Australia $1.50 New Zealand $1.60 Malaysia $4.95 IR £1.30 (inc. VAT)

PRACTICAL ELECTRONICS

NOVEMBER 1983

90p

MOTOCAR ELECTRONICS in the FAMILY CAR

SIMPLE SPEECH

Digital Acquisition & Reproduction

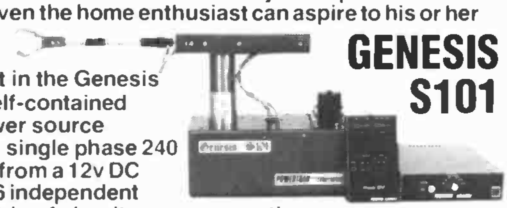
4½ DIGIT MULTIMETER

BAZAAR – USED COMPUTER & EQUIPMENT BARGAINS

Low-price robots from POWERTRAN

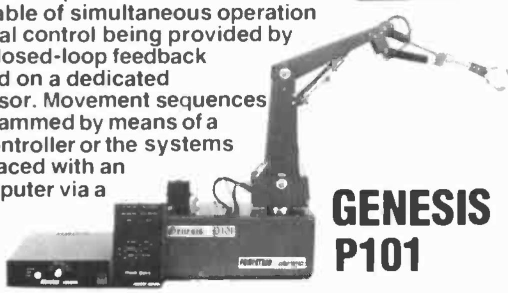
– hydraulically powered
– microprocessor controlled

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



GENESIS S101

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

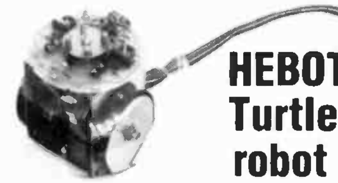


GENESIS P101

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

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

GENESIS P102



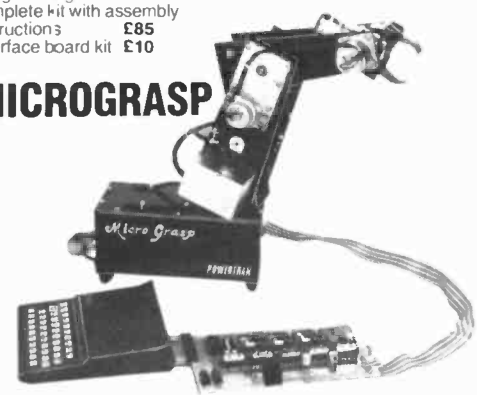
HEBOT II Turtle-type robot

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

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

HEBOT II

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



MICROGRASP

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

MICROGRASP

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

GENESIS S101

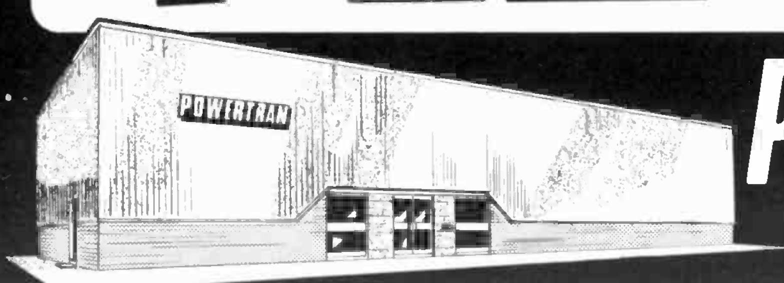
Weight 29kg, lifting capacity 1.5kg	
4-axis model (kit form)	£425
5-axis model (kit form)	£475
5-axis complete system (kit form)	£737
5-axis complete system (ready built)	£1,450

GENESIS P101

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

GENESIS P102

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



POWERTRAN cybernetics

PORTWAY INDUSTRIAL ESTATE, ANDOVER, HANTS SP10 3PE. TEL (0264) 64455 Telex 477407

ALL PRICES ARE EXCLUSIVE OF VAT

PRACTICAL ELECTRONICS

VOLUME 19 No. 11 NOVEMBER 1983

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL SUPPLEMENT

OUR DECEMBER ISSUE WILL BE ON SALE FRIDAY, NOVEMBER 4th, 1983
(for details of contents see page 12/6 Micro-file)

WATFORD ELECTRONICS

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POLYESTER RADIAL LEAD CAPACITORS: 250V; 10n, 20n, 15n, 22n, 27n **6p**; 33n, 47n, 68n, 100n **7p**; 150n, 220n **10p**; 330n, 470n **13p**; 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 **45p**; 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**.

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 **30p** 33, 47 **40p** 100 **75p** 220 **88p** **10V:** 15, 22 **26p** 33, 47 **35p** 100 **55p**.

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 multilayer 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**.

POTENTIOMETERS: Carbon Track, 0·25W Log & Linear Values.

500Ω, 1K & 2K (LIN ONLY) Single	**34p**
5KΩ-2MΩ single gang	**34p**
5KΩ-2MΩ single gang D/P switch	**80p**
5KΩ-2MΩ dual gang stereo	**90p**

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm track
5KΩ-500KΩ Single gang **70p**

PRESET POTENTIOMETERS
0·1W 50Ω-2·2M Mini Vert. & Horiz. **7p**
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			**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

AC127/8	35	BC308B	16	BRY39	40
AC176	28	BC327/8	15	BSX20	20
AC187/8	32	BC337/8	15	BSX29	34
AD142	120	BC441	34	BU105	170
AD149	79	BC461	34	BU205	190
AD161/2	42	BC477/8	40	BU206	200
AF118	95	BC516/7	40	BU208	200
AF139	40	BC547/8	12	MJ2955	70
AF239	55	BC549C	14	MJE340	54
BC107/8	10	BC556/7	15	MJE371	100
BC107B	12	BC558/9	15	MJE2955	99
BC108B	12	BCY70	16	MJE3055	70
BC108C	12	BCY71/2	20	MPF102	40
BC109	10	BD131/2	48	MPF103/4	30
BC109B	10	BD133	60	MPF105	30
BC109C	10	BD135	45	MPSA05	25
BC147/8	9	BD136/7	40	MPSA06	25
BC147B	10	BD138/9	40	MPSA12	32
BC148C	10	BD140	40	MPSA55	30
BC149	9	BD245	45	MPSA56	30
BC149C	12	BD695A	125	MPSA70	30
BC157/8	10	BD696A	125	MPSU02	58
BC159	11	BF194/5	12	MPSU05	55
BC167A	10	BF198/9	18	MPSU06	55
BC168C	10	BF200	30	MPSU52	65
BC169C	10	BF224	25	MPSU55	60
BC171/2	11	BF244A	28	MPSU56	60
BC173	11	BF244B	29	OC23	170
BC177/8	16	BF256B	35	OC28/36	220
BC179/81	20	BF257/8	32	OC41/42	75
BC182/3	10	BF259	35	OC70	40
BC184	10	BF594/5	30	OC76	50
BC182L	10	BFR39/40	23	OC81/82	50
BC183L	10	BFR41/79	23	OC83/84	40
BC184L	10	BFR80/81	25	TIP29A	32
BC186/7	26	BFR98	105	TIP29C	38
BC212/3	10	BFX29/84	28	TIP30A	35
BC212L	10	BFX85/86	28	TIP30C	37
BC213L	10	BFX87/88	28	TIP31A	38
BC214	10	BFY50/51	23	TIP31C	37
BC214L	10	BFY52	23	TIP32A	38
BC237/8	14	BFY56	32	TIP32C	42
BC307B	14	BFY90	80	TIP33A	65
				TIP33C	78
				TIP34A	74
				TIP34C	88
				TIP35A	110

TIP35C	128	2N1131/2	24	2SA636	250
TIP36A	130	2N1303/4/5		2SA671	250
TIP36C	140	2N1307/8	65	2SA715	60
TIP41A	50	2N1613	30	2SC495/6	70
TIP41B	52	2N1671B	160	2SC1061	250
TIP42A	55	2N2160	295	2SC1096	85
TIP42B	58	2N2219A/20A/		2SC1162	30
TIP120	70	21A/22A	25	2SC1172	125
TIP121	73	2N2369A	18	2SC1173	125
TIP141	105	2N2646	45	2SC1306	100
TIP142	105	2N2846	80	2SC1307	150
TIP147	120	2N2904A/05A/		2SC1449	85
TIP2955	60	06A/07A	26	2SC1679	190
TIP3055	60	2N2926G	10	2SC1678	140
TIS43	32	2N3053	26	2SC1923	50
TIS44	45	2N3054	58	2SC1945	225
TIS88A	50	2N3055	48	2SC1953	90
TIS90	30	2N3442	140	2SC1957	90
TIS91/93	32	2N3615	199	2SC1969	140
VK1010	80	2N3702/3	10	2SC2028	85
VN10KM	55	2N3704/5	10	2SC2029	200
VN46AF	78	2N3706/7	10	2SC2078	170
VN66AF	80	2N3708/9	10	2SC2091	85
VN88AF	94	2N3710	10	2SC2166	165
VN89AF	96	2N3771	179	2SC2314	85
ZTX107/8	11	2N3772	195	2SC2465	125
ZTX109	12	2N3773	210	2SC2547	30
ZTX212	28	2N3819	22	2SD234	75
ZTX300	13	2N3820	38	2SK45	90
ZTX301/2	16	2N3822/3	45	2SK288	225
ZTX303	25	2N3866	90	2SJ83	225
ZTX304	17	2N3903/4	15	2SJ85	225
ZTX320/26	30	2N3906/5	15	3N128	112
ZTX500/1	14	2N4427	80	3N140	112
ZTX502/3	18	2N4859	78	40251	150
ZTX504	25	2N5172	18	40311	60
ZTX531	25	2N5180	45	40313	130
ZTX550	25	2N5191	75	40361/62	70
2N696	30	2N5194	80	40408	76
2N697	23	2N5305	24	40412	90
2N698	40	2N5457	30	40467	130
2N699	48	2N5458/9	30	40468	85
2N706A	19	2N5485	36	40594	105
2N708	19	2N5777	45	40595	110
2N914/5	32	2N6027	32	40603	110
2N918	35	2N6109	60	40673	70
2N930	20	2N6290	70	40871/2	90

LINEAR IC's

555 CMOS	80	LM324	30	SAB4209	595
702	75	LM334Z	90	SG3402	295
709C 8 pin	35	LM335	128	SL490	350
710	48	LM339	47	SL6270	150
741	14	LM348	60	SN76013N	350
747C 14 pin	65	LM349	115	SN76023N	350
748C 8 pin	36	LM358	60	SN76033	350
753 8 pin	186	LM377	175	SN76477	420
810	159	LM379	480	SN76488	480
9400CJ	350	LM380	75	SP8629	299
AY-1-1320	225	LM381N	145	TA7120	125
AY-1-5050	99	LM382	115	TA7130	125
AY-1-5051	160	LM384	160	TA7204	195
AY-1-6720	210	LM386	90	TA7205	175
AY-3-1270	730	LM387	120	TA7222	150
AY-3-8910	420	LM389	95	TAA900	395
AY-3-8912	625	LM393	45	TAA621	296
AY-5-1230	450	LM394CH	290	TAA661	190
AY-5-1317A	630	LM725CN	325	TAA700	275
CA3011	130	LM733	70	TAD100	159
CA3012	175	LM1871	325	TBA120S	70
CA3014	275	LM2917	195	TBA540	275
CA3018	86	LM3302	75	TBA550Q	330
CA3019	80	LM3900	50	TBA641	290
CA3020	210	LM3909	85	TBA651	190
CA3023	210	LM3911	125	TBA800	80
CA3028A	95	LM3914	200	TBA810S	95
CA3035	255	LM3915	200	TBA820	80
CA3036	270	LM3916	250	TBA920Q	200
CA3043	275	LS7220	280	TBA950	300
CA3045	365	M51513L	230	TBA990	350
CA3046	70	M51515L	320	TC9109	775
CA3048	220	M51516L	475	TCA270	350
CA3059	285	M706B1	125	TCA280A	220
CA3075	213	MB3712	220	TCA940	175
CA3080E	70	MB3756	440	TCA965	145
CA3081	190	MC1204	250	TDA1004	290
CA3086	48	MC1303	98	TDA1008	310
CA3089E	200	MC1304P	260	TDA1010	198
CA3090AQ	376	MC1310P	150	TDA1022	499
CA3123	165	MC1445	250	TDA1024	115
CA3130	90	MC1455	50	TDA1034	350
CA3140	40	MC1458	35	TDA1490	350
CA3160	95	MC1469	300	TDA2002	325
CA3161E	180	MC1494	694	TDA2003	198
CA3162E	450	MC1495	350	TDA2004	495
CA3189	200	MC1496L	70	TDA2006	330
CA3240	110	MC1596	225	TDA2020	320
HA1366	175	MC1648	290	TDA2030	295
HA1388	255	MC1709G	90	TDB0791	420
ICL7106	690	MC3302	90	TL061CP	40
ICL7107	975	MC3401	65	TL062CP	60
ICL7204	550	MC3403	75	TL064CN	98
ICL7611	99	MC3405	150	TL071CP	24
ICL7660	248	MC3423P	80	TL072CP	45
ICL8038CC	300	MC4016	60	TL074CN	100
ICL8211	350	MF10	350	TL081CP	24
ICM7205	1150	MFC6040	75	TL082CP	45
ICM7207	475	MK50398	635	TL083CP	75
ICM7215	1050	ML924	275	TL084CP	90
ICM7216A	£22	MSM5526	820	TL091CP	55
ICM7217A	750	NE515	275	TL170	50
ICM7224	785	NE529	225	TL430C	90
ICM7240	300	NE531	140	TL507	110
ICM7555	80	NE534	150	TL509	110
ICM7556	150	NE543	225	UA2240	120
LA3350	250	NE544	210	UA78540	230
LA4031P	340	NE555	16	UAA170	180
LA4032	295	NE556DB	45	UAA180	180
LA4400	350	NE558	140	UGN3020T	160
LA4422	320	NE560	325	ULN2001	80
LC7120	300	NE561	395	ULN2003	75
LC7130	340	NE562B	410	ULN2004	75
LC7137	395	NE564	420	ULN2068	290
LF347	150	NE565A	120	ULN2802	200
LF351	48	NE566	155	ULN2804	150
LF353	95	NE567	140	ULN2283	100
LF355	85	NE570	410	UPC575	275
LF356	95	NE571	400	UPC1025H	375
LF357	110	NE5532	145	UPC1032	95
LF398	475	NE5534	105	UPC1182	320
LM10	325	OM335	750	UPC1156H	270
LM301A	24	RC4136D	60	UPC1366	195
LM307	45	RC4558	45	XR2206	300
LM308	95	S566B	225	XR2207	375
LM311	55	SAB3209	425	XR2211	575
LM318	150	SAB3210	325	XR2216	675
LM319	195	SAB3271	485	XR2266	360
				ZN414	80
				ZN419CE	180

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

COMPUTER IC's

1702	350	8251A	250	Z80ACTC	260
2114L-200n	95	8253	400	Z80B	875
2147-3	425	8255	225	Z80DART	495
2532-3	300	8256A	£35	Z80ADART	550
2564	£6	8257A	400	Z80ADMA	895
27L08	450	8259	395	Z80DMA	675
27L32	550	8271	£40	Z80P10	260
2708	250	8272	£17	Z80AP10	275
2716-5V	250	8279	385	Z80S10-1	850
2732	295	8282	450	Z80AS10	900
2764	425	8283	450		
27128-4	£20	8284	350		
27128/250n	£25	8285	365		
3242	590	8287	£17		
4116-150	100	8288	£10		
4118-250	325	8T26A	99		
4164-200	400	8T27	150		
4416-2	475	8T28A	120		
4532 3	270	8T31	350		
4816-100ns	250	8T95N	90		
5101	220	8T97N	90		
6116-150ns	340	9364AP	550		
6116L-120ns	550	9602	220		
6117-100n	490	AM26LS31C	125		
6167-6	795	AM26LS32A	125		
6502 CPU	325	AM26LS33A	125		
6502A	450	AY-3-1015	300		
6520	100	AY-5-1013	300		
6522 VIA	285	AY-5-1350	388		
6530 RRIOT	£11	AY-5-2376	600		
6532 RIOT	570	AY-5-3600	750		
6545 CRTC	899	COM8017	275		
6551 ACIA	650	COM8116	700		
68B54	780	DM8131	275		
6800	220	DP8304BN	250		
6802	250	DS3691N	320		
6803	850	DS8820	110		
6804	160	DS8830	110		
6805	670	DS8831	125		
6808	520	DS8832	250		
6809	630	DS88LS120N	275		
6810	115	E9365	£38		
6820	100	E9366	£38		
68B21	220	FD1691	£15		
6821	100	FD1761	£15		
6840	375	FD1771	£15		
6843	00	FD1791	£22		
6845	£12	FD1793	£23		
6846	625	FD1795	£28		
6847	650	FD1797	£28		
6850	110	FD1799	£28		
6852	250	HD26501	75		
6854	599	HMG167-6	795		
6875	500	IM6402	380		
68000 New msk	£70	INS8060N	1050		
8035	000	INS8154N	£9		
8080A	250	MC1488	55		
8085A	350	MC1489	55		
8088	£18	MC14411	675		
81LS95/96	80	MC14412	725		
81LS97/98	80	MC3446	250		
8118-10	225	MC3447P	315		
8123	125	MC3486	175		
8155	350	MC3487	175		
8156	350	MK3886-2M	£7		
8202	£25	MM5280D	695		
8205	225	MM5303	635		
8212	150	MM5307	1275		
8214	425	MM5387A	475		
8216	100	MM58174	700		
8224	150	RO-3-2513L	650		
8226	250	RO-3-2513U	650		
8228	220	SFF96364E	800		
8243	270	SP0256AL2	950		
8250	850	TMS2716-3	725		
		TMS4164-15	475		
		TMS4416-2	475		
		TMS4532-3	350		
		TMS5100	600		
		TMS9927	£14		
		TMS9928	£20		
		TMS9929	£16		
		TMS9995	£12		
		TMS4164-15	475		
		ULN2003	75		
		UPD7002	425		
		WD1691	£14		
		Z80CPU 2 5	299		
		Z80ACPU4M	300		
		Z80CTC	250		

74S

74S00	24	74S158	195
74S02	24	74S163	300
74S03	30	74S174	250
74S04	30	74S175	320
74S05	60	74S188	140
74S08	60	74S189	140
74S10	40	74S194	295
74S11	50	74S195	275
74S20	40	74S197	400
74S22	50	74S201	350
74S30	40	74S225	500
74S32	70	74S240	300
74S37	60	74S241	300
74S74	75	74S244	290
74S85	295	74S251	225
74S86	70	74S257	225
74S112	90	74S258	250
74S113	90	74S260	70
74S114	80	74S262	850
74S124	300	74S287	225
74S132	110	74S288	210
74S133	60	74S289	200
74S138	100	74S299	540
74S139	115	74S301	360
74S140	60	74S365	250
74S151	180	74S373	400
74S153	182	74S374	365
74S157	250	74S412	380
		74S470	325
		74S471	620
		74S472	1150
		74S474	400
		74S475	800
		74S571	620
		74S573	950

75

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

TTL 74

7400, 7401, 7402, 7403, 7404, 74L04, 7405, 7406, 7407, 7408, 7409, 7410, 7411, 7412, 7413, 7414, 7416, 7417, 7420, 7421, 7422, 7423, 7425, 7426, 7427, 7428, 7430, 7432, 7433, 7437, 7438, 7440, 7441, 7442, 7443, 7444, 7445, 7446, 7447, 7448, 7450, 7451, 7453, 7454, 7460, 7470, 7472, 7473, 7474, 7475, 7476, 7480, 7481, 7482, 7483, 7484, 7485, 7486, 7489, 7490, 7491, 7492, 7493, 7494, 7495, 7496, 7497, 74100, 74104, 74105, 74107, 74109, 74110, 74111, 74112, 74116, 74118, 74119, 74120, 74121, 74122, 74123, 74125, 74126, 74128, 74132, 74136, 74141

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74C

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

74LS

LS00, LS01, LS02, LS03, LS04, LS05, LS08, LS09, LS10, LS11, LS12, LS13, LS14, LS15, LS20, LS21, LS22, LS26, LS27, LS28, LS30, LS32, LS33, LS37, LS38, LS40, LS42, LS47, LS48, LS49, LS51, LS52, LS54, LS55, LS63, LS73, LS74, LS75, LS76, LS78, LS83, LS85, LS86, LS90, LS91, LS92, LS93, LS95, LS96, LS107, LS109, LS112, LS113, LS114, LS122, LS123, LS124, LS125, LS126, LS132, LS133, LS135, LS136, LS138, LS139, LS145, LS147, LS148, LS151, LS153, LS154, LS155, LS156, LS157, LS158, LS160, LS161, LS162, LS163, LS164, LS165, LS166, LS168, LS170, LS173, LS174, LS175, LS181, LS183, LS190, LS191, LS192, LS193, LS194

LS195, LS196, LS197, LS221, LS240, LS241, LS242, LS243, LS244, LS245, LS247, LS248, LS249, LS251, LS253, LS257, LS258, LS259, LS260, LS261, LS266, LS273, LS275, LS279, LS280, LS283, LS290, LS292, LS293, LS294, LS295, LS298, LS299, LS320, LS323, LS324, LS325, LS326, LS327, LS347, LS348, LS352, LS353, LS362, LS363, LS364, LS365, LS366, LS367, LS368, LS373, LS374, LS375, LS377, LS378, LS379, LS384, LS385, LS390, LS393, LS395, LS399, LS445, LS471, LS490, LS540, LS541, LS640, LS641, LS645, LS668, LS669, LS670, LS673, LS674

CMOS

4000	10	4016	20	4451	350
4001	12	4017	32	4490	350
4002	12	4018	45	4500	675
4006	50	4019	25	4501	28
4007	14	4020	42	4502	60
4008	32	4021	40	4503	40
4009	24	4022	40	4504	75
4010	24	4023	13	4505	185
4011	12	4024	32	4506	35
4012	16	4025	15	4507	35
4013	20	4026	80	4508	130
4014	46	4027	20	4510	46
4015	40	4028	39	4511	46
		4029	45	4512	45
		4030	15	4513	199
		4031	125	4514	115
		4032	80	4515	125
		4033	125	4516	65
		4034	140	4517	275
		4035	45	4518	40
		4036	275	4519	30
		4037	116	4520	50
		4038	110	4521	90
		4039	280	4522	125
		4040	40	4526	60
		4041	40	4527	65
		4042	40	4528	50
		4043	40	4529	150
		4044	40	4530	90
		4045	105	4531	130
		4046	46	4532	50
		4047	40	4534	400
		4048	40	4536	275
		4049	25	4538	80
		4050	25	4539	90
		4051	45	4541	140
		4052	60	4543	70
		4053	50	4544	150
		4054	85	4548	40
		4055	85	4549	375
		4056	85	4553	245
		4057	£10	4554	180
		4059	435	4555	35
		4060	45	4556	35
		4061	1195	4557	320
		4062	995	4558	120
		4063	85	4559	395
		4066	24	4560	160
		4067	245	4561	104
		4068	14	4562	495
		4069	16	4566	165
		4070	15	4568	250
		4071	15	4569	178
		4072	15	4572	36
		4073	15	4580	460
		4075	15	4581	250
		4076	50	4582	99
		4077	15	4583	90
		4078	15	4584	48
		4081	15	4585	70
		4082	15	4597	330
		4085	50	4599	290
		4086	60	40097	45
		4089	125	40098	42
		4093	20	40100	215
		4094	70	40101	130
		4095	95	40102	140
		4096	70	40103	175
		4097	275	40104	95
		4098	75	40105	105
		4099	75	40106	35
		4160	95	40107	60
		4161	99	40108	198
		4162	99	40109	100
		4163	99	40110	300
		4174	99	40114	240
		4175	105	40161	194
		4194	105	40163	50
		4408	790	40174	45
		4409	790	40175	50
		4410	725	40181	220
		4411	675	40192	75
		4412	790	40193	95
		4415	480	40194	90
		4419	280	40195	80
		4422	770	40244	195
		4433	770	40245	195
		4435	850	40257	198
		4440	999	40373	240
		4450	350	40374	248

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Now in the course of production, the 1984 GREENWELD catalogue will be published in November. It's Bigger, Brighter, Better, more components than ever before. With each copy there's discount vouchers, Bargain List, Wholesale Discount List, Bulk Buyers List, Order Form and Reply Paid Envelope. All for just £1.00! *Order now for early delivery!*

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A199 A versatile stabilized power supply with both voltage (0-30V) and current (20mA-2A) fully variable. Many uses inc. bench PSU, Ni-cad charger, gen purposes testing Panel ready built; tested and calibrated. £7.75. Suitable transformer and pots, £6.00. Full data supplied.

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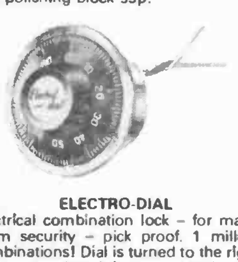

ELECTRO-DIAL

Electrical combination lock – for maximum security – pick proof. 1 million combinations! Dial is turned to the right on one number, left to a second number, then right again to a third number. Only when this has been completed in the correct sequence will the electrical contacts close. These can be used to operate a relay or solenoid. Overall dia 65mm × 60mm deep. Only £3.95.

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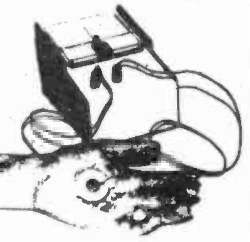
Z901 Can you follow the flashing light/pulsating tone sequence of this famous game? Supplied as a fully working PCB with speaker (no case) plus full instructions. Only £4.95

Z902 Probably the most popular electronic game on the market – based on the old fashioned pencil and paper battleship game, this computerized version has brought it bang up to date! We supply a ready built PCB containing 76477 sound effect chip, TMS1000 micro-processor chip, R's, C's etc. Offered for its component value only (board may be cracked or chipped, it's only £1.95. Instructions and circuit, 30p.



LIE DETECTOR

Not a toy, this precision instrument was originally part of an "Open University" course, used to measure the change in emotional balance, or as a lie detector. Full details of how to use it are given and a circuit diagram. Supplied complete with probes, leads and conductive jelly. Needs 2 4½V batts. Overall size 155 × 100 × 100mm. Only £9.95–worth that for the case and meter alone!!

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SAVE £20 TO £30

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Composite video:
1280 characters:
Over 15 MHZ B/W:
240V AC 34 w:
16" x 11⅛" x 12⅛":
Alphanumeric and Graphic display: Usually £89.95 - £99.95
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Complete PROFESSIONAL Case beautifully constructed with cut out for one 'CHERRY' keyboard, plus ample room to house a COMPLETE SYSTEM and power supply. Complete with fittings (Case top detachable). Unit is silver-grey in colour. Robust construction. Sloping front with side ventilation. Ideal for NASCOM, ACORN, TANGERINE or your own system. Size 18" x 15" x 4" (front slopes).
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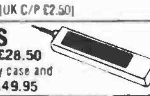
LOGIC PROBES



LP10 10 MHZ £28.50
OLP50 50 MHZ with carry case and accessories £49.95

HIGH VOLTAGE METER

Direct reading 0/40 KV
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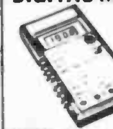
DIGITAL MULTIMETERS



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7030 4 • AS6010 high acc. 0.1% basic	£41.30
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AT1020 18 range 20K/V. Deluxe plus Hfe tester	£18.95
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PULSE	
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LAG 120A 10 HZ-1MHZ Low Distortion	£159.85
RF	
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LSG17 100 KHZ to 150 MHZ	£79.35

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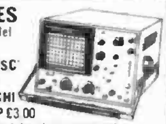

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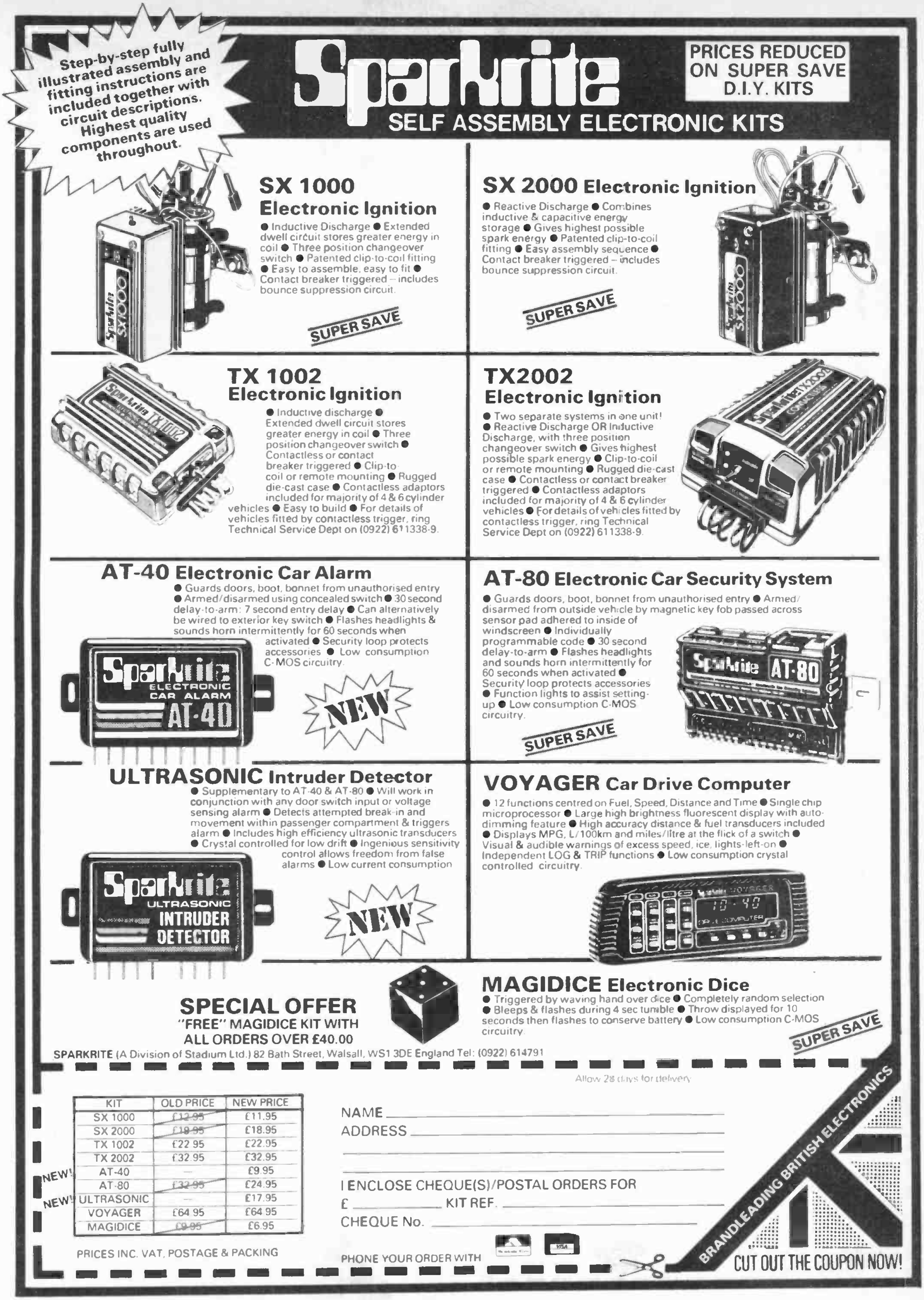
Step-by-step fully illustrated assembly and fitting instructions are included together with circuit descriptions. Highest quality components are used throughout.
Sparkrite
SELF ASSEMBLY ELECTRONIC KITS
PRICES REDUCED ON SUPER SAVE D.I.Y. KITS
SX 1000 Electronic Ignition
● Inductive Discharge ● Extended dwell circuit stores greater energy in coil ● Three position changeover switch ● Patented clip-to-coil fitting ● Easy to assemble, easy to fit ● Contact breaker triggered – includes bounce suppression circuit.
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SUPER SAVE
TX 1002 Electronic Ignition
● Inductive discharge ● Extended dwell circuit stores greater energy in coil ● Three position changeover switch ● Contactless or contact breaker triggered ● Clip-to-coil or remote mounting ● Rugged die-cast case ● Contactless adaptors included for majority of 4 & 6 cylinder vehicles ● Easy to build ● For details of vehicles fitted by contactless trigger, ring Technical Service Dept on (0922) 611338-9.
TX2002 Electronic Ignition
● Two separate systems in one unit! ● Reactive Discharge OR Inductive Discharge, with three position changeover switch ● Gives highest possible spark energy ● Clip-to-coil or remote mounting ● Rugged die-cast case ● Contactless or contact breaker triggered ● Contactless adaptors included for majority of 4 & 6 cylinder vehicles ● For details of vehicles fitted by contactless trigger, ring Technical Service Dept on (0922) 611338-9.
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● Guards doors, boot, bonnet from unauthorised entry ● Armed/disarmed using concealed switch ● 30 second delay-to-arm: 7 second entry delay ● Can alternatively be wired to exterior key switch ● Flashes headlights & sounds horn intermittently for 60 seconds when activated ● Security loop protects accessories ● Low consumption C-MOS circuitry.
Sparkrite ELECTRONIC CAR ALARM AT-40
NEW
AT-80 Electronic Car Security System
● Guards doors, boot, bonnet from unauthorised entry ● Armed/disarmed from outside vehicle by magnetic key fob passed across sensor pad adhered to inside of windscreen ● Individually programmable code ● 30 second delay-to-arm ● Flashes headlights and sounds horn intermittently for 60 seconds when activated ● Security loop protects accessories ● Function lights to assist setting-up ● Low consumption C-MOS circuitry.
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IN916	.05
IN4001	.05
IN4002	.05
IN4003	.06
IN4004	.06
IN4005	.06
IN4006	.07
IN4007	.07
IN5400	.15
IN5401	.15
IN5402	.20
IN5403	.16
IN5404	.16
IN5405	.17

TTL74

7400	11
7401	11
7402	11
7403	12
7404	13
7405	15
7406	20
7407	20
7408	14
7409	14
7410	14
7411	16
7412	18
7413	18
7414	24
7416	20
7417	20
7420	15
7421	20
7422	20
7423	20
7425	18
7426	18
7427	15
7428	26
7430	14
7432	22
7433	22
7437	25
7438	22
7440	15
7441	55
7442	32
7443	90
7444	90
7445	55
7446	60
7447	40
7448	45
7450	16
7451	16
7453	16
7454	16
7460	16
7470	35
7472	24
7473	26
7474	20
7475	25
7476	25
7480	48
7481	120
7482	65
7483	38
7484	70
7485	80
7486	20
7489	170
7490	20
7491	35
7492	25
7493	25
7494	35
7495	35
7496	35
7497	90
74100	80
74104	50
74105	55
74107	20
74109	25
74110	35
74111	55
74112	170
74116	50
74118	55
74119	60
74120	60

74S SERIES

74S00	30
S02	30
S03	30
S04	30
S05	60
S08	60
S20	40
S32	70
S74	75
S86	65
S112	80
S114	80
S132	110
S133	60
S138	100
S139	115
S157	225
S158	210
S188	140
S189	140
S194	195
S195	195

74LS

LS00	11
LS01	11
LS02	11
LS03	12
LS04	12
LS05	13
LS08	12
LS09	12
LS10	13
LS11	13
LS12	13
LS13	20
LS14	26
LS15	13
LS20	13
LS21	12
LS22	12
LS26	14
LS27	13.
LS28	14
LS30	13
LS32	13
LS33	15
LS37	15
LS38	15
LS40	13
LS42	28
LS47	35
LS48	45
LS49	50
LS51	14
LS54	14
LS55	14
LS63	120
LS73	18
LS74	18
LS75	20
LS76	18
LS78	18
LS83	36
LS85	42
LS86	16
LS90	24
LS91	60
LS92	32
LS93	23
LS95	40
LS96	95
LS107	40
LS109	23
LS112	22
LS113	20
LS114	22
LS122	36
LS123	36
LS124	90
LS125	24
LS126	25
LS132	30
LS133	30
LS136	24
LS138	25
LS139	28
LS145	70
LS147	100
LS148	75
LS151	40
LS153	40
LS155	30
LS156	36
LS157	25
LS158	30
LS160	32
LS161	37
LS162	35
LS163	35
LS164	43
LS165	50
LS166	52
LS168	84
LS170	70
LS173	50
LS174	36
LS175	36
LS181	90
LS183	105
LS190	36
LS191	36
LS192	38
LS193	37
LS194	35
LS195	35
LS196	45
LS197	45
LS200	275
LS202	275
LS221	55
LS240	55
LS241	55
LS242	55
LS243	55
LS244	55
LS245	70
LS247	50
LS248	55
LS249	55
LS251	30
LS253	32
LS257	30
LS258	35
LS259	55
LS260	22
LS261	100
LS266	20
LS273	54
LS275	125
LS279	30
LS280	90
LS283	40
LS290	40
LS293	40
LS295	75
LS298	80
LS299	150
LS300	175

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748	.28
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AY3-8912	8.25
CA3019	.80
CA3028	.70
CA3046	.70
CA3080	.70
CA3086	.48
CA3089	2.00
CA3090	4.00
CA3130	.90
CA3160	1.00
CA3161	1.50
CA3162	4.50
CA3189	3.00
LF356	.95
LM101	3.25
LM301	.25
LM311	.70
LM324	.30
LM339	.50
LM348	.65
LM358	.60
LM381	1.80
LM383	1.00
MC3401	.65
MC3403	.75
NE555	.16
NE556	.45
NE567	1.40
TBA800	.80
TBA801	1.00
TBA820	.80
TCA210	3.50
TCA220	3.50
TDA1022	5.00
TDA1024	1.20
TDA1170	3.00
TL010	.39
TL061	.29
TL062	.49
TL064	.98
TL071	.29
TL072	.47
TL074	1.00
TL081	.26
TL082	.46
TL084	1.58
TL091	.40
TL092	.59
TL094	1.34
TL487	.62
TL489	.62
TL494	1.63
TL496	.60
ULN2003	.85
ULN2004	.90

MEMORIES

2708	2.95
2716	3.50
2732	3.45
4118	3.25
4164	5.00
6116	4.20

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PE

VOLUME 19 No. 11 NOVEMBER 1983

ELECTRONIC AIDS

THE Concerned Technology and Microfair are two names that hopefully you will hear more of. They are both tied in with high technology aids for the handicapped.

Two travelling exhibitions are showing technological aids for those with special needs. Concerned Technology is supported by the Department of Trade and Industry and Microfair is organised by the Handicapped Persons Research Unit of Newcastle-upon-Tyne Polytechnic. The exhibitions show many commercially available products from an electric car to simple sequentially switched light communication aids.

HOBBY DEVELOPMENTS

An area that is perhaps most interesting is that of hobby developments which can assist the mentally or physically handicapped. For instance, with the addition of a special light action switch and some fairly simple software, almost any micro computer can be used to build up words or phrases in a sequential manner on screen; a great help to those with speech impediments. This can obviously be taken a step further with speech synthesis.

A simple indicating device can be built employing interchangeable cards, each card containing, say, eight diagrams. With sequentially switched indicator lamps a message may be signalled by indicating first which card and then which picture is required. Thus a severely handicapped person can indicate his or her needs simply by operating a single switch, which could be by a movement of the tongue if necessary. Such devices are easily constructed by the hobbyist, or software written with specific needs in mind. What better way of employing your hobby skills for the benefit of others!

IDEAS

If you are handicapped a visit to one of these exhibitions will show what is available and provide the chance to try it out. If you are not handicapped the exhibitions will give you some idea of how your skills could be best employed to help others—details of venues appear in *Countdown* on page 18. Incidentally, with approximately four million disabled people in the UK such an interest could lead to a "mass production" business in providing aids on a commercial basis.

As an aside we have seen no better use of a 555 timer i.c. than in producing pulses to operate a paralysed person's leg muscles, enabling her to stand and eventually walk without calipers; have you?

Mike Kenward

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

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VIDEO HEAD REPLACEMENT KIT

Monolith Electronics are launching a new video tape head replacment kit for home VCR machines of both VHS and BETAMAX types. The kit will enable the enthusiast to replace worn video heads in his own home without the need to resort to the sophisticated equipment available to professional video technicians. Video heads typically wear out every two or three years and service charges can be expensive.

Monolith have available three universal replacement video heads, the main difference between the two VHS types being the size of the centre hole (either 5mm or 15mm) which locates on the main shaft.

With the exception of a soldering iron every kit supplied with the head includes all the tools necessary to undertake head replacement, including five cleaning tools, cleaning fluid, a can of air blast for dust removal, an inspection mirror, antistatic cloth, cross-head screwdriver and a pair of surgical gloves for handling the head. In addition, a motor speed check disc for VHS machines and an eccentricity gauge for BETAMAX head alignment to an accuracy of about one-fiftieth of a millimetre are supplied.

A maintenance manual together with detailed step-by-step instructions on typical head replacements of both VHS and BETAMAX types are included.

The kit with a VHS head costs £53·25, and with a BETAMAX head costs £65·25, including post, packing and VAT. Steve Fitchett. Monolith Electronics Co. Ltd., 5/7 Church Street, Crewkerne, Somerset (0460 74321).

BRAID-AID

Adcola Products Limited have now introduced a range of 'fine' non-corrosive desoldering braid. This braid, it is claimed, due to its fine weave construction is faster acting by 50%; prevents possible component damage because of reduction in heat transference; gives the user greater comfort as there is no heat transfer through the material; can be used with

low temperature/wattage soldering irons; holds more solder and leaves less flux residue behind.

The material is supplied in either 5 or 100ft reels, in six sizes ranging from ·035" to ·220", and costs between 84–99 pence per 5ft reel. Contact Adcola Products Limited, Adcola House, 113 Gauden Road, London SW4 6LH. (01-622 0291).

AUTO-DIAL TELEPHONE

The new, BT-approved, Ace Telcom autodialling telephone, which incorporates a 50-number memory storage, has three other time-saving features.

The first of these is "on-hook dialling", which allows a call to be initiated without first lifting the handset. This means that progress of the call is followed "hands free" with a monitor loudspeaker, it being only necessary to pick the handset up after the call has been answered.

The second feature is that if a called number is engaged, it can be easily and successively tried again by an automatic-recall (last-number) button—again without the need to lift the handset until the call is answered.

And a third feature is the use of the push-button mechanism, in place of the historically conventional rotary dial—a one-handed operation. The instrument can also be used in the manner of a conventional telephone.

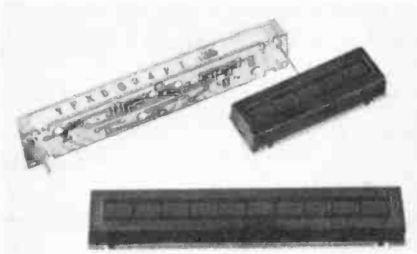
Recall of the fifty stored numbers is by use of a single, individual button for the first twelve numbers and then by using the two appropriate dialling buttons for the balance of the thirty-eight numbers in the memory. A "pause" facility, for securing an external line on a PABX system, is a standard facility.

The Ace Telcom is supplied by Micro Equipment Limited, Freepost, Bath, and can be ordered by telephone (0225 20312) against any credit card. It costs £99·95, including standard British Telecom connector plug, VAT and Securicor delivery. If the standard BT connector socket is not already fitted at the user point, British Telecom will install one at a cost of £11·50, inc. VAT, an application card for this being supplied.

LINEAR INDICATORS

Four new analogue voltage indicating displays from AEG-Telefunken incorporate a built-in decoder/driver integrated circuit. The displays, designated the D600P series, are available in five or ten step configurations.

Because of the internal circuitry no external drive components are required. Supply voltage may be in the range 12 to 15V d.c., with input voltages in the range 0 to 1V d.c. Transition of segments can be linear soft (D620P) or linear abrupt (D630P) depending on the application.



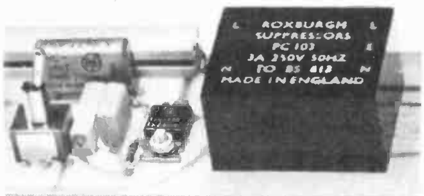
The bargraphs have a wide viewing angle of ±30° with very low cross-talk between segments. The units are designed generally for solid state indication in all forms of linear analogue display. One major application area is in VU meters used in Hi-Fi equipment, and one type (D634P) has been constructed with 7 green and 3 red segments specifically for this purpose. Further information from Brian Penks, AEG-Telefunken (0753 872101).

MARKET PLACE

'PCB' FILTERS

The wide range of Mains Filters available from Roxburgh Suppressors Ltd., now includes two filters designed for direct mounting onto a printed circuit board.

Designated PC 103 and PC 105, they are rated at 3 and 5 amps respectively. The filters are suitable for protecting a wide range of equipment from Mains Transients and Inter-



Rifa Self Healing capacitors ensure reliability and the units are fully encapsulated for complete environmental protection.

The photograph shows the PC 103 mounted on a mains input board. The PC 103 costs £5·76 and the PC 105 is expected to be similarly priced. The filters are supplied by Stotron Ltd., 72 Blackheath Rd., Greenwich, SE10 (01-691 2031).

According to Electronics Weekly the Irish would appear to have a lot in common with the Chinese when it comes to their antiquated telephone systems. Remedial tactics however would appear to be quite different.

The Irish Department of Posts and Telegraphs reports a 30 per cent reduction in installation demand. Not surprising considering the £300 minimum connection fee. In an effort to curb this downward trend a loan scheme has been devised with the Banks offering 22 per cent interest.

The Chinese on the other hand, who statistically have only one telephone for every 200 people, are planning to triple the number of telephones in the country by the year 2000. In at the start are L. M. Ericsson of Sweden who have won the US$11 million contract to supply exchanges to China's Guangdong province.

• • • •

Undersize magnetic bubbles, created by researchers at NEC, will allow a non-volatile computer memory of 1000Mbits to fit into a chip only one centimetre square. NEC's ultra small bubbles are one-hundredth the size of existing bubbles, and the new device offers access times of 10 to 50ms. However, access time in terms of commercial availability is another four years. The memory device, when on the market, will provide a robust alternative to peripheral memories such as disc drives.

• • • •

Attention all budding film producers, with the aid of a new book and a home video system, Cannes could be just around the corner. The book explains in simple terms the systems available for home video taping—the right tripods, lenses and filters needed, how to achieve correct lighting and how to make sound recordings and produce script and screen-play. Professional tricks and techniques are also explained by the author, Peter Lanzendorf. Published by David and Charles, the Video Camera Handbook, systems, recording techniques and production, costs £8·95.

Briefly...

An Australian company have developed a two-way office/car communications system with a difference. Messages are received on a print-out roll and speechless contact with the fleet can thus be maintained.

Security is the name of the game here and because the messages are in written form they cannot be misheard or more to the point overheard by unauthorised evesdroppers. The prototype system provided only limited mobile unit response via a decimal keyboard using a programmed coding system. The second generation machines will have a full keyboard enabling proper two-way conversations to be held. The vehicular unit of the 'Autoprint' system also incorporates a small VDU and is about the size of a standard car radio.

• • • •

Two new clubs have been brought to our attention . . .

Sinclair Amateur Radio User Group (SARUG). Details: c/o Paul Newman G4INP, 3 Red House Lane, Leiston, Suffolk IP16 4JZ.

RAMTOP. Details: c/o The Radio Club, The School, Wellingborough, Northamptonshire NN8 2BX.

To obtain details about these radio amateur and shortwave and computer users groups, send SAE.

Silicon News Corner

Silicon General ▶ 5 bit DAC & positional amp, the SG291 works with SG290 & SG292 to form 3-chip d.c. motor positioning system.

▶ Quad 1·5A darlington switch SG2064–SG2077. 50–80V operation.

▶ Switching regulator power o/p stages SM600–SM612. For 5A pos. & neg. 85% efficient. No reverse recovery spikes.

▶ Switching reg. power o/p stages SM645-647 & SM655–657. As above but for 15A pos. or neg.

▶ Pulse width modulator for d.c. motor SG1731/SG2731/SG3731. Bidirectional pulse train in response to the magnitude & polarity of an analogue error signal i/p. Also audio to 350kHz.

▶ High voltage driver arrays, series 2000. Seven n.p.n. darlington pairs with o/c o/p's & inductive load protection. 600mA peak.

▶ 4A/40V solenoid/motor drivers. SG3638 = dual channel with chopped mode current control and external adjustable chop frequency control. SG3639 = dual channel external adjustable current control. SG3640/3641 = chopped mode current control and external adjustable chop frequency control. SG3642/3642A = operation to 60V

▶ Regulating pulse width modulator SG1524B/SG2524B. Incorporates under-voltage lock-out to prevent spurious outputs when supply voltage falls too low for stable operation. Many other refinements.

▶ Tachometer F-to-V convertor SG290. μP compatible. Ref. V generator & position pulse generator.

▶ SG1526 is a regulating pulse width modulator featuring 8–35V operation, 5V @ 1% ref., 1-400kHz osc. & dual 100mA source/sink o/ps. Also digital current limiting and guaranteed 6-unit synchronisation.

▶ Switchmode driver for d.c. motors, SG292. 2A, 36A @ 18–36V. 30kHz.

▶ SM625–627 & SM635–637 series power o/p stages for 15A pos. or neg. to 100kHz. 85% efficient.

▶ Triple current sense latch SG3551. I-sense comparator with latch & digit reset. Designed for printer coil saturation control. 4·5–25V supply. 40V/25mA o/c o/ps.

▶ SG3636 is a 1·5 dual half-bridge driver for H configuration. 8–25V operation.

▶ Universal quad 2A driver SG3637. Four channel o/ps to +ve or –ve rails. Inbuilt thermal protection, & μP compatability.

▶ Dual hammer driver SG3700. Up to 1A @ 35V. Logic control of pulse duration.

▶ Airflow sensor SG3509 provides control functions to protect equipment from loss of forced air cooling. Detects airflow independent of temperature.

▶ Power op amp SG1173. O/p to 3·5A peak @ supply 30V. Current limit & thermal shutdown included.

▶ Quad bipolar driver SG293A. Current source/sink = 1·5A. Provides two full H bridges with clamp diodes.

▶ Remote shut-down pos. regulators SG78R series. Remote sense A TTL level shut-down. 1·5A @ 5–24V, 1·5%. Rastra Electronics Ltd., 275 King St., Hammersmith, London.

VERSATILE POWER SUPPLY

The PR 655 is a versatile series regulated d.c. power supply that can be constantly varied from 0 to 18V/0 to 5A by normal coarse and fine manual controls or from a varying external resistance when in the

remote programming mode.

Manufactured by Trio, it is available from the House of Instruments, and is highly stable with large independent dual meters for both current and voltage indication. Voltage and current variations as well as ripple and noise have been reduced to a minimum.

Other features include: remote sensing; fixed current protection circuit; series/parallel master/slave mode; l.e.d. indication of regulated voltage and current operation; and rack mounting capability. Front panel switching is provided to disconnect the output terminals for voltage and current adjustments to be made with the load connected.

The PR 655 is priced at £305 ex VAT, and is available from the House of Instruments, Quiswood Ltd., 30 Lancaster Road, St. Albans, Herts AL1 4ET.

Patents-A guide for inventors

Three new booklets explaining what a patent is and how to apply for one are now available from the Patent Office.

"Basic Facts", the first booklet, is intended as a simple introduction for those who know little or nothing about patents for inventions in the United Kingdom. It gives a brief rundown on what patents are, how they are obtained and the kind of protection they give.

The second booklet, *"Introducing Patents—a guide for inventors"*, is aimed at people like private inventors who have a specific interest in the subject and who need more detailed information. It should help inventors to decide whether to patent, and if so, whether to apply for a national patent or to try one of the international routes. Some idea of the costs and the various pitfalls that can occur are given.

The third booklet, *"How to Prepare a UK Patent Application"* is only for those who have decided to apply for a patent without professional help, at least in the initial stages. The pamphlet is not, however, intended as a substitute for the services of a patent agent. It merely seeks to enable those who follow its advice to avoid the serious consequences which may result from filing an application without sufficient knowledge of the patent system. An inadequately-completed application may prejudice the grant of a patent or reduce its commercial usefulness if one is granted.

The pamphlet explains in detail how to prepare a specification and sets out the various procedures involved in filing and prosecution of the application to the stage of substantive examination.

"Basic Facts" and "Introducing Patents—a guide for inventors" are both available free of charge from the Patents Office, 25 Southampton Buildings, London WC2A 1AY. "How to Prepare a UK Patent Application" is only available on personal request from the Patent Office. No charge is made for the booklet.

Countdown ...

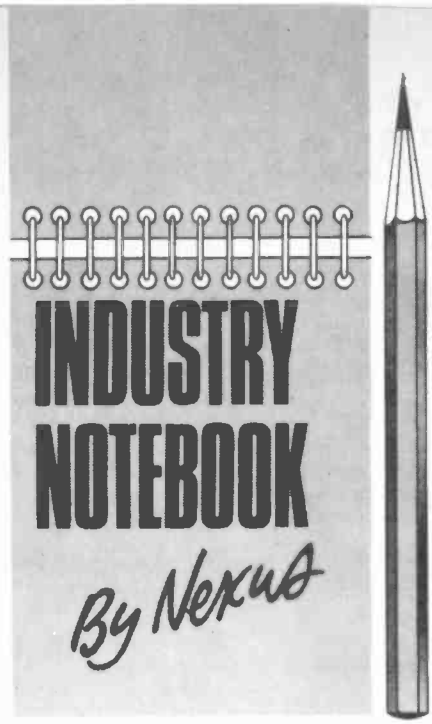
Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to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

Industry & Commerce Oct. 9–12. Leicester. **N4**
Internepcon Oct. 11–13. Metropole, Brighton.
Laboratory London Oct. 12–15. Barbican Centre. **E**
Drives/Motors/Controls Oct. 12–14. Leeds University. **E**
Analyticon (ex. & conf.) Oct. 12–14. Barbican Cntr., London. **L4**
PARC Oct. 17–20. Wembley. **O**
Computer Graphics Oct. 18–20. Wembley. **O**
North East Engineering Oct. 18–20. Newcastle. **O2**
PARC (computers in architecture, conf.) Oct. 18–20. Wembley. **O**
International Business Show Oct. 18–26. NEC. **Z**
Business Efficiency Exhibition Oct. 22–26. Earls Court, London. **Z**
Luton Oct. 25–26. Luton. **O3**
Electronic Displays Nov. 1–3. Kensington Ex. Centre, London. **D4**
Scoteng Nov. 6–10. Kelvin Hall, Glasgow. **M**
Photo Lab Expo Nov. 7–10. NEC, B/ham. **B6**
Software Expo Nov. 8–10. Wembley. **O**

D4	Network	✆ 02802 5226
E	Evan Steadman	✆ 0799 22612
F3	Tomorrow's World	✆ 0272 292156
K	Douglas Temple	✆ 0202 20533
L3	Electrex Ltd.	✆ 0483 222888
L4	Scientific Inst. Manufacturers' Assn.	✆ 01-437 0678
M	Montbuild	✆ 01-486 1951
N4	Silver Collins	✆ 01-729 0677
O	Online	✆ 09274 28211
O2	Eng. Ind. Assn.	✆ 1632 711039
O3	Eng. Ind. Assn.	✆ 01-950 4335
T	Trident	✆ 0822 4671
T1	Cahners	✆ 0483 38085
V	SDL Exhibitions	✆ Dublin 763 871
W2	Trade Exhibitions	✆ 0764 4204
Y2	Ed. Wilson	✆ 0632 664061
Y3		✆ 01-788 7755
Z	BETA Exhibitions	✆ 01-405 6233
ZL	IPC Exhibitions	✆ 01-643 8040

Microfair (1983) Technology for the handicapped. **Y2.**
Opening times: Mon.–Fri. 10am–4pm (Thurs. to 7.30pm) admission free at the following venues: **Hereward College**, Bramston Lane, Tile Hill Lane, Coventry, Oct. 3–7. **Oriental & African Studies School**, London Univ., Mallet St., Oct. 24–28. **The Gallery**, Dept. Design, S. Glam. Inst. Higher Education, Howard Gdns., Cardiff, Oct. 31–Nov. 4. **Scottish Health Service Cntr.**, Crewe Rd. South, Edinburgh, Nov. 28–Dec. 2.

The Concerned Technology (IT for handicapped). **Y3**
At the following venues: **Plymouth.** The Air Domes, Oct. 7–9. **London.** Alexandra Palace, Oct. 12–14. **Newquay.** Contiki Hotel, Oct. 21–23. **Milton Keynes.** Middleton Hall, Oct. 28–30. **Ipswich.** The Corn Exchange, Nov. 4–6. **Norwich.** East Anglian Ex. Cntr., Nov. 11–13.



What's Good!

It was always said that what's good for General Motors is good for the United States. We might also suggest that what's good for Silicon Valley is good for world electronics. As fine a trend indicator today as General Motors ever was. And the trend from Silicon Valley is upward, all the way.

Advanced Micro Devices (AMD) claim to have still made money during the two-year downturn and are now romping away with 30 percent sales increase and lengthening order books. Intel is currently enjoying record sales and near record profits. Monolithic Memories have scored a 55 percent increase in sales and newcomer LSI Logic, still a comparative midget, has an eight-fold boost in business.

On our side of the pond Ferranti brought forward by almost a year a £7 million investment in expansion of production of ICs. ULA sales have doubled in a year and other devices have improved volumes. The generally happier business climate should help all device manufacturers, not least Inmos who should benefit from an expanding market.

But nobody can afford to be complacent. Emergent technological nations like Taiwan and Korea are constantly climbing the learning curve. One Korean firm, for example, expects to be producing 256K rams by 1986. Such is the pace that today's exotic products will be commonplace tomorrow and already within the sights of many third world countries.

Where do we go from here? In VLSI, Japan's NEC Electronics is about to launch an 11,000 gate array. And within five years, it was forecast at a recent seminar in Edinburgh, Ultra Large Scale Integration with over a billion transistors per chip will be feasible.

None of the 50 experts meeting at Edinburgh University was forthcoming on how they would achieve the magic billion. Trade secrets, no doubt. But clearly line width reduction is a pre-requisite. A clue to the possible technology comes from a new Californian company called Micronix who have recognised that ULSI is beyond the resolution of conventional optical lithography, in fact beyond the theoretical limits. Their answer is to graduate to X-ray lithography for mask-making and wafer processing of submicron devices.

After all the recent fuss over transfer of high technology to the Soviet Union one imagines it may be difficult to get a Micronix machine out of the United States. But if you have impeccable credentials you could be lucky. That is if you can also afford 750,000 US dollars for the basic machine.

The League

League tables, although not always entirely accurate, give at least some idea of comparative performance. One of the most fascinating to appear recently is the Mackintosh European Electronics Companies File 'Top 100'. Not least of the difficulties in compiling such a table is the problem of isolating the electronics content in company results from other engineering activities in major groupings like GEC. Another is currency fluctuations which can distort comparative results, not to mention differing fiscal year-ends.

Mackintosh concludes that the electronic-only sales of Europe's leading electronic groups experienced a 4 percent overall fall in sales during 1981/1982 from the previous year. But on a national basis Britain was unique among the Europeans in actually increasing sales from 12·3 billion to 13·4 billion dollars and maintaining profitability. The Japanese group in Europe also increased sales but at lower profit.

The frightening statistic to emerge is that of sales value per employee, an indication of productivity. Here the British score was 48,000 dollars on average, typical for Europe as a whole but less than the Americans and miles behind the Japanese who averaged 128,000 dollars.

ALARM

What was good news for British Aerospace and Marconi was a blow to Texas Instruments and Lucas. After much heart-searching and a rumoured split in the Cabinet the government finally decided to buy the all-British ALARM (Air Launched Anti Radiation Missile) in preference to the US-designed HARM (High-Speed Anti-Radiation Missile) for which Lucas was to be prime British sub-contractor.

To clear any confusion the word 'radiation' in this context is nothing to do with atomic energy. It refers to the electromagnetic emission from ground-based radar installations. The idea is that when a hostile radar is detected by the aircraft's radar warning receiver the missile is launched and homes on to the target, destroying it with a high-explosive fragmentation warhead. An early example is the US Shrike first used in Vietnam. Several models were needed with different guidance heads to accommodate the frequency variations among different categories of hostile radar. The simple defence was to switch the radar off.

Third-generation systems such as HARM and ALARM have wide-band homing heads, eliminating the need for separate models for use against early warning, ground control intercept and surface-to-air missile radar guidance systems. It is probable, too, that the newer missiles with MPU 'brain power' will complete the attack even if the radar is switched off. In technical jargon, dual-mode homing plus the ability to re-program the software to meet future threats as yet unknown.

ALARM is to cost £300 million initially, more costly than HARM and coming into service later. On the credit side it will keep Britain in the forefront of technology and has good export expectations. The British Rapier missile system, for example, has had great export success. Turkey is to buy £150 million worth following on orders from the US Air Force (£150 million) and Switzerland (£200 million).

Falklands

Whatever the merits of the Fortress Falklands policy there is no doubt it's good for business. Before last year's crisis the Cable & Wireless station relied on HF radio for communications with the outside world. Now the Falklands has its own satellite link with high grade telephony and the capability of receiving TV transmission from the UK. The new satellite station, built in a rush program by Marconi, is containerised and installed on hard standings near the Governor's House, Port Stanley.

Two Plessey AR3D three-dimensional air defence radars maintain air surveillance over a radius of 270 nautical miles. Airlifted to their permanent sites by Chinook helicopter they can handle multiple interceptions at a central operations room.

A spin-off from battle experience is a £30 million contract won by Racal Radar Defence Systems for naval electronic warfare equipment. A further development of the Cutlass system, the equipment will go into the Royal Navy's new Type 23 frigates and should provide more effective defence against radar-guided missiles. It is noteworthy that Racal won the contract using Cardinal Point Specification Bidding. This is a procedure which, while meeting Royal Navy requirements, optimises the export potential of the equipment. Racal won a Queen's Award for Export Achievement this year by trebling exports of electronic warfare systems.

Plessey

It is hard to believe that only a few short years ago Plessey was so much in the doldrums that market analysts were suggesting possible takeover. Latest first-quarter figures to hand show a turnover of £287 million, up £72 million from the previous corresponding period. Pre-tax profits were up from £31·5 million to £38·2 million.

Microelectronics was quoted as having strong growth in demand which is further evidence that the Silicon Valley recovery, reported in my opening paragraphs, is well reflected here.

$4\frac{1}{2}$ DIGIT LCD MULTIMETER

BRIAN CURRIE

FIRST FULL PROJECT FEATURING THE ICL 7129 CHIP

LAST month, we featured a $4\frac{1}{2}$ digit Panel Meter based on the Intersil 7129. This is a single chip $4\frac{1}{2}$ digit A/D converter with direct LCD drive. The panel meter itself will have an immense number of different applications, wherever low-cost, portable and accurate measurements need to be made.

An obvious use for the meter is as the heart of a digital multimeter. The project that follows is the first featuring the ICL 7129 that has been published anywhere in the world.

BOARD DESCRIPTIONS

At the moment, there are very few $4\frac{1}{2}$ digit handheld DMMs available. Those that are are extremely expensive, ranging from £200 to £300 each.

This instrument comprises two boards, the DPM60 panel meter as featured last month, and a conditioning board which converts all inputs into a voltage in the range 0-200mV d.c. Classified the DP2010A it is a development of the DP2010 featured in November 1982 issue, but utilising a $4\frac{1}{2}$ digit display.

As the panel meter construction and operation was fully described last month, we will only now consider the conditioning board.

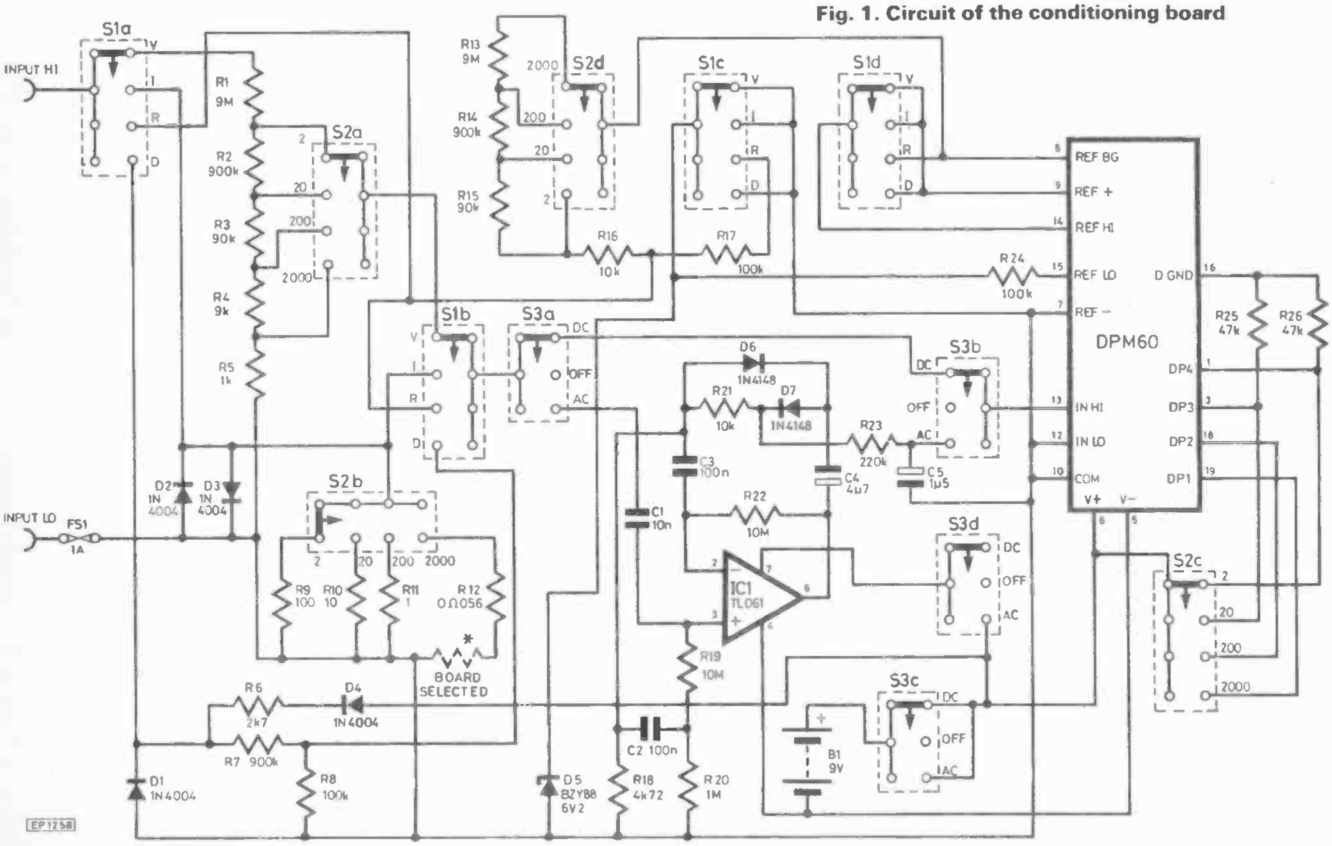
CONDITIONING BOARD

The circuit diagram of the DP2010A is shown in Fig. 1. Switch S3 selects d.c. or a.c. functions whilst connecting the battery to the appropriate circuitry via S3c and S3d. When the switch is in the centre 'off' position, S3a and S3b isolate the input to the module to prevent damage. Switch sections S1a and S1b route the input to voltage, current, resistance or diode check stages.

For the measurement of a d.c. voltage an input attenuator is formed by resistors R1 to R5 which are high stability metal film types. The attenuator settings ensure that each input range is reduced to 200mV full scale for input to the module. The input impedance of the mulitmeter is the standard value of 10 megohms and ensures that negligible current is drawn from the voltage source.

When a current range is selected, S2b selects one of four

Fig. 1. Circuit of the conditioning board



COMPONENTS . . .

Resistors

R1	9M	Metal film	0·25%
R2	900k	,, ,,	,,
R3	90k	,, ,,	,,
R4	9k	,, ,,	,,
R5	1k	,, ,,	0·1%
R6	2k7	Carbon film	5%
R7	900k	Metal film	1%
R8	100k	,, ,,	,,
R9	100R	,, ,,	,,
R10	10R	,, ,,	,,
R11	1R	,, ,,	,,
R12	0R056	Wire wound	10%
R13	9M	Metal film	0·25%
R14	900k	,, ,,	,,
R15	90k	,, ,,	,,
R16	10k	,, ,,	,,
R17	100k	Carbon film	5%
R18	4k72	Metal film	1%
R19	10M	Carbon film	5%
R20	1M	,, ,,	,,
R21	10k	Metal film	1%
R22	10M	Carbon film	5%
R23	220k	,, ,,	,,
R24	100k	,, ,,	,,
R25	47k	,, ,,	,,
R26	47k	,, ,,	,,

Capacitors

C1	10n	Polystyrene
C2	100n	,,
C3	100n	,,
C4	4µ7	Tantalum bead
C5	1µ5	,, ,,

Semiconductors

D1	1N4004
D2	,, ,,
D3	,, ,,
D4	,, ,,
D5	BZY88 6V8
D6	1N4148
D7	1N4148
IC1	TL061

Switches

S1	4 pole 4 way slide
S2	,, ,, ,, ,, ,,
S3	4 pole 3 way slide

Fuse

1A 20mm glass

Miscellaneous

Case, p.c.b., fuseholders (2), input sockets (2), case fixing screws (2), PP3 clip

A kit containing the DPM components plus all parts needed to construct the complete Multimeter is available at £49.95 including VAT and p&p from **Lascar Electronics Ltd., Module House, Whiteparish, Salisbury, Wilts, SP5 2SJ.** (Tel. 07948 567).

SPECIFICATION

Function	F.s.d.	Resolution	Accuracy	Protection
	2V	0·1mV	0·3% ± 1 digit	500V for 1 minute
Volts	20V	1mV	0·3% ± 1 digit	
(d.c.)	200V	100mV	0·3% ± 1 digit	
	500V	1V	0·3% ± 1 digit	
	2mA	0·1µA	1% ± 1 digit	1A/250V
Current	20mA	1µA	1% ± 1 digit	
(d.c.)	200mA	10µA	3% ± 1 digit	
	1000mA	100µA	5% ± 1 digit	
	2V	0·1mV	3% ± 10 digits	500V for 1 minute
Volts	20V	1mV	3% ± 10 digits	
(a.c.)	200V	10mV	3% ± 10 digits	
	500V	100mV	3% ± 10 digits	
	2mA	0·1µA	3·5% ± 10 digits	1A 250V
Current	20mA	1µA	3·5% ± 10 digits	
(a.c.)	200mA	10µA	5% ± 10 digits	
	1000mA	100µA	10% ± 10 digits	
	2k	0·1	0·3% ± 1 digit	260V r.m.s. for
Resistance	20k	1	0·3% ± 1 digit	10 seconds
	200k	10	0·3% ± 1 digit	
	2000k	100	0·3% ± 1 digit	
Diode Test	2V	0·1µV	1% ± 1 digit	260V r.m.s.

shunt resistors R9 to R12, each of which should develop 200mV with full scale current input. The value of R12 is set to allow for the effect of switch and p.c.b. track resistance. A series chain configuration could have been used for current sensing, but the low value resistors required could be difficult to obtain.

A fuse protects against excessive input currents and diodes D2 and D3 protect the instrument from the application of high input voltages.

A.C. FUNCTIONS

When S3a selects a.c. functions the output from either the voltage attenuator or current shunts is fed through C1 to remove any d.c. component.

The operational amplifier IC1 is a TL061 connected as a precision rectifier. The j.f.e.t. input results in high input impedance and the supply consumption is only 250µA. Diodes D3 and D4 rectify the alternating input and the positive component is sampled by R14 and filtered by R16 and C5. The circuit is mean sensing and calibrated to indicate the r.m.s. value of sine wave inputs by establishing the correct gain of the amplifier stage. The gain is set by R15 and R11 and use of the values indicated will eliminate the need for calibration. Alternatively, a 10k potentiometer could be substituted for R11.

RESISTANCE RANGE

In order to minimise the components required for resistance measurement and eliminate the need for calibration adjustment, a ratiometric method of resistance measurement is employed.

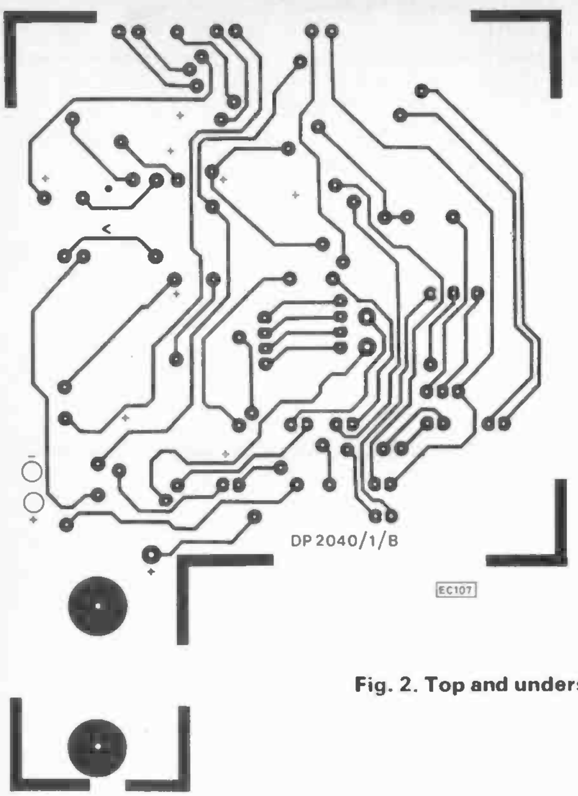
For all other multimeter functions, the voltage reference within the module is employed and the 1V output is connected to the module reference inputs via S1c and S1d. All inputs to the module are thus compared against the reference voltage. For resistance measurement the supply is applied across the reference resistor Rr and the unknown resistor Rx. The voltage developed across each resistor is dependent upon the ratio of the two resistors and the value of the unknown resistor may be read directly using the equation: Reading $= 10^5 R_x/R_r$.

Metal film resistors R13 to R16 are used as references. It would have been possible to use the resistors from the voltage attenuator as references but the resistors required are in reverse order to those for the voltage ranges, resulting in the decimal points on the display being incorrectly positioned. Additional switch sections would be required to provide correct decimal point location and to isolate R5 from circuit common.

Resistance measurements should not be made on live circuits but protection against the application of high input voltage is provided. R17, D5 and R24 form a voltage clamp and current limiter.

DIODE TEST

When a silicon diode is forward-biased into conduction the voltage drop across the device is approximately 0·6V.



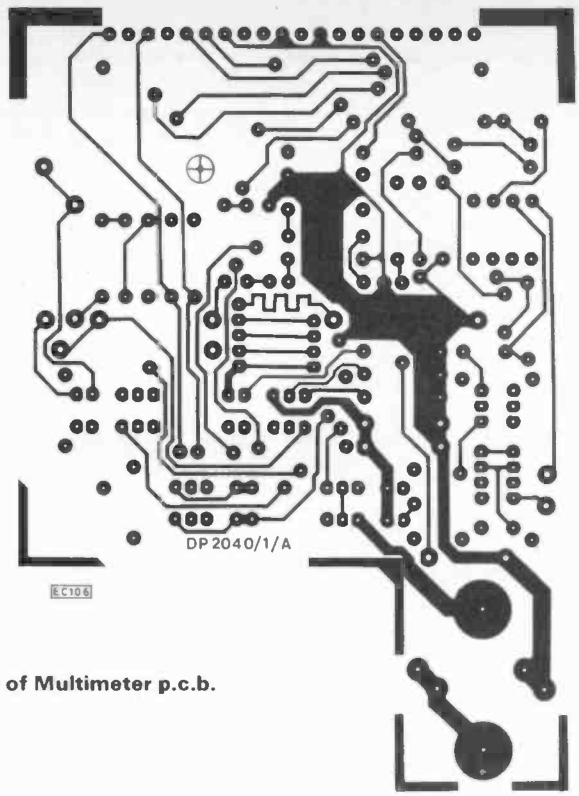


Fig. 2. Top and underside details of Multimeter p.c.b.

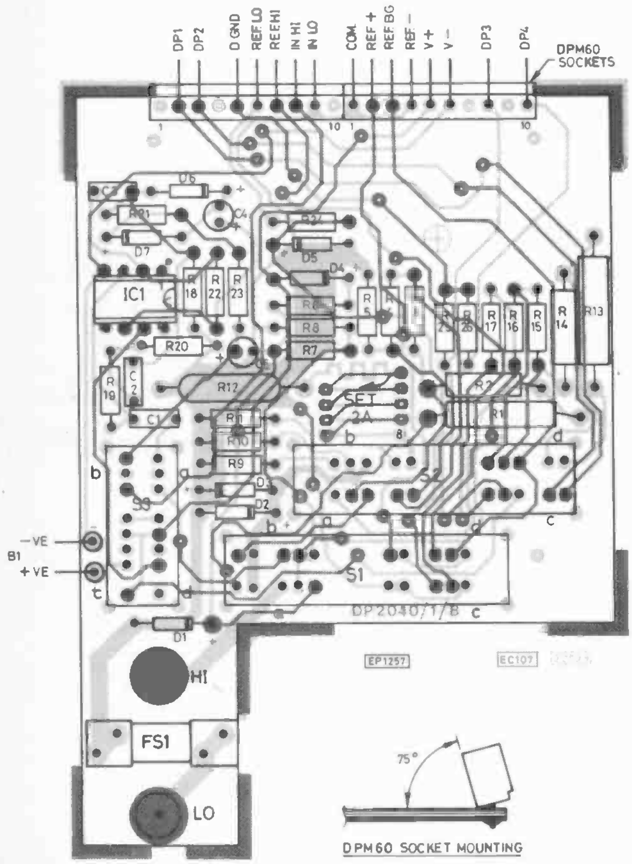


Fig. 3. Board layout and below right, showing how the two sockets for the DPM60 (featured last month) are angled relative to the board. To calibrate the 2A range, solder a wire to the p.c.b. as shown and touch the free end to pads 1–8 to obtain the most accurate reading. When this is done solder the wire into place

The 200mV full scale of the module is however too low to measure this voltage drop. When S1 selects Diode Test function, biasing from the battery is available via D4 and R6. When the applied diode is forward-biased the voltage drop will be attenuated by a factor of 10 by R7 and R8 to bring it within the measurement range of the module. If the 2V range is selected the decimal point will be correctly positioned on the display for direct readout of the diode voltage.

If the applied diode is open-circuit or reverse biased, it will not conduct and the display will be over-range. If the diode is short circuit the display will read zero. Because of the accuracy of measurement available close matching of transistor V_{be} can be carried out.

The diode test should not be made on live circuits but diode D1 will protect the instrument from the application of high negative input voltages which would otherwise be shunted onto the supply by D4. Positive input voltages are held off by D4. and safely attenuated by R7 and R8.

PANEL METER DPM60

Constructional details of the DPM60 featuring the Intersil 7129 chip were given last month.

CONDITIONING MODULE

Components should be checked against the component list and assembly commenced by soldering the resistors and capacitors in place, followed by the diodes and integrated circuit carefully noting the orientation. The three slider switches should now be fitted to the p.c.b. and prior to soldering check that each switch is perpendicular to the board and pushed down as far as possible. Remember the boards are plated-through-hole and difficult to desolder.

The fuse clips and fuse may now be fitted followed by the

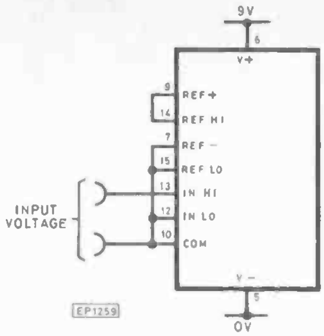


Fig. 4. Module connections for measuring a floating voltage source with 200mV full scale and autopolarity indication implemented

p.c. mounting terminals, battery connector leads and socket. The other end of the ribbon cable may now be soldered to the panel meter module.

TESTING

The DPM is a self-contained instrument and may be tested and calibrated before connection to conditioning modules if required.

Fig. 4 shows how the instrument may be connected to measure a floating voltage source in the 0-200mV range with the DPM powered from a 9V battery.

The voltage between COM and V+ should be approximately 3·2V and battery consumption about 1–2mA. When the IN HI and IN LO connections are shorted together the display should show 0000.

With a 100mV source connected between IN HI and IN LO the display should read 10000 when VR1 is adjusted. Calibration may also be carried out by comparison with a meter of known accuracy.

The testing of the instrument should be carried out before the case is fitted and after checking all the soldering, the battery should be connected.

With the input switch to 20V d.c. the display should be 0·000 and the voltage between IN LO and battery positive should be approximately 3·2V. The voltage between pins 9 and 7 of the module should be 1V. Apply a 10V input and adjust VR1 until the display reads 10·000.

Switch to 20mA d.c. and check the reading with a 10mA source connected. To calibrate the 2A range, switch to 2000mA and apply a current of up to 1A. The meter should give a reading which is too high. To set the correct reading refer to Fig. 3 and select the appropriate board resistance.

Fig. 5. Showing the meter in use

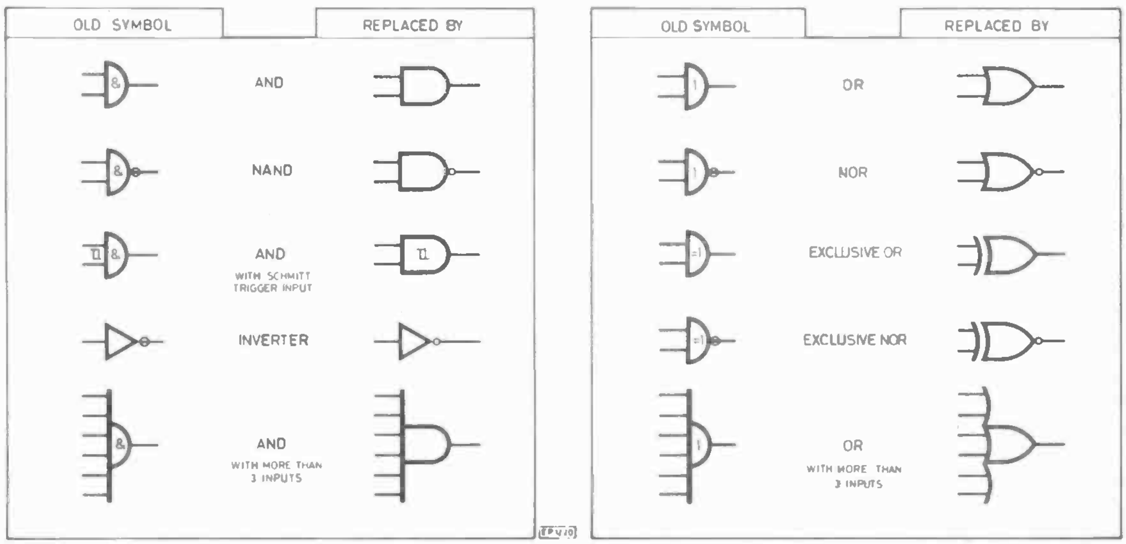
Switch to 20k range and check that with the input open circuit the display shows a 1 in the most significant digit with the other three digits suppressed, which is the overrange indication. Connect a standard 10k resistor and check the reading.

With the instrument switched to 20V a.c. apply a 10V a.c. source and check the display.

The diode test function should be checked with a known diode and the reading should be approximately 600mV with a silicon diode or 300mV with a germanium diode.

The "Continuity" annunciator will be activated on any range if the input to the meter is less than about 230mV (see last month). This is very useful when checking for electrical connection because it is much more rapid in operation than the meter, which has to recover from overrange every time continuity is established. If the continuity feature is not required, then link pins 11 and 16 on the panel meter socket.

NEW LOGIC SYMBOLS



Simple Speech

P. Creighton

Digital Acquisition & Reproduction

Part One

Experimental Speech System

OVER recent years some extremely sophisticated techniques have been developed for the digital encoding of speech, and for its reconstitution. The purpose of this article is not to discuss these techniques (see references), but to present a very simple method, and its implementation using a 6502-based microcomputer with minimal extra hardware, whereby speech may be digitised, and subsequently regenerated, with an adequate degree of intelligibility. This method is relatively economic in its use of memory for storage of the speech data, and has the outstanding advantage that the encoding process is simple. One may readily construct any chosen vocabulary, whether composed of complete words, phrases, or phonemes. This is in distinct contrast to the most commonly used method of speech digitisation, involving linear predictive coding to reduce redundancy, and utilising a digital model (a lattice filter) of the human vocal tract for the reconstitution of speech. Although highly complex, this hardware is now cheap and readily available. However, it is not at all easy for the user to construct his own vocabulary, as the encoding process is so complicated.

The method presented here is not new in concept and is based upon the well-known observation that the intelligibility of infinitely clipped, or zero-crossed speech, is remarkably high. This is due to the particular spectral characteristics of speech, especially its quasi-periodic nature. Anyway, given this observation, it is but a simple step to see that one may encode zero-crossed speech waveforms by storing digitally the time intervals between successive zero-crossings. The zero-crossed speech waveform may be faithfully reconstructed by an inverse process of generating switching intervals corresponding to the magnitudes of the digital speech data. Note also that speech may be speeded up or slowed down on replay (but the pitch also changes accordingly). In practice it was not found possible to speed up the speech appreciably on replay, because of the limited speed of the microprocessor.

Initial experiments had the simple aim of digitising a few seconds of continuous speech (including any periods of silence). Once this had been achieved, and the reconstituted speech shown to be almost identical to the original zero-crossed speech waveform, the programs and hardware were developed further to enable isolated words or word segments to be digitised and stored between known limits in memory. Knowing where in memory the speech data comprising a word starts and ends, it becomes a simple matter to replay any particular chosen word under program control.

FIRST STEP: Acquisition and replay of a few seconds of continuous speech, including silences.

A little consideration suggested that sufficient speed could be obtained only by using the 6502 interrupt system; it would take rather too long to repeatedly examine a digital input line, testing for a change of state. The acquisition hardware operates as follows:

First a source of audio signal with a peak amplitude of a few volts rather than millivolts, is required. This can be obtained from a microphone followed by a suitable preamplifier (Fig. 1.1.), but if such a pre-amp is not available, then the

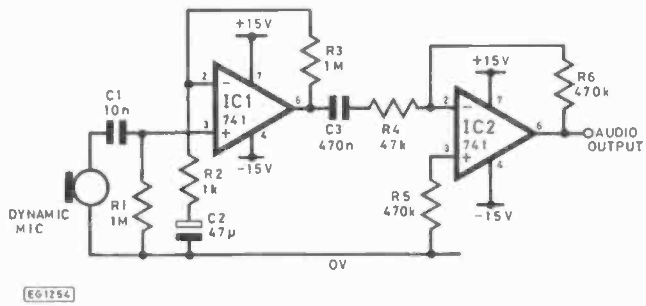


Fig 1.1. Preamplifier circuit

audio signal may be pre-recorded and replayed from a cassette recorder at maximum volume, taking the audio output from the earphone socket.

In Fig. 1.2, IC1 is configured as a comparator receiving an input which is filtered to give a bandpass response between about 300 and 3,200Hz. The comparator threshold may be set within a certain range either side of zero by means of VR1. Ideally, the threshold should be set at zero, but in practice it is preferable to set the threshold just above the noise level, either positively or negatively. Clearly it is necessary to conduct these experiments in an environment relatively free of acoustic noise.

The comparator provides a "zero-crossed" output or, expressed another way, an infinitely clipped version of the audio waveform. The function of the pre-filtering is to restrict the bandwidth to the minimum compatible with reasonable intelligibility. This will economise on memory usage for the storage of the words, especially those with a high sibilant content.

IC1 is followed by an edge detector, consisting of a simple delay and an exclusive-OR gate. This gives positive-going pulses of minimal duration (the acquisition Count routine must not interrupt itself). These pulses are inverted by IC3a ½ 74LS20 and then supplied to the $\overline{IRQ}$ input of the 6502

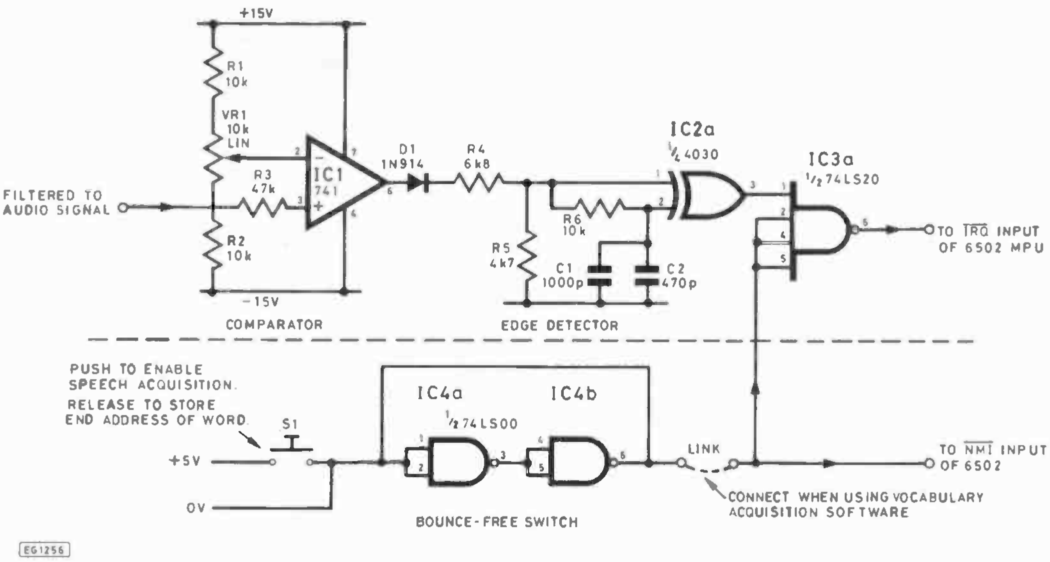


Fig. 1.2. Additional circuitry for systematic vocabulary acquisition

microprocessor. The reason for using a 4-input NAND gate rather than a simple inverter is to enable the system to be expanded later on.

ACQUISITION SOFTWARE

Table 1.1 gives the assembly listing. Table 1.2 gives a hexdump of the acquisition program. The storage area reserved for speech data is $1000 to $1FF, so a minimum of 8K of memory must be available. 4K of memory is thus available for storage of speech data, which is enough for a few seconds of speech.

INTA1 is the acquisition program. It consists of two parts, an Initialisation routine, and a Count routine.

Superboard II has a small area of free memory, located at addresses $0250 to $02FF, which is not used by BASIC, so it was decided to assemble the programs into this area. Note that the machine used was fitted with WEMON; on machines without WEMON this area of free memory in page 3 is slightly larger.

The first part of the acquisition program is concerned with initialisation. It ensures that all arithmetic operations are conducted in twos complement binary rather than in BCD; then it sets up the system IRQ vector to access the Count routine. The remaining instructions set up a 2-byte indirect pointer to access memory for the storage of zero-crossing intervals, starting at $1000; then the counter (the X-register) used for timing the intervals is cleared, interrupts are made possible, and the processor cycles in a jump-self wait loop until the first interrupt pulse arrives.

Operation of the second part, the Count routine, is best understood by reference to the assembly listing. Essentially it stores the last count value, and counts again until another interrupt pulse occurs, in which case the counting starts again, or until a count of $FF is reached, in which case the same thing happens, except this time via a JMP rather than

```
5                          ; INTA1: Initialisation
10 START=624               ; Start assembly at $0270
20        CLD              ; Clear decimal mode flag
30        LDYIM    76      ; Set up IRQ vector to
                             access Count routine
40        STY      561
50        LDYIM    80      ; L byte of start address of
                             Count routine
60        STY      562
70        LDYIM    2       ; H byte of start address of
                             Count routine
80        STY      563
90        LDYIM    0       ; Set indirect pointer P1
                             to $1000
100       STYZ     1
110       LDYIM    16
120       STYZ     2
130       LDYIM    0       ; P1 offset = zero
140       LDXIM    0       ; Clear counter
150       CLI              ; Enable interrupts
160 WAIT  JMP      WAIT    ; Jump-here wait loop
170 END                    ; Location counter=
                             dec. 656
173                        ; INTA1: Count routine
175 START=592              ; Start assembly at $0250
180 NXT   TXA              ; Transfer last count
                             value to location
                             currently addressed
                             by P1
190       STAIY    1
200       LDXIM    0       ; Clear counter
210       CLC              ; Increment P1
220       LDAZ     1
230       ADCIM    1
240       STAZ     1
250       LDAZ     2
260       ADCIM    0
270       STAZ     2
280       CMPIM    32      ; Exit if P1 = $2000
290       BEQ      EXIT
300       CLI              ; Enable interrupts
310 CNT   INX              ; Start counting
320       CPXIM    255     ; Continue to count until
                             an interrupt occurs, or
                             count reaches $FF, in
                             which case back to NXT
330       BNE      CNT
340       JMP      NXT
350 EXIT  BRK
370 END                    ; Location counter =
                             dec. 624
```

N.B. All operands in decimal
The object code for these routines is executed from $0270

Table 1.1. The assembly listing

Count Routine

0250	8A	91	01	A2	00	18	A5	01
0258	69	01	85	01	A5	02	69	00
0260	85	02	C9	20	F0	09	58	E8
0268	E0	FF	D0	FB	4C	50	02	00

Initialisation Routine

0270	D8	A0	4C	8C	31	02	A0	50
0278	8C	32	02	A0	02	8C	33	02
0280	A0	00	84	01	A0	10	84	02
0288	A0	00	A2	00	58	4C	8D	02

Replay Routine

0290	D8	A9	00	85	01	A9	10	85
0298	02	A0	00	B1	01	AA	CA	E0
02A0	00	D0	FB	C9	FF	F0	03	8D
02A8	82	EF	18	A5	01	69	01	85
02B0	01	A5	02	69	00	85	02	C9
02B8	20	D0	E0	4C	90	02		

Table 1.2. Hexdump of Acquisition programs

an interrupt. Thus intervals longer than $FF count units will be truncated to that value. In practice most intervals do not exceed $FF units, but the reason for incorporating this feature is to enable silences also to be encoded, as a train of bytes of value $FF. For this first experiment this was of interest, because some words do contain brief silences, and also to enable continuous speech to be encoded. Later it is attempted to record single words one at a time, both with and without this feature, to see how great a difference the omission of brief intra-word silences makes. For the purposes of the present programs, however, it is enough to note that the replay program is designed to skip over bytes having the value $FF, i.e. it treats them as silence.

At the other extreme there is a minimum interval between consecutive zero-crossings that can be correctly resolved; this is the time taken for the execution of instructions in lines 180 through 300. Again, the quality of the resuts obtained suggests that intervals so brief are rare in band-limited speech.

REPLAY OF ZERO-CROSSED SPEECH

The hardware required for reconstitution of the zero-crossed speech is even simpler than that employed for acquisition. Best results are obtained if the replay is filtered to remove the high-frequency raggedness of the sound, and the low-frequency rumble component. This is easily achieved using an audio amplifier (Fig. 1.3.) equipped with bass and treble controls. Alternatively, a simple audio amplifier may be used in conjunction with the same pair of filters used for the acquisition process.

The replay program, Table 1.3, generates pulses on a particular write line, in this case W2, whose address is decimal

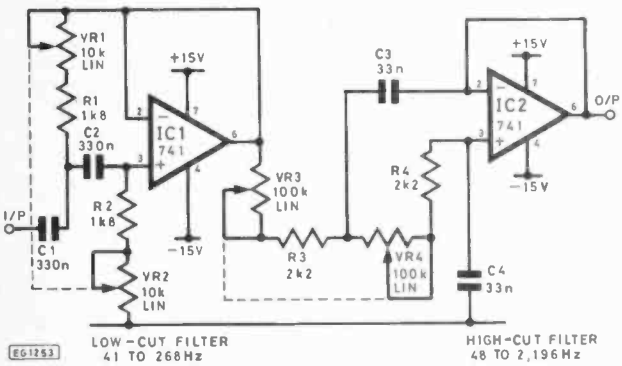


Fig. 1.3. Audio amplifier incorporating bass and treble controls

```
355                                ; RPFF3, replay program
360 START=656                      ; $0290
370 START     CLD                  ; Clear decimal mode flag
380           LDAIM    0           ; Set P1 to $1000
390           STAZ     1
400           LDAIM    16
410           STAZ     2
420           LDYIM    0           ; P1 offset = 0
430 NXTBT     LDAIY    1           ; Put next byte in X-register
440           TAX
460 LOOP      DEX                  ; Count down with X until
                                     zero
470           CPXIM    0
480           BNE      LOOP
490           CMPIM    255         ; Check if byte = dec. 255
500           BEQ      NOTOG       ; If so, skip over toggle
510           STA      61314       ; Toggle flip-flop
520 NOTOG     CLC                  ; Increment pointer P1
530           LDAZ     1
540           ADCIM    1
550           STAZ     1
560           LDAZ     2
570           ADCIM    0
580           STAZ     2
590           CMPIM    32          ; Repeat for next byte until
                                     P1 = $2000
600           BNE      NXTBT
610           JMP      START       ; Back to beginning
620 END                            ; Location counter = dec. 702
```

Execute from $0290

Table 1.3. Replay program

61314. The pulses occur at intervals corresponding to the original zero-crossing intervals, and are used to toggle a flip-flop, Fig. 1.4, to generate the reconstituted infinitely clipped speech waveform. Clearly at least one address-decode write line is needed. See references for suitable circuitry. The functions of capacitors C1 and C2 is not immediately obvious,

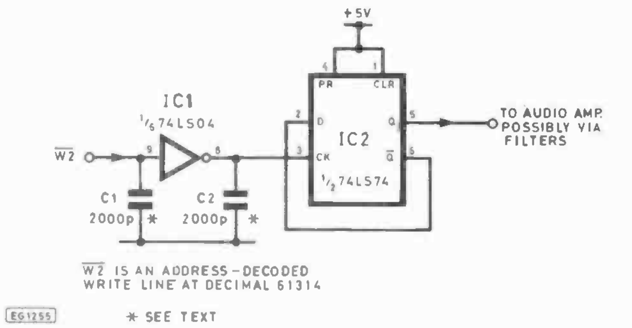


Fig. 1.4. Toggling flip-flop

but they were found necesary to ensure clean toggling operation of the flip-flop. I speculate that there may have been double-pulsing or ringing on the write line, although I could not detect it by eye on an oscilloscope. Thus these capacitors may not prove necessary, and I suggest experimenting with their values.

NEXT MONTH: The second part of this article will deal with programs and additional hardware for building up a vocabulary of isolated words, and for replaying specific words under program control. It will also consider some of the possible uses of these techniques for producing complex sound effects rather than speech, and look at zero-crossed speech data graphically with a view to possibilities for speech recognition.

REFERENCES

1) *Speech Synthesis.* Practical Electronics *Nov., Dec. 1980*
2) *Interfacing Compukit, by D. E. Graham,* Practical Electronics *Jan.-July 1981.*

VERNON TRENT at Large!

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

THOUSANDS of milkmen up and down the country leap into them every working day of the week. Harrod's, the thinking man's corner shop, used to run a fleet of them. There are the physically-handicapped who find them a wonderful aid to a fuller life. It is even said that Prince Philip, when in town, uses one to pop round to his barber for a short back and sides or to slap a couple of quid on a horse at his friendly neighbourhood Ladbroke's.

What am I on about? Readers of PE, ever quick on the uptake, will have already realised that I'm referring to Battery Operated Vehicles. Or, if you haven't much time to spare, BOVs.

Like the poor, BOVs seem to have been with us always. Yet they do not seem to have made much of an impact on the ordinary motoring public. Neither does the technology appear to have made any spectacular advances. If it has, then I must apologise to the manufacturers. But they have been a bit reticent about it.

So what's the current state of the art? How strong is support for a wholesale switch from petrol to electric power? Is the BOV the heir apparent of internal combustion? Or will its principal role continue to be the bearer of our daily pintas and an absorbing hobby for an exclusive band of buffs?

Which brings me to Brian Hampton. He's an instrumentation engineer with an aircraft industry background. He is also PRO of the Battery Vehicle Society (BVS). In that capacity I met up with him because he seemed like a chap well-qualified to throw some light on the subject.

"Let's get one thing straight," he said. "There are two bodies with a special interest in BOVs. One is the Electric Vehicle Association, that's the manufacturers' outfit, and ourselves, the BVS.

"We have a kind of love-hate relationship, alternately reviling and encouraging each other."

The BVS was born in 1973 when a number of milk float enthusiasts got together. Later in 1979 they organised a race meeting at Rushmoor Arena, Aldershot. This proved to be the catalyst for a series of regular contests.

BVS membership now stands at around 280 and includes fans from such faraway places as Sweden and Hong Kong. "Not," says Brian, "that such distant members really get a lot for their £5 a year subscription. Membership, by the way, seems to have a four-year life, approximately. Whenever we make a survey we find that the numbers of joiners and leavers roughly tally. You won't be surprised to learn there's usually a surge, albeit often only temporary, whenever the price of petrol rises."

What motivates your BOV devotee? Is he at heart really a dedicated ecologist who sees the BOV as a vital tool in the battle against environmental pollution?

Brian exploded that myth with devastating frankness. "I've never, to be honest, ever met up with that kind of motivation. In any case, although BOVs may be cleaner runners in themselves, the objective is defeated if you're going to use coal to generate the power they consume. No. The main advantage as I see it is that if offers flexibility of energy resources. Or, to put it another way, it enables you to change the flavour of pollution!"

A body like the BVS, with a small membership and slender finances, obviously relies a lot on sponsorship for its activities. Back in 1979, for instance, Lucas ran a competition to boost their battery sales. They called it How Far Can You Get? Entrants had to submit a design for a BOV and those whose efforts showed the most promise were invited to build upon their designs and take part in the field section of the contest. As a matter of interest, the winner clocked up some 40 miles, using a battery of 48 lb.

"We have a kind of love-hate relationship"

Looking a long way ahead, could the BOV, we asked Brian, conceivably take over from the family car?

"I'd say it was feasible," he replied. "Although the present models available have a maximum range of not more than about 100 miles. The root of the matter, in my personal view, is that car manufacturers in general are not all that well engineering-balanced. Motor design has not changed all that much over the years, really. It hasn't been shaken up enough. Of course, it's relatively easy to take out an internal combustion engine and put an electric one in its place. But to design and build a BOV from scratch calls for substantial investment and development. And manufacturers are not falling over themselves to take it on.

"Battery development is an important factor in the BOV's future. Technically it would be perfectly possible to design a vehicle which would carry you from London to Edinburgh on a single charge. But for that you'd need a purpose-built battery which might cost as much as £40,000.

Another key element is the direction in which public demand is likely to swing. Brian reckons that the motor industry has been more than sluggish in the area of market research.

"They don't really know what customers want," he says, "and they tend to base their designs on wishful thinking. It could be that there are millions of people driving around in cars they don't really like."

Readers of PE, who have a proper respect for the particle, will be understandably shocked by Brian Hampton's equally individualistic and forthright views on electronic control.

"You go along to a dealer to buy a BOV and he'll tell you that for about £700 you can have electronic control. Give it a whirl, he says. It will give you both higher efficiency and more mileage. I've tried it, and it doesn't. An efficient circuit needs copper. Nothing matches up to it. A lot of silicon in the circuit does no good at all."

Now is the time for you all to slip quietly away and pray for Brian Hampton's soul.

Overall, I get the impression that the boys of the BVS brigade are by no means a bunch of crusading zealots, fervently dedicated to sweeping internal combustion from the Queen's highway and turning us all into propellors of purring runabouts with speeds which make old Aesop's tortoise look like Concorde at full throttle. No. For them it's a grand fun thing. And what's wrong with that?

Nevertheless, the BOV's technical potential is obviously considerable. All seems to rest with the manufacturers. Perhaps the airing of the subject may encourage them to respond.

* * *

Harking back to that very successful Schools Electronic Design Award Competition, jointly sponsored by Mullard and our sister journal Everyday Electronics.

Winner of the first prize was Martin Cragg (15) from Roland Green School, Nottingham, who carried the day with his electronic pendulum project. Without going into the hi-tech plus points of his design, his teacher believes that it will make the teaching of the principles of the pendulum a lot easier. For his effort, Martin went home with the judges' praise still ringing in his ears, a handsome trophy, £300 and components to the value of £200.

What is slightly baffling, in view of a talent so evidently displayed, is that Martin, who has just taken his O levels and hopes to carve out a career in electronics, was turned down by John Player and given a silent big elbow by the giant Plessey who didn't even bother to reply to his application.

Take heart, Martin. History is littered with such instances of worth unappreciated. Everybody fell about laughing when little Beethoven first climbed on to the piano stool. Few believed that Davey's lamp would ever see the light of day. Newton's descending apple was initially regarded as a simple windfall. When Hargreaves tried to tell people about his spinning jenny they thought it was some drunken bird he'd picked up. The Marks family warned him to steer clear of unknown entrepreneurs when he came home one day and told them he'd run into a bright young lad called Spencer.

Subsequent events have put the record straight.

OVER the next few years we are going to see a lot more electronics in our cars. Of course electronics have been used in cars for some time—there are very few cars produced today that do not have an alternator with a rectifier bridge and electronic regulator. The build up to the explosive growth in on-vehicle electronics systems that is anticipated in Europe has been going on for some time, most obviously in the area of electronic ignition systems. These have been available as after-market add-ons, DIY projects and, increasingly, as standard equipment. Most of these systems are of the simple "breakerless" type, just controlling coil current and dwell angle. However, the latest production types are more sophisticated, up to the level of full Microcomputer control, allowing very complex ignition timing maps to be used as is now the case on some models of the Volkswagen Polo.

Other sophisticated electronics systems are already in production but these tend to be expensive and available only on luxury cars. Examples of these are the electronically controlled fuel injection and anti-skid braking systems made by Bosch for BMW's top models.

The emissions legislation in the USA and Japan forced the car manufacturers there to become involved with electronics to solve their engine control problems. Once involved, investigation of the potential benefits of the use of electronics in other areas become a natural course. In Europe we have lacked the legislative push, but have of course been able to learn from what was happening elsewhere. Nevertheless, although we are late coming to the automotive electronics field, we do have the advantage of being able to tackle it on a much broader front.

Motorola owes its existence, and its name, to the very earliest use of electronics in the car—the radio. The company was founded in the USA in 1928 by Paul Galvin to make car radios and in the jingoism of the time, motor-ola meant just that, car radio. Since then Motorola has grown into a large corporation with interests in many fields, and is now the largest supplier of semiconductors to the motor-car industry in the USA.

The MOTOCAR is part of Motorola Semiconductor Product Sector's commitment to the European Automotive industry and is intended to demonstrate some of the various electronics systems that can be included in the production car of the future.

What we have done is strip down a small five door car (a Delta lent to us by Lancia for the purpose), take out all the

It looks like a standard Lancia Delta yet underneath the skin lurks an electronic extravaganza using over a score of microcomputer chips

P.E.V. PHILLIPS
Motorola

The Motocar

Wire, wires, wires! Enough to stretch ½km were ripped out of the conventional Delta to be replaced with 75 metres of wire and fibre-optic cable

"Let's get comfortable first." Any one of four preprogrammed seat and driver's mirror positions may be selected at the touch of a switch. The vacuum fluorescent displays include a trip computer readout and a message centre which flags faults

wiring, instruments, etc. and build it up again using our own design of some of the systems that we believe will be used over the next ten years—using Motorola semiconductors of course!

DRIVER INFORMATION SYSTEM

The most obvious system from the driver's point of view is the Driver Information System, This occupies the position that used to be called the dashboard. A large multi-colour display gives road speed and engine speed (in numbers, not on dials), complete with a red line at 70 mph! It also has bar-graphs for fuel and temperature, an indicator to show whether you are in gear or not, warning signs for ignition, parking brake, seat belts and so on. The odometer is a smaller display showing through a window in the larger one.

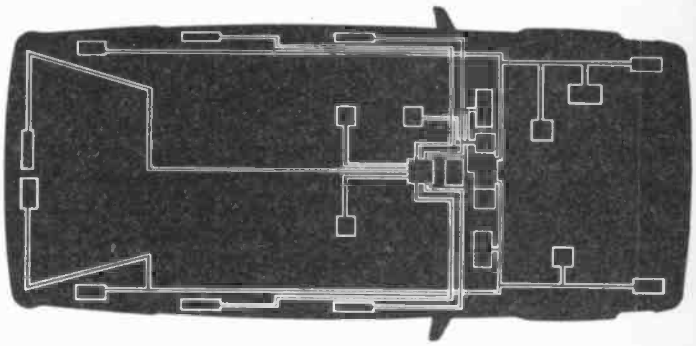
There are two separate twenty character alpha-numeric displays that give information in words and numbers, one for the trip computer and the other for a message centre. The trip computer includes a clock and the usual readings of average speed, average fuel consumption and so on, plus a reading of the outside temperature. The message centre gives a variety of warning messages such as 'door open', 'brake fluid low', 'washer fluid low', etc, plus comprehensive fault indications for all of the units and loads included in the major wire multiplex system.

All of the displays are vacuum fluorescent. At the moment this is the preferred technology for this application although liquid crystal displays could be in use soon. Each type has its own particular disadvantages, the main one for the vacuum fluorescent type being its requirement for a high voltage supply, typically 30 to 45 volts, which means that an inverter is required. The main problem with liquid crystal displays is one of slow response times at sub-zero temperatures, significant as the normal automotive temperature spec. is −40 to +85 degrees C.

The driver Information System is run by an MC6801 (see Fig. 1), used in expanded multiplexed mode to allow the use of 8K bytes of EPROM. The trip computer clock information is generated by an MC146818 real time clock chip, which also includes 50 bytes of user RAM, and an MCM2801 EEPROM is used to store the odometer reading so that the information is not lost when the battery is disconnected.

Also immediately obvious to the driver are the extra switches around the gear lever. These control the electric seats (the motorised rather than the lethal variety) for the driver and front passenger, electric door mirrors, electric windows and electric (central) locking. The seat control system also includes a memory so that four separate positions can be set and recalled for each seat. The driver has the door mirror positions included in his system as an added bonus. What is not so obvious is that all of these systems are controlled by a fibre optic "multiplex"

Electronics in the Family Car



Motorola's Converted Lancia Delta. An electronic key allows windows to be wound up and down, and doors to be unlocked remotely, but the vehicle is "no gimmick". The whole car can be tested via one diagnostic socket

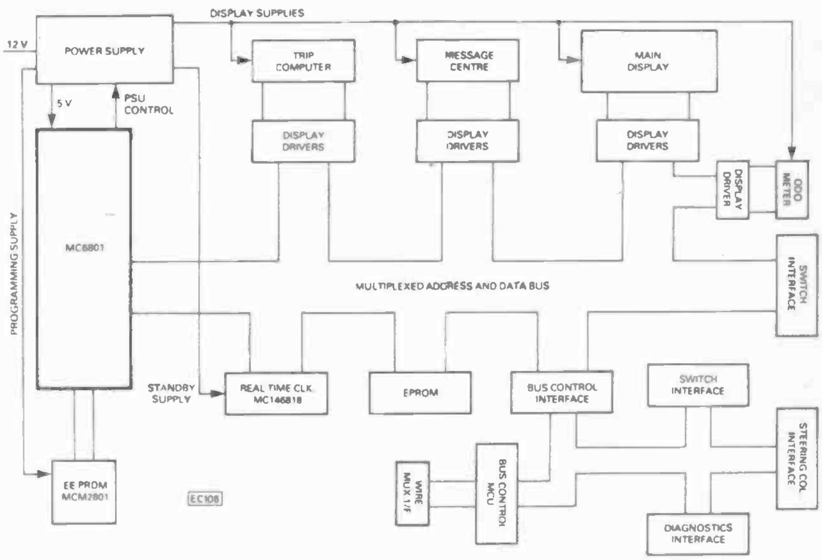


Fig. 1. Block diagram of the Driver Information System. The trip computer and message centre each uses a twenty character alpha-numeric display. All displays are vacuum fluorescent, which will remain the preferred technology until l.c.d.s are developed further

system which is not likely to be in any production car for at least five years.

OUTSTATION CONTROL

The method of operation of this microcomputer controlled system is as follows—The (MC68705U3) scans the switches, encodes the information and sends it to one of the seven outstations (5 doors, 2 seats) by pulsing the appropriate l.e.d. for that unit. Each of the seven fibre-optic links is run in half duplex mode, *with the l.e.d. being used in photovoltaic mode as a receiver*. All of the outstations include an MCU to decode the information plus load driving circuits using discrete components. In the case of the seat and front door units an MCM144102 CMOS RAM is used for memorising seat and mirror positions and the MCU is a MC68705R3, which includes on-board A/D for position information conversion.

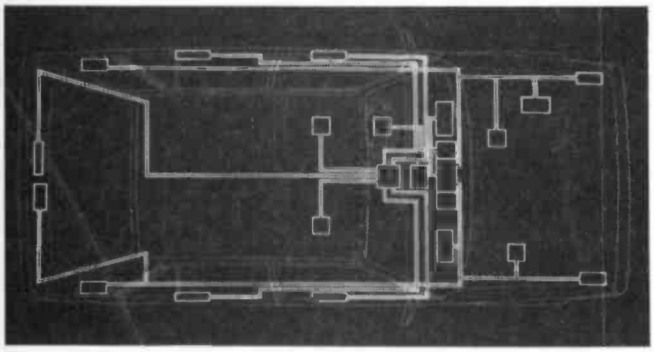
The units in the door send back information on whether the door is locked or unlocked and whether it is closed or not. The units in the seat can detect whether or not there is somebody sitting there, and if so, whether their seat belt is fastened and send this information back.

The use of the fibre optic system has made it relatively easy to include another system that is beginning to appear on some up-market cars; an electronic key. The hand-held remote unit (key) is pointed at a detector on the dashboard and the appropriate button pressed to lock or unlock the doors, or wind the windows up or down.

This uses an infra-red technique similar to television remote controls and incorporates MC145026/MC145027 remote control transmitter/receiver parts designed for that purpose.

There are two other multiplex systems in the car, both using normal wiring rather than optical fibres. One of these is a large system for controlling all of the "normal" loads in the car such as lights, wipers, etc. The principle is similar to the fibre optic system, but in this case there are four wires that run down each side of the car and across behind the "dashboard" to form an "H". The central control box is located behind the "dashboard" in the centre of the "H" and encodes all the switch information as electrical pulses on two of the wires; the other two are for battery supply and ground. There are several load control outstations connected to the system, one in each corner to control the lights and horns, one for the windscreen wiper motor and one for the rear screen wiper and heated rear window. Each of these units is capable of sending information back to the central control if any of the loads are not working, so that the driver can be told by the message centre.

Each of the units in this system, including the central control, is run by an MC68705P3 MCU. All load switching is done by TMOS power FETs, up to eight loads each of up to ten amps can be controlled by each unit, although not all of this capability is used.



Computer graphic of the Motocar's H configured wire and fibre-optic multiplex systems. The main wire multiplex bus consists of four wires. One is a heavy battery positive line which supplies power to the outstations and to the controlled loads (current is returned to the battery by chassis return in the normal way). Another is a ground for the outstation electronics. The third is the data transfer line (bi-directional in a half duplex mode), and the fourth controls the direction of data transfer, and synchronises transmission

The other multiplex system uses just three wires to send all the information from the steering column switches back to the central control of the larger system. This system is constructed entirely from standard MC14000 series CMOS parts and uses a simple parallel in/serial out to serial in/parallel out shift register technique.

ENGINE CONTROL

The car has been converted from carburettor to fuel injection, electronically controlled, of course. This gives the ability to control the fuel going into the engine more accurately, which means better economy without sacrificing performance. If we ever get emissions regulations as stringent as those in the USA, this type of system will be absolutely necessary to have any hope of keeping reasonable fuel economy.

The system used here employs two processors, one to manage the engine control and another, an MC68705P3, to interface the unit to the wire multiplex bus. The engine control (see Fig. 2) is achieved using an MC68705R3 plus several standard CMOS parts and is very much an experimental system. A more powerful processor, such as the MC6801, would be needed to realise a system that would be practical for good drivability, emissions and fuel efficiency performance, without the need for a lot of extra integrated circuits round the MCU.

CREATURE COMFORT

Another system that has been included to give the driver and passengers a bit of extra creature-comfort is the climate control. This automatically controls the heating and air-conditioning system so that the driver just dials up the temperature he wants and the system takes care of the rest, no matter what the temperature is outside. Again this system uses a combination of an MC68705P3 to interface to the wire multiplex bus and an MC68705R3 to perform the real time control function.

The systems included in the MOTOCAR are only some of those that exist already or can be foreseen as production systems; also none of the units are intended to resemble a final production form, they are all purely for experimental purposes.

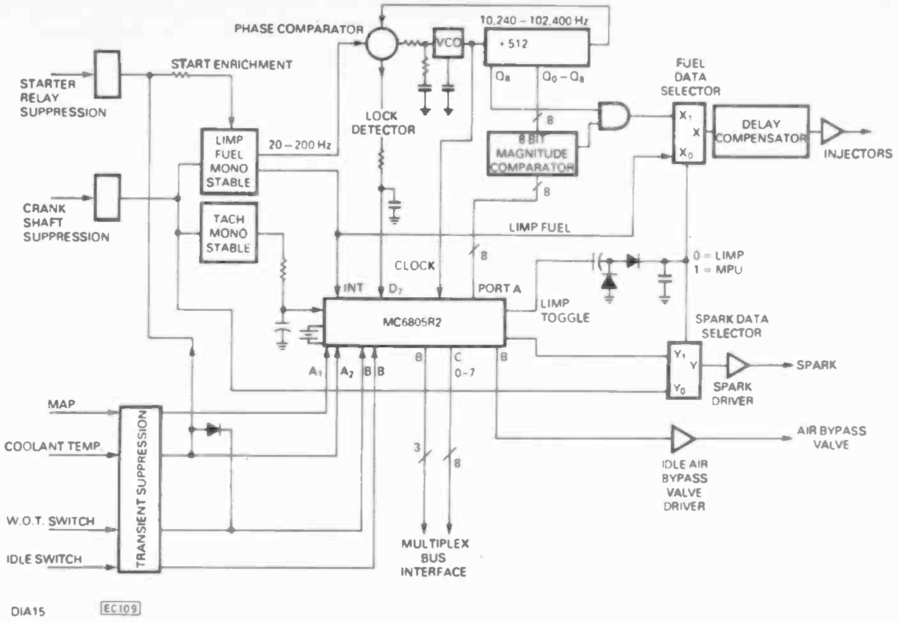


Fig. 2. Engine Control block diagram. Using a phase-locked loop to multiply the distributor signal, the system synchronises to high resolution engine angle signals representing 0·35 deg. each.

The insistence of car manufacturers on negative earth electrics (to minimise body corrosion) makes the n-channel TMOS device awkward to apply to outstations in a "production acceptable" vehicle. Alternatively, the efficiency of p-channel TMOS is such that a supply voltage several times higher than 12V is necessary. Motorola's investigations will reveal whether it is more practical to distribute a shared HT from a central invertor, or incorporate a dedicated invertor in each TMOS outstation. This is a typical example of the engineering questions that the Milton Keynes team must answer

ANTI-SKID

Anti-skid braking is one system that has already been mentioned, and a lot of work is going on to make this important safety feature available in a cheaper form. The search for better fuel economy has lead to the concept of power train management. This involves the use of a single control system looking after the engine (fuel quantity and spark timing) and the gearbox (ratio) so that the optimum performance can be achieved for any given driver demand.

The development work here is directed not so much at the control system as at the special type of gearbox that is required to make this system work. This is a constantly variable transmission that has no clutch or torque converter but *can* still cope with the driving wheels being stationary while the engine is running. The best known of this type is the Van Doorne belt type that was used in Daf cars. There are a lot of interim solutions to gear box control that are being investigated to provide automatic control while avoiding the losses associated with a torque converter.

All of the various systems mentioned above can provide technical benefits in terms of improved fuel consumption, safety and appearance. When they are likely to appear on the average family car is largely a question of economics. It is certain that the process has begun, as is demonstrated by the complex ignition system on the Volkswagen Polo and by the electronic dashboard and MCU engine control on the new Austin Maestro. ★

LOGIC ANALYSER

Part Four

D. MANDELZWEIG MSc Eng

THIS month, the operation of the Z-Modulation and Internal Clock options is described, and construction details are given. The Z-Modulation option, which can only be used with the Scope Display option, uses the Z-Modulation input of the oscilloscope to brighten up the word at which the analyser was triggered. The word is intensified whenever and where-ever it is displayed on the screen. The Internal Clock (or Asynchronous Clock) option works independently of the other options, and allows asynchronous operation of the analyser at three selectable sample frequencies. The selected frequency is also available at the CLOCK OUT socket (SK7) to drive the unit under test.

Z-MODULATION OPTION

Refer to Fig. 4.1. IC301 is an 8-bit latch, and IC302 is a 4-bit latch, only two of which are being used. TRIG LATCH, which is generated when the analyser is triggered (see main circuit description, Part 1), latches the address present on the address bus into IC301 and IC302. This address is the address in the memory, where the data word at the input to the analyser when the analyser was triggered, is stored. The latched address at the outputs of IC301 and IC302, are connected to the B set of inputs of the three 4-bit magnitude comparators, IC's 303, 304 and 305. The corresponding A inputs of the comparators are also connected to the address bus. Now when the scope option scans a section of the memory (see Part 3) that, for example, includes the address in which the "trigger word" was stored, the comparator IC305 produces a pulse on the A = B output every time that address appears on the address bus. (The reason being, that address is obviously equal to the address originally held in the latches.)

"Trigger word" is in quotes to indicate that the word intensified by the option is not necessarily the word that triggered the analyser via the word recogniser. It could also be the word that was at the input of the analyser when the unit was triggered via the EXT or MANUAL triggers, if either of those trigger modes were selected.

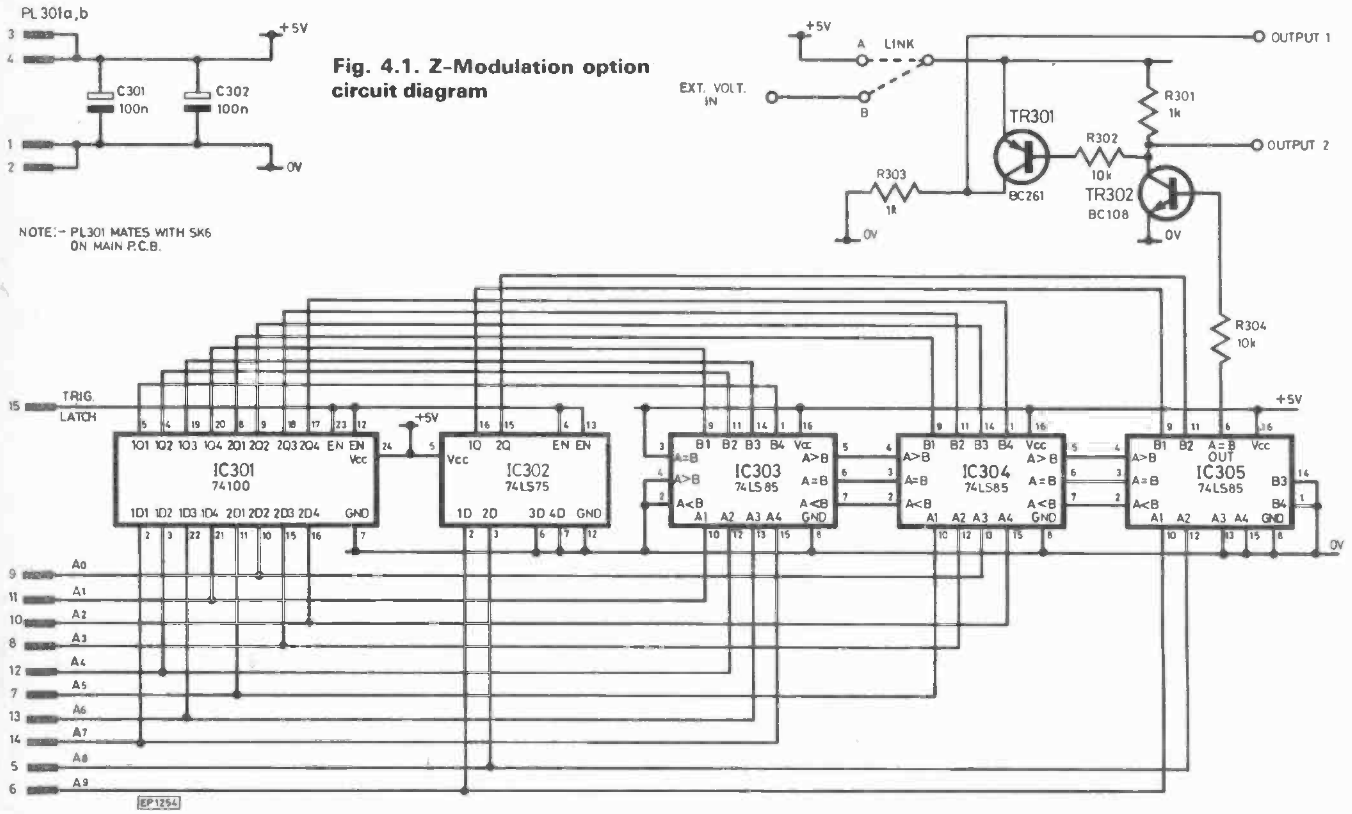
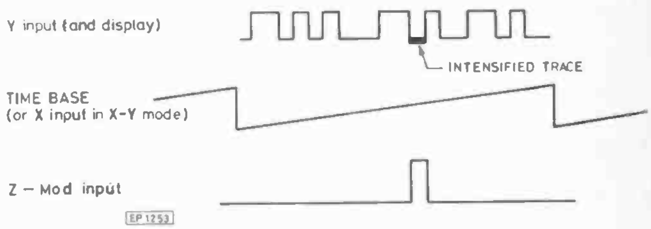
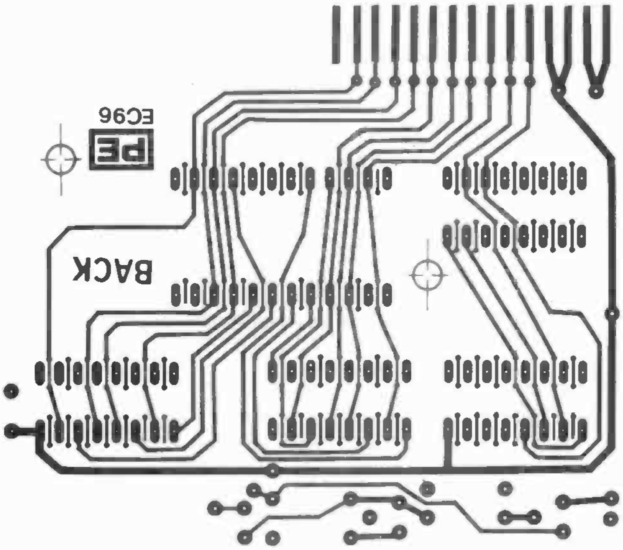


Fig. 4.1. Z-Modulation option circuit diagram

The output at pin 6 of IC305 pulses high as described above, causing TR302 to pulse on, and OUTPUT 2 goes low for the duration of the pulse. TR302 switches TR301 on, and it in turn causes OUTPUT 1 to pulse high. Thus two pulses are provided as outputs, one positive going and the other negative going. Consult your oscilloscope manual to see which should be used—the pulse direction that causes the scope trace to intensify should be selected. The Z-Mod input to an oscilloscope is usually at the rear of the instrument. The author's Advance-Gould oscilloscope uses OUTPUT 1, the positive going pulse. An input to the Z-Mod connection on an oscilloscope causes the trace to intensify (or dim) at the point on the trace which was drawn at the instant the Z-Mod input was applied. See Fig. 4.2 for a graphic example. The last bit of circuitry to be described concerns the LINK. Some oscilloscopes require larger amplitude pulses than others to produce an acceptable level of intensification. 5V was more than adequate for the author's oscilloscope, and therefore the link was connected to point A. Should 5V be

Fig. 4.2. "Bright-up" timing diagram





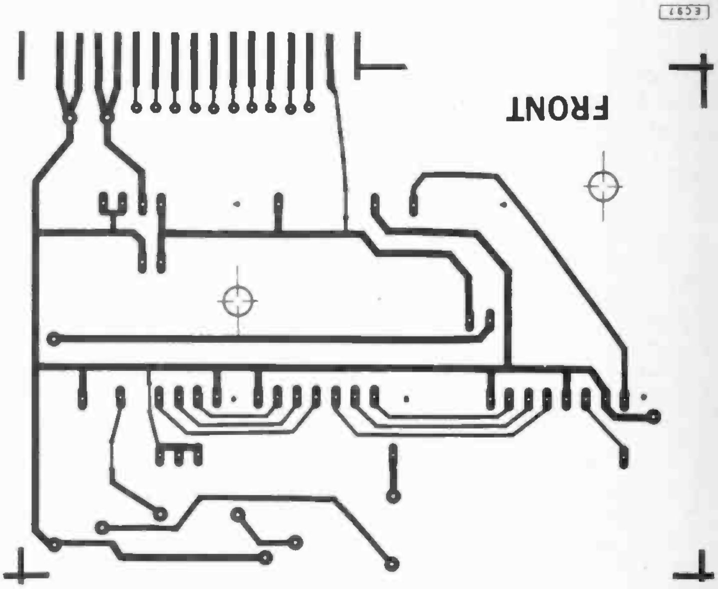
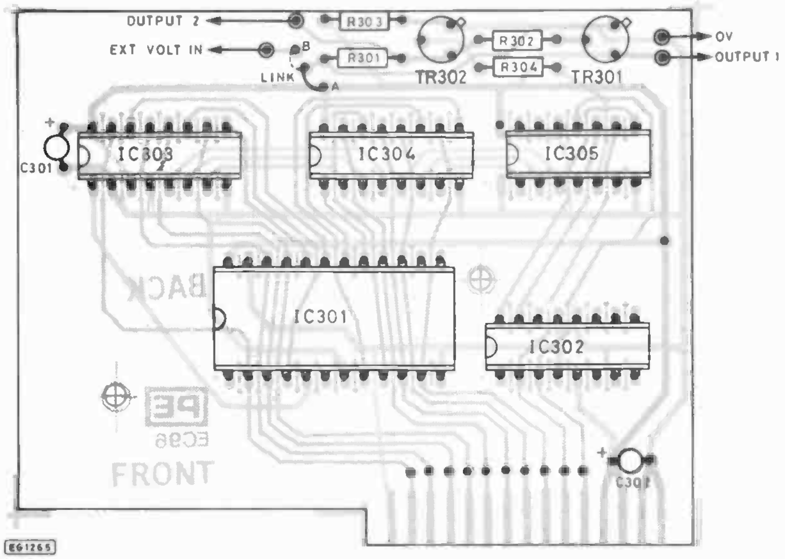


Fig. 4.3 (above). Z-Mod option p.c.b. layout (track-side)

Fig. 4.4 (above right). Z-Mod option p.c.b. layout (component-side)

Fig. 4.5 (below). Z-Mod option component layout (actual size)



COMPONENTS . . .

MODULATION OPTION

Integrated Circuits

IC301	74100
IC302	74LS75
IC303, 304, 305	74LS85 (3 off)

Transistors

TR301	BC108
TR302	BC261

Resistors

R301, 303	1k (2 off)
R302, 304	10k (2 off)
All $\frac{1}{4}$W 5%	

Capacitors

C301, 302	100n 16V Tant. (2 off)

Miscellaneous

Soldercon i.c. socket strips as for main unit.
Female chassis mount BNC connector

not sufficient, however, any external voltage (perhaps 12V from the analyser 12V line) can be applied to EXT VOLT IN, and the link soldered to point B.

CONSTRUCTION

Construction follows the procedures given previously for the other p.c.b.s already described. Veropins can be used for the outputs and EXT VOLT IN. Make sure all the required holes have been connected through, in the manner already described.

The through connections at the p.c.b. fingers are included to ensure connection to either the a or b side of SK6. The author experienced a bad solder joint on the side of SK6 nearest ICS18 and 19 and could not rectify it once the unit had been completed (the soldering iron wouldn't fit!). The other side of SK6 is easier to get to, and hence the through hole connections.

TESTING AND USE

Once the p.c.b. has been thoroughly checked, it can be fitted in SK6, and the correct output connected (temporarily) direct to the oscilloscope Z-Mod input. Switch on the analyser, trigger it, and store some data. When the analyser is finished and converts to the display mode, the left-most word displayed on the oscilloscope screen should be intensified (as described in earlier parts, this word is of course the word at which the analyser was triggered). Moving the UP/DOWN switch should cause the intensified word to either move off the screen (to the left) or across the screen (to the right). It is worthwhile scanning through the whole memory (it will take some time, but be patient!) to check that only one word is intensified. More than one intensified word points to one of the address lines on the p.c.b. being open circuit (or may be held high or low). When the p.c.b. has been proven operational, mount a BNC connector on the rear panel, and connect the selected output to it (an earth point is provided on the p.c.b.—see overlay, Fig. 4.5). In use, connect the oscilloscope Z-Mod input to this connector.

INTERNAL CLOCK OPTION

Refer to Fig. 4.6. IC401 is a crystal controlled oscillator i.c. designed for operation up to 20MHz and with a high fan-out capability. In this application, a 5MHz crystal is used. The i.c. application data recommends a crystal with low motional capacitance (less than 5mp) and a capacitance of 10p to achieve high stability. The author has used a standard

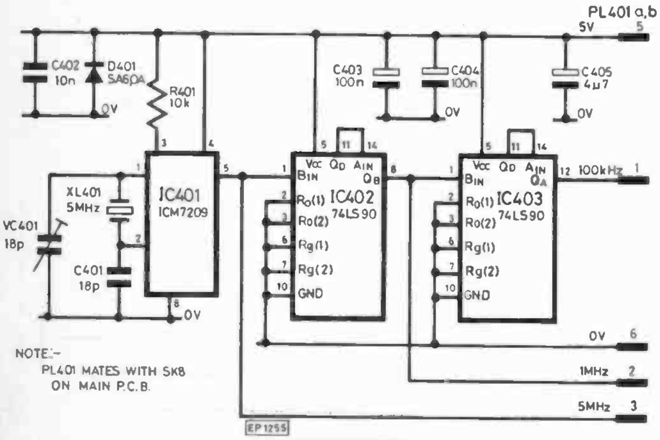


Fig. 4.6. Internal Clock option circuit diagram

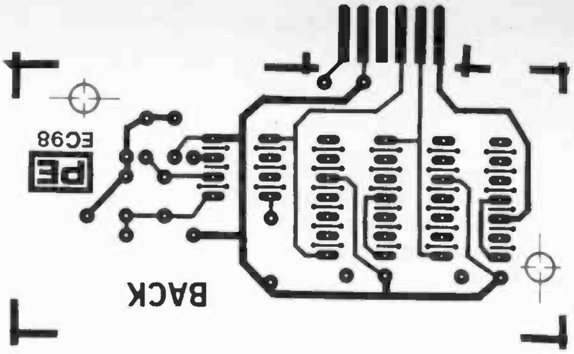


Fig. 4.7. Clock option p.c.b. layout (track-side)

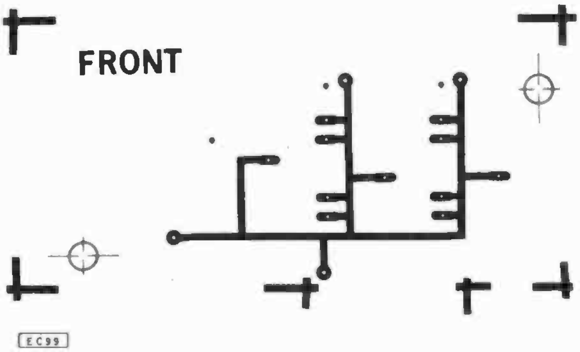


Fig. 4.8. Clock option p.c.b. layout (component-side)

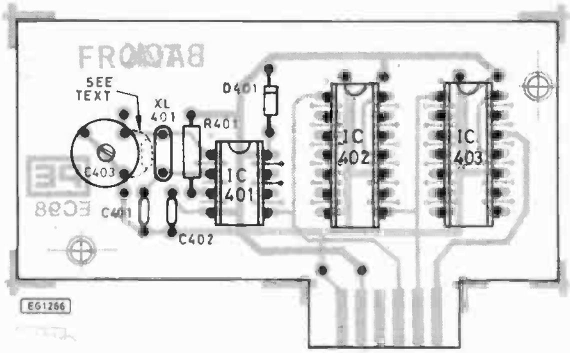


Fig. 4.9. Clock option component layout (actual size)

30p capacitance crystal (which is cheaper) with no detectable effect on the analysers operation. VC401 can be used to trim the frequency to exactly 5MHz, but if such high accuracy is not required, an 18p ceramic capacitor can be fitted instead (holes are provided on the p.c.b. for this purpose). As is required with all oscillator circuits, the supply rails are decoupled by C402. D401 is a tranzorb, which is required to prevent transient spikes on the supply rails causing the i.c. output to latch up, and consequently damage the i.c. The 5MHz output is taken to the p.c.b. edge connector, and to IC402's B input. IC402 is connected as a bi-quinary counter, and a divide-by-five output (1MHz) is available at its QB output. IC403 is connected in a similar manner, however, a divide-by-ten output (100kHz) is taken from its QA output. C403, 404 and 405 complete the power rail decoupling. It may be agreed that a simple oscillator constructed from NAND gates would be cheaper, and would work just as well.

However, there are further options under consideration, and if these materialise, they would require an accurate, stable clock. Hence it was decided to include a better class clock from the beginning.

CONSTRUCTION AND TESTING

Once again, construction follows the same pattern as for the other p.c.b.s. Fig. 4.9 gives the component layout. When construction has been completed and checked, apply 5V to the card. Using a DFM or an oscilloscope, check that the correct frequency is available at the respective p.c.b. edge connector fingers. If VC401 has been fitted, adjust it for exactly 5MHz at IC401 pin 5. If all is well, plug the p.c.b. into the mother board, and switch the analyser on. Again, check with a DFM or oscilloscope that the frequency selected by S14 is available at SK7 output, for all the positions of S14.

NEXT MONTH: This final part describes the CMOS compatible input option.

NOTE: A hex dump of the contents of IC10 and IC11 of the Analyser's Display board may be obtained from *PE* (Poole office) by sending a SAE.

COMPONENTS . . .

ASYNCHRONOUS CLOCK OPTION

Integrated Circuits	
IC401	ICM7209
IC402, 403	74LS90 (2 off)
Resistors	
R401	10k 5% $\frac{1}{4}$W
Capacitors	
C401	18p Ceramic
C402	100n Ceramic
C403, 404	100n 16V Tant. (2 off)
C405	4µ7 16V Tant.
VC401	18p miniature trim cap
Miscellaneous	
Soldercon i.c. socket strip as for main unit	
D401	SA6.0A (GE)
XTAL 401	5MHz*
*See text	

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PE BAZAAR NOVEMBER '83

Space Watch...

DISCOVERY

The Science and Engineering Research Council (SERC) has been in the news again with the exploits of IRAS (Infrared Astronomical Satellite)—its most recent discovery being a 'shell' around the bright star Vega. The astronomical name for this star is Alpha Lyra. It is a very bright star and has often been used as a steering marker for spacecraft since it is considerably brighter than the Sun. The class of star to which it belongs is that of AO, its magnitude 0·04, it is a blue star and is some 26·5 light years from Earth.

The actual discovery was made by Dr. Hartmut C. Aumann and Dr. Fred. Gillett of the Kitt Peak National Observatory. They were studying Vega as a means of calibrating the telescope and discovered that it appeared much larger and brighter than expected. They soon determined that the region which was so much larger in infrared was coming from an extended region around the star. This seemed to extend for about 80 AU (astronomical units). This is about 7,400 million miles. The temperature of the material appeared to be around 88° Kelvin. This is about equal to that of the Pluto complex. From theoretical considerations it was clear that the material was much larger in its size than would be if it were dust grains that had been left over at Vega's formation.

SPACE TECHNOLOGY

Once again the expanding technology of space has brought immediate rewards. However there is of necessity a word of warning to be given. Because of this recent discovery it is almost certain that there will follow a spate of claims of a knowledgeable populated system with the flying saucer know-how etc. To forestall any such red herring treatment of the subject perhaps it would be of some use to go over the principles of the telescope.

The infrared telescope relies on temperature not visible light. It measures the departure of bodies from a certain temperature source. These changes are recorded and an examination made of the results. The results that led to the discovery of events around Alpha Lyra are infrared results and are consistent with a body or bodies surrounding that star. It must be appreciated that this star because of its brightness has always been of interest to astronomers. What has now emerged is a new dimension to enable the star to be better understood. It is another bonus to the team who are controlling the satellite from Chilton in Oxfordshire. The team is led by Dr. Eric Dunford.

MORE INFRARED FINDS

The satellite also discovered a 20 million mile long tail on Comet Tempel 2. No tail had ever been seen before this. It was discovered by John Davies of the University of Leicester, who has since April discovered 4 such bodies.

Tempel 2 is one of a number of well known comets. Its orbit round the Sun has a relatively short period coming inside the orbit of Mars every 5·28 years. The nucleus of this comet is probably only a mile or so in diameter. From early September till mid-October it will be about 100 million miles from earth. It will then go back to the outer regions of space. The discovery of the extraordinary elongated tail is exciting because most comets of short period (less than 15 years) have lost their tails because at each passage round the Sun some of the material is lost. Some observers now feel that such tails might still be detected by infrared light.

X-RAY DISCOVERY

The X-Ray Satellite EXOSAT was launched on the 26th of May last. It passed its commissioning period successfully and started actively to carry out its task. When this began at the end of June it discovered that its sensitivity was much greater than had been expected. It was built by Marconi Space and Defence Systems in Portsmouth who provided three-axis pointing control to 1-2 seconds of arc. This was better than specified. The first task of EXOSAT was the observation of a source which might be a 'Black Hole'. After obtaining the most up-to-date information on Gygnus X-1 the telescopes were focused on a young supernova remnant, Cassiopeia A. Images from the low energy telescopes show an intense ball of hot gas, expanding from the site of the initial explosion, which occurred around AD 1634. The proportional counters show clear features that are characteristic of the heavy elements of iron, sulphur, silicon and the magnesium group. This supports the view that it is in such massive explosions that all elements other than priordial hydrogen and helium are present.

The array of gasfilled proportional counters were designed and developed by Leicester University in collaboration with the Max Plank Institute. The gas scintillation counter which was being flown in a satellite for the first time was designed and developed by ESA (European Space Agency) Science Department with support from the MSSL and university groups from Milan and Palermo.

EXOSAT has a highly elliptical orbit, 340–192,000 km. It is operated from the ESA Operations Centre in Darmstadt, West Germany. It is expected that the EXOSAT will operate for about four years.

MARS ORBITER

There has been considerable disappointment about discarding the satellite visit to the planet Mars during the past few years. It seems now that such a mission may well be planned during the next few years. Indeed it has been put down for the budget of 1985. If it should succeed it is to be hoped that a flight could be possible in August 1990. This would arrive over Mars in August 1991. Some considerable detail has already gone into the proposals which seem to have been favourably received.

The approach most likely to be adopted would involve an orbiter/observer according to the space studies which have been carried out. It seems that A.V. Diaz who is in charge as deputy director of Solar Exploration at NASA would agree "Our belief is that, other than some generic changes like a deep-space transponder, there are no changes to be made. We have been looking at the technical and management interface between the contractors and JPL in an attempt to optimise efficiency. We want to let the contractors do what they do best in the production line mode and JPL do what it does best in terms of mission science."

PRIMARY PAYLOAD

The essential instruments at present are considered to be—

A gamma ray spectrometer: Experience on Apollo-17 recommends this, it would be used for surface composition studies.

An infrared reflectance spectrometer: This would be used to provide a mineralogical map and would also map on a seasonal basis the water vapour and carbon dioxide in the atmosphere and on the surface.

A radar altimeter: Earlier planetary experience was gained on the Pioneer Venus mission.

An atmospheric sounder: Martian atmospheric temperature and pressure, dust and water vapour profiles can be obtained using this technique. Experience has been gained with both Pioneer and Mariner.

An ultraviolet spectrometer/photometer: To measure ozone in the Martian atmosphere.

It is hoped that with the previous experience and well tried 'kit' the maximum benefit should be gained at minimum cost.

USA AND EUROPE

The USA has told the European Space Agency that if they want to fly a co-operative mission to Saturn they must decide by the Autumn. If they do not then America will drop participation and go on with Mariner Mk2 mission. They claim they must do this to avoid any interference that might arise. The Mariner Mk2 is a mission to Comet Honda Mrkos-Pajdusakova.

This is not the first time that the European Agency has been confronted with what amounts to a fait accompli. The sooner that this situation is resolved the better. At the moment American science prestige seems to be paramount. How much will they risk to be first?

Frank W. Hyde

SEMICONDUCTOR CIRCUITS

TOM GASKELL B.A.(Hons)

TOUCH SWITCH (MM 58312N)

THE concept of replacing conventional electromechanical switches with purely electronic 'touch' switches is an attractive one in many applications. However, this type of switch can provide many pitfalls for the unwary designer. The most usual areas of difficulty are:

(a) Susceptibility to radio frequency interference (RFI), or mains borne interference, which can cause false operation of the switching circuitry and

(b) Difficulty in adapting to different environmental conditions. Stray capacitance on the touch sensor input, long connecting leads between sensor and circuit, and varying levels of mains or RF electric fields in the vicinity of the sensor or circuitry can all cause incorrect operation of the switch.

The MM 58312N is a CMOS i.c. specifically designed as a touch activated switching device. It has a latching action, and is capable of switching loads via a suitable external semiconductor power device. Normally, it is designed to operate as a mains switch, using an external triac to control the load, although it can be used as a d.c. switch if required.

SPECIAL FEATURES

The i.c. has a number of features which make it ideal for this sort of application. An automatic gain control (AGC) circuit is provided on the touch control input, which automatically compensates for different lengths of lead between the touch wire (or plate) and the circuitry. A 'valid touch' is detected when three consecutive voltage pulses, measured with respect to the i.c.'s negative supply rail, are detected within a short fixed time interval. These pulses must be of a higher positive peak amplitude than the steady state ambient level. This AGC circuitry allows input leads of any length up to 20 metres to be used, with as many touch plates as required mounted along this lead. A mains detector input is used to sense any sudden transients, or spikes, on the mains, and this prevents erroneous operation if these occur by inhibiting any change in switch state for their duration. The mains detector input has the same type of AGC control as the touch input to the device. Zero current sensing circuitry ensures that switching of the external triac only occurs at the point of zero load current, resulting in a minimisation of the generation of radio frequency interference. Finally, an internal timer is provided to optionally turn the switch off after 123 seconds.

The pinout and specifications for the MM 58312N are given in Fig. 1, and apply to the circuit configuration shown in Fig. 3. All parameters are referenced to the negative supply to the i.c., which is connected to mains live in this case, so the utmost care should be taken if any measurements are to be made.

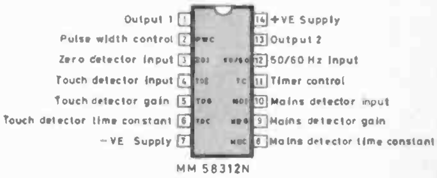


Fig. 1. Pin-out and specifications

Characteristic	Notes	Min.	Typically	Max.	Units
Supply voltage	All specs measured at +8V d.c.	7	8	10	V
Quiescent current	Pins 2,4,10,11,12 at −ve supply		50	200	μA
Temp range		−40		+85	°C
Input voltage for logic 0	Pin 2 Pin 11 Pin 12 Pin 3 via 1M resistor			2 0·3 1 −1	V V V V
Input voltage for logic 1	Pin 2 Pin 11 Pin 12 Pin 3 via 1M resistor	6 7·7 7		+1	V V V V
Input currents	Pin 3, held at 0V Pins 4 & 10, held at 4V Pins 11 & 12, held at 4V	−2 60 −1		−10 114 +1	μA μA μA
Output currents	Pin 2, sink current at 4V Pins 6 & 8, sink current at 2V Pins 6 & 8, source current at 6V	0·75 0·5 −5		1·35 1·5 −15	mA μA μA
Output currents, pins 1 & 13 (triac drive)	Outputs on Outputs off (held at 0V)	20		30 −50	mA μA

OPERATION

Fig. 2 shows the block diagram of the internal circuitry of the i.c., which can be considered in conjunction with the circuit diagram in Fig. 3. The touch input circuitry and mains input circuitry are identical, with only the external components used differing to suit their different purposes. R2 and R3 determine the gains of the circuits, while the time constants of the AGC circuits are determined by C12 and C13. Pin 3, the zero detector input, is used to detect when the current through the load is zero, and hence synchronise the switching of the triac to this point for minimum generation of RFI (and minimum loading of the triac). The timing of the pulse to be fed to the triac is determined by the values of the resistor and capacitor connected to pin 2: R4 and C5. The 50/60Hz input to the i.c. is used to provide strobe pulses to the logic control unit, which determine the time periods during which the touch input and mains input circuits look for input pulses. The 50/60Hz input is also used to clock the internal counter if

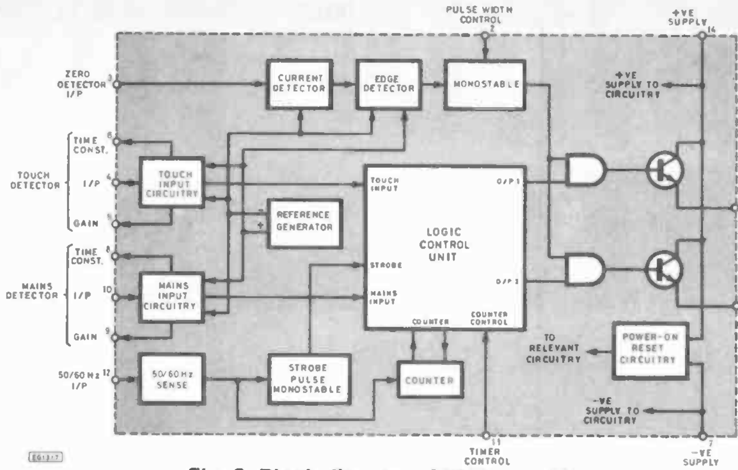


Fig. 2. Block diagram of MM 58312N

the 'two minute' timer facility is to be used. (Because this delay period is frequency dependent, it will be only 103 seconds if 60Hz mains is used). The timer is enabled by connecting pin 11 to the positive supply while using output 2 (pin 13) of the i.c. to trigger the triac, and is disabled by connecting pin 11 to the negative supply, and using output 1 (pin 1) of the i.c. to trigger the triac.

APPLICATIONS CIRCUIT

The circuit of Fig. 3 is a typical application of the MM 58312N. The positive supply for the i.c. is derived from the neutral mains input, using C1, R1, and the Zener diode D1 to drop the full 250V a.c. down to 8·2V peak. This half wave rectified signal then charges up C3 via D2, providing a d.c. supply of 7·5V approximately. The mains detector input is fed via R5 and R6, with C6 decoupling, and C7 attenuating, the signal. (Some filtration is provided by these components, too). For the 50/60Hz input, R7, R8, and C8 provide attenuation and filtering, and for the touch input a similar configuration is used, with the addition of R11 to prevent charge build-up. In all these cases, pairs of resistors have been used in series, to provide protection in case one resistor was to become short circuited. D3 and D4 are high voltage rated 3A diodes which provide a well-defined voltage drop to allow the zero detection circuitry to work effectively, when fed via R12. Finally, R14 and C14 form a 'snubber' network which helps to protect CSR1 from transients, and C2 acts similarly for the whole circuitry.

CONSTRUCTION NOTES

This section is very important. **Mains circuitry of this type is potentially lethal.** All the circuitry 'floats' at the mains live voltage, so touching any part of it (other than the input to R9) would give you a serious electric shock. The touch input is only safe because of the extremely high value resistors R9 and R10. These should be high quality (metal oxide if possible, or a good make of carbon film) half-watt types. They should be spaced well apart from the rest of the circuitry, and all the Veroboard trackwork around them should be removed; see Fig. 5. Under no circumstances should any other connections or wires be allowed to approach these two resistors or the touch input itself. Generally, be very careful to use the correct component values. (3M3 is coded orange-orange-green, then gold, silver or red). Wire up the board carefully, and ensure that all the holes shown cut away in the trackwork in Fig. 5 are cut properly. Use a 2A or 3A fast blow fuse, and mount the board in a *fully earthed* metal box, or in a plastic box with plastic fixings. C6, C7, C8, C9, C10 and C11 should be 100V rated ceramic types (either 100V monolithic or 100V plate). C1, C2 and C14 should be 250V a.c. types, specifically described as suitable for connection across the mains. The triac must be a high voltage type, but must only draw very low gate currents; the specified types BT139 or 2N6073 meet this requirement.

For the touch plate, any piece of metal can be used, a piece of p.c.b. material, or any conductor. Maplin Electronic Supplies sell very smart 'touch pads' with built in fixing screw threads. The unit can be tested, very carefully, using a domestic light bulb as the load. If it 'flickers' when turned on, then adjusting R4 (try the range 33k to 680k) or R13 (from 150 ohms to 330 ohms) will often help. (Adjusting R4 may affect the amount of RFI generated, too). The touch switch sensitivity can be adjusted by altering the value of R2.

Bear in mind that the circuit adapts to the incoming signal on the touch input; if you hold your finger on it for several seconds it will adjust itself to recognise this as a normal ambient level; releasing it and touching it again quickly will have no effect! The AGC loop will first have to re-adjust to the original background level; the speed at which it does this can be adjusted by altering the value of tantalum capacitor C12. The circuit is designed to switch up to 3A (720 watts); if higher currents than this are required, then D3 and D4 must be changed to higher current types (ensure that the diodes chosen are 600 p.i.v. types, or higher if possible). Also check that triac CSR1 is capable of taking the extra current required. At this point it becomes a dubious idea to use Veroboard, due to the large currents that will be flowing along the tracks, so a p.c.b. should be made up in preference.

Finally, for something a little different, try the circuit of Fig. 4. It's much safer, being powered from a conventional 9V supply. The latching is not very effective any more, but a useful effect can be obtained by connecting pin 11 to +9V (i.e. 'timer on'). Because the CMOS oscillator fed to pin 12 of the MM

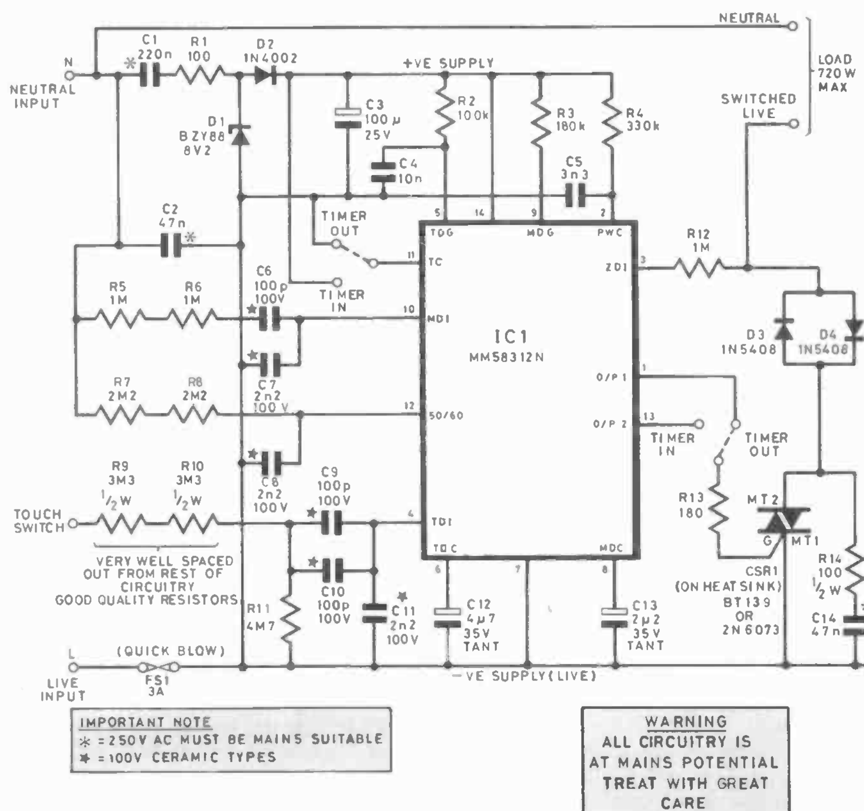


Fig. 3. Circuit diagram of mains touch switch

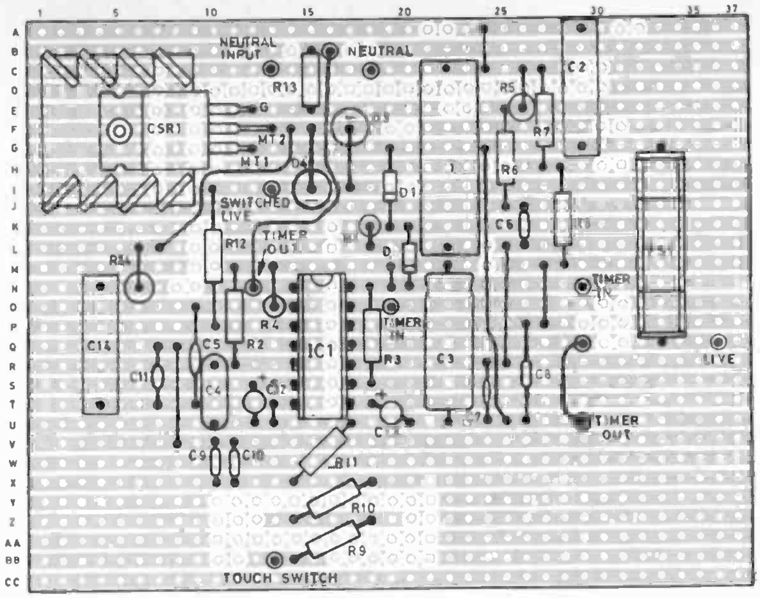


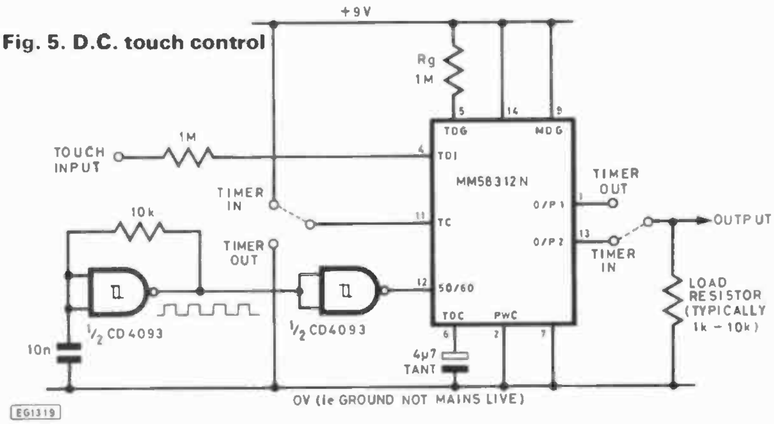
Fig. 4. Veroboard assembly of touch switch

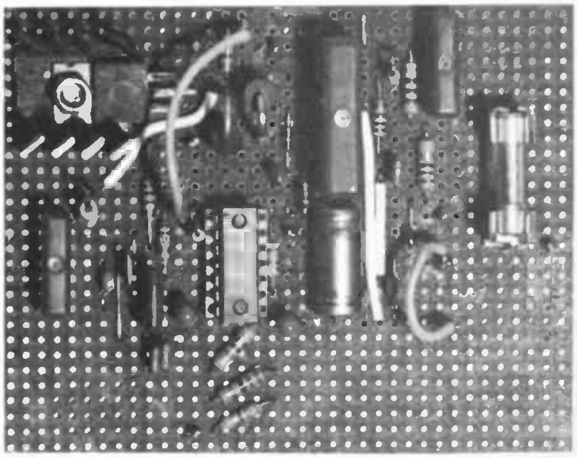
58312N is running at a very high frequency (many kHz) the timer's duration is now very short, around one second. If pin 13 is used as the output, the result is a one second pulse produced when the touch input is touched. If pin 1 is used as the output, then one short pulse is generated when the touch plate is touched, and a second one is generated when the plate is released. The sensitivity is very high; it can be varied by altering the value of Rg.

The MM 58312N is a very versatile and interesting solid state touch switch i.c. which shows great tolerance of those problems which can affect the operation of many other electronic switches. Great care must be taken with the design and construction of the circuitry, however; mains should always be treated with caution and respect.

Suitable triacs are available from Ambit, Maplin or Cricklewood Electronics. The MM 58312N is available from Ace Mailtronix Ltd., 3a Commercial St., Batley, West Yorks WF17 5HJ, price £5 including VAT, postage and packing.

Fig. 5. D.C. touch control





BAZAAR

WANTED several Goodmans 12 inch loudspeakers chassis types 201/301. Disposal few very old valves free. E. Bardwell-Jones, 15 Deer Park, Saltash, Cornwall. Tel: Saltash 2144.

MURPHY CB base station. Model CBH 1500 brand new unused, unwanted prize £50. Phone West Drayton (0895) 447888.

COMMODORE PR100 program. calculator PIS. Book, £9.00 Casio for FX31 scientific £7.00. Holdway No. 20 Studland Close, Millbrook, Southampton, Hants.

WANTED copy of Mullard book Circuits for Audio Amplifiers reasonable price paid. Phone after 6p.m. Mr. T. Bateman, 22 Nelson Rd, Rayleigh, Essex SS6 8HB. Phone Rayleigh (0268) 775113.

FREE diodes coded, and resistor colour code charts. Yours for the asking + s.a.e. Dave, 29 St. John's Close, Leatherhead, Surrey.

COMPUTER Sharp MZ-80K (48k) excellent condition with £100 worth software including Forth, games, documentation £295 o.n.o. Neil Chilton, 175 Warwick Ave, Littleover, Derby. Tel: (0332) 760773.

I HAVE a list of PWs, PEs, Televisions, EEs, The Radio Constructor. Please send s.a.e. for list. R. H. K. Grayson, 34 Victoria Road, Haywards Heath, West Sussex RH16 3LY.

PHILIPS TX portable t.v., N1500 v.c.r. chassis, both almost complete no sensibe offer refused. Mr. A. Bouskill, 129 Lyminster Road, Sheffield. S. Yorks S6 1HY. Tel: 0742 311191 after 4.30p.m.

TELETYPE, RS232 interface, tape reader and punch, stand, box of paper, 3 spare ribbons £100 o.n.o. Martin Ward, 9 St. Andrews Ave, Crewe, Cheshire CW2 6JJ. Tel: 0270 256165.

WANTED to purchase or borrow service sheet or circuit diagram for Trophy CR100 cass. recorder. E. G. Everett, 4 Deben Drive, Sudbury, Suffolk CO10 6QH.

PHILIPS N1500 v.c.r. for spares with video head plus all electronics cheap to clear. Mr. A. Bouskill, 129 Lyminster Rd, Sheffield S6 1HY. Tel: 0742 311191 after 4.30p.m.

ELECTRONIC dwell angle (points) adjuster for spot on ignition, new with instructions and connections £3.95. D. J. Head, 113 Raleigh Crescent, Stevenage. Tel: 0438 62179.

JAYKIT FG-1a sine-square-triangle-TTL function generator. 1Hz to 100kHz. 0-10V £25. Call Chang 041 332 7695 after 9p.m. K. Y. Chang, 70, 1-up Ashley St., Glasgow G3 6HW.

8 INCH UK101 disc drive with p.s.u., controller, operating software and discs. Plugs straight in J1 £220. Mr. D. Fellows, 26 Westbourne Ave., Emsworth, Hants PO10 7QU. Tel: Emsworth 5548.

FOR SALE National PE-145 electronic flash £8 + 50p p&p write to: Paul Januarius, 28 Blagrove Lane, Wokingham, Berkshire.

WANTED 4 or 5 octave keyboard with or without 1 pole 2 way contacts (Type "GJ"). Mr. M. D. Rudnicki, 32 King's Drive, Pagham, Bognor Regis, W. Sussex PO21 4PZ.

WANTED ZX81 (working at least). Synthesiser — two v.c.o., e.d.p. Wasp (factory made) £150 o.n.o. P. S. Wady, 85 Mentore Ave., Liverpool 18 L18 3HP. Tel: 051 722 3361.

CHIPS 8202A — £10, 8253/8275 — £3. ZBOAS/10/0 — £7. 2716 (5V) — £1.50. 4116 16 — £7. J. Walker, 7 Warwick Place, Peterlee, Co. Durham. Tel: 868255 after 7p.m.

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PHILIPS G7000 video game with 4600D cassettes £75. For further details please telephone Adam Paylor (0924) 472532 Batley, Yorkshire.

DISK drives pair $5\frac{1}{4}$ inch double sided, double density cased with p.s.u. and data suit BBC offer. D. W. Jowett, 197 Victoria Road East, Thornton, Blackpool FY5 3ST. Tel: (0253) 869108.

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ACORN Atom 12k + 12k V.I.A., F.P. £140 o.n.o. ASC11 keyboard as new £20. Elekterminal £20. G. Watson, 19 Kelvin Rd., Clydach, Swansea, West Glam SA6 5JP. Tel: 0792 843948.

INTRODUCTION TO DIGITAL ELECTRONICS

MICHAEL TOOLEY BA   DAVID WHITFIELD MA MSc CEng MIEE

O & A Level   Part Two

GATE circuits are often used in analogue electronics to pass or stop signals, depending on the presence or absence of a command (or 'gate') signal. An analogue gate has an effect which is similar to that of a set of traffic lights; whenever there is a red light, the traffic stops, while on green the traffic is able to flow freely. We can, therefore, think of the flow of traffic as a type of analogue signal, and which may be gated (and therefore controlled) by the presence or absence of the green command signal. There is a similar concept of gates to be found in digital electronics. Indeed, the use of gates (which are often referred to as 'logic gates') is fundamental to the design of digital circuits, and we shall return frequently to this point throughout this series.

The inputs to a digital gate are always assumed to be in the form of digital signals. As we saw last month, therefore, these inputs will always represent either a 0 or a 1. Similarly, the output of the gate will always be a 0 or a 1. The output from a gate will in turn be completely determined by two factors: the type of gate involved, and by the combination of inputs present. In a digital gate, in contrast to an analogue gate, both command signals and information signals are purely digital; the exact significance of each signal is decided by the circuit designer.

We can now see that there are two quite distinct aspects of digital gates which have to be considered when designing digital circuits. Firstly, we must know what it is that each signal is being used to represent, i.e. what does it mean when a particular line is a 0 or a 1. Secondly, we need to know how a particular gate will combine its inputs to produce the output signal, e.g. what happens when all of the inputs are a 1? Only then is it possible to predict the output produced by a logic gate, and to interpret its significance.

In order to illustrate some of these seemingly abstract ideas, it is really necessary to consider a practical example. Fig. 2.1 shows the use of a single gate (shown in symbolic form) in an

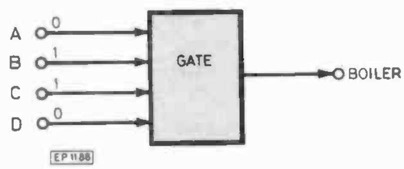


Fig. 2.1. Central heating boiler control logic

application where its output is being used to switch a central heating boiler off/on. The four inputs to the gate are as follows:

- A = 1 when the temperature is below 18°C
- B = 1 when the time is between 8 a.m. and 6 p.m.
- C = 1 when the pilot light is lit
- D = 1 when the gas supply is on

Let us assume that the logic gate in the circuit is of a type which has an output of 1 only when all of its inputs are 1. Then, if we are using a boiler which turns on when a 1 is applied, and off for a 0, we have the basis of a circuit which could be used to keep the temperature in (say) a shop above 18°C during opening hours. As we mentioned earlier, however, this circuit depends very much on the meaning of the signals coming into the gate, the way in which they are combined, and the significance attached to the gate's output. What, for example, would we expect to happen if the same circuit was used, say, with a boiler turned on with a 0, instead of a 1?

SWITCH LOGIC

Before we move on to consider some real digital logic gates, let us first look at some other ways of representing the actions of logic gates which can be useful in illustrating how digital gates work. By now we expect that most logic gates that we meet will be semiconductor circuits, but it is worth noting that many of the gate functions can just as easily be built using switches or relays. In these situations, the significant point to note is that these switches are simple two-state components which are either off or on. In such cases it is usual to consider 'off' as 0, and 'on' as 1.

If we look again at the circuit arrangement in Fig. 2.1, we can quickly see that we could probably replace A, B, C and D by switches, e.g. A could be a thermostat (temperature-sensitive switch), B could be a time switch, etc. In this case the circuit shown in Fig. 2.2 would seem to work in exactly the same way as the one described in Fig. 2.1 using the logic gate. The information (the 1 signal) will still not get through unless all four switches (A to D) are on, and only then will the boiler

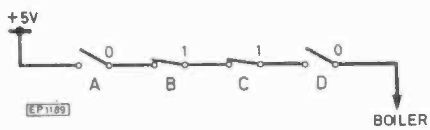


Fig. 2.2. Switch logic for boiler control

be switched on by the 1 signal.

In practice, switch logic is often still used in situations where mechanical sensors (usually in the form of switches) are already being used to provide information. Other reasons for the use of switch logic include applications where the amount of power to be controlled is more than can conveniently be handled by standard logic circuits. In other cases it is still simpler and cheaper to use switch logic rather than digital logic circuits. In many cases switch logic is used as an addition to digital logic in order to provide a 'fail-safe' back-up. In all cases, however, the logic principles remain the same. The reason for introducing the analogy is that, at first sight, the operation of switch logic circuits can be easier to understand than the equivalent digital gates, but very quickly this situation tends to reverse!

LOGICAL COMBINATIONS

So far, we have looked at the idea of combining digital signals, using logic gates, to produce 'new' signals. The next step is to look at the different types of gate that we can use for this purpose. Our overall aim is to see if we can predict the output from a digital circuit by looking at its inputs, and the way in which the various gates are interconnected.

In the first part of the series we looked at the simplest of all logic elements: buffers and inverters. Although these 'gates' have only one input and one output, and as such do not allow signals to be combined, they are still nevertheless referred to as gates. The majority of logic gates, however, deal with two or more input signals, and we will start by considering two of the most important types of gate, the AND gate and the OR gate. From a clear understanding of the operation of these two gates, and of the inverter, it is actually possible to explain the operation of even the most sophisticated logic element. Something as complex as a microprocessor, however, may well require many thousands of such gates in the explanation, but the basic idea still remains true.

In the explanations of the AND and OR gate which follow, we will initially consider only gates which have two inputs. In practice, however, TTL gates are available which have up to thirteen inputs. The basic principles of these multi-input gates follow logically from the operation of the basic two-input gates, and so for the moment we will confine our discussions to the basic gate of each type. Future parts of the series will deal with examples of gates with many inputs.

Before we look in detail at the operation of AND and OR gates, however, it is appropriate at this point to first look at the various ways of representing logic gates in circuit diagrams.

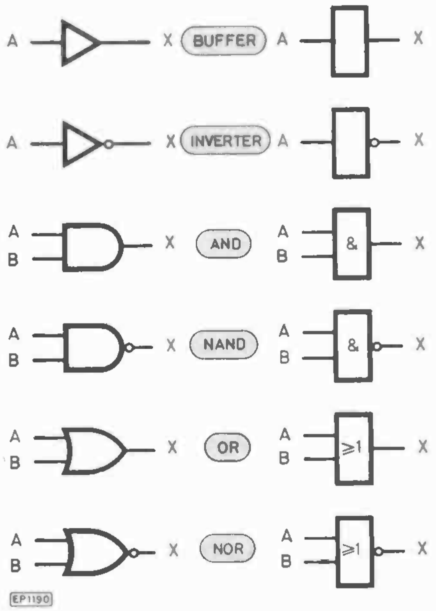


Fig. 2.3. MIL and BS logic symbols

LOGIC SYMBOLS

When drawing logic gates, there are a number of different sets of logic symbols in common use. The two most frequently encountered sets of symbols are the British Standard (BS) symbols, and the International (MIL) symbols. The BS symbols are commonly used in the UK, particularly in examinations; they are not, however, used by the i.c. manufacturers or the majority of international users of digital i.c.s. For this reason, it is necessary to be able to recognise both sets of symbols.

The BS symbols all consist of the same rectangular shape, and the differences between them are indicated by the symbols shown inside the boxes. The MIL symbols use different shapes for the different gate types, and the function of the gate can therefore be identified more readily. In this series we have introduced both sets of symbols for each type of gate, but hereafter only the MIL symbols will be used.

The MIL symbols, and corresponding BS symbols, for buffers, inverters, and the common two-input gates are shown in Fig. 2.3. For convenience, we have labelled the inputs and outputs, but it is important to appreciate that there is actually no practical difference between the two inputs on the same gate. In real circuits, it is usual for the signals coming in to a gate to have names associated with them (e.g. Temperature High), rather than simple letters. When drawing logic circuits, it is also usual to show gates with their inputs on the left hand side, and the outputs on the right, with the overall signal flow from left to right.

Now that we have looked at the reasons for the use of logic gates, and the ways in which they are shown in circuits, we are in a position to discuss particular types of gate. We will begin with the AND gate, which is one of the fundamental decision-making gates.

THE AND GATE

One simple way of describing the action of an AND gate is to say that its output is 0 unless all of its inputs are 1. This description, however, gives no clue as to why we might want to use such a gate in the first place. In order to appreciate this, it is really necessary to consider a practical example. Fig. 2.4 shows a circuit which could be part of the electronically controlled shop we discussed earlier. The circuit uses the MIL symbol for an AND gate which was introduced in Fig. 2.3.

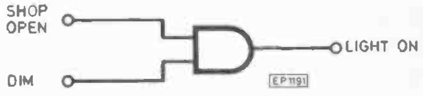


Fig. 2.4. Shop lighting controller

The operation of this circuit is as follows. When the light sensor circuit detects that there is not enough light in the shop, the signal called Dim changes from a 0 level to a 1 level. The time switch output, Shop Open, is a 1 every day between 8 a.m. and 6 p.m., and a 0 at all other times. These two signals are applied to the inputs of the AND gate, and the output of the gate is used to turn the light on. The gate output, here called Light On, is thus equal to a combination of the Dim and the Shop Open signals. From the description above, we can see that the Light On output is a 1 only when both Dim and Shop Open are 1. If either of the inputs are a 0, then the output will remain at a 0 level, e.g. it is likely that Dim will be a 1 at midnight, but the

Shop Open signal will be 0, and will thus prevent the lights being switched on when the shop is closed.

The switch logic equivalent of the AND gate used in the circuit just described is shown for comparison in Fig. 2.5. From this, it can be seen that

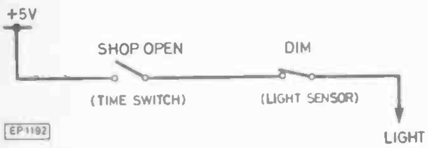


Fig. 2.5. Switch logic shop lighting control circuit

an AND gate is modelled in switch logic by connecting the switches in series. The lamp is then only illuminated when all of the switches are closed (equivalent to the 1 state), and in this way the digital logic and switch logic circuits behave in the same way.

In this example we have seen the way in which signals are combined so that all of a set of conditions must be satisfied before the output goes to a 1. What we must now do is to look at some practical AND gates, and see how they can be applied to solving real problems.

7408 TTL AND GATE

The 7408 is a quadruple 2-input TTL AND gate, the pin connections for the i.c. are shown in Fig. 2.6. All four AND

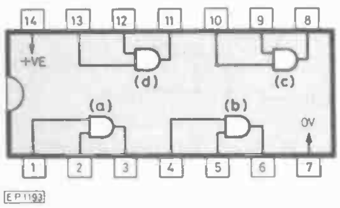


Fig. 2.6. The 7408 quad 2-input AND gate

gates in this package may be used independently, and the gates are usually labelled (a) to (d) for convenience of reference. On any one gate, when either input is 0, the output will also be a 0; both inputs must be 1 for the output to be a 1. The two gate inputs are electrically identical, and either may be used; the actual gates and inputs used are often decided mainly by the combination which gives the neatest circuit layout.

The PE Logic Tutor may be used to demonstrate the behaviour of the 7408 by using the circuit shown in Fig. 2.7. This drawing shows how to con-

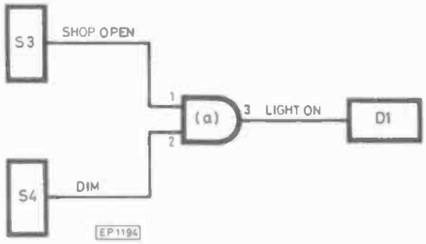


Fig. 2.7. The shop light control circuit

nect up the circuit of Fig. 2.4, and uses the Logic Tutor's logic level generators to provide the Dim and Shop Open signals. A logic state indicator, D1, is used to indicate the state of the Light On signal. Assuming that the i.c. is placed in socket A, with pin 1 in location A1 and pin 14 in location A16, the links required to set up the circuit are as follows:

S3	to	A1	(Shop Open signal)
S4	to	A2	(Dim signal)
A3	to	D1	(Light On output)
+5V	to	A16	(Supply)
A7	to	0V	(Supply)

Any of the four AND gates in the package could have been used, but we have chosen the (a) gate for convenience. Readers may, however, like to verify that interchanging the inputs to the gate selected does not affect the operation of the circuit.

The next step is to continue the idea of combining logic signals in a gate to produce new logic signals. We will now look at an example of a circuit which uses two gates to combine signals. The circuit shown in Fig. 2.8 is based on

Fig. 2.8. Occasional store room light circuit

that of Fig. 2.7. To set up the circuit on the Logic Tutor, the following links must be ADDED to those already set up above:

A3	to	A4	(Light On signal)
S1	to	A5	(Lights Please signal)
A6	to	D2	(Lights output)

The idea is to prevent wasting energy by only allowing the lights to be turned on when it is dark (i.e. Dim is a 1), when the shop is open (i.e. Shop Open is a 1), and when someone has asked for them to be turned on (i.e. Lights Please is a 1). D2 now shows the new signal being produced. This would be a useful circuit, for example, for conserving energy in store rooms where lighting is only required occasionally, when dark, and never when the shop is closed. What the circuit does is to gate the previous Light On signal with the new Lights Please request signal (from a wall switch, probably) to produce the new Lights signal. In effect our new circuit is a three-input AND gate; all three inputs must be a 1 to cause the output to be a 1.

As a final problem concerning the behaviour of TTL AND gates, consider the effect of the circuit shown in Fig. 2.9. Does this have an equivalent in any previously encountered logic element?

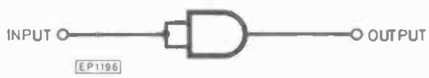


Fig. 2.9. Does this equal something else?

THE OR GATE

In the same way as we saw for the AND gate, there is a simple description of the action of an OR gate; its output is a 1 if any of its inputs is a 1. Restating this in a slightly different way, all of the inputs to an OR gate must be a 0 in order for its output also to be a 0.

Fig. 2.10 shows an example of an OR gate being used in a security alarm.

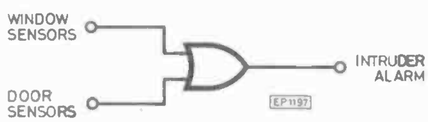


Fig. 2.10. Security alarm circuit

The basic idea is that if any of the door/window sensors are activated, then the alarm bell is switched on. The operation of the system assumes that the output from the sensors is a 1 when an intruder is detected, e.g. when a window is opened.

The switch logic equivalent of the OR gate used in this security alarm is

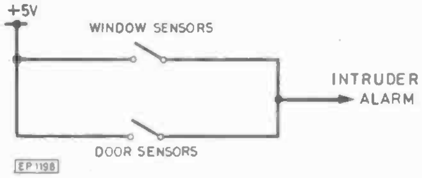


Fig. 2.11. Switch logic security alarm circuit

shown in Fig. 2.11. From this figure it can be seen that an OR gate is modelled in switch logic by connecting the switches in parallel. The alarm then sounds when any (or all) of the switches are closed.

At this point it is interesting to compare the switch logic models of the AND and OR gates. In an AND gate, all of the input conditions must be satisfied (i.e. at a 1 level) before the output goes to a 1, whereas in an OR gate the output goes to a 1 if any of the inputs are a 1. We will now look at the use of some of the OR gates available in the 7400 TTL family.

7432 TTL OR GATE

The 7432 is a quadruple 2-input TTL OR gate, whose internal layout and pin connections are shown in Fig. 2.12. All four gates are electrically identical, and each may be used independently. As we saw with the 7408 earlier, the inputs on each gate are interchangeable.

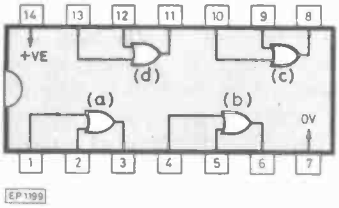


Fig. 2.12. The 7432 quad 2-input OR gate

The choice of input/gate is left to the circuit designer, and it is often a matter of choosing gates in such a way as to produce the neatest circuit layout. Comparing the internal arrangement with that of the 7408 will show significant similarities, and it is worth noting that this is quite a common arrangement for 2-input gates in the 7400 TTL family, but beware of non-conformist i.c.s!

The circuit shown in Fig. 2.13 is an example of the use of the 7432 in an extended security system. In this circuit there are four sensors, which are combined by two stages of gating to produce the signal which sets off the

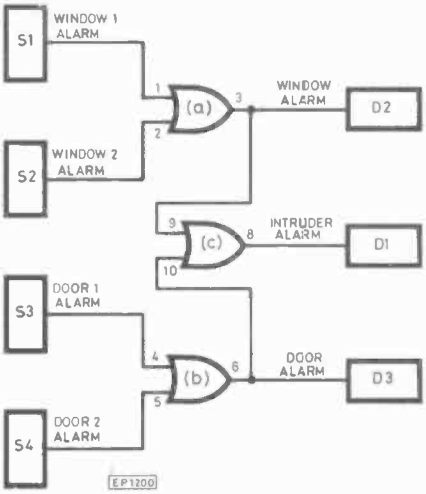


Fig. 2.13. Extended security system

alarm. The circuit is set up on the Logic Tutor by inserting an i.c. in socket A, with pin 1 in location A1, and then adding the following links:

S1	to	A1	(Window 1 Alarm i/p)
S2	to	A2	(Window 2 Alarm i/p)
S3	to	A4	(Door 1 Alarm i/p)
S4	to	A5	(Door 2 Alarm i/p)
A3	to	D2	(Window Alarm o/p)
A3	to	A11	(Window Alarm signal)
A6	to	D3	(Door Alarm o/p)
A6	to	A12	(Door Alarm signal)
A10	to	D1	(Intruder Alarm o/p)
+5V	to	A16	(Supply)
A7	to	0V	(Supply)

If any of the sensors indicate an intruder, the alarm is set off. The overall effect of the circuit, as might be guessed, is the same as using a single 4-input OR gate.

As a final problem for the budding designer, how could the gates discussed so far be used to provide a simple way of disabling this security system? (A single extra input is required, and ideally the minimum extra gating is involved.)

TRUTH TABLES

So far in our discussions on the operation of logic, we have relied on the use of words to describe the actions of the logic gates involved. Although this is a useful approach, and it is definitely an essential introduction, it soon becomes clear that misunderstandings are possible, and that the description of complex circuits can become extremely lengthy. The danger then is that we lose sight of what the circuit is actually going to do with its inputs. After all, one of the objects of this introduction to logic design is to allow us to predict the behaviour of a circuit from a knowledge of its inputs. What we need, therefore, is a simple way of expressing on paper how a logic element behaves. Once we can express this, we can build up a description of how the overall circuit will behave by looking at the way in which the logic elements are interconnected. One of the simplest ways of expressing logic operations on paper uses what is known as a Truth Table.

A Truth Table provides a concise method of allowing us to show how a logic element or circuit will behave for any possible combination of input signals. The method of constructing a truth table is essentially to list all of the inputs and outputs for a logic element or circuit, and then to answer (in a tabular form) the question, "What will be the output(s) for this combination of inputs?". The idea is then to run through all of the possible combinations of input so that we can build up a complete picture of the circuit behaviour.

So much for the theory, but how do we go about constructing such a truth table in practice? We will answer this question by first looking at truth tables for the gates covered so far in the series. From then on, as new logic elements are introduced, they will be accompanied by their truth tables.

Table 2.1 shows the truth table for a 2-input AND gate. If we look at the table we will see that it indicates that the gate output is a 0 unless inputs A and B are both at a 1, i.e. the output is 1 if A AND B are 1, hence the name of the gate. In the two columns on the left

INPUTS		OUTPUT
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

EP1184

Table 2.1. Truth table for a 2-input AND gate

of the table, all possible combinations of input are listed. These may be listed in any order, but it is normal practice for the inputs to be in a binary counting sequence; here it will be seen that the number pair A, B counts from 0 to 3 in binary. The main reason for doing this is to ensure that no combination of inputs are omitted. In particular cases, a different ordering can be used for the combinations of inputs, but the truth table is still incomplete unless all of the input combinations are listed somewhere on the left of the table.

Tables 2.2 and 2.3 show the shortest possible truth tables; Table 2.2 is for the buffer, and Table 2.3 is for the inverting buffer. To complete the picture so far, the truth table for the two-input OR gate is shown in Table 2.4.

INPUT	OUTPUT
A	X
0	0
1	1

EP1185

Table 2.2. Truth table for a buffer

INPUT	OUTPUT
A	X
0	1
1	0

EP1186

Table 2.3. Truth table for an inverting buffer

INPUTS		OUTPUT
A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

EP1187

Table 2.4. Truth table for a 2-input OR gate

In general, for a gate or circuit with n inputs, there will be 2^n lines in the complete truth table. Thus two-input gates have four lines in the table, three-input gates have eight, four-input gates have sixteen, etc. Now that we have covered the gates used to date, we are in a position to consider what the truth table for the circuit shown in Fig. 2.13 looks like. As a start, we can say that it will have sixteen lines, and that the inputs will take values from 0 0 0 0 to 1 1 1 1, but what does the complete table look like?

FAN-OUT

As we have already mentioned, there are a number of practical differences between ideal logic gates and real TTL gates. One of these differences concerns the extent to which gates may be connected together in a digital circuit, and relates to gate 'fan-out'.

In the first part of the series, we described one of the basic rules for connecting up gates. This rule said that a single output may be connected to a number of different inputs. In reality this rule must be modified to reflect that there is a practical limit to the number of different inputs which may be connected to a single output. This number is known as the 'fan-out' of the gate. The fan-out for most of the gates in the 7400 TTL family is at least ten, and is more in many cases. This means that we can connect up to ten TTL gates to a single output, and that reliable operation will still be achieved.

The reasons for the fan-out of a gate being limited at all are related to the way in which the gate circuits themselves operate. In part one we looked briefly at the internal circuitry of the basic TTL gate. While we do not need to understand the detailed operation of this gate, it is necessary to appreciate that it requires input current in order to function. This current in turn represents a load on the gate which is driving the input and, as in any circuit, the drive current available has a finite limit. What we must do, therefore, is to look at the current which is required by each load, and then compare it with the drive capability of the output. This then allows us to determine the fan-out of the gate.

In order to hold the input of a TTL gate at a 0 level, it is necessary to pass a current of 1·6mA to ground. Thus, the gate driving the load must be able to sink 1·6mA (i.e. current flows into

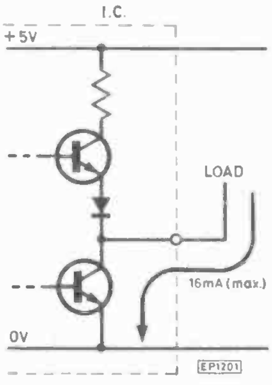


Fig. 2.14a. Current flow in the logic 0 state

the driving gate) for each gate connected to its output. The output stage of a standard TTL gate is able to sink at least 16mA in the 0 state, as shown in Fig. 2.14 (a), and thus it has a fan-out of ten in the 0 state.

In order to hold a TTL input at a 1 level, it is necessary to supply that input with a current of 40μA. A standard TTL gate is able to supply up to 400μA in the 1 state, as shown in Fig. 2.14 (b), and thus it has a fan-out of ten in this state.

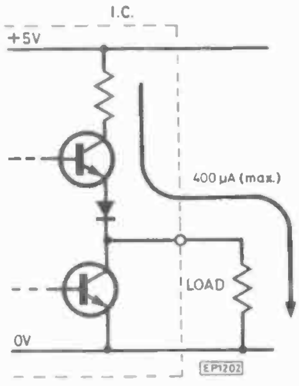


Fig. 2.14b. Current flow in the logic 1 state

In 7400 TTL, therefore, all gates have a fan-out of at least ten, and often more. The majority of the gates connected to an output will be loads of exactly the type described above, known as unity loads (i.e. loads of one). However, in some exceptional cases (usually concerning complex gates) an input may present a load of two. In all cases, however, the rule to remember is that the total number of loads must not exceed the fan-out of the driving gate. In cases of doubt, the data books should be consulted to ascertain the load and fan-out figures. In this series it can be assumed that all logic inputs represent a load of one (or less) unless specifically stated otherwise.

The fan-out figures quoted in the data books always assume that 'standard' loads are being used. The designers of gate circuits have, over the years, evolved circuits which require lower input current levels, so as to make it possible to operate with larger amounts of fan-out. As a general rule, therefore, we can say that a TTL gate can be connected to up to ten other TTL gates, and still operate correctly. This rule will usually ensure that the actual gate loading is less than the limit allowed, and is therefore a useful rule-of-thumb for the designer.

TTL SUB-FAMILIES

Our discussions in this series so far have concentrated on the standard TTL family, in which i.c.s are typically labelled in the style of '7400'. There are, however, a number of other TTL 'sub-families' which have been developed over the years to offer the designer a range of alternative trade-offs of power consumption against maximum operating frequency.

The various sub-families are recognised by letter(s) placed between the '74' and the type number, which remains constant for all of the TTL sub-families. In this way, 74xx00 is always a quad 2-input NAND gate, with 'xx' identifying the TTL sub-family. The different TTL sub-families are summarised in Table 2.5; further details are given in the data sheets which accompany the series. For the rest of the series we shall continue to confine our attention to the standard TTL range.

TTL Sub-Family	Typical Device	Maximum Frequency
Standard	7400	25MHz
High-Power	74H00	43MHz
Low-Power	74L00	3MHz
Schottky	74S00	110MHz
Low-Power Schottky	74LS00	33MHz
Advanced Schottky	74AS00	125MHz
Advanced Low-Power Schottky	74ALS00	50MHz

Table 2.5. TTL Sub-Families

DEFAULT INPUTS

There is often some considerable uncertainty regarding what happens when we leave an unused input of a TTL gate unconnected ('floating'). The answer is actually quite definite, although it is perhaps not one which might be expected, hence the confusion. An unconnected TTL gate input will always behave as if it is connected to a logic 1 level. This is quite a surprise to many logic designers at first, since the opposite is often expected. A full explanation would, however, require a detailed study of the internal gate, which is beyond the scope of this series. Suffice it to say that we can introduce this as another of the rules for using TTL gates; an unused logic input will assume a 1 state.

In passing, it is worth pointing out that default logic states do vary between logic families. If the default logic state is important to a circuit's operation, then the details should be checked in a data book. The MECL 10k series, for example, has a default input state of 0.

The circuit shown in Fig. 2.15 provides a demonstration of the default state assumed by a floating TTL input.

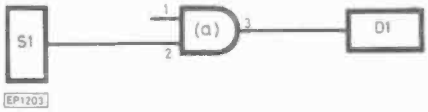


Fig. 2.15. Demonstration of the default input state

This circuit is set up on the Logic Tutor using a 7408 in socket A. With pin 1 of the i.c. in position A1, the links required for the circuit are as follows:

S1 to A2 (Input signal)
A3 to D1 (Output signal)
+5V to A16 (Supply)
A7 to 0V (Supply)

In this circuit, the signal provided by S1 will be completely unaffected by the floating input, and the output will always follow the input. The gate in effect acts as a simple buffer, as would be predicted by a truth table which only included the lines for one of the inputs fixed at 1.

UNUSED GATE INPUTS

Although we can now predict the behaviour of the type of circuit shown in Fig. 2.15, it is still not good design practice to float unused inputs on gates which are being used to process signals. There are essentially two reasons why this is not to be encouraged as normal practice.

Firstly, a floating input is susceptible to the noise spikes which inevitably exist in any electrical environment. This type of problem will show itself as a gate input which usually behaves as if it is at a good 1 level, but occasionally a noise spike will pull it down to a 0. The problem then is that this will only happen intermittently, and it will therefore result in a circuit which is unreliable for reasons which are almost impossible to trace, a real troubleshooting nightmare!

The second, and the most commonly quoted, reason for avoiding floating inputs becomes apparent only when dealing with higher speed circuits. The effect of a floating input is to add stray capacitance to the gate input, which in turn slows down the switching of the gate.

In general, therefore, it is good design practice to avoid leaving inputs floating on active gates, but what are we to do with any 'surplus' inputs? Fig. 2.16 shows three common ways of dealing with unused gate inputs. We

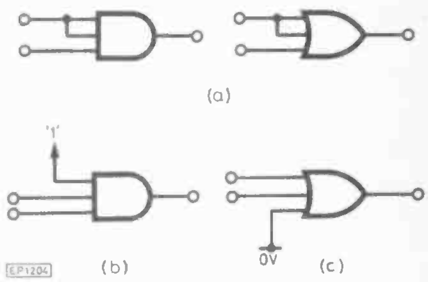


Fig. 2.16 a, b and c. Dealing with unused gate inputs

have illustrated the techniques using three-input AND and OR gates, but the principles are generally applicable. If in doubt as to the validity of any of the techniques, we suggest that a truth table will quickly demonstrate the underlying principle.

It should be noted in Fig. 2.16 (a) that tying TTL inputs together does *not* increase the load on the driving gate, provided that the inputs are on the same gate. This again is a consequence of the internal design of the TTL gate circuit, and is against most initial expectations. In effect this approach 'removes' the unused input from the circuit, from a design point of view at least.

Fig. 2.16 (b) and (c) demonstrate how unused AND/OR inputs may be 'disabled' by tying them to fixed logic 1/0 levels, respectively. A logic 0 level is readily obtained by means of a direct connection to 0 volts. The preferred method of providing a logic 1 level avoids a direct connection to the positive supply, but goes via a resistor. The reasons again relate to speed of operation, and also to protecting the gate input against destruction by supply-borne spikes. A single 1kΩ resistor may be used to supply up to twenty-five unused gate inputs; this in fact is how the logic 1 sources on the PE Logic Tutor are provided. The number of resistors actually used in a circuit to provide 'pull-up' is, however, more often affected by layout than by any theoretical limit.

NEXT MONTH: NAND and NOR gates and Boolean Algebra.

VERSATILE TIMER

R.A.Penfold

THIS Timer was designed for use with an ultraviolet exposure box, and provides two switch-on times of 10 and 20 minutes. However, the use of a versatile precision timer integrated circuit (the UA2240) enables the unit to be easily modified for other output times which can be anything from less than one second to a few hours, and with the appropriate switching a large number of switch-on times can be obtained. The Timer is mains powered and is designed to control mains loads of up to 2·4kW.

TIMER DEVICE

The UA2240 is a timer device of the type which uses a C – R oscillator and divider chain rather that just a simple C – R charging circuit and voltage detector. The advantage of this system is that it gives a longer output pulse duration for given C – R timing values than a simple timer circuit such as one based on the popular 555 device. This gives greater accuracy and consistency for times of a few seconds to a few minutes where the use of high C – R timing values is avoided. Output pulse lengths of up to several hours can be achieved, but this would be impossible using a simple timer circuit which would require impractically high C – R timing values.

An unusual feature of the UA2240, but one which makes the device very versatile, is the use of a divide by N counter in the divider chain rather than a circuit having a fixed division rate. Fig. 1 shows a simplified block diagram of the UA2240.

The counter is an eight stage binary type having open collector outputs which can be connected in parallel and used with a single discrete load resistor. In normal monostable operation the appropriate outputs are coupled to the reset input of the device so that the output pulse ceases after the required number of oscillator cycles. For example, using outputs 032, 08, and 04, at least one of the outputs would pull the output voltage down to the low state until 44 oscillator cycles (32 + 8 + 4) had been received by the counter. After 44 cycles the three output transistors concerned would all be switched off, the output would go high, resetting the counter and blocking the oscillator.

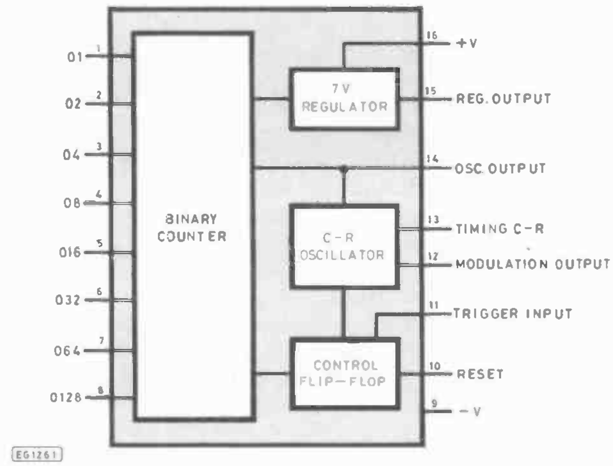


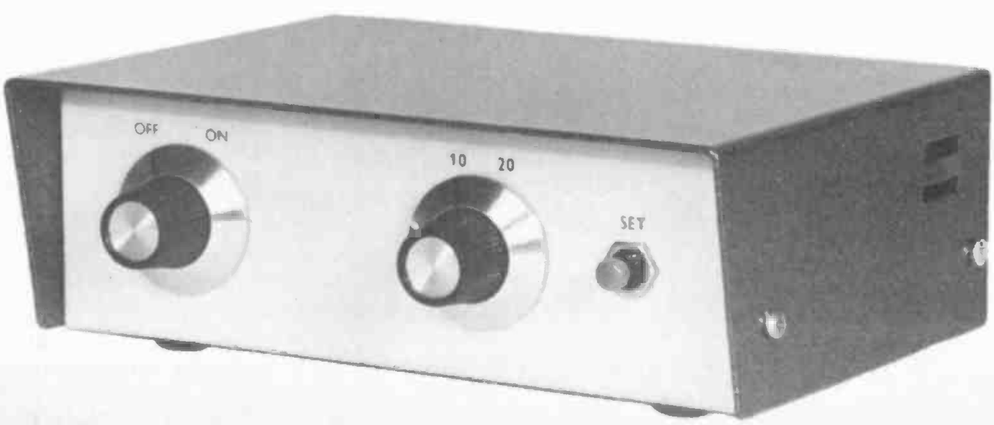
Fig. 1. Block diagram of the UA2240

Thus it is possible to obtain any division rate from 1 to 255 by using the appropriate output terminals, and with suitable switching several different division ratios (and output pulse durations) can be obtained without changing the timing resistor or capacitor values. Once accurately trimmed to give the correct output time in one switch position an identical level of accuracy is obtained at other switch positions and it is not necessary to individually trim each output time in order to obtain good consistency and accuracy at all switch positions. Obviously the output times must all be an integer multiple of the time taken for one oscillator cycle, and can be no more than 255 cycles in duration, but for many applications these limitations are not a problem.

Incidentally, the UA2240 can be used as a very low frequency astable by simply omitting any connection to the reset terminal.

Triggering is achieved by taking the trigger input to a potential of more than 2 volts, but no more than the positive supply voltage. This activates the oscillator, sets the counter outputs low, and enables the counter section. The nominal

The Timer's control fascia



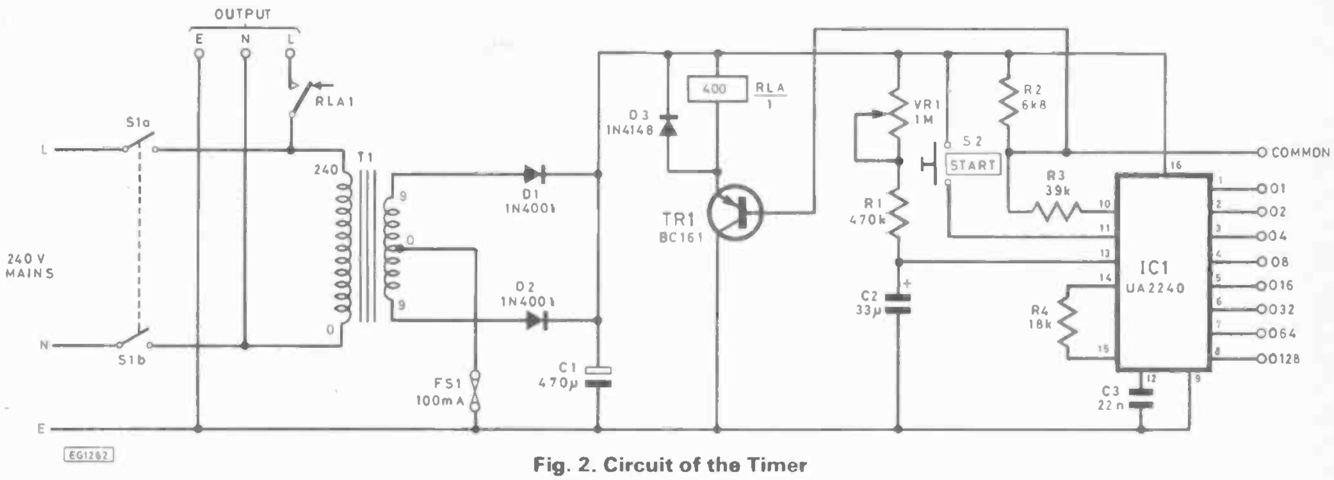


Fig. 2. Circuit of the Timer

duration of each oscillator cycle is a convenient 1CR, and the timing resistor should be between 1k and 10M. The timing capacitor should be between 10n and 1000μ. The oscillator has a modulation input which enables the output time to be trimmed by about −50% and +100%, but in most applications this feature is not required.

THE CIRCUIT

Fig. 2 shows the full circuit diagram of the Timer. R2 is the load resistor for the counter outputs, and no switching or programming connections are shown since these must be varied to suit individual requirements. R3 couples the output of IC1 to the reset terminal. R4 is the load resistor for output stage of the oscillator, and C3 provides decoupling at the modulation input of IC1.

Operating S2 connects the trigger input of IC1 to the positive supply rail and activates IC1. The trigger input has precedence over the reset input, and it is therefore necessary for the trigger pulse to end before the end of the timing period. As the circuit is intended for use where fairly long switch-on times are required it is not necessary to have a short pulse generator circuit at the trigger input since the trigger pulse will presumably end well before the output pulse finishes.

The timing components for the oscillator are VR1, R1, and C2. VR1 is adjusted to give one oscillator cycle every thirty seconds which gives the circuit an output pulse length of up to 127½ minutes in half minute steps. A tantalum bead component is used in the C2 position as electrolytic types tend to have rather high tolerances and leakage currents and consequently could give unsatisfactory results in this circuit. Of course, the timing component values can be changed to give a different timebase frequency, and with a nominal duration for each cycle of 1CR it is not difficult to calculate suitable values.

A relay is used to control the load with a set of normally open relay contacts being connected in series with the "live" mains output lead. The output current from IC1 is inadequate to directly drive the relay coil, and emitter follower TR1 is therefore used to provide buffering between the two. The outputs of IC1 go low when IC1 is triggered using S2, and the relay is switched on during the output pulse with the relay contacts connecting power to the load throughout this period.

A supply potential of about 12 volts is needed, and the stand-by current consumption is only about 10mA, although this rises to about 40mA when the relay is switched on. The supply does not need to have a low ripple and noise content. A simple non-regulated power supply using fullwave push-pull rectification is therefore perfectly adequate. The loaded supply potential is around 11 volts. S1 is the on/off switch, and the unit can be reset by momentarily switching off using this control.

CONSTRUCTION

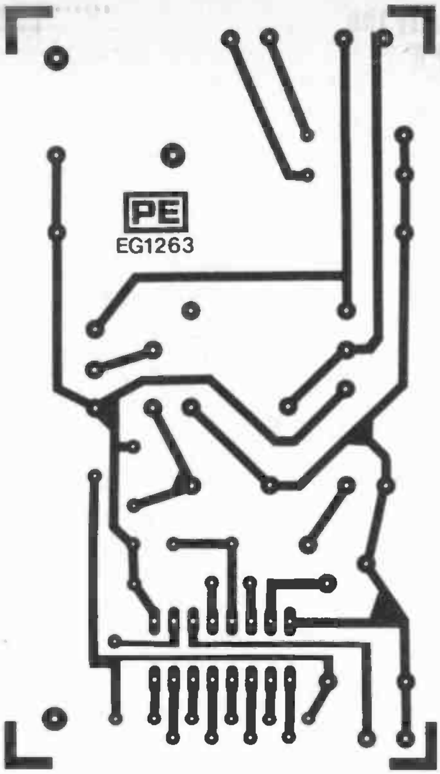
A metal instrument case measuring about 150 by 100 by 50mm makes a suitable housing for this project and is just large enough to accommodate all the components. The three controls are mounted on the front panel and the rear panel is drilled to take the mains input and output cables. Both these holes should be fitted with grommets to protect the leads. If preferred a mains outlet could be mounted on the case, and this would be a more practical solution in applications where the timer is to be used with more than one item of equipment. However, a somewhat larger case would probably be needed if a mains outlet is fitted to the unit. T1 is bolted on the base of the cabinet on the left hand side of the unit, and a soldertag is fitted to one mounting bolt to provide a convenient way of connecting the mains earth lead to the case.

The other components, including the fuseholder and relay, are mounted on a printed circuit board which measures 97 by 54mm. Details of the printed circuit and wiring of the timer are shown in Fig. 3. The circuit will operate properly using any 12 volt relay that has a coil resistance of about 300 ohms or more and contacts of adequate rating, but it is obviously necessary to use the specified component if it is to fit onto the printed circuit board properly without making any modifications to the track pattern. The completed board is mounted in the case using 25mm 6BA bolts with spacers about 12mm long being used to ensure that mains connections on the underside of the board are held well away from the case.

Be careful to complete the wiring to T1 and S1 correctly, and make quite sure that the mains input and output leads are connected correctly. Mistakes here could result in damage to the unit and could be dangerous.

SETTING UP

Initially VR1 should be set at about half maximum resistance, and only Output 1 should be coupled to the common terminal of the printed circuit board so that the relay switches on for just one oscillator cycle when S2 is operated. VR1 is then adjusted by empirical means to give a



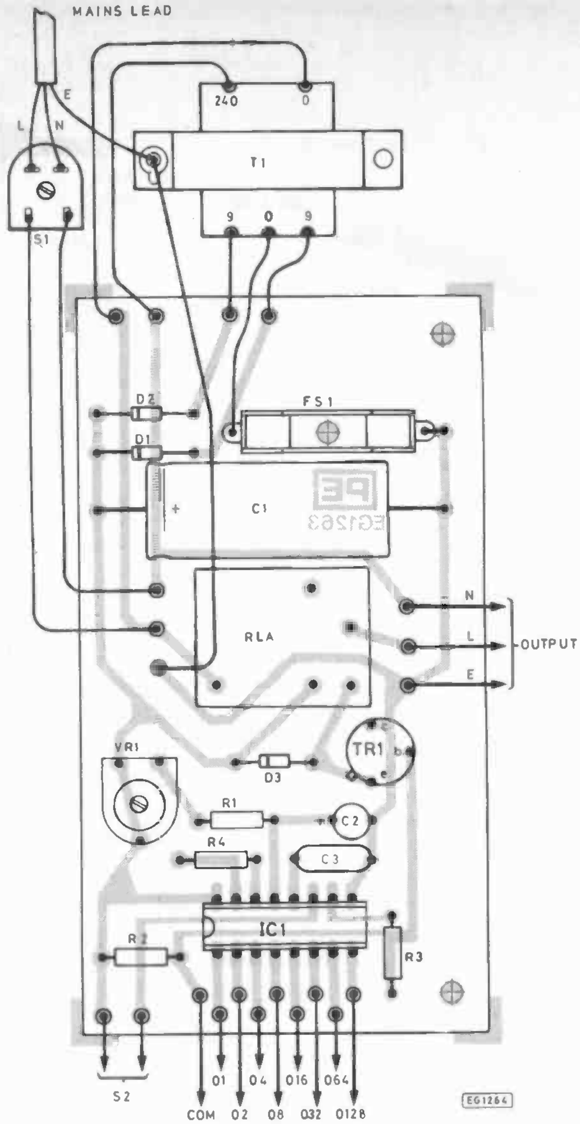


Fig. 3. P.c.b. and wiring detail (right)

COMPONENTS . . .

Resistors

R1	470k
R2	6k8
R3	39k
R4	18k

All $\frac{1}{3}$W carbon

Capacitors

C1	470µF 16V axial elect
C2	33µF 10V tantalum bead
C3	22nF polyester

Potentiometer

VR1	1M 0·1W horizontal preset

Semiconductors

D1, 2	1N4001 (2 off)
D3	1N4148
IC1	UA2240
TRI	BC161

Miscellaneous

T1	Standard mains primary, 9 – 0 – 9V 100mA secondary,
S1	Rotary mains switch,
S2	Push-to-make, release-to-break type,
FS1	100mA 20mm quick blow,
RLA	12V 400 ohm coil, 240V a.c. 10A changeover contacts (M.E.S.),
	150 x 100 x 50mm instrument case,
	Printed circuit board,
	Two control knobs,
	20mm chassis mounting fuseholder,
	16 pin DIL i.c. socket,
	Mains lead and plug,
	Veropins, wire, solder, etc.

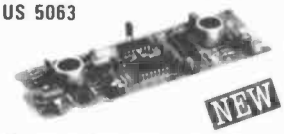
suitably accurate thirty second switch-on time. When used to provide longer switch-on times the error is multiplied by the division ratio used in the counter circuit, and slight readjustment of VR1 may be needed when the unit is programmed for normal use if a high degree of accuracy is required.

The required switch-on time is produced by coupling the appropriate outputs to the common terminal of the board, and the total of the output numbers must be double the required output time in minutes (bearing in mind that each timebase cycle takes half a minute and not a minute). The process used to calculate which outputs are required is extremely simple. For example, assume an output time of 100 minutes is required, and the counter must be programmed to divide by 200. First take the highest output number that is equal to or less than 200, which is obviously 128. This is deducted from 200 to give the total that the other outputs must contribute, which is 72, and the highest output number which is equal to or less than 72 is then selected. This is 64 of course, and 64 is then deducted from 72 to give the remaining number which the other outputs must contribute, or 8 in other words. Again the highest output which is equal to or less than this figure is selected, and in this case output 8 clears the remaining figure and completes the calculation. Thus outputs 128, 64, and 8 give the required division ratio of 200. If more than one output time is required this can be achieved using suitable switching. ★

SECURITY

Build your own system and SAVE POUNDS!

DIGITAL ULTRASONIC DETECTOR US 5063

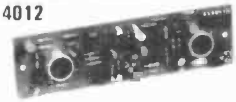


- 3 levels of discrimination against false alarms
- Crystal control for greater stability
- Adjustable range up to 25ft.
- Built-in delays
- 12V operation

This advanced new module uses digital signal processing to provide the highest level of sensitivity whilst discriminating against potential false alarm conditions. The module has a built-in exit delay and timed alarm period, together with a selectable entrance delay, plus many more outstanding features. This advanced new module is available at

only £13.95 + V.A.T.

ULTRASONIC MODULE US 4012

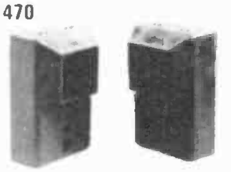


- Adjustable range from 5-25ft.

This popular low cost ultrasonic detector is already used in a wide range of applications from intruder detectors to automatic light switches and door opening equipment, featuring 2 LED indicators for ease of setting up, the unit represents outstanding value at

£10.95 + V.A.T.

INFRA–RED SYSTEM IR 1470



Consisting of separate transmitter and receiver both of which are housed in attractive moulded cases, the system provides an invisible modulated beam over distances of up to 50ft, operating a relay when the beam is broken. Intended for use in security systems, but also ideal for photographic and measurement applications, the system is available at

only £25.61 + V.A.T. Size: 80 × 50 × 35mm.

POWER SUPPLY & RELAY UNIT PS 4012

Provides stablised 12V output at 85mA and contains a relay with 3 amp contacts. The unit is designed to operate with up to 2 ultrasonic units or 1 infra-red unit IR 1470. **Price £4.25 + V.A.T.**

SIREN MODULE SL 157

Produces a loud penetrating sliding tone which, when coupled to a suitable horn speaker, produces S.P.L.'s of 110dbs at 2 metres. Operating from 9-15V, the module contains an inhibit facility for use in 'break to activate' circuits. **Price £2.95 + V.A.T.**

5½" HORN SPEAKER HS 588

This weather-proof horn speaker provides extremely high sound pressure levels (110dbs at 2 metres) when used with the CA 1250, PS 1865 or SL 157. **Price £4.95 + V.A.T.**

3-POS. KEY SWITCH 3901

Single pole, 3-pos. key switch intended for use with the CA 1250. **Price £3.43 + V.A.T.**

ALARM CONTROL UNIT CA 1250

The heart of any alarm system is the control unit. The CA 1250 offers every possible feature that is likely to be required when constructing a system whether a highly sophisticated installation, or simply controlling a single magnetic switch on the front door.

- Built-in electronic siren drives 2 loud speakers
- Provides exit and entrance delays together with fixed alarm time
- Battery back-up with trickle charging facility
- Operates with magnetic switches, pressure pads, ultrasonic or I.R. units
- Anti-tamper and panic facility
- Stabilised output voltage
- 2 operating modes - full alarm/anti-tamper and panic facility
- Screw connections for ease of installation
- Separate relay contacts for switching external loads
- Test loop facility

Price £19.95 + V.A.T.

SIREN & POWER SUPPLY MODULE PSL 1865

A complete siren and power supply module which is capable of providing sound levels of 110dbs at 2 metres when used with a horn speaker. In addition, the unit provides a stabilised 12V output up to 100mA. A switching relay is also included so that the unit may be used in conjunction with the US 5063 or US 4012 to form a complete alarm.

Price £9.95 + V.A.T.

HARDWARE KIT HW 1250

only £9.50 + V.A.T.

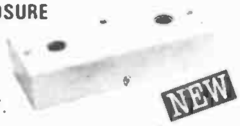
This attractive case is designed to house the control unit CA 1250, together with the appropriate LED indicators and key switch. Supplied with necessary mounting pillars and punched front panel, the unit is given a professional appearance by an adhesive silk screened label. Size: 200 × 180 × 70mm.

HARDWARE KIT HW 5063

only £9.95 + V.A.T.

This hardware kit provides the necessary enclosure for a complete self-contained alarm system which comprises the US 5063, PS 1865, loud speaker type 3515 and key switch 3901. Attractively styled, the unit when completed, provides an effective warning system without installation problems. Size: 200 × 180 × 70mm.

ULTRASONIC MODULE ENCLOSURE



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Patents Review

Copies of British Patents can be obtained from: The Patent Office, Sales, St. Mary Cray, Orpington, Kent (£1.75); and copies of Foreign Patents can be obtained from The Science Reference Library, 25 Southampton Buildings, London, WC2A 1AJ. (Prices on application.)

MOVIE SOUND SYSTEM

British patent application 2104344 from Polaroid is interesting on several counts. The lengthy specification offers some interesting ideas on a microphone system for a film or video camera, with the microphone output adjustable to cut out camera noise and pick up only subject sound. But the application is also interesting because examiners at the British Patent Office have not been able to find any prior publications. This is surprising because the basic idea of a multi-microphone array with adjustable pick up pattern dates back to Alan Blumlein, and his famous British patent 394325. The invention also appears to have much in common with the MS (Main-Side) stereo recording technique, which has for many years been used by broadcast and studio engineers. Furthermore all directional "gun" mics, as for instance widely sold by Sennheiser, use a space array similar to that described in the patent. Perhaps the Patent Office examiners were bewildered by the none-too-clear technical description in the patent, which is typical of applications that originate from the USA where brevity and clarity are not seen as virtues in a patent.

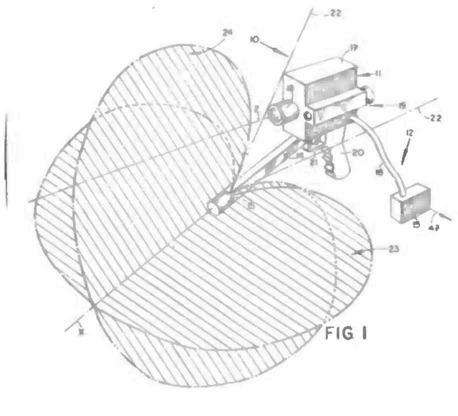

FIG I

Fig. 1 shows the microphone array in conjunction with what is probably a Polaroid instant movie film camera, of the type which was launched a few years ago and failed in the face of video competition, but the system could equally well be used with any camera that generates unwanted noise. Fig. 2 shows how a plane sound wave 30 hits a linear array of four omni-directional microphones M1, M2, M3 and M4 at different times, so that they are each producing a different output signal at any given instant in time. Fig. 3 shows a circuit for processing the signals which come from the four microphones. Summing channel

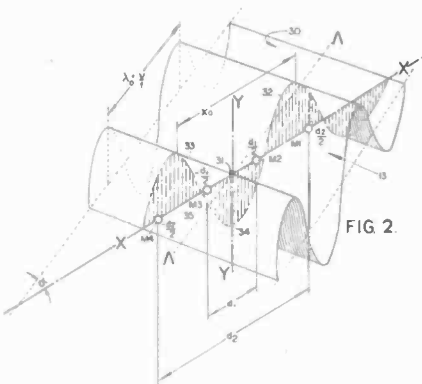

FIG 2.

40 adds the signals from the inner pair of microphones M2, M3 and subtractor 41 produces a difference signal from the M1, M4 outputs. This is integrated, with respect to time, and after gain control at 44, 45 the sum and difference signals are combined at adder 46. The output from 46 is the overall output of the microphone array. When M4 is closest to the camera the array rejects sound proceeding from M4 to M1. If integration is inverted, the pattern is reversed. Other rejection patterns are created by adjusting the relative gains at 44, 45. A cardioid or directional pickup pattern can be created with a null facing the camera. Obviously this reduces the pickup of noise from the camera. Alternatively a figure-of-eight pattern can be created, or a separate left and right pickup for stereo. By the use of directional microphones in the array, instead of omni-directional mics, the same effect can be achieved with two instead of four units. Although the circuit details described are modern, the line of thought is very similar to that started by Alan Blumlein while he was working with EMI in the early 30's. At that time Blumlein did not have directional microphones available so was forced to use omnis, with their outputs "shuffled" to produce a directional response pattern. The MS recording technique, which uses a main omni mic and side figure-of-eight, to produce a stereo response pattern, stemmed from this work and is still favoured by some recording engineers. It would be interesting to know whether the British Patent Office examiners were aware of the various pioneering work, but took a considered decision not to cite it against the Polaroid application, or whether they are unfamiliar with this field of audio technology.

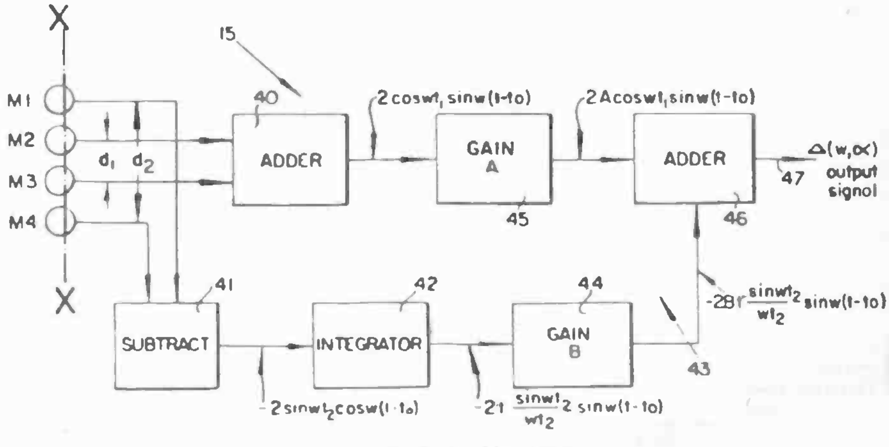

FIG. 3.

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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.

EARTH-LEAKAGE CIRCUIT TESTER

EARTH leakage circuit breakers (e.l.c.b.s) are a useful aid to electrical safety in the home. The problems come, however, when a domestic appliance such as a cooker, starts tripping the e.l.c.b. and taking out the whole electricity supply.

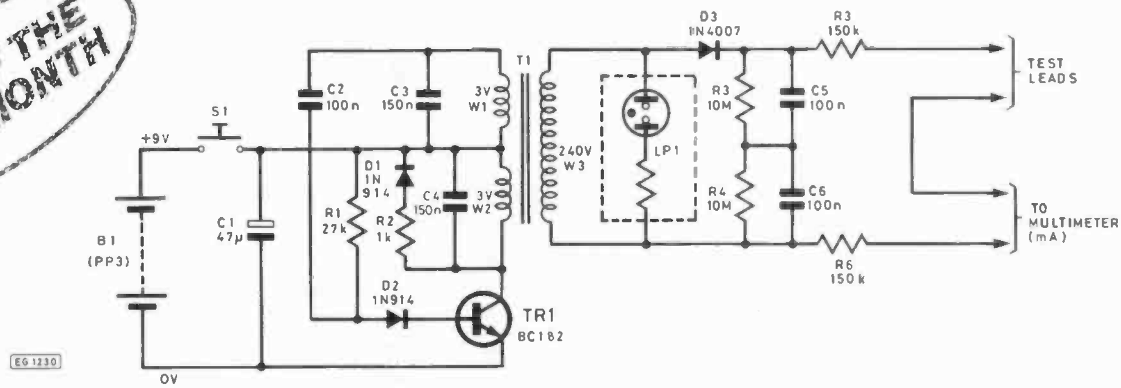
In order to rapidly trace the fault it is necessary to have a device to measure this leakage. The problem is that the leakage may only occur at high voltages, so the few volts put out by the trusted multimeter is insufficient to show the fault, unless you have access to a Megger (which measures resistance at several hundred volts).

The simple circuit shown here is a blocking oscillator used to generate 300V d.c. from a 9V battery, so that a cheap multimeter (set on d.c. current) can locate earth leakage faults. The prime consideration for this design was that all the parts should be readily available 'off the shelf'. For this reason, instead of using the usual obscure pot core and a large number of turns of fine copper wire, a mains transformer was used. Whilst it is true that the iron losses in a mains transformer become large at inverter operating frequencies it does not matter too much in this application. Since there is no power output required the circuit is running at zero efficiency. The only consideration, therefore, is the operating current required. If this can be kept to a minimum the design is satisfactory.

The circuit operation is difficult to quantify but easy to describe. In one sentence, it is a feedback circuit where the loop gain is high enough to produce a self sustaining oscillation. In fact in any high gain feedback circuit the problem is usually to stop it oscillating. When the momentary action switch (S1) is made, current flows into the base of TR1 via R1 and D2. This causes an amplified current to flow in the collector circuit via winding (W2) of the transformer. Since W1 and W2 are a centre tapped pair, the voltage developed across W2 by the collector current in TR1 also appears across W1. The phase of this voltage is such that when fed back to TR1 via C2 it tends to increase the bias on TR1. This positive feedback continues until TR1 saturates. When the collector current can no longer increase the induced e.m.f. in the coil falls (since the induced e.m.f. is proportional to the rate of change of current with time). The falling e.m.f. is fed back to TR1 rapidly shutting it off. The voltage on D2 falls several volts below the negative power rail and TR1 is completely shut off. C2 then charges via R1 until the voltage on D2 reaches about 1V. The cycle is then repeated.

The oscillation can be described as a brief current pulse at a repetition period governed by R1 and C2. In fact this is not a rectangular pulse since the energy stored in C3 and C4 causes an LCR 'ring' to occur. (If R1 is reduced to about 3k3 this results in a nearly sinusoidal oscillator being produced.) The oscillation is simply taken out from the 240V winding (W3) and rectified by D3. C5 and C6 are used to store the generated voltage and R3 and R4 are used to discharge C5 and C6 when the circuit is not operating so that the test terminals can be safely touched. Two resistors and capacitors are used to cope with the high voltages generated. R5 and R6 limit the short circuit output current. The mains neon (LP1) indicates that the high voltage is being generated.

Because of the marked asymmetry of the oscillation waveform, there is little to be gained from full wave rectification of the W3 output. (Note that if W3 is connected the wrong way round the output voltage is greatly reduced.) For any given transformer some adjustment of C2, C3, C4, and R1 will yield an improvement by way of reduced operating current or increased output voltage. In the prototype these were 11mA and 290V respectively. (The transformer should be 240V primary, 3-0-3V, 100mA secondary and kept as small as possible to minimise the iron losses.)



In use the faulty appliance should be disconnected from the mains and leakage tests to the Earth connection made using the two flying leads. The multimeter should be set to d.c. current on its least sensitive range—switching down to the most sensitive range in stages. There should be minimal leakage shown on the most sensitive range.

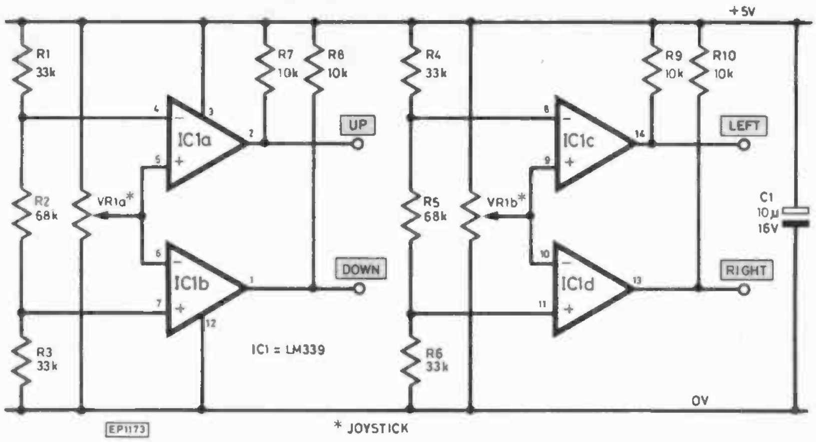
L. O. Green,
Norwich.

JOYSTICK CONTROL

THIS simple joystick control was designed to provide a digital output for a computer from a potentiometer-type joystick. Four outputs are provided for connection to a parallel input port, allowing the other four bits of the port to be used for another joystick or pushbuttons. Nine combinations of output are possible giving eight compass points and the central zero position.

TRUTH TABLE FOR JOYSTICK CONTROL

Up	Down	Left	Right	Direction
0	0	0	0	Centre
0	0	0	1	West
0	0	1	0	East
0	1	0	0	South
0	1	0	1	Southeast
0	1	1	0	Southwest
1	0	0	0	North
1	0	0	1	Northeast
1	0	1	0	Northwest



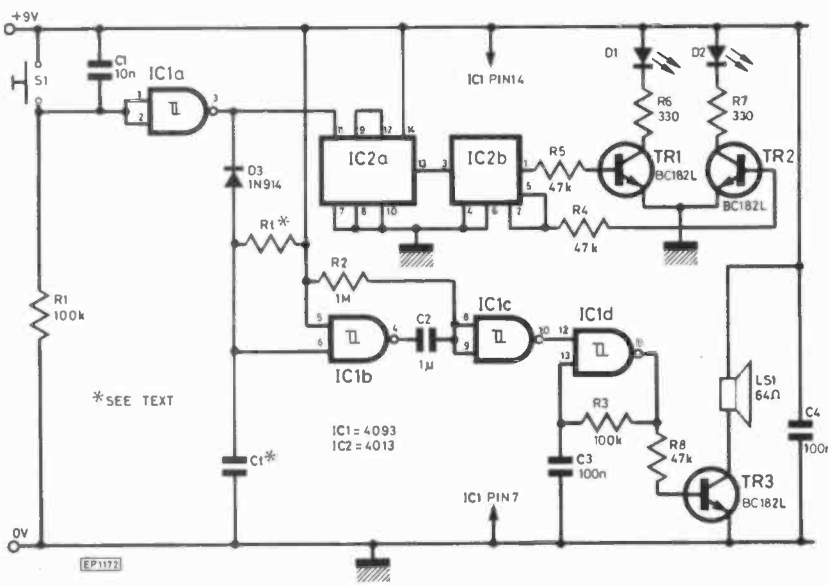
The voltage on the potentiometer wipers are compared to the levels set by the potential dividers R1, R2, R3 and R4, R5, R6. In the circuit shown the comparator outputs are high when the wipers are at the top or bottom quarters of the tracks, giving a 50 per cent deadband in the centre. Reducing R2 and R5 to 33k will give a smaller deadband and consequently a more sensitive control which some may prefer.

It should be noted that the LM 339 comparators have open collector outputs and need pull-up resistors R7, R8, R9 and R10.

This circuit is in use with an 8255 PPI chip interfaced with a Sinclair ZX-81, but should be suitable for other computers and parallel ports.

J. H. Flores,
Washington,
Tyne & Wear.

LIGHTNING CHESS-TIMER



THIS circuit allows each player a maximum of ten seconds to make his move and push the switch or the buzzer will sound and he will have lost the game. The l.e.d.'s indicate which player has lost when the buzzer sounds.

When the pushbutton (S1) is depressed, IC1a debounces the pulse which is fed to IC2. The outputs from this divide by four circuit, drive the buffer transistors TR1 and TR2 so that the two l.e.d.'s light alternately with each depression of the pushbutton. The negative edge of the debounced pulse also discharges capacitor Ct which then charges via Rt. When the threshold is reached a pulse is sent to the monostable IC1c and this enables the oscillator IC1d for one second. The output of this oscillator is fed to TR3 which drives (LS1).

The time allowed for each move can be adjusted since t(seconds) = Rt.Ct. Alternatively several switched values of Rt could be used. The values for ten seconds were Rt = 10M and Ct = 1µF. A low leakage capacitor for Ct is recommended.

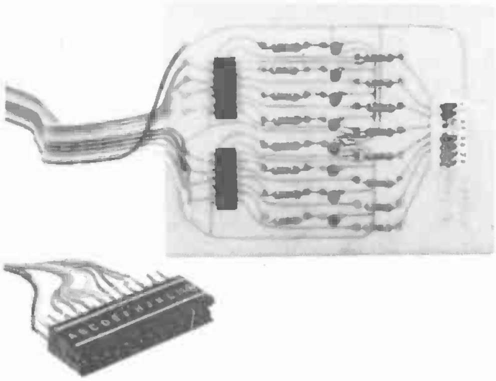
It should be noted that difficulty may be encountered in locating the 64Ω speaker.

B. Fitzpatrick,
Aylesbury,
Bucks.

EXPANDING THE VIC 20

PART TWO SAM WITHEY

LEDS & SWITCHES SIMULATOR



FOR AROUND £5

FOLLOWING the article on memory expansion for the Vic 20, we continue the series with input/output boards which enable the User Port to be utilised for the control of external devices.

VIA

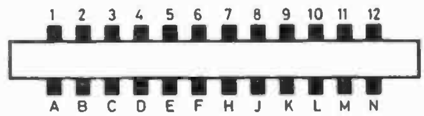
The 6502 based Vic 20 has a 6522 Versatile Interface Adapter (VIA) installed, which provides 16 memory mapped registers that can be used for the control of input/output (I/O) devices. On the Vic 20, access to these facilities is through the User Port. 8 bi-directional data lines are provided, each of which can be individually programmed to serve for input or output. These are identified as pins C to L and labelled P0 to P7.

The VIA is subdivided into two sections that are programmed individually. These are the Data Direction Register and the Input/Output Register.

A Data Direction Register (DDR) in the VIA controls whether the I/O lines at the User Port are to be operational as inputs or outputs, each bit in the DDR having a directly related data line in the User Port. To set data lines as inputs, the corresponding bits in the DDR are set to 0, whilst for those data lines to be set as outputs, the corresponding bits in the DDR are set at 1. As these bits are in a binary form, they can be converted easily to a decimal value acceptable to Commodore Basic.

In Fig. 2.1, all lines are set as outputs, the data in the DDR and consequently in the I/O Register being all logic 1's. This instruction is made to the computer with the command POKE 37138,255; 37138 being the decimal address of the DDR in the Vic 20 memory and 255 being the decimal value of 11111111, where all bits are set at 1 to make all 8 lines

THE VIC 20 USER I/O PORT



PIN	TYPE	NOTE	PIN	TYPE
1	GND		A	GND
2	+5V	100mA MAX	B	CB1
3	RESET		C	PB0
4	JOY 0		D	PB1
5	JOY 1		E	PB2
6	JOY2		F	PB3
7	LIGHT PEN		H	PB4
8	CASSETTE SWITCH		J	PB5
9	SERIAL ATN IN		K	PB6
10	+9V	100mA MAX	L	PB7
11	GND		M	CB1
12	GND		N	GND

EP1240

available as outputs. Now that the DDR has been set up, it is necessary to do likewise to the I/O Register, located at decimal address 37136 in Vic 20 memory. In the case of Fig. 2.1, the instruction would be POKE 37136,255.

User Port	128 P7	64 P6	32 P5	16 P4	8 P3	4 P2	2 P1	1 P0	
DDR.37138	1	1	1	1	1	1	1	1	= 255 decimal
I/O Reg. 37136	1	1	1	1	1	1	1	1	= 255 decimal

Fig. 2.1. Binary to decimal conversion for controlling the VIA

The following short programs suggest a few different methods of manipulating bits in the I/O Register, to provide changes of operation at the port.

In order to vary the output, the program of Fig. 2.2 asks for a decimal value to be typed from the keyboard and the output monitored on a display of l.e.d.s. The DDR is set for outputs and the I/O Register made variable.

Fig. 2.2. Program to display a decimal number on the row of l.e.d.s

```
10 POKE 37138,255
15 REM Set all 8 DDR bits to logic 1
20 INPUT X
25 REM Input a number from keyboard
30 IF X<0 OR X>255 THEN END
35 REM Numbers must be between 0 and 255 inclusive
40 POKE 37136,X
45 REM Put the number into the I/O Reg
50 GOTO 20
55 REM Wait for the next input
```

Should any lines be used as inputs the DDR is set to the corresponding decimal value and the I/O lines ready to accept an input. This can be monitored on the screen with the PEEK command. See Fig. 2.3.

Fig. 2.3. Screen monitoring of inputs, using PEEK

```
10 POKE 37138,240
15 REM Set bits 0 to 3 as inputs, 4 to 7 as outputs
20 PRINT PEEK (37136)
25 REM Display contents of I/O Register on screen
26 REM    This will be total of outputs and 15 in respect
27 REM    of bits 0 to 3. This is reduced as inputs appear
30 GOTO 10
35 REM Display any changes
```

Fig. 2.4. Register contents

User Port	128 P7	64 P6	32 P5	16 P4	8 P3	4 P2	2 P1	1 P0	
DDR,37138	1	1	1	1	0	0	0	0	= 240 decimal
I/O Reg.37136	1	1	1	1	0	0	0	0	= 240 decimal

NOTE: Without an input signal, the VIA holds bits 0 to 3 at logic '1'. Therefore the l.e.d.s. will be on until inputs bring them to logic '0'.

It may be desired to program a sequence of changes to the initial I/O Register settings of the User Port, such as controlling a pattern for disco lights. This can be done by using the AND and OR facilities of Commodore Basic to change the functions of some data lines without affecting the rest. Supposing that initially the DDR and I/O Registers were set up using data lines 0 to 1 as inputs and 2 to 7 as outputs as in Fig. 2.5.

User Port	128 P7	64 P6	32 P5	16 P4	8 P3	4 P2	2 P1	1 P0	
DDR,37138	1	1	1	1	1	1	0	0	= 252 decimal
I/O Reg.37136	1	1	1	1	1	1	0	0	= 252 decimal

Fig. 2.5. Bits 0 to 1 as inputs, and bits 2 to 7 as outputs

Supposing it is required to disable bits 3 to 6 without the other bits being affected. This can be achieved by using the AND Function.

I/O Register	128 P7	64 P6	32 P5	16 P4	8 P3	4 P2	2 P1	1 P0	
Initial status	1	1	1	1	1	1	0	0	= 252 decimal
AND Function	1	0	0	0	0	1	1	1	= 135 decimal
New status	1	0	0	0	0	1	0	0	= 132 decimal

Fig. 2.6. Using AND to disable bits 3 to 6 only

This may be included in a program as:

```
POKE 3138,252
POKE 37136,PEEK(37136)AND135
```

It may now be required to reset bits 4 and 5, without having any effect on the state of the other bits. This is achieved by using the OR function. See Fig. 2.7.

I/O Register	128 P7	64 P6	32 P5	16 P4	8 P3	4 P2	2 P1	1 P0	
Status 2	1	0	0	0	0	1	0	0	= 132 decimal
OR Function	0	0	1	1	0	0	0	0	= 48 decimal
New status	1	0	1	1	0	1	0	0	= 180 decimal

Fig. 2.7. Using OR to reset bits 4 and 5 only

POKE 37136,PEEK(37136) OR48 would be included in the program. Suitable delays would be inserted between the changes.

Try the program of Fig. 2.8 as a starter in using the routines suggested.

Fig. 2.8. Initialisation for suggested routines

```
10  POKE 37138,255
20  POKE 37136,255
21  FOR I=1 TO 200:NEXT:REM Delay routine
25  PRINT PEEK(37136):REM Monitor changes on screen
30  POKE 37136,PEEK(37136) AND 126
31  FOR I=1 TO 200:NEXT
35  PRINT PEEK(37136)
40  POKE 37136,0
41  FOR I=1 TO 200:NEXT
45  PRINT PEEK(37136)
50  POKE 37136,PEEK(37136)OR 24
51  FOR I=1 TO 200:NEXT
55  PRINT PEEK(37136)
60  GOTO 20:REM Do it again
```

NOTE: When writing repetitive program lines, such as 21,25; 31,35; 41,45 etc. just type in the first lines of the series and renumber. The original is retained.

Have you noticed that the AND function is used to delete output bits and the OR function to reinstate them?

Now disable bits 0,3,4 and 7 with the switches and see what happens.

These programming hints are intended as suggestions and may be developed further, to produce an interesting program of light sequences, to enhance, perhaps, a short music program.

LEDS AND SWITCHES BOARD

In order to familiarise oneself with the functioning of the User Port it is necessary to be able to develop programs without being encumbered with large external systems. This can be simulated with arrays of l.e.d.s and switches, where outputs are indicated by the associated l.e.d. being turned on and inputs being activated by the switches in an 8 way d.i.l. switch bank being closed to pull the associated data lines down to ground potential. Whilst using the board, all DDR bits are set as outputs, the impression of inputs being achieved by the disabling of the outputs at the port.

(REF: "Vic 20 Revealed"—Nick Hampshire, and "Vic 20 Programmer's Reference Manual")

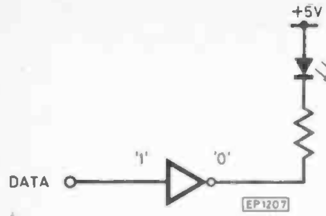


Fig. 2.9. Logic state indicator

COMPONENTS...

Resistors
- R1–8 470 $\frac{1}{4}$W (8 off)
- R9–16* 470 (or higher) $\frac{1}{4}$W (8 off)

Diodes
- D1–8 Red l.e.d. (8 off)
- D9 IN4001

Integrated circuits
- IC1, IC2 7405 (2 off)

Miscellaneous
- P.c.b.
- D.i.l. switch, 8-way
- 10-way ribbon cable, plus connector to suit

*Must sink output, yet draw as little current as possible

Please note that sockets used in this series are also available from **Technomatic.**

The simple, low cost board (approx. £5 on a completely d.i.y. basis) described here allows the computer to simulate being used to turn on and off devices such as small motors or model railway circuits and signals and the functioning of safety devices such as 'limit' switches to prevent over-running.

The interface is constructed on a single sided fibreglass p.c.b. measuring 80mm x 100mm and uses 4 of the inverters of each of 2 x 7405 (or 7406) Open Collector Hex Inverters to sink the cathodes of the l.e.d.s to indicate a logic '1'.

When there is a logic 1 at the output from the port, there is a logic 0 at the output of the inverter. This makes the cathode of the l.e.d. low relative to the supply voltage, allowing it to draw current and switch on, making it compatible with the logic state of the data line. Fig. 2.9. The switches are connected between the outputs of the port and ground. Closing a switch immediately pulls the output of the port to logic 0, turning the associated l.e.d. off, no matter what its programmed state should be. It is essential that all switches are 'open' when the ports are being used in output mode. This permits the VIA to pull the outputs up to +5V.

The Vic 20 is provided with +5V at 100mA at Pin 2 of the User Port, which is sufficient to drive this interface. Provision is made for an external +5V power supply to be connected if the board is to be used with the PET or other computers not having a +5V line available at the output port. In this respect it should be noted that there is approximately 0·6V drop across D9, therefore the supply used should account for this.

Connection to the computer is by means of a 10 way ribbon cable and a 12/2 way 0·156 or 4mm edge connector socket. Whilst sacrificing the use of the red and black wires for positive and negative it is worth while using the colour coding to indicate the port position of the data lines.

The connector is pin compatible with the Commodore 64 and with the exception of the +5V rail also with the PET. There should be no difficulty using the interface with Z80 based computers fitted with a PIO.

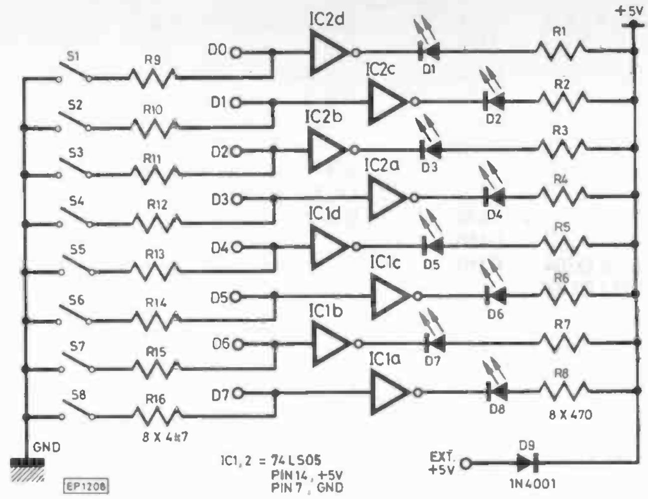


Fig 2.10. Full circuit diagram

For users of Z80 based computers wishing to build the l.e.d.s and switches interface board, the source listing of Fig. 2.11 at 1000H can be easily relocated anywhere in memory.

The delay routine has been placed at the beginning to enable easy extension of the patterns, which are put in the A Register (Accumulator) in Hex form. Line 710 should be deleted before entering new routines, then reinserted at the end. The program uses no system monitor calls and will work on any Z80 based control board.

1000	0010	ORG	£1000;Z80 LIGHT SEQUENCE PROGRAM
1000 0640	0020 DELAY	LD	B,£40; Set up delay count
1002 08	0030 DELY1	EX	AF,AF'
1003 AF	0040	XOR	A;Set A to zero to start
1004 F5	0050 DELY2	PUSH	AF; Loop 256 times
1005 F1	0060	POP	AF; Recall contents of A
1006 F5	0070	PUSH	AF; Repeat last two steps
1007 F1	0080	POP	AF
1008 3D	0090	DEC	A;Decrement A register
1009 20F9	0100	JR	NZ,DELY2;Repeat until A is zero
100B 00	0110	NOP	
100C 10F4	0120	DJNZ	DELY1;Repeat until count is zero
100E C9	0130	RET	;Return to program
100F 00	0140	NOP	
1010 3E0F	0150 START	LD	A,£0F;Set up PIO Port A
1012 D306	0160	OUT	(£06),A;all lines set as outputs
1014 3E18	0170	LD	A,£18; Load A with pattern *......*
1016 D304	0180	OUT	(£04),A;Output through PIO
1018 CD0010	0190	CALL	DELAY;Go to DELAY subroutine
101B 3E24	0200	LD	A,£24; Pattern .*....*.
101D D304	0210	OUT	(£04),A
101F CD0010	0220	CALL	DELAY
1022 3E42	0230	LD	A,£42;Pattern ..*..*..
1024 D304	0240	OUT	(£04),A
1026 CD0010	0250	CALL	DELAY
1029 3E81	0260	LD	A,£81; Pattern ...**...
102B D304	0270	OUT	(£04),A
102D CD0010	0280	CALL	DELAY
1030 3E42	0290	LD	A,£42;Pattern ..*..*..
1032 D304	0300	OUT	(£04),A
1034 CD0010	0310	CALL	DELAY
1037 3E24	0320	LD	A,£24;Pattern .*....*.
1039 D304	0330	OUT	(£04),A
103B CD0010	0340	CALL	DELAY

```
103E 3E18           LD     A,£18;Pattern*......*
1040 D304           OUT    (£04),A
1042 CD0010         CALL   DELAY
1045 3EC3           LD     A,£C3;Pattern **....**
1047 D304           OUT    (£04),A
1049 CD0010         CALL   DELAY
104C 3E3C           LD     A,£3C; Pattern ..****..
104E D304           OUT    (£04),A
1050 CD0010         CALL   DELAY
1053 3EF0           LD     A,£F0;Pattern ....****
1055 D304           OUT    (£04),A
1057 CD0010         CALL   DELAY
105A 3E0F           LD     A,£0F;Pattern ****....
105C D304           OUT    (£04),A
105E CD0010         CALL   DELAY
1061 3E3C           LD     A;£3C;Pattern **....**
1063 D304           OUT    (£04),A
1065 CD0010         CALL   DELAY
1068 3EC3           LD     A,£C3;Pattern ..****..
106A D304           OUT    (£04),A
106C CD0010         CALL   DELAY
106F3EA5            LD     A,£A5;Pattern .*.**.*.
1071 D304           OUT    (£04),A
1073 CD0010         CALL   DELAY
1076 3E5A           LD     A,£5A;Pattern *.*..*.*
1078 D304           OUT    (£04),A
107A CD0010         CALL   DELAY
107D 3EFF           LD     A,£FF;Pattern ********
107F D304           OUT    (£04),A
1081 CD0010         CALL   DELAY
1084 3E7E           LD     A,£7E;Pattern ***..***
1086 D304           OUT    (£04),A
1088 CD0010         CALL   DELAY
108B 3E3C           LD     A,£3C;Pattern .******.
108D D304           OUT    (£04),A
108F CD0010         CALL   DELAY
1092 C31010         JP     START;Go back to
                           beginning of sequence
1095 00             NOP
```

Fig. 2.11. ZEAP Z80 assembler source listing

We would like to thank South Coast Computers, of Ferndown, Dorset, for the loan of the VIC 20 used on the October 83 issue front cover

NEXT MONTH: We describe the construction of an I/O control board for the VIC 20

Fig. 2.12, P.c.b. layout (actual size)

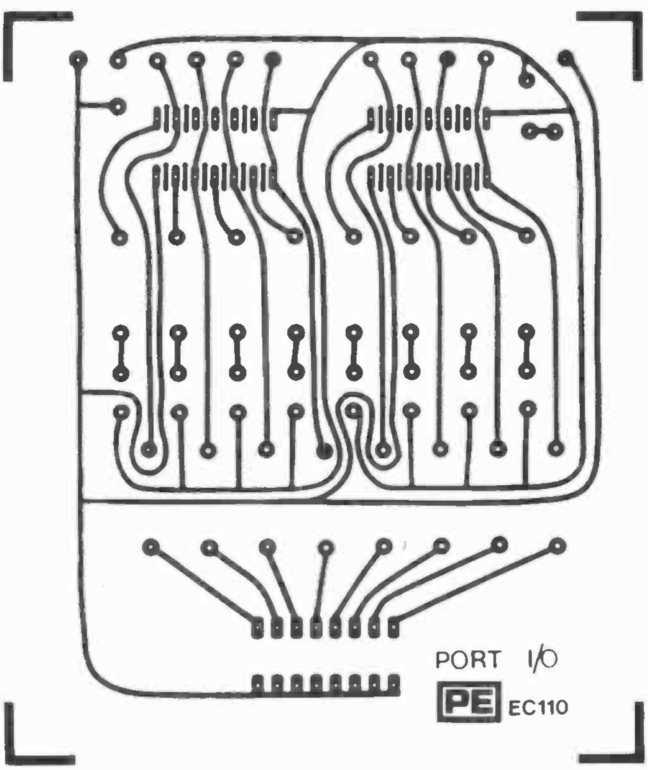
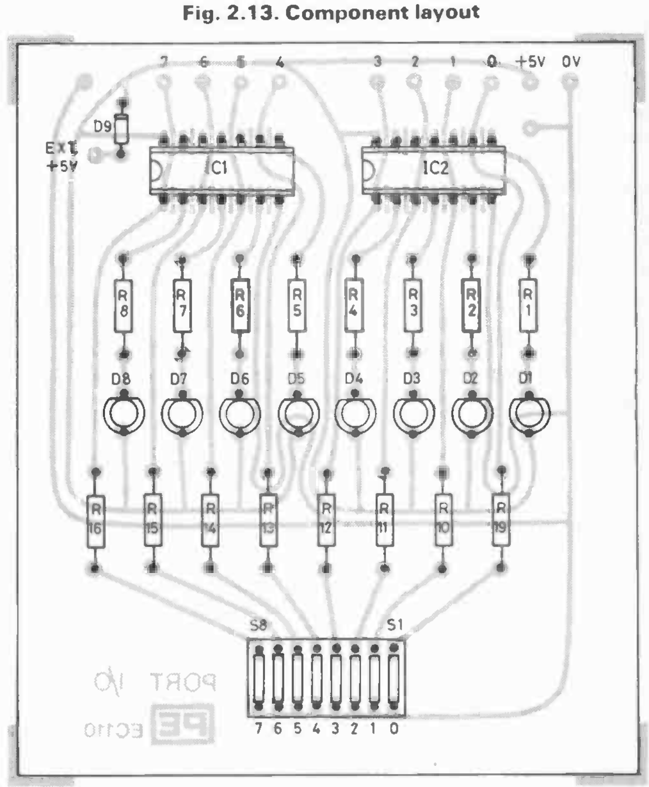


Fig. 2.13. Component layout



EXPANDING THE VIC 20

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.

SIX YEARS OF MICRO-BUS

SEPTEMBER'S was the last Micro-Bus in the familiar bi-monthly format. In future the column will appear monthly, combined with Micro Prompt, and will not be compiled by me.

The first Micro-Bus appeared in the *October 1977* issue of *Practical Electronics*, and it was not until a year later that any magazines devoted to home computing were launched. Now, six years and 36 instalments of Micro-Bus later, there are upwards of 40 different computing magazines available, and what was once an interest available only to the experienced electronics enthusiast is now a consumer industry.

When Micro-Bus started there were no complete home computers available in this country, and amateurs who wanted to learn about microprocessors had to buy an "evaluation kit" direct from one of the chip manufacturers. Two such kits were the SC/MP Introkit, from National Semiconductor, and the 6800 D2 Kit, from Motorola, and the first issue of Micro-Bus featured experimental applications for both of these. It should perhaps be mentioned, for those who have only recently acquired an interest in micros, that these kits were programmed directly in hexadecimal from a 16-key keypad, and by today's standards they were somewhat limited in memory size, each having only 256 bytes! For this luxury you had to pay between £150 and £250—the cost of a complete home computer with BASIC and 32K of memory today.

PE was a pioneer in the field of microcomputing, featuring reviews of most of the kits as they became available, and several complete constructional articles, providing experimenters with virtually the only source of information on micros outside the manufacturers' data sheets. More recently, the topics featured in Micro-Bus have tended to be written in BASIC, rather than machine-code, designed to run on complete home computer systems, such as the ZX81 or BBC Microcomputer.

Throughout this time the shape of Micro-Bus has largely been determined by the contributions received from readers, and many of these were highly original and extended the uses of micros in ways that had not been anticipated by the manufacturers. I am very grateful for the kind comments received over the years, and would particularly like to thank all those who devoted their time and energy to describing their micro-based inventions for publication, so that other readers could benefit from them; sincere apologies to the many readers whose submissions could not be included within the space available for the column each month.

DJD

JULY WINNERS

The July issue of Micro-Bus featured a miscellany of problems, based on BASIC programs, and prizes were offered for the best solutions received before the solutions appeared in the September issue. The VIEW word-processing package for the BBC Computer goes to *Eric Chan* of London for the most concise set of solutions; *Geoff Morris* of Herts receives a year's subscription to *Practical Electronics* for his solutions.

PSG MOD

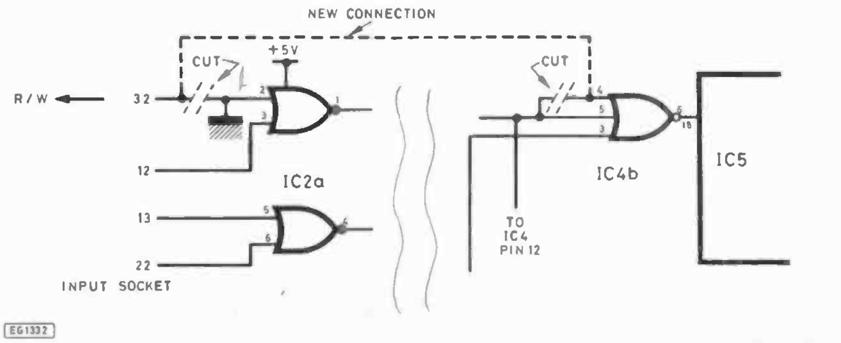
Sir—One possible feature that had been overlooked in the programmable Sound Generator's design (PE Sept. 80), was that of being able to read from (i.e. PEEK) the sound board. The address decoding is so configured as to enable the board only when the READ/WRITE line is low, i.e. when the board is being written to. The following modifications allow the board to be read from, which is useful for discovering the contents of the registers and also, more importantly, it allows the AY-3-8912's input/output port to be used in input mode.

The modification is as follows: Pin 2, IC2, is tied to ground and the R/W line is connected to pin 4, IC4, instead (see Fig. 1). This can be effected by cutting the track between pin 2 IC2 and pin 32 of the input connector. Pin 2 of IC2 is then taken to OV (the OV rail runs around the edge of the sound board). Pin 4 IC4 is separated from pins 5 and 12 IC4 and instead connected to pin 32 of the input connector. Care should be taken to ensure that pins 5 and 12 IC4 are still connected to one another and to the rest of the circuit, after this operation.

With the modification, the PSG behaves in the following manner: when writing to the PSG the Read/Write line is low and so IC4b behaves as normal; however, when reading from the PSG the R/W line goes high, inhibiting IC4b. This means that PEEKing the register address (61680 on the original design, 61808 if the address decoding corrections, November 1980 PE, have been used) causes pin 20 to go high and pin 18 to stay low. These are the conditions necessary to read from the AY-3-8912.

A. D. Love,
Swansea

Fig. 1. PSG modification



SYNCHRONOUS 2MHz CHANGEOVER

Sir,—Your readers may be interested in the circuit shown in Fig. 1, which permits reliable manual or software switching of the UK101 between 1MHz & 2MHz whilst a program is running. It is an improvement on D. P. Goulder's circuit (Micro Prompt July 81), in that reliable dynamic operation is ensured by synchronising the changeover so that the Microprocessor (IC8) always receives an unbroken clock cycle.

The selection may also be performed by software. This has the advantage that 2MHz can be employed to speed-up tedious calculations, and the program can select 1MHz to access EPROMs which are still rated at less than 250nSecs.

The circuit gates the appropriate frequency from IC29 dependent upon the state of the D type flip/flop. The "D" input is derived from a NAND gate which in turn senses the state of the switch. Any available software latch can be fed to pin 9 of the NAND gate to control the circuit when the switch is open.

Synchronisation is achieved by connecting the flip/flop clock input to the selected microprocessor clock frequency.

Alan Stott,
Bristol.

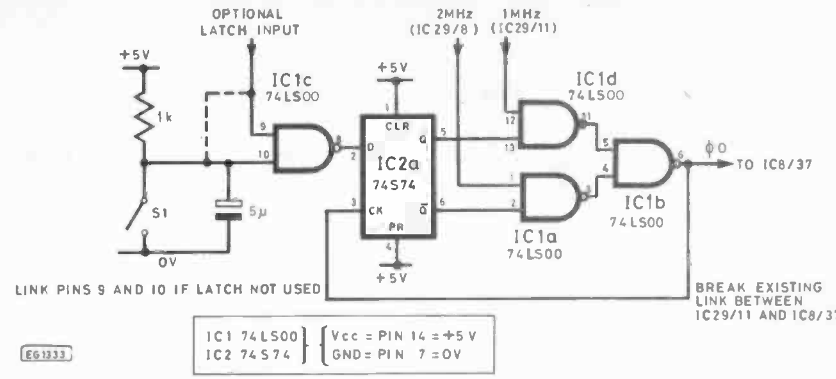


Fig. 1. 1MHz to 2MHz dynamic changeover for UK101

OLD CANCELS NEW!

Sir—I have a UK101 with the original monitor and 8K of user RAM.

Some hobby computers have an "OLD" function available. This enables the user to restore a program after typing "NEW". The enclosed program in 6502 code is my version of "OLD" for the UK101. The program was disassembled by my UK101.

Once you have the function loaded you require a program in memory to try it out. List the program, then type "NEW", try listing it again—nothing should happen. Reset, type "M", then "280" and "G". If the code has been entered correctly you should be back in BASIC, and you should be able to list, run or edit the program quite normally, if not, check the code.

Typing "NEW" accidentally seems rather a remote possibility, a more likely occurrence is a cold start when a warm one was intended. In this case all you do is enter some valid number to the "MEMORY SIZE" question, if you enter-over the program is really lost. For a 4K machine enter 4095, for 8K enter 8191. You may of course enter smaller values if you wish to restrict memory usage. Now reset and proceed as before, and you should be back in business.

One further interesting point is that using Andy Fisher's "Cassette Save/Hex Dump" program (see manual) in conjunction with the OLD function makes it possible to save, load and run interpreted versions of programs. If you wish to try this proceed as follows:

i) You require CASSETTE SAVE, OLD and a BASIC program in memory.

ii) Save the program using CASSETTE SAVE, as described in the manual. The start location will always be $0301, the end location may be found in the zero-page locations $7B and $7C—strictly you should subtract 2 from the value of the end location, but this is not too important.

iii) Perform a cold start, making sure you enter-over the "MEMORY SIZE" question.

iv) The program now no longer exists, using the OLD function will lock the machine. Reset, type "M" then "L" and play back the tape.

v) Once loaded run the OLD function. Since the program already has the address of the second line it is possible to enter the function at $0293, entering at $0280 is not harmful however. The program should behave quite normally.

The ability to load and run interpreted versions of programs may be useful to someone developing a super-fast cassette interface. P. Martin (P.E. May 81 "600 Baud Cassette Interface") states that a major problem in using a high speed interface is the fact that the software cannot keep up with the incoming data—mainly due to the interpreter. Using the above method the interpreter is not involved at all.

"OLD" FUNCTION DISASSEMBLED

```
0280              ORG  $0280

0280 A0 06        LDY#$06
0282 B9 FF 02     LDA  $02FF,Y
0285 F0 04        BEQ  $028B
0287 C8           INY
0288 D0 F8        BNE  $0282
028A 00           BRK
028B 8C 01 03     STY  $0301
028E A9 03        LDA#$03
0290 8D 02 03     STA  $0302
```

The above code finds the address of the second line of the Basic program and loads it into locations $0301 and $0302

```
0293 A9 01        LDA#$01
0295 85 30        STA  $30
0297 A9 03        LDA#$03
0299 85 31        STA  $31
029B A0 00        LDY#$00
029D B1 30        LDA  ($30),Y
029F 85 32        STA  $32
02A1 C8           INY
02A2 B1 30        LDA  ($30),Y
02A4 F0 09        BEQ  $02AF
02A6 85 31        STA  $31
02A8 A5 32        LDA  $32
02AA 85 30        STA  $30
02AC 4C 9B 02     JMP  $029B
02AF A5 32        LDA  $32
02B1 D0 21        BNE  $02D4
```

The above code finds the end address of the Basic program

```
02B3 18           CLC
02B4 A9 03        LDA#$03
02B6 65 30        ADC  $30
02B8 85 7B        STA  $7B
02BA A9 00        LDA#$00
02BC 65 31        ADC  $31
02BE 85 7C        STA  $7C
02C0 18           CLC
02C1 A9 06        LDA#$06
02C3 65 7B        ADC  $7B
02C5 85 7D        STA  $7D
02C7 85 7F        STA  $7F
02C9 A9 00        LDA#$00
02CB 65 31        ADC  $31
02CD 85 7E        STA  $7E
02CF 85 80        STA  $80
02D1 4C 74 A2     JMP  $A274
02D4 00           BRK
```

The above code loads the zero-page locations $7B to $80 with values equal to those that would have been present if the program had just been loaded.

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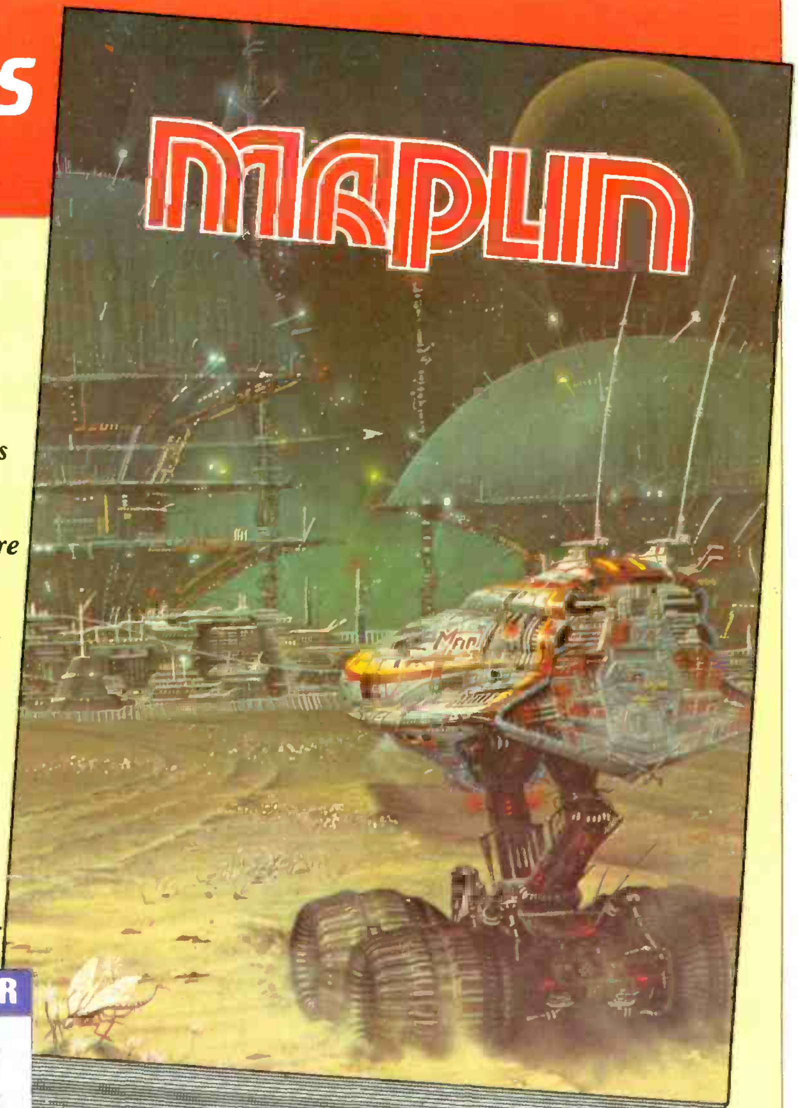

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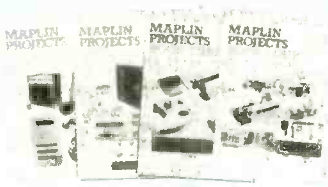

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