73p
TIC 126D 77p
TIC 126M 96p

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

DIACS
BR100 29p
ST2 29p

ZENER'S

many inc specials see our CAT
400 500mW E24 Series 2.4-47V 7p
1.3 Watt E24 Series 3.3-82V 14p

BRIDGE

(PIV shown in brackets)
1½ amp type
W01 (100) 28p
W02 (200) 34p
W04 (200) 38p
W08 (800) 50p
2 amp type Square with hole
SO1 (100) 46p
SO2 (200) 50p
SO4 (400) 55p
SO8 (800) 66p

6 amp type Square with hole
PW01 (100) 95p
PW02 (200) 99p
PW04 (400) 1.30
PW06 (600) 1.39

25 amp type Metal clad with hole
KO1 (100) 2.62
KO2 (200) 2.75
KO4 (400) 3.25
KO6 (600) 4.10
BYW64 35A 400V 4.50

OPTO

many inc specials see out CAT
LED LAMPS
R = Red
G = Green
Y = Yellow
Large Diffused 1+
R5D 9p
G5D 15p
Y5D 15p
Small diffused
R3D 8p
G3D 12p
Y3D 12p
Micro 0.1"
R1M 25p
G1M 27p
Y1M 27p
Lage clear
R5C 12p
G5C 17p
Y5C 17p
Super bright high efficiency Large (100 times brighter)
R5U 38p
G5U 42p
Y5U 42p
Rectangular Stackable LEDs
R5R 17p
G5R 18p
Y5R 19p

LINICS

AY1-5050 95p
AY3-8910 3.99
AY3-8912 4.95
CA3048 2.15
CA3059 2.80
CA3090AQ 3.70
CA3130E 87p
CA3130T 2.35
CA3140E 39p
CA3140T 1.40
HA1366W 2.40
HA388 2.54
ICL7106 7.50
ICL7107 9.50
ICL7611 97p
ICL8038 2.99
ICM7555 80p
ICM7556 1.50
LC7120 3.20
LC7130 3.40
LC7137 3.95
LF347 1.50
LF351 47p
LF353 92p
LF355 83p
LF356 1.25
LF357 1.30
LF398 4.62
LM335Z 1.60
LM348N 62p
LM349N 1.09
LM350K 4.60
LM379S 5.50
LM380N14 1.10
LM380N8 1.50
LM381AN 2.26
LM381N 1.40
LM382N 1.12
LM383T 2.40
LM384N 1.40
LM386 88p
LM388N 2.43
LM391N60 2.10
LM391N80 2.40
LM723CH 95p
LM723CN 35p
LM725CH 3.40
LM725CN 3.19
LM741CH 96p
LM741CN 22p
LM741CN14 80p
LM747CN 69p
LM748CH 1.00
LM748CN 35p
LM1871 3.25
LM1872 4.39
LM1877 5.95
LM1886 7.44
LM1889 3.77
LM2907N 2.76
LM2907N8 2.60
LM2917N 2.40
LM2917N8 2.40
LM3900 48p
LM3911 1.20
LM3914 3.25
LM3915 3.25
LM13600 1.15
MF10 3.50
NE531N 1.38
NE543N 2.50
NE544N 1.95
NE555 22p
NE556 65p
NE558 1.89
NE560 3.25
NE565 1.18
NE566 1.49
NE567 1.37
NE570 4.07
NE571 3.99
NE5534A 1.45
RC4194 3.95
RC4195 2.95
RC4558 44p

SL490 3.47
SN76003 2.95
SN76013 2.95
SN76023 2.95
SN76033 2.95
TA7204 1.99
TA7205 1.20
TA7222 1.76
TA7227 5.82
TBA500 2.97
TBA500Q 3.11
TBA510 2.95
TBA510Q 3.05
TBA520 2.57
TBA520Q 2.57
TBA530 2.55
TBA530Q 2.76
TBA540 2.72
TBA540Q 2.74
TBA550 3.25
TBA550Q 3.27
TBA560C 2.87
TBA570 2.37
TBA570Q 2.48
TDA1002 3.39
TDA1003 3.94
TDA1004 P.O.A.
TDA1005 3.94
TDA1010A 2.25
TDA1022 4.95
TDA2002 3.25
TDA2003 3.25
TDA2020 2.99
TDA2030 2.25
TDA2611A 2.50
TDA7000 3.45
TL061 40p
TL062 60p
TL064 1.35
TL071 34p
TL072 45p
TL074 1.35
TL081 34p
TL082 45p
TL084 1.20
UAA170 2.49
UAA180 2.49
ULN2003 75p
UPC575C2 2.00
UPC1156 2.75
UPC1156H 2.75
UPC1182 3.75
UPC1185 1.95
UPC2002 2.95
XR2206 3.95
ZN409 2.25
ZN414 1.00
ZN1034 1.99

TRANSFORMERS

All 240V Primary
6.0.6V, 9.0.9V
12.0.12V
15.0.15V
100mA 95p
1A 2.65
20.0.20V
0.125A 2.65
12.0.12V
50VA 5.25
12.0.12V
100VA 9.50
0-6-6-9-9
1.25A 4.25
These goods are heavy send extra p & p. We will credit any difference

VERO

0.1" COPPER TRACKS
2.5 × 3.7 83p
2.5 × 5 99p
3.75 × 3.75 99p
3.75 × 5 1.14
2.5 × 17 2.99
3.75 × 17 3.85
4.79 × 17 4.93
VO Board 1.92
Dip Board 3.90
Track Cutter 1.48
Pin Insertor 1.79
100Pins 55p
Veroblock 3.99
Vero Wiring Pen + Spool 3.35
Spare Spool 75p
Combs 6p

PCB

FERRIC CHLORIDE
Quick dissolving Enough to make over 1 litre 1.69
ETCH RESIST TRANSFERS
1 Thin lines
2 Thick lines
3 Thin bends
4 Thick bends
5 DIL pads
6 Circular pads
7 Dots + holes
8 0.1" edge connectors
9 Mixture
Any sheet of above 35p
GRADE ONE GLASS PCB SINGLE SIDED
178 × 240mm 1.50
420 × 195mm 1.95
420 × 245mm 2.95
DALO ETCH RESIST PEN + spare nib 1.20
PHOTO SENSITIVE PCB 1st Class Epoxy Glass For better results than spraying Expose to UV

100 × 160 2.10
100 × 220 2.50
203 × 114 2.40
233 × 220 5.20
Double Sided
100 × 160 2.20
100 × 200 2.80
203 × 114 2.90
233 × 220 5.90
Developer for above (do not use Sodium Hydroxide)
500 ml 2.95

WIRE

PRICES PER METRE
Solid connecting wire
MAINS/SPEAKER
Twin 1 Amp 14p
Twin 2½ Amp 16p
3 Core 2½ Amp 18p
3 Core 6 Amp 31p
3 Core 13 Amp 56p
SCREENED
Single 14p
Stereo 27p
Mini Single 12p
Mini Stereo 15p
4 Core 4 Screens 44p
4 Core Single Screen 54p
8 Core 61p
12 Core 80p
Heavy Duty Mike/Guitar Lead 25p
AERIAL
50Ω RG58A 25p
75Ω UHF 29p
75Ω VHF 28p
300Ω Flat 14p
RAINBOW RIBBON
Prices per foot
8 way 25p
10 way 25p
16 way 39p
20 way 48p
24 way 62p
30 way 75p
32 way 82p
40 way 88p
64 way 1.49

RECHARGE BATTERIES

Top quality Don't throw these batteries away — they charge up to 1000 times!
HP2(1.2AH) 2.39
HP2(4AH) 4.75
HP7(½AH) 99p
HP11(1.2AH) 2.29
PP3(110mAH) 4.95
Chargers
TYPE H: Adjusted to 6 of any HP type Above £15.59
TYPE M: As above but faster charge for 4AH £25.95
TYPE P PP3 £5.50
TYPE A: HP7 (Up to 4 at a time) £5.85

SOLDER

ANTEX SOLDERING IRONS
C240 (15W) 5.20
XS240 (25W) 5.40
Iron Stand 1.75
Elements (State Iron) 2.05
C240 Bits
No 2 (Small) 85p
No 3 (Med) 85p
No 6 (Micro) 85p
XS240 X25 Bits
No 50 (Small) 85p
No 51 (Med) 85p
No 52 (Lge) 85p
SOLDER 125gms
18swg 2.95
22swg 3.10

PLUGS & SOCKETS

'D' Connectors 25 Way Solder
Male 1.60
Female 2.09
PCB Wire Wrap
Male 1.80
Female 2.09
Covers 1.00
Phono Plugs Blk, Red, Grn, Wt or Yell 15p
Line Skts 1.20
Chas Skt + 1 20p
Dual 30p
Quad 40p

ZIF SOCKET

24pin 4.35
28pin 5.00
40pin 5.35

SWITCHES

TOGGLE (MINI)
SPST 49p
SPDT 59p
DPDT 69p
DPDT C OFF 90p
4PDT 2.95

MAPLIN Massive range of components for your hobby....insist on Maplin quality!

MAPLIN'S TOP TWENTY KITS

THIS MONTH	LAST MONTH	DESCRIPTION OF KIT	ORDER CODE	KIT PRICE	DETAILS IN PROJECT BOOK
1.	(1)	75W Mosfet Amp Module	LW51F	£12.95	Best of E&MM
2.	(2)	Modem	LW99H	£44.95	5 XA05F
		Case also available: YK62S Price £9.95.			
3.	(4)	Car Burglar Alarm	LW78K	£6.95	4 XA04E
4.	(5)	Partylite	LW93B	£9.45	Best of E&MM
5.	(3)	ZX81 I/O Port	LW76H	£9.25	4 XA04E
6.	(19)	Spectrum Keyboard	LK29G	£28.50	9 XA09K
		Also required: LK30H £6.50; Case: XG35Q £4.95 — Total £39.95. Also available complete ready-built: XG36P £44.95.			
7.	(9)	Syntom Drum Synthesiser	LW86T	£11.95	Best of E&MM
8.	(8)	VIC20/64 RS232 Interface	LK11M	£9.45	7 XA07H
9.	(7)	8W Amp Module	LW36P	£4.45	Catalogue
10.	(10)	Harmony Generator	LW91Y	£17.95	Best of E&MM
11.	(15)	Logic Probe	LK13P	£9.95	8 XA08J
12.	(6)	Keyboard for ZX81	LW72P	£23.95	3 XA03D
		Case also available: XG17T £4.95. Complete ready-built: XG22Y £32.50			
13.	(14)	Ultrasonic Intruder Detctor	LW83E	£10.95	4 XA04E
14.	(11)	Spectrum RS232 Interface	LK21X	£17.95	8 XA08J
15.	(17)	Hexadrum	LW85G	£19.95	Best of E&MM
16.	(–)	Noise Gate	LK43W	£9.95	Best of E&MM
17.	(–)	Guitar Tuner	LW90X	£10.75	Best of E&MM
18.	(–)	Freq. Meter Adaptor	LK20W	£8.99	9 XA09K
19.	(16)	Car Battery Monitor	LK42V	£6.25	Best of E&MM
20.	(20)	ZX81 Speech Synthesiser	LK01B	£16.95	6 XA06G

Over 80 other kits also available. All kits supplied with instructions.

The desriptions above are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate Project Book mentioned in the list above.

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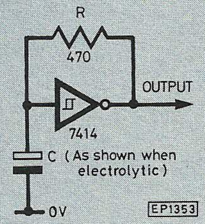
OSCILLATOR CIRCUITS

(a) Simple Oscillator using a Schmitt Inverter

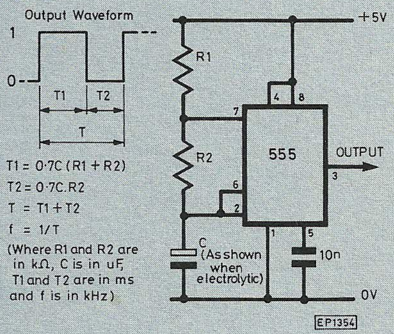
This circuit uses a single inverting gate and requires only one capacitor and one resistor. The output duty cycle is approximately 1:3. It is good practice to follow the stage with an additional inverting gate to act as a buffer. Where a square wave output is required the duty cycle can be improved by placing a 1kΩ resistor in parallel with the capacitor. A precise 1:1 duty cycle can be obtained by applying the oscillator output to the clock input of a J–K bistable. This technique can also be used to provide complementary outputs where necessary. Note that the bistable output frequency will be half that of the oscillator. The table gives capacitor values for a range of approximate output frequencies:-

f (Hz)	C (F)
350k	4n7
40k	47n
4k	470n
400	4μ7
40	47μ
4	470μ



(b) Oscillator using an I.C. Timer

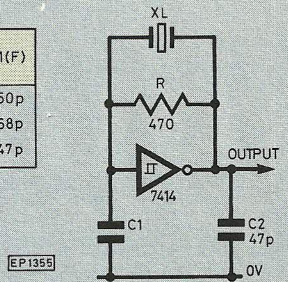
A 555 timer connected in astable mode can be used to provide a clock, as shown in the circuit below. For a near unity duty cycle, R2 should be very much larger than R1. To vary the frequency, R2 may be replaced by a variable resistor.



(c) Crystal Oscillator

A quartz crystal should be used as the frequency determining element in an oscillator which is to have a precise output frequency, as shown in the circuit below. Note that this stage should normally be followed by a buffer which may be either inverting or non-inverting, as required.

Crystal Frequency Range	C1(F)
1–3MHz	150p
3–6MHz	68p
6–12MHz	47p

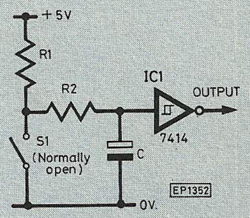


SWITCH DE-BOUNCING

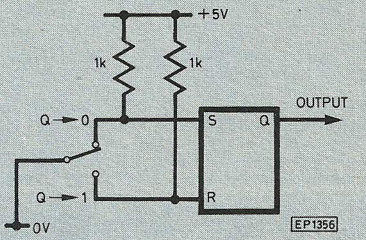
De-bouncing switch inputs is usually essential with all types of switch. In general, immunity to transient spikes is enhanced by the use of active-low inputs. The following circuit can be used to remove switch bounce. Note that the value chosen for R2 must take into account the low-state sink current required by IC1. This will normally be 1·6mA and 0·4mA maximum for standard and LS TTL gates, respectively. R2 should not normally exceed approximately 470 ohms. Note also that, on power-up, this circuit generates a logic 1 level for approximately 1ms before the output reverts to a logic 0 in the inactive state.

Switch Condition	Logic Output
Closed	1
Open	0

TYPICAL VALUES (FOR 1ms DELAY)
R1 = 4k7
R2 = 100
C = 10μ

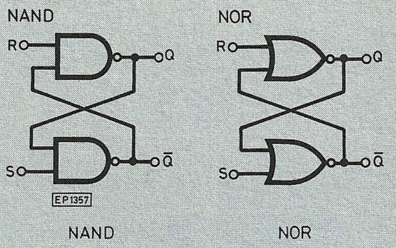


An alternative de-bouncing technique uses a bistable element as shown below.



DISCRETE BISTABLES

Occasionally it is expedient to construct simple R–S bistable elements using spare logic gates. This can be done using either NAND or NOR, as shown below. Note, however, that care should

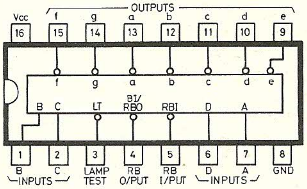


be taken to avoid the input condition when both S and R are taken to logic 1 at the same time since, in this condition, the output state is indeterminate. Either of these arrangements can be used to form the R–S bistable used in the switch de-bounce arrangement described previously.

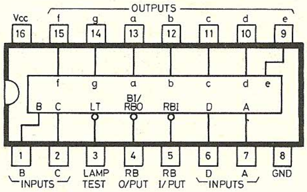
DECOUPLING CAPACITORS

When the output of a TTL gate changes from 0 to 1, or vice-versa, a surge of current is drawn from the supply. This 'spike' must be prevented from spreading to other parts of the circuit via the supply rails. If not, it can affect the operation of other i.c.s in the circuit. The solution is to add small-value (decoupling) capacitors along the supply rails near to the i.c. supply pins. These supply the energy for the spikes, thus preventing them from spreading. Decoupling capacitors should be high frequency types (e.g. 10V disc ceramic), connected according to the rules below.

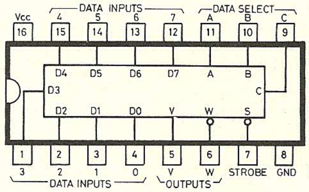
1. Use h.f. capacitors of 4·7 to 100n, typically 10n.
2. Connect close to the i.c. supply pins, using short leads.
3. Use one capacitor for every 4–5 i.c.s.
4. Add a capacitor at any i.c. more than 10cms from decoupling.
5. Distribute the decoupling around the circuit board.
6. Add a 10μ 10V tantalum capacitor for every 10–20 i.c.s.
7. If in doubt, add more decoupling capacitors.



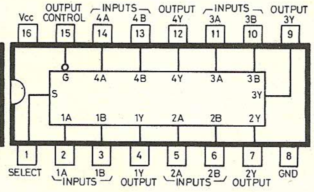
74247 BCD
7-segment decoder



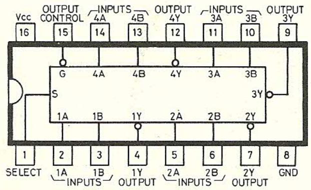
74248 BCD
7-segment decoder



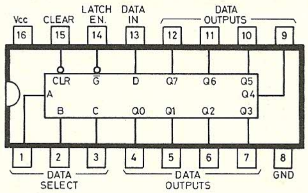
74251 8-input
selector 3-state



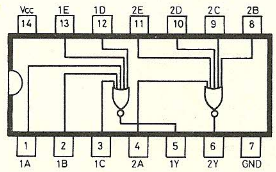
74257A Quad
2-input multiplexer 3-state



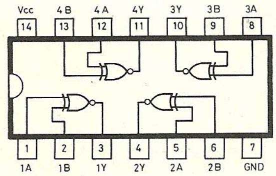
74258A Quad
2-input multiplexer 3-state



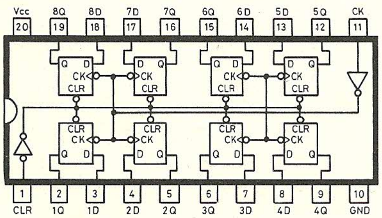
74259
8-bit addressable latch



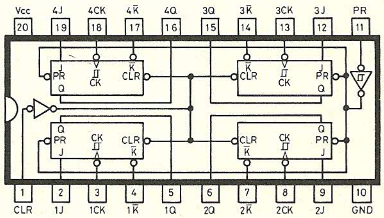
74260 Dual
5-input NOR gate



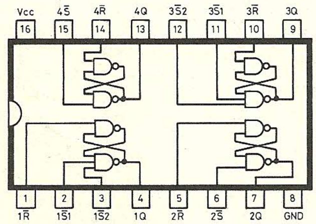
74266 Quad
2-input Ex-OR oc



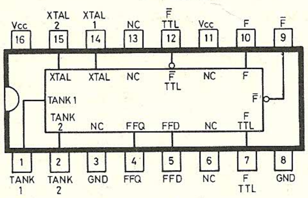
74273 Octal
D-type



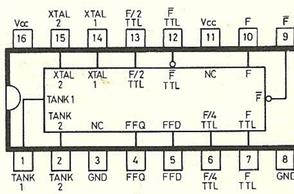
74276 Quad
J–K



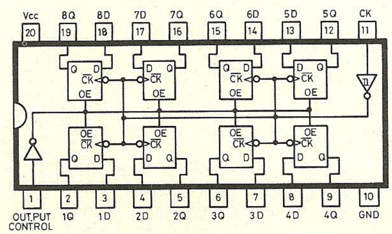
74279 Quad
S–R latch



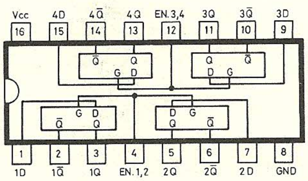
74320
Crystal-controlled osc LS



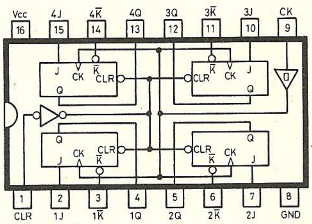
74321
Crystal-controlled osc LS



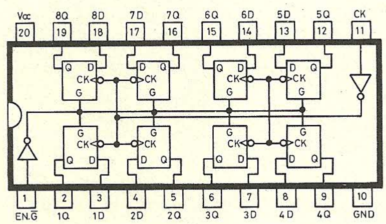
74374 Octal D-type LS



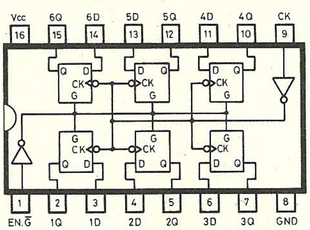
74375 Dual
2-bit bistable with enable LS



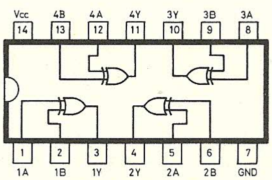
74376 Quad
J–K



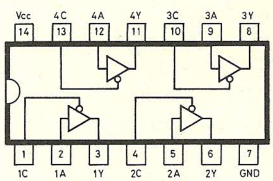
74377 Octal
D-type with enable LS



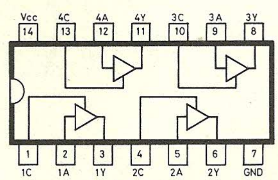
74378 Hex D-type LS



74386 Quad
2-input Ex-OR



74425 Quad 3-state
outputs active low



74426 Quad 3-state
outputs active high