PRACTICAL

ELECTRONICS

NOVEMBER 1982

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TRANSCENDENT SOUNDS by *POWERTRAN*

For over 2000 years man has entertained himself and his friends with music played upon instruments he has fashioned with his own hands. From the earliest pipes of hollow reed in the cradles of civilisation, the brazen trumpets of ancient Rome, to the subtle strings of renaissance Europe. Pleasure in the making – Pleasure in the playing and Pleasure in the listening.

Now – in the 1980's its the turn of the electronics age, the age of Powertran.

In our twelve years of research and development we have introduced probably the most comprehensive and sophisticated range of synthesisers and supporting equipment ever offered to the music making, home-constructor.

Each kit is a perfect example of how craftsman-made components, ingenious design technology, originality of concept – and rigid quality and price control – combine together in kits that are both fascinating and satisfying to construct. Our clear step by step instruction manuals ensure that the kits are well within the capability of the first time builder as well as the dedicated enthusiast.

Once you've made your Transcendent Synthesiser you will be able to make the music of all the ages – from the earliest sounds of the simple pipe, through the most complex harmonies, to the most modern tonalities of Stockhausen . . . or Steel Eye Span!

TRANSCENDENT POLYSYNTH – A four octave polyphonic synthesiser with outstanding design characteristics and versatility and performance to match.
Complete kit **£275.00** plus VAT (single voice)
Extra voice (up to three more) **£42.00** plus VAT

EXPANDER – A new matching 4 voice expander to team up with your polysynth for even a greater range and capability.
Complete kit **£249.00** plus VAT

TRANSCENDENT DPX – Offers a five octave keyboard with power to match. Two audio outputs (can be used simultaneously) to give harpsichord and piano/honkytonk or reed with strings/brass and both are fully polyphonic. Other features include switchable touch sensitivity and a chorus ensemble unit with strong/mild effect switching. An advanced design made simple with our clearly laid out instruction manual.
Complete kit **£295.00** plus VAT

TRANSCENDENT 2000 – Although only a 3 octave keyboard the '2000' features the same design ingenuity, careful engineering and quality components of its larger brethren. The kit is well within the scope of the first time builder – buy it, built it – play it! You will know you have made the right choice.
Complete kit **£165.00** plus VAT

1024 COMPOSER – Come right up to the minute with this new design. It will control your synthesiser with a sequence of up to 1024 notes – or an equal selection of shorter sequences. The Composer is mains powered with automatically charged battery to preserve your programme after switch-off.
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POWERTRAN

WORLD LEADERS IN ELECTRONIC KITS

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PRACTICAL
ELECTRONICS

VOLUME 18 No. 11 NOVEMBER 1982

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL SUPPLEMENT

OUR DECEMBER ISSUE WILL BE ON SALE FRIDAY, NOVEMBER 12th, 1982
(for details of contents see page 39)

WATFORD ELECTRONICS

33, CARDIFF ROAD, WATFORD, HERTS WD1 8ED, ENGLAND
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POLYESTER CAPACITORS: (Axial Lead) 400V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8 11p; 10n, 15n, 18n, 22n 12p; 33n, 47n, 68n 16p; 100n, 150n 20p; 220n 30p; 330n 42p; 470n 52p; 680n 60p; 1µF 68p; 2µ2, 4µ7 85p. 1000V: 1nF 17p; 10nF 30p; 15n 40p; 22n 36p; 33n 42p; 47n, 100n 50p.

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 48p; 2200 90p; 25V: 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 each; 220, 250, 270, 330, 360, 390, 470, 600, 800 & 820pF 21p each; 1000, 1200, 1800 30p each; 3300, 4700 60p each

SIEMENS multilayer miniature capacitors. 250V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 8n2, 10n, 12n, 15n, 22n 7p; 18n, 27n, 33n, 47n 8p; 39n, 56n, 68n 9p. 100V: 100n, 120n, 10p; 150n 11p; 220n 13p; 330n 18p; 470n 23p; 680n 30p; 1µF 34p; 2µ2 50p.

MYLAR Film CAPACITORS 100V: 1nF, 2n, 4n, 4n7, 10 6p; 15nF, 22, 30, 40, 47n 7p; 56nF, 100, 200n 9p

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

CERAMIC Capacitors: 50V Range 1pF to 6800pF 4p; 10nF, 15n, 22, 33, 47nF 5p; 100nf 30V 7p; 220n/6V 8p.

PROGRAMMABLE MULTIFUNCTION MUART 8256A £35; Data Booklet 75p

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

500Ω, 1K & 2K (LIN ONLY) Single	30p
5KΩ-2MΩ single gang	30p
5KΩ-2MΩ single gang D P switch	78p
5KΩ-2MΩ dual gang stereo	88p

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm track

5KΩ-500KΩ Single gang	70p
10KΩ-500KΩ Dual gang	110p

PRESET POTENTIOMETERS

0·1W 50Ω-2·2M Mini Vert. & Horiz.	7p
0·25W 100Ω-3·3MΩ Horiz. larger	10p
0·25W 250Ω-4·7MΩ Vert.	10p

RESISTORS—Hi-stab, Miniature, 5%, Carbon.

	RANGE	Val.	1-99	100+
0·25W	2Ω2-4·7M	E24	2p	1p
0·5W	2Ω2-4·7M	E12	2p	1p
1W	2Ω2-10M	E12	5p	3p
2% Metal Film 10Ω-1M			6p	4p
1% Metal Film 51Ω-1M			8p	6p

RESISTORS S.I.L. Package 2%
7 Commoned: 100Ω, 680Ω, 1K, 2K2, 4K7, 10K, 47K, 100K 25p
8 Commoned: 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K 26p

TRANSISTORS

AC125/6	35	BC337/8	15	BFY52	23	TIP34A	74	2N1613	30	2SA671	250
AC127/8	35	BC441	34	BFY56	32	TIP34C	88	2N1671B	160	2SA715	60
AC141/2	30	BC461	34	BFY64	35	TIP35A	110	2N2160	295	2SC495/6	70
AC176	28	BC477/8	40	BFY81	120	TIP35C	128	2N2219A	28	2SC1061	250
AC187/8	32	BC516/7	40	BFY90	80	TIP36A	130	2N2220A	26	2SC1096	85
ACY17/18	70	BC547/8	14	BRY39	40	TIP36C	140	2N2221A	26	2SC1162	30
ACY19/20	75	BC549C	16	BSX20	20	TIP41A	50	2N2222A	25	2SC1172	125
ACY21/22	75	BC556/7	15	BSX29	34	TIP41B	52	2N2369A	18	2SC1173	125
AD142	120	BC558/9	15	BSY95A	25	TIP42A	55	2N2646	45	2SC1306	100
AD149	79	BCY70	16	BU105	170	TIP42B	58	2N2846	80	2SC1307	150
AD161/2	42	BCY71/2	20	BU205	190	TIP120	70	2N2904	28	2SC1449	85
AF118	95	BD124	115	BU206	200	TIP121	73	2N2905A/6	26	2SC1678	140
AF139	40	BD131/2	48	BU208	200	TIP141	105	2N2907A	26	2SC1679	190
AF239	55	BD133	60	MD8001	250	TIP142	105	2N2926G	10	2SC1923	50
BC107/8	10	BD135	45	MJ2955	70	TIP147	120	2N3053	26	2SC1945	225
BC1078	12	BD136/7	40	MJE340	54	TIP2955	60	2N3054	58	2SC1953	90
BC108B	12	BD138/9	40	MJE370	100	TIP3055	60	2N3055	48	2SC1957	90
BC108C	12	BD140	40	MJE371	100	TIS43	32	2N3442	140	2SC1969	140
BC109	10	BD144	198	MJE520	95	TIS44/45	45	2N3565	15	2SC2028	85
BC109B	12	BD245	45	MJE2955	99	TIS48	50	2N3614	199	2SC2029	210
BC109C	12	BD378	70	MJE3055	70	TIS88A	50	2N3615	199	2SC2078	170
BC117/8	20	BD434	55	MPF102	40	TIS90	30	2N3663	15	2SC2091	85
BC140/42	30	BD695A	125	MPF103/4	30	TIS91/93	32	2N3702/3	10	2SC2166	165
BC147/8	9	BD696A	125	MPF105	30	UC734	65	2N3704/5	10	2SC2314	85
BC147B	10	BDY56	180	MPF106	40	VK1010	50	2N3706/7	10	2SC2465	125
BC148C	10	BDY60	160	MPSA05	25	VN10KM	55	2N3708/9	10	2SC2547	30
BC149	9	BF167	29	MPSA06	25	VN46AF	78	2N3710	10	2SD234	75
BC149C	12	BF177	25	MPSA12	32	VN66AF	80	2N3771	179	2SK45	90
BC153/4	27	BF178	30	MPSA55	30	VN88AF	94	2N3772	195	2SK288	225
BC157/8	10	BF179	35	MPSA56	30	VN89AF	96	2N3773	210	2SJ83	225
BC159	11	BF180	38	MPSA70	30	ZTX107/8	11	2N3819	22	2SJ85	225
BC167A	10	BF194/5	12	MPSU02	58	ZTX109	12	2N3820	38	3N128	112
BC168C	10	BF196/7	12	MPSU05	55	ZTX212	28	2N3822/3	45	3N140	112
BC169C	10	BF198/9	18	MPSU06	55	ZTX300	13	2N3866	90	40097	120
BC170	15	BF200	30	MPSU52	65	ZTX301/2	16	2N3903/4	15	40100	215
BC171/2	11	BF224	25	MPSU55	60	ZTX303	25	2N3906/5	15	40101	130
BC173	11	BF244A	28	MPSU56	70	ZTX304	17	2N4037	46	40250	95
BC177/8	16	BF244B	29	OC23/26	170	ZTX314	25	2N4058	10	40251	150
BC179/81	20	BF256B	35	OC28/36	220	ZTX320/26	30	2N4061/2	10	40311	60
BC182/3	10	BF257/8	32	OC41/42	75	ZTX451	23	2N4069	45	40313	130
BC184	10	BF259	35	OC44	75	ZTX341	30	2N4427	80	40315	90
BC182L	10	BF274	42	OC45/70	40	ZTX500/1	14	2N4859	78	40316	95
BC183L	10	BF336	40	OC71/72	40	ZTX502/3	18	2N4871	56	40317/20	80
BC184L	10	BF451	35	OC76	50	ZTX504	25	2N5135/6	20	40360	80
BC186/7	26	BF594/5	19	OC81/82	50	ZTX531	25	2N5138	18	40361/62	70
BC212/3	10	BFR39/40	23	OC83/B4	40	ZTX550	25	2N5172	18	40406/7	75
BC212L	10	BFR41/79	23	OC170/1	50	2N696	30	2N5179	45	40408	75
BC213L	10	BFR80/81	25	OC200/2	50	2N697	23	2N5180	45	40411	285
BC214	10	BFR98	105	TIP29A	32	2N698	40	2N5191	75	40412	90
BC214L	10	BFX29/84	28	TIP29C	38	2N699	48	2N5194	80	40467	130
BC237/8	14	BFX85/86	28	TIP30A	35	2N706A	19	2N5305	24	40468	85
BC307B	14	BFX87/88	28	TIP30C	37	2N708	19	2N5457	30	40594	105
BC308B	16	BFY50/51	23	TIP31A	38	2N914/5	25	2N5458/9	30	40595	110
BC327/8	16			TIP31C	37	2N918	35	2N5485	36	40603	110
				TIP32A	38	2N930	20	2N5777	45	40636	175
				TIP32C	42	2N1131/2	24	2N6027	32	40673	70
				TIP33A	65	2N1303/4	65	2N6109	60	40871/2	90
				TIP33C	78	2N1305/7	60	2N6290	70		
						2N1308	68	2SA636	250		

LINEAR IC's

555 CMOS	80	LF398	475	OM335	705
702	75	LM10	325	RC4136D	69
709C 8 pin	35	LM301A	24	S5668	225
710	48	LM307	45	SAB3209	425
741	14	LM308	95	SAB3210	325
747C 14 pin	65	LM311	70	SAB3271	485
748C 8 pin	36	LM318	150	SAB4209	595
753 8 pin	185	LM319	215	SAS560	150
810	159	LM324	30	SAS570	150
9400CJ	350	LM334Z	90	SG3402	295
AY-1-1320	225	LM335	128	SL490	350
AY-1-5050	99	LM339	47	SN76003N	360
AY-1-5051	160	LM348	64	SN76013N	350
AY-1-6720	210	LM349	115	SN76018	195
AY-3-1270	730	LM358	115	SN76023N	350
AY-3-8910	375	LM377	175	SN76033	350
AY-3-8912	625	LM379	480	SN76115N	215
AY-5-1230	450	LM380	75	SN76131	125
AY-5-1317A	630	LM381N	145	SN76227N	95
AY-5-4007D	520	LM382	115	SN76477	420
AY-5-8100	775	LM384	140	SN76488	480
CA3011	130	LM386	90	SN76660	120
CA3012	175	LM387	120	SP8629	299
CA3014	275	LM389	95	TA7120	150
CA3018	86	LM393	100	TA7204	200
CA3019	80	LM394CH	290	TA7205	90
CA3020	210	LM725CN	325	TA7222	150
CA3023	210	LM733	70	TA7310	150
CA3028A	95	LM2917	195	TAA621AX1	295
CA3035	255	LM3302	75	TAA661A	190
CA3036	270	LM3900	60	TAA700	275
CA3043	275	LM3909	85	TAA900	395
CA3045	365	LM3911	125	TAD100	159
CA3046	70	LM3914	180	TBA120S	70
CA3048	220	LM3915	220	TBA540	275
CA3059	285	LM3916	220	TBA550Q	330
CA3075	213	LM13600	110	TBA641-A12/	
CA3080E	70	LS7220	280	BX1	290
CA3081	190	M252AA	625	TBA651	190
CA3086	48	M253AA	1150	TBA800	80
CA3089E	215	M51513L	230	TBA810S	95
CA3090AQ	375	M51515L	320	TBA820	80
CA3123	165	MB3712	220	TBA920Q	200
CA3130	90	MB3756	440	TBA990	350
CA3140	40	MC1303	88	TCA270	350
CA3160	95	MC1304P	260	TCA280A	220
CA3161E	160	MC1310P	150	TCA940	175
CA3162E	450	MC1445	250	TCA965	120
CA3189	200	MC1458	35	TDA1004	290
CA3240	110	MC1469	300	TDA1008	310
HA1336W	240	MC1494	694	TDA1010	198
HA1388	255	MC1495	350	TDA1022	499
ICL7106	750	MC1496L	70	TDA1024	420
ICL7107	975	MC1596	225	TDA1034	350
ICL7611	99	MC1648	290	TDA1490	325
ICL7660	190	MC1709G	90	TDA2002	325
ICL8038CC	300	MC3302	90	TDA2004	495
ICL8211	350	MC3340P	120	TDA2006	300
ICM7204	550	MC3360P	120	TDA2020	320
ICM7205	1150	MC3401	65	TDA2030	295
ICM7207	475	MC3403	75	TDB0791	420
ICM7215	1050	MC3405	150	TL061CP	40
ICM7216A	1950	MC3423P	80	TL062CP	60
ICM7216B	1950	MFC6040	75	TL064CN	98
ICM7216C	1950	MK50398	635	TL071CP	24
ICM7217A	790	ML924	275	TL072CP	45
ICM7224	785	MSM5526	820	TL074CN	100
ICM7240	300	NE515	275	TL081CP	24
ICM7555	80	NE529	225	TL082CP	45
ICM7556	150	NE531	140	TL083CP	75
LA3350	250	NE543	225	TL084CP	90
LA4031P	340	NE544	210	TL091CP	55
LA4032	295	NE555	16	TL170	60
LA4400	440	NE556DB	45	UA2240	120
LC7120	300	NE560	325	UA78540	230
LC7130	340	NE561	395	UAA170	170
LC7137	395	NE5628	410	UAA180	170
LF347	150	NE564	420	UAA1003-3	935
LF351	48	NE565A	120	ULN2003	85
LF353	95	NE566	155	ULN2004	90
LF355	85	NE567	140	ULN2283	100
LF356	95	NE570	410	UPC575	350
LF357	110	NE571	400	UPC1025H	375
		NE5534	150	UPC1182	330

UPC1156H	290
UPC1366	195
XR2206	300
XR2207	375
XR2211	575
XR2216	675
XR2266	360
ZN414	80
ZN419CE	190
ZN423E	138
ZN424E	130
ZN425E-8	345
ZN426E-8	300
ZN427E-8	590
ZN428E	410
ZN429E-8	210
ZN459	570
ZN1034E	200
ZN1040E	675
ZNA234E	850

COMPUTER IC's

1702	350	8085A	450
1802CP	650	81LS95	85
2102-2	80	81LS96	85
2112-2	250	81LS97	85
2114L-300n	88	81LS98	85
2114L-200n	88	8155	350
2147-3	425	8123	125
2532-450n	350	8156	350
2564	£12	8202	£25
2708	225	8205	00
2716-5V	215	8212	110
2732-450n	350	8214	425
2764	£11	8215-300	300
3242	590	8216	100
4027	190	8224	150
4116-150	80	8226	250
4116-200	75	8228	250
4118-250	325	8243	270
4164-200	480	8250	00
4334-3 (CMOS 2114)	325	8251A	320
4816-100ns	225	8253	450
4864-3 64K	480	8255	225
5101	220	8256A	£35
6116-150ns	390	8257A	500
6116L-120ns	550	8259	395
6117-100n	490	8271	£36
6167-6	795	8279	385
6502 CPU	325	8288	00
6503	600	8284	350
6504-250	550	8T26A	99
6520	115	8T27	150
6521	115	8T28A	120
6522 VIA	300	8T31	350
6530 RRIOT	600	8T95N	90
6532 RIOT	570	8T97N	80
6545 CRTC	899	9364AP	550
6551 ACIA	650	9602	220
6592 PC	650	AM26LS31C	125
6800	275	AM26LS32A	125
6802	335	AY-3-1015	300
6803	850	AY-5-1013	300
6804	180	AY-5-1350	388
6805	670	AY-5-2376	600
6808	520	AY-5-3600	750
6809	799	COM8017	275
6810	115	COM8116	700
6820	115	DM8131	275
68821	335	DP8304BN	250
6821	115	DS3691N	320
6840	395	DS88LS120N	275
6843	700	FD1761	£15
6845	850	FD1771	£15
6847	850	FD1791	£22
6850	135	FD1793	£23
6852	275	FD1795	£28
6854	755	FD1797	£28
6875	500	HD26501	75
68000	£59	IM6402	380
74C922	450	INS8060N	1050
8080A	260	INS8154N	£9
		MC1488	60
		MC1489	55
		MC14411	675
		MC14412	775
		MC3446	250
		MC3447P	315
		MK3886-2M	£7
		MM5280D	695
		MM5303	635
		MM5307	1275
		MM5387A	475
		MM58174	770
		RO-3-2513L	700
		RO-3-2513U	600
		SFF96364E	800
		TMS2716-3	725
		TMS6011	365
		TMS4164-15	475
		TMS9918	£35
		TMS9928	£35
		ULN2003	90
		UPD7002	440
		Z80CPU 2·5	299
		Z80ACPU4M	350

Z80CTC	265
Z80ACTC	290
Z80B	875
Z80DART	495
Z80ADART	550
Z80ADMA	895
Z80DMA	675
Z80P10	260
Z80AP10	275
Z80S10-1	850
Z80AS10	980

74C

74C244	195
74C245	195
74C373	240
74C374	245
74C922	420

74S Series

74S00	30
74S02	32
74S04	32
74S10	40
74S20	40
74S30	40
74S32	70
74S74	75
74S132	110
74S133	60
74S138	125
74S139	150
74S158	195
74S188	210
74S189	158
74S194	320
74S201	350
74S225	525
74S241	390
74S260	50
74S262	850
74S287	300
74S288	210
74S289	290
74S301	000
74S365	000
74S374	365
74S470	325
74S471	620
74S472	1150
74S475	825
74S571	620

75 Series

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

TTL 7400

7400	11	7412	18	74156	40
7401	11	7413	18	74157	30
7402	11	7414	20	74159	80
7403	12	7416	20	74160	60
7404	13	7417	20	74161	48
74L04	85	7420	15	74162	40
7405	15	7421	20	74163	40
7406	20	7422	20	74164	40
7407	20	7423	20	74165	48
7408	14	7425	18	74166	48
7409	14	7426	18	74167	150
7410	14	7427	18	74170	125
7411	16	7428	25	74172	250
		7430	14	74173	60
		7432	20	74174	54
		7433	22	74175	50
		7437	25	74176	40
		7438	22	74177	45
		7440	15	74178	60
		7441	55	74179	80
		7442	32	74180	40
		7443	90	74181	115
		7444	90	74182	60
		7445	65	74184	90
		7446	60	74185	95
		7447	35	74186	470
		7448	40	74188	250
		7450	16	74190	48
		7451	16	74191	46
		7453	16	74192	46
		7454	16	74193	45
		7460	16	74194	40
		7470	30	74195	40
		7472	24	74196	46
		7473	24	74197	40
		7474	20	74198	80
		7475	25	74199	84
		7476	25	74221	54
		7480	40	74246	120
		7481	120	74247	120
		7482	65	74248	120
		7483	38	74249	120
		7484	70	74251	65
		7485	60	74259	150
		7486	20	74265	55
		7489	170	74273	150
		7490	20	74276	120
		7491	20	74278	100
		7492	25	74279	50
		7493	25	74283	50
		7494	35	74284	155
		7495	35	74285	155
		7496	35	74290	105
		7497	90	74293	80
		74100	80	74297	236
		74104	50	74298	100
		74105	55	74351	195
		74107	20	74365	30
		74109	25	74366	30
		74111	55	74367	30
		74112	170	74368	30
		74116	50	74393	90
		74118	50	74490	95
		74119	60		
		74120	60		
		74121	25		
		74122	35		
		74123	35		
		74125	35		
		74126	35		
		74128	35		
		74132	28		
		74136	28		
		74141	55		
		74142	175		
		74143	210		
		74144	210		
		74145	50		
		74147	75		
		74148	60		
		74150	50		
		74151	40		
		74153	40		
		74154	55		
		74155	40		

74LS

LS00	11	LS26	14	LS248	55
LS01	11	LS27	12	LS249	55
LS02	11	LS28	14	LS251	32
LS03	12	LS30	12	LS253	32
LS04	12	LS32	13	LS257	30
LS05	13	LS33	14	LS258	35
LS08	12	LS37	14	LS259	55
LS09	12	LS38	15	LS260	22
LS10	13	LS40	13	LS261	100
LS11	13	LS42	28	LS266	18
LS12	12	LS47	35	LS273	54
LS13	20	LS48	45	LS275	125
LS14	28	LS49	50	LS279	30
LS15	13	LS51	14	LS280	90
LS20	13	LS54	14	LS283	40
LS21	12	LS55	14	LS290	53
LS22	12	LS63	120	LS293	40
		LS73	18	LS295	75
		LS74	18	LS298	80
		LS75	20	LS299	150
		LS76	18	LS320	200
		LS78	18	LS323	160
		LS83	36	LS324	168
		LS85	42	LS325	295
		LS86	18	LS326	240
		LS90	24	LS327	240
		LS91	60	LS347	95
		LS92	24	LS348	90
		LS93	23	LS352	62
		LS95	95	LS353	62
		LS107	40	LS362	750
		LS109	23	LS363	140
		LS112	22	LS364	140
		LS113	16	LS365	28
		LS114	22	LS366	32
		LS122	36	LS367	28
		LS123	37	LS368	35
		LS124	90	LS373	60
		LS125	24	LS374	55
		LS126	25	LS375	50
		LS132	30	LS377	85
		LS133	26	LS378	80
		LS136	24	LS379	110
		LS138	25	LS384	395
		LS139	28	LS385	250
		LS145	70	LS390	46
		LS147	100	LS393	42
		LS148	70	LS395	95
		LS151	40	LS399	150
		LS153	40	LS445	100
		LS154	80	LS471	620
		LS155	40	LS490	200
		LS156	36	LS540	100
		LS157	27	LS541	80
		LS158	30	LS640	180
		LS160	32	LS641	180
		LS161	37	LS645	180
		LS162	37	LS668	125
		LS163	37	LS669	120
		LS164	43	LS670	100
		LS165	50	LS673	650
		LS166	52		
		LS168	85		
		LS170	70		
		LS173	55		
		LS174	50		
		LS175	40		
		LS181	90		
		LS183	180		
		LS190	36		
		LS191	36		
		LS192	36		
		LS193	37		
		LS194	33		
		LS195	33		
		LS196	45		
		LS197	45		
		LS221	55		
		LS240	65		
		LS241	55		
		LS242	55		
		LS243	55		
		LS244	55		
		LS245	70		
		LS247	50		

CMOS

4000	10	4022	40	4500	675
4001	10	4023	13	4501	28
4002	12	4024	32	4502	80
4006	50	4025	13	4503	35
4007	14	4026	80	4504	75
4008	32	4027	20	4505	185
4009	24	4028	39	4506	35
4010	24	4029	45	4507	35
4011	10	4030	15	4508	130
4012	16	4031	125	4510	46
4013	20	4032	80	4511	46
4014	46	4033	125	4512	42
4015	40	4034	140	4513	199
4016	20	4035	45	4514	125
4017	32	4036	275	4515	125
4018	45	4037	115	4516	65
4019	25	4038	110	4517	275
4020	42	4039	290	4518	40
4021	40	4040	40	4519	30
		4041	40	4520	70
		4042	40	4521	130
		4043	40	4522	125
		4044	40	4526	60
		4045	105	4527	50
		4046	46	4528	50
		4047	40	4529	150
		4048	40	4530	90
		4049	25	4531	130
		4050	25	4532	50
		4051	45	4534	455
		4052	60	4536	275
		4053	50	4538	70
		4054	85	4539	90
		4055	85	4541	140
		4056	85	4543	70
		4057	1915	4544	150
		4059	435	4548	40
		4060	45	4549	375
		4061	1195	4553	245
		4062	995	4554	190
		4063	85	4555	35
		4066	24	4556	35
		4067	245	4557	320
		4068	14	4558	120
		4069	13	4559	395
		4070	13	4560	160
		4071	13	4561	104
		4072	13	4562	495
		4073	15	4566	165
		4075	13	4568	250
		4076	50	4569	175
		4077	13	4572	36
		4078	15	4580	460
		4081	13	4581	250
		4082	13	4582	99
		4085	50	4583	99
		4086	60	4584	48
		4089	125	4585	99
		4093	20	4597	330
		4094	70	4598	290
		4095	95	4599	290
		4096	70	40097	45
		4097	190	40098	42
		4098	75	40100	215
		4099	75	40101	130
		4160	95	40102	140
		4161	99	40103	175
		4162	99	40104	15
		4163	99	40105	110
		4174	99	40106	75
		4175	105	40107	60
		4194	105	40108	450
		4408	790	40109	100
		4409	790	40110	300
		4410	725	40114	240
		4411	690	40163	50
		4412	790	40174	45
		4415	480	40192	95
		4419	280	40193	95
		4422	770	40194	90
		4433	770	40195	80
		4435	850	40244	195
		4440	999	40245	195
		4450	350	40373	240
		4451	350	40374	245
		4490	350	45106	595

SPEAKERS
8Ω. 0 3W. 2"; 2 25". 2 5". 3" 80p
0 3W. 2 5" 40Ω; 64Ω or 80Ω 80p

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

Noise Diode
Z5J 195

BRIDGE RECTIFIERS (plastic case)	
1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	56
VM18	50

ZENERS
Range 2V7 to 39V 400mW **8p each**
Range 3V3 to 33V 1 3W **15p each**

VARICAPS	
MVAM2	165
BA102	30
BB105B	40
BB106	40

SCR's Thyristors	
0·8A-100V	32
5A/300V	38
5A/400V	40
5A/600V	48
8A/300V	60
8A/600V	95
12A/100V	78
12A/400V	95
12A/800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5062	32
2N5064	38
2N4444	130

TRIACS	
3A/100V	48
3A/400V	56
3A/800V	85
8A/100V	60
8A/400V	69
8A/800V	115
12A/100V	78
12A/400V	82
12A/800V	135
16A/100V	103
16A/400V	105
16A/800V	220
25A/400V	185
25A/800V	295
25A/1000V	480
30A/400V	525
T2800D	120

DIAC
ST2 25

SOLDERCON PINS
100 70p
500 325p

OPTO ELECTRONICS	
LEDS including Clips	
TIL209 Red 3mm	10
TIL211 Green 3mm	14
TIL212 Yellow	14
TIL220 2" Red	12
0 2" Yel, Grn, Amber	14
Rectangular LEDs with two part clip. R, G & Y	29
Rectangl. Stackable LEDS	18
Triangular LEDs R& G	18
0 2" Flashing LED Red	55
0 2" Bi colour LEDs Red/Green	65
Green/Yellow	80
0 2" Tri colour LEDs Red/Green/Yellow	85
0 2" Red High Bright	59
LD271 Infra Red (emit)	46
TIL32 Infra Red (emit)	52
SFH205 (detector)	118
TIL78 (detector)	54
TIL38 45; TIL81	82
TIL100	90

7 Segment Displays	
TIL321 ·5" C.An	115
TIL322 ·5" C.th	115
DL704 ·3" C.Cth	99
DL707 ·3" C.Anod	99
·8" Orange C.A.	250
FND357 or 500	120
·3" Green C.A.	140
±1·3" Red or Green	150
Bargraph 10 seg. Red	225
Bargraph NSM3914	500

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

DALO ETCH RESIST
Pen + Spare tip 90p

0·5" LIQUID CRYSTAL DISPLAYS	
3½ digit	495
4 digit	530
6 digit	640

BPX25	195
BPW21	295
IL74	45
ILD74	99
ILQ74	185
TIL111	75
TIL117	90
OCP71	120
ORP12	78
ORP61	85
2N5777	45
4N33	135

OPTO SWITCH
Reflective TIL139 170
Slotted similar to RS 186

ALUM. BOXES	
3x2x1"	65
4x2¾x2"	85
4x2¾x2½"	103
4x4x2½"	120
5x4x2	105
5x2¾x1½"	90
5x2¾x2½"	130
5x4x1½"	99
5x4x2½"	120
6x4x2"	120
6x4x3"	150
7x5x3"	180
8x6x3"	210
10x4¼x3"	240
10x7x3"	275
12x5x3"	260
12x8x3"	295

COPPER CLAD BOARDS

Fibre Glass	Single-sided	Double-sided	SRBP 9·5"x8 5"
6"x6"	90p	110p	95p
6"x12"	150p	195p	

VEROBOARDS 0·1"	Clad	Plain
2½x3¾"	80p	—
2½x5"	91p	—
3¾x3¾"	91p	—
3¾x5"	105p	87p
3¾x17"	360p	232p
4¾x18"	470p	—
Pkt. of 100 pins		50p
Spot Face Cutter		135p
Pin Insertion Tool		178p

'VQ' Board	180
'DIP' Board	374
Vero Strip	144
S100 Board	£14
PROTO-DECs	
Veroblock	405
S-Dec	350
Eurobreadboard	520
Bimboard 1	695
Superstrip SS2	£13

VERO WIRING PEN and Spool 350p
Spare Wire (Spool) 75p; Combs 6p ea.
Wire Wrapping Stakes 100 250p

SPECIAL OFFER

	1+	25+
2114L-2	80p	75p
2532	350p	330p
2716	215p	199p
2732	350p	330p
4116	75p	70p
4816-100ns	225p	205p
6116-150ns	390p	360p
6520/21	115p	105p
6522	300p	280p
6820/6821	115p	105p

BBC Micro Mod. A to B Expansion Kit **£45**

EPSON PRINTERS

- **MX80T** 10" Tractor Feed, 9x9 matrix, 80 column, 80 CPS, Bi-directional, Centronic Interface. Baud Rate 110-9600. **£275**
- **MX80FT/3** Tractor & Friction feed. Has hi-resolution, bit image graphics, Subscript & Superscript, italics & underlining facility plus all the MX80FT features. **£322**
- **NEC PC-8023BE-C,** 100CPS bi-directional, logic seeking, 80 -column, 7x9 Dot matrix, super/subscript, underlining, true decenders Tractor/Friction, Hi-Res, 2K Buffer, Proportional Spacing, etc. **£295**

ANTEX Soldering Irons	
C15W	450
CX17W	475
CCN15W	490
X25W	500
Spare bits	65
Elements	210
Iron stands	165
Heat Shunt	30

Buy with Access
Just phone your order through, we do the rest.

ASTEC UHF MODULATORS
6MHz 280p
8MHz Wide Bandwidth 425p

ULTRASONIC TRANSDUCERS
40KHz Transmitter & Receiver 325p/pair

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

ZIF DIL SOCKET	
16 way	475p
24 way	675p
28 way	850p
40 way	975p

DIL PLUGS (Headers) Pins	Solder	IDC
14	38p	95p
16	42p	100p
24	88p	138p
40	195p	218p

RIBBON CABLE (price per foot) Ways	Grey	Color
10	12p	22p
16	25p	40p
20	25p	40p
26	35p	52p
34	48p	60p
40	55p	70p
60	75p	115p

ULTIMUM

WATFORD'S most versatile MICRO EXPANSION SYSTEM. Interfaces with: APPLE, ATOM, DRAGON, PET, RESEARCH MACHINE, SPECTRUM, SUPERBOARD, VIDEO GENIE, ZX81, etc. As published in P.E. starting from Nov., 1982.
Send SAE for details.

IDC CONNECTORS (Speed block type)

	PCB PLUG with latch Strt. Pins	PCB PLUG with latch Angle Pins	female Header Socket	PCB Plugs Unshrouded Male Strat.	PCB Plugs Unshrouded Male Angle
2 x 5 way	90p	99p	85p	60p	65p
2 x 8 way	130p	150p	110p	70p	78p
2 x 10 way	145p	166p	125p	80p	92p
2 x 13 way	175p	200p	150p	95p	110p
2 x 17 way	205p	236p	169p	110p	135p
2 x 20 way	220p	250p	190p	125p	150p
2 x 25 way	235p	270p	200p	150p	175p

EURO CONNECTORS	SOCKETS Strt.	SOCKETS Angle	PLUGS Strt.	PLUGS Angle
DIN 41617	170p	—	—	175p
DIN 41612 2x32 way	285p	325p	220p	295p
DIN 41612 2-3x32 way	300p	340p	240p	300p
DIN 41612 3x32 way	360p	385p	260p	400p

'D' CONNECTORS:
Miniature

Pins	9 way	15 way	25 way	37 way
PLUGS				
Solder	80p	110p	160p	240p
Angle	150p	210p	250p	355p
Strait	170p	160p	220p	310p
SOCKETS				
Solder	105p	160p	200p	338p
Angle	165p	215p	290p	440p
Strait	175p	200p	300p	420p
COVERS Top & Side Entry	95p	90p	100p	110p

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

TRANSFORMERS (mains Prim. 220-240V)
3-0-3V, 6-0-6V 100mA; 9-0-9V 75mA; 12-0-12V 75mA; 15-0-15V 75mA **98p**
6VA: 2x6V-·5A; 2x9V-·4A; 2x12V-0·3A; 2x15V-·25A **220p**
12VA: 2x4V5-1·3A; 2x6V-1·2A; 2x12V-·5A; 2x15V-·4A **295p** (35p p&p)
24VA: 6V-1·5A 6V-1·5A; 9V-1·2A 9V-1·2A; 12V-1A 12V-1A; 15-·8A 15-·8A; 20V-·6A 20V-·6A **330p** (60p p&p)
50VA: 2x6V-4A; 2x9V-2·5A; 2x12V-2A; 2x15V-1·5A; 2x20V-1·2A; 2x25V-2A; 2x30V-0·8A **465p** (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2·5A; 2x30V-1·5A; 2x40V-1·25A; 2x50V-1A **920p** (60p p&p)

Amphenol Plugs
24 way IEEE 575p
36 way Centronics Parallel 550p

SIL Sockets
0 1" 20 way 65p

EDGE CONNECTORS Two rows	·1	156
2x10 way	—	135p
2x15 way	—	140p
2x18 way	180p	145p
2x22 way	199p	200p
2x23 way	210p	—
2x25 way	225p	220p
2x28 way	210p	—
2x30 way	245p	—
2x36 way	295p	—
2x40 way	315p	—
2x43 way	395p	—
2x75 way	550p	—

JUMPER LEADS Ribbon Cable Assembly
DIL Plug (Headers)

Single Ended Lead, 24" long Length	14pin	16pin	24 pin	40 pin
24"	145p	165p	240p	380p
Double Ended Leads				
6"	185p	205p	300p	465p
12"	198p	215p	315p	490p
24"	210p	235p	345p	540p
36"	230p	250p	375p	595p

IO HEADER SOCKET Jumper Leads 24"	20pin	26pin	34pin	40pin
1 end	160p	200p	260p	300p
2 ends	290p	370p	480p	525p

COMPUTER CORNER

- **EPSON MX** Series Printers. Full range available. See box above for details.
- **SEIKOSHA GP100A** – Unihammer Printer, normal & double width characters, dot resolution graphics 10" Tractor feed, parallel interface standard. FREE 500 Sheets **£185**
- **EPSON HX20** Microcomputer. Portable, Full size Keyboard, LCD Virtual Screen, 5x7 Dot Matrix Printer incorporated **£399**
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1A	T03 +ve		–ve	
5V	7805	145p	7905	220p
12V	7812	145p	7912	220p
15V	7815	145p	7915	220p
18V	7818	150p		—
1A	T0220 Plastic Casing			
5V	7805	40p	7905	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p		
100mA	T092 Plastic Casing			
5V	78L05	30p	79L05	60p
6V	78L62	30p		—
8V	78L82	30p		—
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

LM300H	170	LM305H	140
LM304H	160	LM309K	135
78H05 5V/5A	550	LM317K	320
78H12 12V/5A	580	LM317P	99
78HG+5 to		LM323K	500
+24V 5A	599	LM337T	175
79HG –2.25V to		LM723	35
–24V 5A	685	TBA625B	75

SWITCHES

SLIDE 250V	
1A DPDT	14
1A DPDT C/OFF	15
½A DP on/on/on	40
4 pole c/over	240

TOGGLE 2A 250V	
SPST	33
DPDT	44
4 pole on off	54

PUSH BUTTON Spring loaded Latching or Momentary 6A	
SPDT c/over	99
DPDT c/over	145
MINIATURE Non Locking	
Push to make	15p
Push break	25p

SUB-MIN TOGGLE	
SP changeover	60
SPST on off	54
SPDT c/off	85
SPDT Biased	105
DPDT 6 tags	75
DPDT C/OFF	88
DPDT on/on/on	185
DPDT Biased	145
3 pole c/over	205

ROCKER: 5A, 250V, SPST 28p
ROCKER: 10A 250V SPDT 38p
ROCKER: With neon lights red when on. 10A 250V, DPST 85p
ROCKER: (White) 10A/250V DPDT 72p
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Break before make Wafers. Silver contacts. 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6 pole/2 way 85p
Mains DPST Switch to fit 45p
Screen & Spacers 6p
ROTARY: (Adjustable Stop Type) 1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way 45p
ROTARY: Mains 250V AC, 4 Amp 58p
DIL SWITCHES: (SPST) 4 way 65p; 6 way 80p; 8 way 87p; 10 way 135p; (SPDT) 4 way 190p.
THUMBWHEEL Mini front mounting
Decade Switch Module 220p
B.C.D. Switch Module 275p
Mounting Cheeks (pair) 75p
PROXIMITY Switch with magnet 125p

CRYSTALS	
32·768KHz	100
100KHz	235
200KHz	268
455KHz	370
1MHz	275
1·008M	275
1·28MHz	392
1·5MHz	420
1·6MHz	395
1·8MHz	395
1·8432M	200
2·0MHz	225
2·4576M	200
2·5MHz	225
3·2768M	150
3·57954M	98
3·6864M	300
4·0MHz	150
4·032MHz	290
4·194304M	200
4·433619M	100
4·608MHz	200
4·80MHz	200
5·0MHz	160
5·185MHz	300
5·24288M	390
6·0MHz	140
6·144MHz	150
6·5536MHz	200
7·0MHz	150
7·168MHz	250
7·68MHz	200
8·0MHz	150
8·08333M	395
8·867237M	175
9·00MHz	200
9·375MHz	350
10·0MHz	175
10·5MHz	250
10·7MHz	150
10·24MHz	200
12·0MHz	175
12·528MHz	300
14·31818M	170
14·765MHz	250
15·0MHz	200
16·0MHz	200
18·0MHz	160
18·432M	150
19·968MHz	150
20·0MHz	200
24·0MHz	170
24·930MHz	325
26·69M	150
26·670MHz	325
27·125MHz	295
27·145M	190
27·648MHz	330
38·66667M	175
48·0MHz	175
55·5MHz	400
100·0MHz	375
116·0MHz	300
145·8MHz	225

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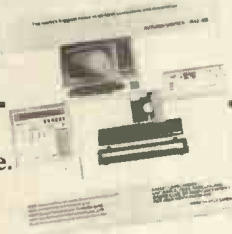
To Heath Electronics (UK) Limited, Dept (PE11), Bristol Road, Gloucester GL2 6EE



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The toroidal transformer is now accepted as the standard in industry, overtaking the obsolete laminated type. Industry has been quick to recognise the advantages toroidals offer in size, weight, lower radiated field and, thanks to I.L.P., PRICE.

Our large standard range is complemented by our SPECIAL DESIGN section which can offer a prototype service within 7 DAYS together with a short lead time on quantity orders which can be programmed to your requirements with no price penalty.

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
30 VA 70×30mm 0.45Kg Regulation 18%	1x010	6+6	2.50	£5.12 +p/p £1.04 +VAT £0.92 TOTAL £7.08
	1x011	9+9	1.66	
	1x012	12+12	1.25	
	1x013	15+15	1.00	
	1x014	18+18	0.83	
	1x015	22+22	0.68	
	1x016	25+25	0.60	
	1x017	30+30	0.50	
50 VA 80×35mm 0.9Kg Regulation 13%	2x010	6+6	4.16	£5.70 +p/p £1.30 +VAT £1.05 TOTAL £8.05
	2x011	9+9	2.77	
	2x012	12+12	2.08	
	2x013	15+15	1.66	
	2x014	18+18	1.38	
	2x015	22+22	1.13	
	2x016	25+25	1.00	
	2x017	30+30	0.83	
	2x028	110	0.45	
	2x029	220	0.22	
	2x030	240	0.20	
80 VA 90×30mm 1Kg Regulation 12%	3x010	6+6	8.64	£6.08 +p/p £1.67 +VAT £1.18 TOTAL £8.91
	3x011	9+9	4.44	
	3x012	12+12	3.33	
	3x013	15+15	2.66	
	3x014	18+18	2.22	
	3x015	22+22	1.81	
	3x016	25+25	1.60	
	3x017	30+30	1.33	
	3x028	110	0.72	
	3x029	220	0.36	
	3x030	240	0.33	
120 VA 90×40mm 1.2Kg Regulation 11%	4x010	6+6	10.00	£6.90 +p/p £1.67 +VAT £1.29 TOTAL £9.86
	4x011	9+9	6.66	
	4x012	12+12	5.00	
	4x013	15+15	4.00	
	4x014	18+18	3.33	
	4x015	22+22	2.72	
	4x016	25+25	2.40	
	4x017	30+30	2.00	
	4x018	35+35	1.71	
	4x028	110	1.09	
	4x029	220	0.54	
	4x030	240	0.50	
160 VA 110×40mm 1.8Kg Regulation 8%	5x011	9+9	8.89	£7.91 +p/p £1.67 +VAT £1.44 TOTAL £11.02
	5x012	12+12	6.66	
	5x013	15+15	5.33	
	5x014	18+18	4.44	
	5x015	22+22	3.63	
	5x016	25+25	3.20	
	5x017	30+30	2.66	
	5x018	35+35	2.28	
	5x026	40+40	2.00	
	5x028	110	1.45	
	5x029	220	0.72	
	5x030	240	0.66	

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225 VA 110×45mm 2.2Kg Regulation 7%	6x012	12+12	9.38	£9.20 +p/p £2.00 +VAT £1.68 TOTAL £12.88
	6x013	15+15	7.50	
	6x014	18+18	6.25	
	6x015	22+22	5.11	
	6x016	25+25	4.50	
	6x017	30+30	3.75	
	6x018	35+35	3.21	
	6x026	40+40	2.81	
	6x025	45+45	2.50	
	6x033	50+50	2.25	
	6x028	110	2.04	
	6x029	220	1.02	
	6x030	240	0.93	
300 VA 110×50mm 2.6Kg Regulation 6%	7x013	15+15	10.00	£10.17 +p/p £2.00 +VAT £1.83 TOTAL £14.00
	7x014	18+18	8.33	
	7x015	22+22	6.82	
	7x016	25+25	6.00	
	7x017	30+30	5.00	
	7x018	35+35	4.28	
	7x026	40+40	3.75	
	7x025	45+45	3.33	
	7x033	50+50	3.00	
	7x028	110	2.72	
	7x029	220	1.36	
	7x030	240	1.25	
500 VA 140×60mm 4Kg Regulation 4%	8x016	25+25	10.00	£13.53 +p/p £2.35 +VAT £2.38 TOTAL £18.26
	8x017	30+30	8.33	
	8x018	35+35	7.14	
	8x026	40+40	6.25	
	8x025	45+45	5.55	
	8x033	50+50	5.00	
	8x042	55+55	4.54	
	8x028	110	4.54	
	8x029	220	2.27	
	8x030	240	2.08	
625 VA 140×75mm 5Kg Regulation 4%	9x017	30+30	10.41	£16.13 +p/p £2.50 +VAT £2.79 TOTAL £21.42
	9x018	35+35	8.92	
	9x026	40+40	7.81	
	9x025	45+45	6.94	
	9x033	50+50	6.25	
	9x042	55+55	5.68	
	9x028	110	5.68	
	9x029	220	2.84	
	9x030	240	2.60	

IMPORTANT: Regulation – All voltages quoted are FULL LOAD. Please add regulation figure to secondary voltage to obtain off load voltage.

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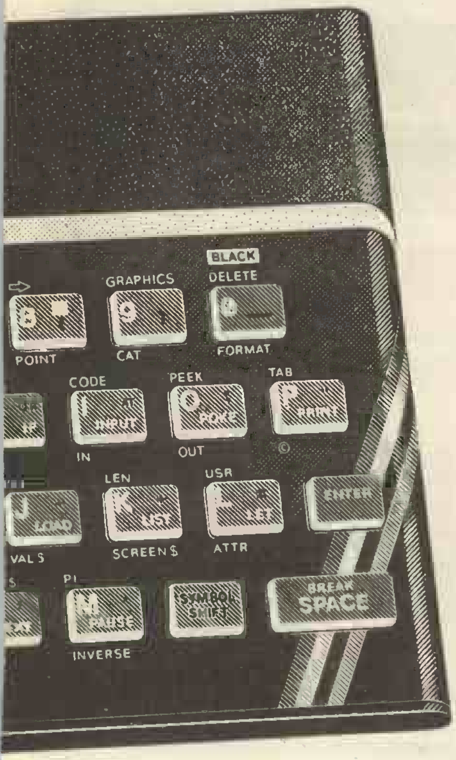

RS232/network interface board

This interface, available later this year, will enable you to connect your ZX Spectrum to a whole host of printers, terminals and other computers.

The potential is enormous. And the astonishingly low price of only £20 is possible only because the operating systems are already designed into the ROM.

ZX Spectrum

Available <u>only</u> by mail order and <u>only</u> from

sinclair

Sinclair Research Ltd,
Stanhope Road, Camberley,
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Tel: Camberley (0276) 685311.

The ZX Printer – available now

Designed exclusively for use with the Sinclair ZX range of computers, the printer offers ZX Spectrum owners the full ASCII character set – including lower-case characters and high-resolution graphics.

A special feature is COPY which prints out exactly what is on the whole TV screen without the need for further instructions. Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your ZX Spectrum. A roll of paper (65ft long and 4in wide) is supplied, along with full instructions. Further supplies of paper are available in packs of five rolls.

The ZX Microdrive – coming soon

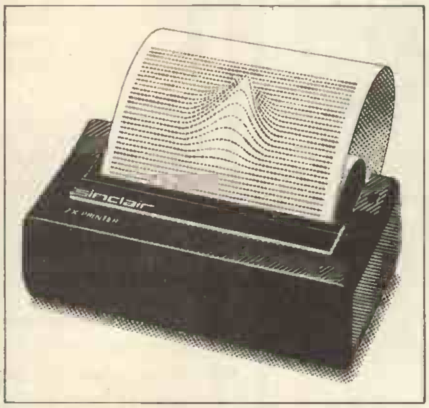
The new Microdrives, designed especially for the ZX Spectrum, are set to change the face of personal computing.

Each Microdrive is capable of holding up to 100K bytes using a single interchangeable microfloppy.

The transfer rate is 16K bytes per second, with average access time of 3.5 seconds. And you'll be able to connect up to 8 ZX Microdrives to your ZX Spectrum.

All the BASIC commands required for the Microdrives are included on the Spectrum.

A remarkable breakthrough at a remarkable price. The Microdrives are available later this year, for around £50.



How to order your ZX Spectrum

BY PHONE – Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day. BY FREEPOST – use the no-stamp needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option, of course. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research, FREEPOST, Camberley, Surrey, GU15 3BR. **Order**

Qty	Item	Code	Item Price £	Total £
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	Sinclair ZX Spectrum – 48K RAM version	101	175.00	
	Sinclair ZX Printer	27	59.95	
	Printer paper (pack of 5 rolls)	16	11.95	
	Postage and packing: orders under £100	28	2.95	
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			Total £	

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PLEASE PRINT

Name: Mr/Mrs/Miss

Address

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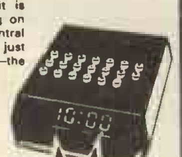
FREEPOST – no stamp needed. Prices apply to UK only. Export prices on application.

THE MULTI-PURPOSE TIMER HAS ARRIVED

Now you can run your central heating, lighting, hi-fi system and lots more with just one programmable timer. At your selection it is designed to control four mains outputs independently, switching on and off at pre-set times over a 7 day cycle, e.g. to control your central heating (including different switching times for weekends), just connect it to your system programme and set it and forget it—the clock will do the rest.



FEATURES INCLUDE:-

- 0.5" LED 12 hour display.
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(Kit includes all components, PCB, assembly and programming instructions).

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These kits contain all necessary components and full instructions & are designed to replace a standard wall switch and control up to 300w. of lighting.

TDR300K	Remote Control Dimmer	£14.30
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TDE/K	Extension kit for 2-way switching for TD300K	£ 2.00
LD300K	Rotary Controlled Dimmer	£ 3.50

MINI KITS

MK1 TEMPERATURE CONTROLLER/THERMOSTAT
Uses LM3911 IC to sense temperature (80°C max.) and triac to switch heater. 1KW £4.00

MK2 Solid State Relay
Ideal for switching motors, lights, heaters, etc. from logic. Opto-isolated with zero voltage switching. Supplied without triac £2.60

MK3 BAR/DOT DISPLAY
Displays an analogue voltage on a linear 10 element LED display as a bar or single dot. Ideal for thermometers, level indicators, etc. May be stacked to obtain 20 to 100 element displays. Requires 5-20V supply. £4.50

MK4 PROPORTIONAL TEMPERATURE CONTROLLER
Based on the SL441 zero voltage switch, this kit may be wired to form a "burst fire" power controller, enabling the temperature of an enclosure to be maintained to within 0.5°C. Max. load 3KW £5.56

MK5 MAINS TIMER
Based on the ZN1034E Timer IC this kit will switch a mains load on (or off) for a preset time from 20 mins. to 35 hrs. Longer or shorter periods may be realised by minor component changes. Max. load 1KW. £4.50

3-NOTE DOOR CHIME

Based on the SAB0600 IC the kit is suppied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 x 71 x 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete. AN IDEAL PROJECT FOR BEGINNERS.
Order as XK102. **£5.00**

For a detailed booklet on remote control – send us 30p & SAE today.

THE HOME CONTROL CENTRE

This New Remote Control Kit enables you to control up to 16 different appliances anywhere in the house from the comfort of your armchair. The transmitter injects coded pulses into the mains wiring which are received by receiver modules connected to the same mains supply and used to switch on the appliance addressed. Receivers are addressed by means of a 16-way keyboard, followed by an on or off command. Since pushing buttons can become rather boring, the transmitter also includes a computer interface so you can programme your favourite micro to switch lights, heating, electric blanket, make your coffee in the morning, etc. without rewiring your house. JUST THINK OF THE POSSIBILITIES. The KIT includes all PCBs and components for one transmitter and two receivers plus a pre-drilled box for the transmitter.

Order as XK112

£42.00

DISCO LIGHTING KITS

DL 1000K
This value-for-money kit features a bi-directional sequence, speed of sequence and frequency of direction change, being variable by means of potentiometers and incorporates a master dimming control. **Only £14.60**

DLZ100K
A lower cost version of the above, featuring undirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum. **Only £8.00**

Optional opto input DLA1 Allowing audio ("beat")—light response. **60p**

"OPEN-SESAME"

The XK103 is a general purpose infra-red transmitter/receiver with one momentary (normally open) relay contact and two latched transistor output. Designed primarily for controlling motorised garage doors and two auxiliary outputs for drive/garage lights at a range of up to 40 ft. The unit also has numerous applications in the home for switching lights, TV, closing curtains, etc. Ideal for aged or disabled persons.
The kit comprises a mains powered receiver, a four button transmitter, complete with pre-drilled box, requiring a 9V battery and one opto-isolated solid state switch kit for interfacing the receiver to mains appliances. As with all our kits, full instructions are supplied.

Only £23.75

Extra Solid State Switch Kits (XK104) and transmitters (XK105) can be supplied.

XK104 £2.40 XK105 £10.50

ALL PRICES EXCLUDE VAT

DVM/ULTRA SENSITIVE THERMOMETER KIT

This new design is based on the ICL7126 (a lower power version of the ICL7106 chip) and a 3½ digit liquid crystal display. This kit will form the basis of a digital multimeter (only a few additional resistors and switches are required—details supplied), or a sensitive digital thermometer (−50°C to +150°C) reading to 0.1°C. The basic kit has a sensitivity of 200mV for a full scale reading, automatic polarity indication and an ultra low power requirement—giving a 2 year typical battery life from a standard 9V PP3 when used 8 hours a day, 7 days a week. **£15.50**

REMOTE CONTROL KITS

MK6 SIMPLE INFRA RED TRANSMITTER
Pulsed infra red source complete with hand-held plastic box. Requires a 9V battery. £4.20

MK7 INFRA RED RECEIVER
Single channel, range approx. 20ft. Mains powered with a triac output to switch loads up to 500W at 240V ac. £9.00 (RC500K –Special Price for MK6 and MK7 together £12.50)

MK8 CODED INFRA RED TRANSMITTER
Based on the SL490, the kit includes all components to make a coded transmitter and only requires a 9V (PP3) battery. 8 x 2 x 1.3cms £5.90

MK10 16-WAY KEYBOARD
For use with MK8 and MK18 to generate 16 different codes for decoding by the ML928 or ML926 receiver (MK12) kit. £5.40

MK11 10-Channel + 3 Analogue o/p IR Receiver
Based on ML922 decoder IC. Functions include on/standby output, toggle, control of volume, tone and lamp brightness. Includes its own mains supply. £12.00

MK12 16-CHANNEL IR RECEIVER
For use with MK8 kit with 16 on/off outputs, which was further interface circuitry, such as relays or triacs, will switch up to 16 items of equipment on or off remotely. Latched or momentary outputs – please specify when ordering. Includes its own mains supply. £11.95

MK13 11-WAY KEYBOARD For use with MK8, MK18 and MK11 kits. £4.35

MK16 Mains Powered IR Transmitter
Mains powered for continuous operation – single channel, for applications such as burglar alarms, automatic door openers, etc. Range approx. 6 ft. £2.50

MK17 12V d.c. IR RECEIVER
For use with MK6 or MK16. Relay output with DP3 Amp change-over contacts, may be used as latched, momentary or "break beam" receiver. Operates from 6-13V d.c. £9.50

MK18 HIGH POWER IR TRANSMITTER
Similar to MK8 but with range of approx. 60ft. £6.20

Ancillary Kits : MK2 Solid State Relay
Opto-isolated with zero voltage switching. No. triac supplied. £2.60

MK15 DUAL LATCHED SOLID STATE RELAY
Comprises 2 x solid state relays and latch for use with momentary version of the MK12. 2 output triacs required (not supplied). £4.50

We have the SOFTY 2 EPROM programmer in stock at £169

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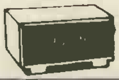

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40251	2.77
40254	2.75
40264	2.63
40280	2.00
40290	2.00
40309	1.80
40311	97p
40312	1.64
40313	1.83
40315	1.94
40316	95p
40360	60p
40361	67p
40362	67p
40363	2.22
40364	2.90
40372	4.80
40373	2.60
40374	2.84
40406	1.39
40407	75p
40408	1.59
40410	1.80
40411	2.85
40412	90p
40594	99p
40595	99p
40600	2.58
40601	2.36
40602	1.68
40603	1.09
40604	1.85
40606	2.44
40637	2.00
40643	1.90
40673	83p
40822	1.80
40871	89p
40872	89p
AC125	35p
AC126	25p
AC127	25p
AC128	25p
AC132	39p
AC151	51p
AC152	45p
AC153	55p
AC153K	64p
AC176	27p
AC176K	37p
AC187	25p
AC187K	28p
AC188	25p
AC188K	40p
ACY17	70p
AD136	7.90
AD145	1.65
AD149	79p
AD150	1.31
AD161	39p
AD162	39p
AF106	75p
AF109	75p
AF114	65p
AF117	70p
AF118	89p
AF124	72p
AF125	72p
AF126	72p
AF130	53p
AF170	88p
AF172	88p
AF178	88p
AF200	65p
AF201	75p
AF239	1.24
AF240	1.00
AF279B	75p
AF279G	75p
AL102	3.48
AU110	2.20
AU113	2.30
BC107	10p
BC107A	12p
BC107B	12p
BC108	10p
BC108A	12p
BC108B	12p
BC108C	14p
BC109	10p
BC109B	12p
BC109C	12p
BC113	30p
BC140	29p
BC141	37p
BC142	29p
BC143	34p
BC147	10p
BC147A	10p
BC147B	10p
BC147C	20p
BC148	10p
BC148A	12p
BC148B	13p
BC148C	13p
BC149	10p
BC149B	12p
BC149C	13p
BC152	35p
BC153	23p
BC154	27p
BC157	11p
BC157A	12p
BC157B	13p
BC158	10p
BC158A	12p
BC158B	13p
BC159	11p
BC159A	12p
BC159B	13p
BC159C	18p
BC160	42p
BC161	48p
BC167	10p
BC167A	10p

BC167B	13p
BC168	10p
BC168B	10p
BC168C	10p
BC169	10p
BC169B	10p
BC169C	10p
BC170	15p
BC170A	17p
BC170B	17p
BC170C	18p
BC171	12p
BC171A	15p
BC171B	15p
NC172	12p
BC172A	15p
BC172B	15p
BC172C	16p
BC173	11p
BC173B	16p
BC173C	16p
BC174	11p
BC174A	14p
BC174B	14p
BC175	15p
BC177	16p
BC177A	15p
BC177B	16p
BC178	16p
BC178A	24p
BC178B	25p
BC179	20p
BC179A	25p
BC179A	25p
BC179B	25p
BC179C	27p
BC182	10p
BC182A	12p
BC182B	13p
BC182L	10p
BC182L	13p
BC182L	14p
BC183	10p
BC183A	11p
BC183B	12p
BC183C	13p
BC183L	10p
BC183LA	13p
BC183LB	13p
BC183LC	14p
BC184	10p
BC184B	12p
BC184C	13p
BC184L	10p
BC184LB	13p
BC184LC	14p
BC186	24p
BC187	24p
BC212	10p
BC212A	12p
BC212B	13p
BC212L	10p
BC212LA	13p
BC212LB	14p
BC213	10p
BC213A	11p
BC213B	12p
BC213C	13p
BC213L	10p
BC213LA	13p
BC213LB	13p
BC213LC	14p
BC214	10p
BC214B	12p
BC214C	13p
BC214L	10p
BC214LB	13p
BC214LC	14p
BC237	14p
BC237A	16p
BC237B	17p
BC237C	18p
BC238	14p
BC238A	15p
BC238B	16p
BC238C	17p
BC239	15p
BC239A	16p
BC239B	17p
BC239C	18p
BC300	45p
BC301	44p
BC302	43p
BC303	47p
BC304	46p
BC307	13p
BC307A	14p
BC307B	15p
BC308	12p
BC308A	13p
BC308B	14p
BC309	14p
BC309A	15p
BC309B	16p
BC309C	17p
BC317	15p
BC318	15p
BC320	25p
BC321	25p
BC327	14p
BC328	14p
BC337	15p
BC338	15p
BC347	20p
BC350	20p
BC382	30p
BC382L	30p
BC383	30p
BC383L	30p
BC384	30p
BC384L	30p
BC407	30p
BC408	24p
BC409	30p
BC413	25p
BC414	25p
BC415	30p
BC416	30p
BC418	30p
BC440	32p
BC441	33p
BC460	32p

BC461	33p
BC478	29p
BC479	30p
BC516	40p
BC517	40p
BC547	13p
BC547A	14p
BC547B	14p
BC548	12p
BC548A	13p
BC548B	14p
BC548C	15p
BC549	13p
BC549B	14p
BC549C	15p
BC550	30p
BC550C	33p
BC557	15p
BC557A	16p
BC557B	15p
BC558	14p
BC558A	15p
BC558B	16p
BC558C	17p
BC559	15p
BC559B	16p
BC559C	17p
BC560	32p
BC560C	34p
BCY30	1.15
BCY30A	1.30
BCY31	1.15
BCY31A	1.30
BCY32	1.15
BCY32A	1.30
BCY33	90p
BCY33A	1.00
BCY34	90p
BCY34A	90p
BCY54	1.91
BCY58	32p
BCY59	33p
BCY66	1.80
BCY67	2.00
BCY70	16p
BCY71	16p
BCY72	19p
BCY77	34p
BCY78	22p
BCY79	22p
BCY87	6.60
BCY88	4.30
BCY89	4.10
BCZ10	4.60
BCZ11	4.60
BD115	58p
BD116	2.50
BD121	2.25
BD124	1.50
BD131	44p
BD132	44p
BD135	40p
BD136	40p
BD137	42p
BD138	39p
BD139	39p
BD140	39p
BD142	2.40
BD153	1.25
BD155	1.20
BD157	54p
BD158	55p
BD160	3.80
BD181	1.75
BD182	2.50
BD183	2.70
BD187	1.09
BD201	1.30
BD202	1.39
BD204	1.44
BD220	1.00
BD221	95p
BD223	1.00
BD224	95p
BD232	1.11
BD233	70p
BD234	72p
BD237	58p
BD238	58p
BD239A	57p
BD239C	64p
BD240	59p
BD240C	73p
BD241A	60p
BD241C	67p
BD242A	65p
BD242C	70p
BD243A	72p
BD243C	85p
BD244A	82p
BD244C	1.00
BD245A	1.14
BD245C	1.30
BD246A	1.20
BD246C	1.50
BD249A	2.00
BD249C	2.31
BD250A	2.11
BD250C	2.46
BD433	79p
BD434	55p
BD435	81p
BD436	81p
BD437	88p
BD438	88p
BD439	90p
BD440	91p
BD441	91p
BD442	93p
BD529	1.20
BD530	1.30
BD535	75p
BD536	75p
BD537	80p
BD538	80p
BD539	80p
BD539C	1.10
BD540	85p
BD540C	1.20
BD675	72p
BD676	77p
BD677	78p

BD678	83p
BD711	1.32
BD712	1.32
BDX14	1.20
BDX18	1.59
BDX32	3.47
BDY10	2.00
BDY11	2.50
BDY17	2.00
BDY23	3.40
BDY25	3.75
BDY38	1.74
BDY54	1.70
BDY55	1.75
BDY56	1.80
BDY57	5.25
BDY58	6.15
BDY60	1.60
BDY61	2.30
BDY62	2.34
BDY92	3.75
BF115	35p
BF119	1.00
BF121	75p
BF123	70p
BF127	80p
BF153	38p
BF154	25p
BF157	80p
BF158	25p
BF159	58p
BF160	55p
BF161	58p
BF163	50p
BF166	57p
BF167	29p
BF170	79p
BF173	25p
BF174	77p
BF177	25p
BF178	30p
BF179	35p
BF180	35p
BF181	36p
BF182	36p
BF183	38p
BF184	36p
BF185	37p
BF194	12p
BF195	12p
BF196	12p
BF197	12p
BF198	15p
BF199	15p
BF200	1.49
BF224J	32p
BF225J	35p
BF240	38p
BF241	38p
BF244A	35p
BF244B	39p
BF245A	30p
BF245B	51p
BF246	52p
BF246A	39p
BF246B	53p
BF247A	54p
BF247B	55p
BF254	39p
BF255	42p
BF256A	25p
BF256B	45p
BF256C	62p
BF257	30p
BF258	32p
BF259	35p
BF262	90p
BF263	90p
BF270	65p
BF271	68p
BF273	40p
BF274	40p
BF324	38p
BF336	36p
BF337	28p
BF338	48p
BF355	60p
BF362	85p
BF363	85p
BF457	46p
BF458	56p
BF459	82p
BF469	86p
BF470	86p
BFR39	25p
BFR40	25p
BFR41	25p
BFR79	25p
BFR80	25p
BFR81	25p
BFR90	2.11
BFS28	2.95
BFS61	1.00
BFS98	1.10
BFT19	1.65
BFT19B	1.88
BFT66	2.48
BFW10	1.48
BFW10	1.48
BFW11	1.48
BFW43	2.47
BFW59	1.08
BFW87	1.53
BFW90	1.53
BFX12	1.00
BFX13	91p
BFX19	50p
BFX20	80p
BFX29	26p
BFX30	27p
BFX34	1.00
BFX37	70p
BFX43	70p
BFX68	1.00
BFX84	27p
BFX85	28p
BFX86	28p
BFX87	25p
BFX88	26p
BFX89	1.75
BFY18	48p
BFY19	1.10

BFY37	1.20
BFY39	50p
BFY41	1.16
BFY50	23p
BFY51	23p
BFY52	23p
BFY53	31p
BFY56	31p
BFY56A	68p
BFY75	75p
BFY76	50p
BFY77	80p
BFY78	80p
BFY90	79p
BSV81	1.87
BSW41	95p
BSW67	1.00
BSW70	1.00
BSX19	24p
BSX20	20p
BSX21	40p
BSX26	34p
BSX27	78p
BSX28	56p
BSX29	34p
BSX39	80p
BSX60	75p
BSX61	80p
BSX76	50p
BSX77	55p
BSY24	77p
BSY25	1.00
BSY26	35p
BSY29	70p
BSY39	47p
BSY54	40p
BSY65	55p
BSY95A	25p
BU104	2.22
BU105	1.70
BU109	3.29
BU126	1.47
BU204	2.25
BU205	1.75
BU206	1.89
BU208	1.98
BU326S	2.35
BU406	1.45
BU407	1.45
BU408	4.35
BU409	1.25
BU500	2.95
BUY20	11.00
BUY21	10.90
BUY23	13.60
BUY24	12.10
BUY25	15.00
BUX20	17.00
BUY18S	3.95
E430	5.60
J300	48p
J310	53p
MA8001	45p
MA8002	62p
MA8003	39p
MD7000	2.60
ME0401	25p
ME0402	30p
ME0404	25p
ME0411	35p
ME0412	35p
ME0413	35p
ME0414	48p
ME0461	45p
ME0462	45p
ME1001	45p
ME1002	45p
ME1075	45p
ME1100	45p
ME1120	48p
ME3002	25p
ME4001	45p
ME4002	45p
ME4003	45p
ME4101	25p
ME4102	25p
ME4013	25p
ME4104	25p
ME6001	25p
ME6002	25p
ME6003	25p
ME6101	25p
ME6102	28p
MJ481	1.69
MJ491	1.72
MJ802	3.99
MJ900	2.90
MJ901	3.10
MJ1000	2.50
MJ1001	3.00
MJ1800	3.60
MJ2500	2.19
MJ2501	2.25
MJ2955	1.00
MJ3000	2.19
MJ3001	2.25
MJ3701	2.55
MJ4502	3.99
MJE340	53p
MJE370	97p
MJE371	99p
MJE520	92p
MJE521	94p
MJE2955	99p
MJE3055	69p
MJE3739	4.58
MP8111	1.00
MP8112	1.39
MP8121	1.35
MP8122	1.40
MP8123	1.16
MP8512	1.59
MPF102	39p
MPF103	29p
MPF104	29p
MPF105	29p
MPF112	59p
MPSA05	23p
MPSA06	25p
MPSA10	28p
MPSA12	29p
MPSA13	48p

MPSA14	45p
MPSA16	30p
MPSA18	65p
MPSA20	48p
MPSA42	49p
MPSA43	49p
MPSA55	28p
MPSA56	30p
MPSA65	40p
MPSA66	47p
MPSA70	45p
MPSA92	39p
MPSA93	39p
MPSL01	42p
MPSL51	48p
MPSU01	94p
MPSU04	1.22
MPSU05	55p
MPSU06	56p
MPSU07	75p
MPSU51	96p
MPSU55	58p
MPSU56	59p
MPSU57	1.20
MAF421	poa
MFR450A	poa
MRF453	poa
MRF454	poa
MRF475	7.56
MRF477	poa
MRF479	poa
MRF604	poa
OC20	2.30
OC22	2.00
OC23	2.00
OC25	2.50
OC28	1.70
OC29	2.35
OC35	2.36
OC41	80p
OC43	70p
OC44	82p
OC70	50p
OC71	50p
OC72	50p
OC82	50p
OC82D	70p
OC83	75p
P346A	58p
R2008B	2.14
R2010B	1.88
SC107	27p
SC108	27p
SC109	27p
TIP29A	32p
TIP29C	38p
TIP30A	35p
TIP30C	38p
TIP31A	38p
TIP31C	39p
TIP32A	38p
TIP32C	42p
TIP33A	65p
TIP33C	78p
TIP34A	74p
TIP34C	88p
TIP35A	1.09
TIP35C	1.28
TIP36A	1.29
TIP36C	1.39
TIP41A	49p
TIP41C	55p
TIP42A	55p
TIP42C	65p
TIP49	1.20
TIP50	1.40
TIP53	1.57
TIP54	1.59
TIP110	74p
TIP112	90p
TIP115	81p
TIP117	96p
TIP120	69p
TIP122	73p
TIP125	1.20
TIP127	1.27
TIP130	1.50
TIP132	1.60
TIP135	1.60
TIP137	1.60
TIP140	1.04
TIP142	1.04
TIP145	1.19
TIP147	1.19
TIP2955	77p
TIP3055	70p
TIS37	62p
TIS43	40p
VN10KM	60p
VN46AF	84p
VN66AF	85p
ZTX107	10p
ZTX108	10p
ZTX109	10p
ZTX300	13p
ZTX301	15p
ZTX302	15p
ZTX303	23p
ZTX304	15p
ZTX310	35p
ZTX311	32p
ZTX312	35p
ZTX313	36p
ZTX314	24p
ZTX320	35p
ZTX330	35p
ZTX341	28p
ZTX500	14p
ZTX501	14p
ZTX502	14p
ZTX503	17p
ZTX504	24p
ZTX510	34p
ZTX530	24p
ZTX531	25p

LINEAR ICs

AN103	2.20
AY1-0212	6.80
AY3-0215	7.95
AY1-1320	2.20
AY1-5050	95p
AY1-1270	7.28
AY3-8910	5.39
AY3-8912	5.59
AY5-2376	5.89
CA3000	4.80
CA3001	4.95
CA3002	4.60
CA3005	3.15
CA3007	4.82
CA3010	1.30
CA3012	1.75
CA3013	4.12
CA3014	2.35
CA3015	2.62
CA3018	75p
CA3018A	2.00
CA3020	2.00
CA3020A	3.90
CA3021	3.20
CA3022	3.12
CA3026	1.52
CA3028A	1.21
CA3028B	2.53
CA3029	1.44
CA3030A	2.97
CA3033	5.44
CA3034	5.18
CA3035	2.715
CA3039	1.50
CA3041	3.47
CA3042	3.47
CA3043	3.92
CA3046	69p
CA3047	4.60
CA3048	2.98
CA3049	3.21
CA3050	4.11
CA3051	3.80
CA3052	2.82
CA3053	1.00
CA3054	1.66
CA3059	2.80
CA3060	4.09
CA3062	13.84
CA3065E	4.62
CA3068	4.23
CA3070	3.20
CA3071	3.30
CA3075	2.25
CA3076	3.42
CA3078T	2.25
CA3080	1.89
CA3080A	3.95
CA3080E	70p
CA3081	1.90
CA3085	1.35
CA3086	56p
CA3088E	2.35
CA3089E	1.95
CA3090AQ	3.70
CA3130E	87p
CA3130T	1.80
CA3140E	39p
CA3140T	85p
HA1366W	2.40
HA1388	2.54
ICL7106	7.40
ICL7107	9.50
ICL8038	2.99
ICM7555	80p
LC7120	3.20
LC7130	3.20
LF351	47p
LF353	82p
LF355	83p
LF356	92p
LF357	1.00
LF13201	2.98
LF13331	3.30
LF13741H	68p
LF13641N	58p
LM10CH	4.25
LM11CH	4.50
LM114	6.75
LM137K	11.52
LM301AH	1.00
LM301AN	25p
LM305AH	2.90
LM305H	88p
LM307H	1.05
LM307N	55p
LM308AH	3.16
LM308AN	2.14
LM308H	95p
LM308N	88p
LM309K	2.80
LM310H	1.95
LM310N	1.89
LM311H	1.04
LM311N	70p
LM317K	2.80
LM317MP	1.04
LM318H	2.40
LM318N	1.49
LM319H	2.46
LM319N	2.10
LM320 – See 79XX Series Volt Regulators	
LM324N	29p
LM337K	4.75
LM337MP	1.65
LM337T	1.99
LM339AN	1.60
LM339N	47p
LM340 – See 78XX Series Volt Regulators	
LM345K	3.60
LM348N	62p
LM349N	1.15
LM350K	4.00
LM359N	1.44
LM360N	3.88
LM376N	65p
LM377N	1.69
LM378N	3.40
LM379S	4.79
LM380N14	75p
LM380N8	1.50

LM381AN	2.28
LM381N	1.40
LM382N	1.12
LM383T	3.40
LM384N	1.40
LM386N1	85p
LM386N4	1.20
LM388N	2.43
LM391N60	1.70
LM391N80	1.83
LM392N	75p
LM393N	94p
LM394H	3.80
LM396K	13.52
LM709N8	64p
LM709CH	1.00
LM710CH	89p
LM710CN	52p
LM711CH	1.38
LM711CN	70p
LM723CH	1.21
LM723CN	40p
LM725CH	3.40
LM725CN	3.19
LM733CN	77p
LM741CH	94p
LM741CN	15p
LM741CN14	80p
LM747CN	69p
LM748CH	1.00
LM748CN	35p
LM1303N	1.20
LM1304N	2.50
LM1305N	3.10
LM1307N	2.75
LM1310N	1.45
LM1330N	2.25
LM1458	44p
LM1496	1.08
LM1800	3.24
LM1801	2.99
LM1812	8.00
LM1818	2.99
LM1820	2.15
LM1828	4.79
LM1830	2.44
LM1845	4.12
LM1848	2.89
LM1850	2.75
LM1871	4.39
LM1872	4.39
LM1886	7.44
LM1889	3.77
LM2907N	2.75
LM2907N8	2.60
LM2917N	1.89
LM2917N8	1.89
LM3524	6.77
LM3301	1.00
LM3302	74p
LM3401	85p
LM3403	75p
LM3405	1.45
LM3900	48p
LM3905	1.25
LM3908	79p
LM3911	1.20
LM3914	1.79
LM3915	1.99
LM3916	2.19
LM4250CN	2.63
LM4250N	2.39
LM13600	1.09
MB3712	1.99
MB3756	3.80
MB8719	7.95
MC1352	1.75
MC1456	1.80
MC3340	1.46
MOST MC Prefix = LM Prefix	
NE531N	1.36
NE543N	2.50
NE544N	1.50
NE555	16p
NE556	46p
NE558	1.89
NE560	3.25
NE562	4.09
NE565	1.18
NE566	1.49
NE567	1.37
NE570	3.75
NE571	3.75
NE5534	1.49
PLL02A	4.85
PLL03A	12.75
RC4136	59p
SS66B	2.59
SAD1024A	8.49
SAS560	2.59
SAS570	2.59
SAS580	2.59
SAS590	2.59
SFF96364	7.99
SL610C	4.00
SL611C	4.00
SL612C	4.00
SL620C	6.00
SL621C	6.00
SL623C	10.00
SL630C	6.00
SL640C	6.00
SL641C	6.00
SN76001N	2.80
SN76008	3.80
SN76477	4.49
SN76488	4.49
SN76550	80p
SN76666	2.90
SO41P	1.60
SO42P	1.60
TA7210	1.49
TA7204	1.95
TA7205	89p
TA7222	1.45
TA7310	1.49
TAA263	1.50
TAA300	3.95
TAA320	2.05
TAA350	3.60
TAA521	1.50
TAA522	2.47
TAA550	73p
TAA560	2.35
TAA570	2.35
TAA621AX1	2.75
TAA661A	1.50

TAA661B	1.70
TAA700	2.00
TAA930	2.50
TAA930B	2.63
TAA970	2.45
TAA991D	2.45
TAD100	2.00
TBA120AS	75p
TBA331	1.50
TBA341	2.05
TBA395	1.65
TBA396	1.50
TBA450	1.95
TBA460	1.53
TBA500	2.87
TBA500Q	3.11
TBA510	2.96
TBA510Q	3.06
TBA520	2.57
TBA520Q	2.75
TBA530	2.56
TBA530Q	2.76
TBA540	2.72
TBA540Q	2.74
TBA550	3.25
TBA550Q	3.27
TBA560Q	2.87
TBA570	2.37
TBA570Q	2.48
TBA581	3.11
TBA641	3.00
TBA651	1.90
TBA673	4.15
TBA700	2.38
TBA700Q	2.47
TBA720AQ	2.60
TBA750	2.25
TBA750Q	2.46
TBA790A	2.11
TBA800	78p
TBA810	95p
TBA820	75p
TBA820M	75p
TBA920	1.95
TBA920Q	1.97
TBA950	2.25
TBA990	2.65
TBA990Q	2.74
TCA105	3.00
TCA160C	2.87
TCA220	3.44
TCA270	2.44
TCA440	2.20
TCA450	2.68
TCA640	4.15
TCA650	4.15
TCA660B	4.15
TCA730	4.80
TCA740	4.80
TCA750	4.85
TCA760	2.75
TCA800	3.50
TCA800Q	3.60
TCA830S	1.90
TCA910	2.19
TCA940	1.69
TDA1002	3.39
TDA1003	3.94
TDA1004	2.87
TDA1005	3.94
TDA1010A	2.25
TDA1022	4.95
TDA1024	1.19
TDA1034	3.20
TDA2020	2.99
TDA2030	2.85
TDA2522	4.20
TDA2530	3.30
TDA2540	4.10
TDA2541	4.10
TDA2560	4.10
TDA2571	4.40
TDA2581	3.75
TDA2590	5.20
TDA2591	4.73
TDA2600	6.15
TDA2610	3.90
TDA2611A	2.50
TDA2640	3.64
TDA3000	2.76
TL061	40p
TL062	80p
TL064	99p
TL071	36p
TL072	50p
TL074	1.30
TL081	50p
TL082	75p
TL083	85p
TL084	89p
TL170	49p
TL430	69p
UAA170	1.69
UAA180	1.69
ULN2003	85p
UPC575C2	2.65
UPC1156	2.76
UPC1181	8.75
UPC1182	2.99
UPC1185	6.45
XR2206	2.92
XR2207	3.75
KR4212	1.83
ZN414	79p
ZN418	2.25
ZN1034	1.99
ZN1040	6.69
ZTK22	85p
ZTK33	85p

TTL

7400	10½p
7401	11p
7402	11p
7403	12p
7404	12p
7405	15p
7406	20p
7407	20p
7408	14p
7409	14p
7410	14p
7411	16p
7412	18p
7413	10p
7414	25p
7416	20p
7417	20p
7420	15p
7421	20p
7422	20p
7423	20p
7425	24p
7426	28p
7427	22p
7428	26p
7430	14p
7432	22p
7433	22p
7437	25p
7438	25p
7440	15p
7441	65p
7442	22p
7443	90p
7444	80p
7445	80p
7446	80p
7447	40p
7448	44p
7450	75p
7451	15p
7453	15p
7454	14p
7460	15p
7470	34p
7472	25p
7473	24p
7474	20p
7475	25p
7476	28p
7480	48p
7481	1.19
7482	80p
7483	38p
7484	69p
7485	60p
7486	20p
7489	2.20
7490	20p
7491	25p
7492	25p
7493	25p
7494	25p
7495	25p
7496	40p
7497	80p
74100	80p
74104	50p
74105	55p
74107	22p
74109	25p
74110	35p
74116	50p
74118	59p
74119	80p
74120	59p
74121	25p
74122	40p
74123	40p
74125	35p
74126	34p
74128	25p
74132	29p
74136	20p
74141	55p
74142	1.99
74143	2.48
74144	2.10
74145	80p
74147	80p
74148	70p
74150	49p
74151	40p
74153	40p
74154	40p
74155	40p
74156	40p
74157	30p
74159	75p
74160	60p
74161	48p
74162	48p
74163	48p
74164	48p
74165	48p
74166	48p
74170	1.25
74172	2.75
74173	60p
74174	54p
74175	49p
74176	39p
74177	45p
74178	79p
74180	40p
74181	1.15
74182	80p
74184	90p
74185	90p
74186	4.69
74188	2.50
74190	48p
74191	48p
74192	45p
74193	45p
74194	45p
74195	46p
74196	45p
74197	40p
74198	83p
74199	83p
74221	53p

74LS TTL

74LS00	11p
74LS01	11p
74LS02	11p
74LS03	12p
74LS04	12p
74LS05	12p
74LS08	12p
74LS10	12p
74LS11	12p
74LS12	12p
74LS13	18p
74LS14	30p
74LS15	12p
74LS20	12p
74LS21	12p
74LS22	12p
74LS27	12p
74LS28	14p
74LS30	12p
74LS32	13p
74LS33	14p
74LS37	14p
74LS38	15p
74LS40	13p
74LS42	28p
74LS47	35p
74LS51	14p
74LS54	14p
74LS56	14p
74LS73	18p
74LS74	18p
74LS75	20p
74LS76	20p
74LS78	18p
74LS80	1.20
74LS83	36p
74LS85	48p
74LS86	16p
74LS90	24p
74LS92	25p
74LS93	24p
74LS95	20p
74LS96	24p
74LS107	20p
74LS109	27p
74LS112	22p
74LS113	22p
74LS114	22p
74LS122	24p
74LS123	24p
74LS124	89p
74LS125	24p
74LS126	25p
74LS132	39p
74LS136	28p
74LS138	32p
74LS139	30p
74LS145	70p
74LS147	1.57
74LS148	75p
74LS151	20p
74LS153	20p
74LS154	79p
74LS155	29p
74LS156	36p
74LS157	27p
74LS158	25p
74LS160	35p
74LS161	35p
74LS162	35p
74LS163	35p
74LS164	40p
74LS165	80p
74LS168	84p
74LS169	85p
74LS170	70p
74LS173	55p
74LS174	46p
74LS175	39p
74LS181	50p
74LS183	1.78
74LS190	36p
74LS191	36p
74LS192	36p
74LS193	37p
74LS194	32p
74LS195	32p
74LS196	45p
74LS197	48p
74LS221	50p
74LS240	55p
74LS241	55p
74LS242	55p
74LS243	55p
74LS244	60p
74LS245	70p
74LS247	50p
74LS248	55p
74LS249	55p
74LS251	30p
74LS253	32p
74LS267	35p
74LS268	35p
74LS259	55p
74LS261	1.35
74LS266	18p
74LS273	60p
74LS275	2.25
74LS279	30p
74LS280	1.60
74LS283	40p
74LS289	4.70
74LS290	45p
74LS293	40p
74LS295	86p
74LS298	86p
74LS299	2.50
74LS323	1.76
74LS324	1.45
74LS325	2.96
74LS326	2.36
74LS327	2.30
74LS347	95p
74LS348	1.00
74LS352	79p
74LS353	79p
74LS362	7.25
74LS365	29p
74LS366	25p
74LS367	29p
74LS368	29p
74LS373	54p
74LS378	58p
74LS386	1.14
74LS390	46p
74LS393	42p
74LS395	80p
74LS395	1.90
74LS398	2.70
74LS399	1.50
74LS445	90p
74LS490	2.20
74LS540	77p
74LS541	90p
74LS640	1.60
74LS641	1.00
74LS643	2.25
74LS644	2.75
74LS668	1.18
74LS669	1.20
74LS670	1.40
74LS673	5.50
74LS674	9.99

74C CMOS/TTL

74C00	27p
74C04	29p
74C10	28p
74C14	89p
74C20	28p
74C30	35p
74C42	96p
74C48	1.40
74C73	64p
74C76	57p
74C83	1.74
74C85	1.34
74C86	1.10
74C89	5.95
74C90	1.05
74C93	1.44
74C95	1.00
74C107	60p
74C151	2.55
74C154	4.95
74C157	2.20
74C160	1.54
74C161	1.15
74C162	1.16
74C163	65p
74C164	1.15
74C165	2.00
74C173	90p
74C174	65p
74C175	75p
74C192	89p
74C193	68p
74C194	89p
74C195	70p
74C200	10.00
74C221	1.20
74C901	1.91
74C902	71p
74C903	2.30
74C904	1.84
74C905	10.88
74C907	1.91
74C908	1.87
74C911	9.59
74C912	8.00
74C914	2.88
74C915	1.99
74C918	2.50
74C9200	8.50
74C922	4.50
74C923	5.00
74C925	6.00
74C926	6.58
74C928	5.00
74C929	5.20
74C930J	7.80
74C932	3.12

COMPUTER ICs

CPUs

1802	7.00
2650A	11.98
6502	3.24
6800	2.74
6802	2.69
6808	8.50
8036	3.49
8060	10.90
8060A	2.79
8086A	3.49
8900	57.75
8980	21.00
SCMP1	17.06
Z80A	2.96

MEMORIES

1702A	3.50
2101	4.00
2102AL2	1.35
2111-1	3.00
2114 (200ns)	80p
2532	3.60
2708	2.25
2716 (5V)	2.11
4027	3.00
4044	7.00
4080	9.50
4116 (200ns)	75p
4118-3	3.25
4164	4.50
5204	7.80
6116	4.40
6514	3.30
6810	1.15
7480	4.20
74189	4.00
74LS288	3.25
74S188	2.25
74S287	3.05
74S288	2.25

40 CMOS

4000	10p	4044	41p
4001	10p	4045	99p
4002	11p	4046	44p
4006	40p	4047	39p
4007	15p	4048	39p
4008	32p	4049	22p
4009	24p	4050	23p
4010	10p	4051	44p
4011	10p	4052	45p
4012	15p	4053	45p
4013	20p	4054	79p
4014	46p	4055	83p
4015	58p	4056	80p
4016	20p	4059	4.35
4017	32p	4060	42p
4018	46p	4063	79p
4019	26p	4066	22p
4020	44p	4067	2.48
4021	39p	4068	14p
4022	46p	4069	13p
4023	12p	4070	13p
4024	32p	4071	13p
4025	12p	4072	13p
4026	75p	4073	13p
4027	20p	4075	13p
4028	29p	4076	46p
4029	29p	4077	13p
4030	14p	4078	13p
4031	1.19	4081	12p
4032	80p	4082	12p
4033	1.20	4085	49p
4034	1.29	4086	53p
4035	50p	4089	1.50
4036	2.40	4093	20p
4037	1.30	4094	69p
4038	50p	4095	64p
4039	2.80	4096	90p
4040	46p	4097	2.88
4041	40p	4098	74p
4042	39p	4099	90p
4043	46p		

For higher numbers in 40 Series, substitute 74C for 40 prefix, e.g. 40107 = 74C107

45 CMOS

4502	59p
4503	29p
4507	33p
4508	1.19
4510	35p
4511	48p
4512	39p
4514	1.17
4515	1.17
4516	59p
4518	39p
4519	29p
4520	45p
4521	99p
4526	59p
4527	59p
4528	46p
4532	69p
4534	[illegible]
4536	[illegible]
4538	[illegible]
[illegible]	99p
[illegible]	65p
[illegible]	2.25
4555	36p
4556	35p
4560	1.49
4566	1.49
4569	1.59
4584	39p
4585	79p

ZERO INSERTION DIL SOCKETS

24 pin	4.80
40 pin	5.20

LOGIC ICs including COMPUTER SUPPORT

ADC0800	22.50	81LS95	90p
ADC0816	14.90	81LS96	1.20
ADC0817	10.06	81LS97	90p
AYS-2376	6.90	81LS98	1.20
ICM7555	80p	6522	3.19
INS1671	20.00	6532	8.85
INS1771	20.00	6821	1.12
INS1791	20.00	6845	10.00
MC1466L	6.50	6847	10.00
MC1488	85p	6850	1.35
MC1489	85p	6852	2.48
MC4024	3.25	6875	4.85
MC4044	3.25	8131	3.75
MK50250	30.00	8154	8.42
MK50398	8.95	8155	3.50
MM5303	6.25	8212	1.10
MM5307	12.75	8216	1.00
MM5357	22.50	8223	1.90
MM57106	14.00	8224	1.10
MM57109	12.00	8226	2.80
MM57160	9.00	8228	2.50
MM57161	9.00	8238	6.75
MM58174	11.80	8243	4.88
RO2513LC	5.99	8250	8.65
RO2513UC	7.50	8251	3.15
SAA5000	3.00	8253	7.95
SAA5010	7.10	8254	10.00
SAA5012	7.10	8255	2.48
SAA5020	5.50	8257	4.00
SAA5030	9.00	8258	4.00
SAA5040	15.00	8278	4.40
SAA5041	15.00	8304	4.50
SAA5050	8.50	8544	1.50
SAA5052	8.80	8601	1.20
TMS6011	3.65	8678CABN	19.50
ULN2003A	85p	8832	2.90
8T26	1.36	8833	2.25
8T28	1.36	9097	3.00
8T95	1.36	9099	3.00
8T97	1.36	9601	5.50
		9602	2.50
		Z80ACTC	2.65
		Z80ADART	8.00
		Z80ADMA	10.00

PE VOLUME 18 No. 11 NOVEMBER 1982

FIRST STEPS

The microprocessor has now been with us for many years although few have been used in projects for the hobbyist. Perhaps this is because their use has often been a more expensive solution than smaller chips in any given project, except perhaps the "hobby computer". Well, PE did its bit for computing with the publication of the Compukit UK101 design back in '78 and of course we have published various projects using dedicated micros. The PE *Bandbox, Car Computer, Robots* and *Telectric* being shining examples that are going strong on the retail market. However, the big breakthrough that microprocessors promised has been slow in coming to the hobbyist, until now!

This month we take the first of a series of steps to put that right. No, we are not going to expand our computer projects (even though the amazing *Ultimum Interface* system starts in this issue). What we hope to achieve is the use of micros to expand the range and sophistication of our projects without necessarily making them more expensive or more difficult to build.

We have decided that it's high time the micro is used as a "regular" component by the hobbyist and high time that hobbyists understand the devices more fully. With this in mind we are launching *Micro-file* in this issue. This file system will consist of a pull out section, in the centre of each issue, describing a wide range of microprocessors. The section can be extracted from the issue and filed for easy reference.

The first *Micro-file* consists of an introductory four page article, which will form the covers of the file, plus the first Datasheet and backup article on the 8080A/8085A. Each month we will present a Datasheet plus back up information on a different chip, so that over a period of about a year the sheets will form into a file packed with data on all the popular microprocessors. A file full of valuable information that will enable the hobbyist to choose and use microprocessor chips in dedicated applications.

CONTROL

In addition to *Micro-file* we are also proud to present the *Microcontroller*, which is not a project in the truest sense: the boards come ready built at an unbelievable price! What we have done is commission Mike Tooley and David Whitfield to unravel the intricacies of the unit and write a monitor program for it, so that the hardware can be used as a "universal controller".

What we want you to do is to let us know how you have applied the unit (maybe to a robot, central heating or overall house electrical management system etc.) so that we can interest others in doing something similar. To encourage readers to do this, Display Electronics (the *Microcontroller* suppliers) are running a competition for *Microcontroller* uses and PE will publish any suitable winning entries — and pay for them of course! So here's your chance to obtain and use a micro system in a control application at a very low price and maybe reap a reward for your ideas.

We believe the time of the dedicated micro has now come for the hobbyist in a big way. We intend to provide the necessary information and more, exciting projects as the months go by.

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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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Binders for PE are available from the same address as back numbers at £4·60 each to UK or overseas addresses, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

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

...NEWS &

New Computer Systems

The Dragon 32 micro computer is just one of five new systems which have been launched this month. The others include the Micro 8 from the Japanese mainframe giant Fujitsu, the latest Colour Genie from Lowe Electronics and from two new companies, ORIC I and Jupitor Ace.

Based around the 6809E microprocessor the Dragon 32 has 32K of RAM, extended microsoft basic, eight graphic pages from 512 text points to 49,152 points, nine colours and a five octave range for both music and speech synthesis. The unit is available from Dragon Data Ltd., Queensway, Swansea Industrial Estate, Swansea (0792 580651). Price £199·50 including VAT.

The Micro 8 from Fujitsu boasts no fewer than three microprocessors; two 6809's which handle 640 × 200, 8 colour dot high resolution graphics, 8 × 8 matric block graphics and a Z80A for use with CP/M based software. Other features of the system include a real time clock, 32K of Microsoft Basic, 128K of total memory and provision for bubble memory. The Micro 8 is available from Minichip Limited, Enterprise House, Terrace Road, Walton, Surrey (09322 42777). Price £895 excluding VAT.

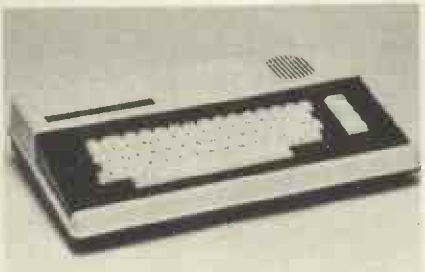
Lowe Electronics have added another Genie to their range of home computers the Colour Genie has 16K RAM, 16K ROM, 16K basic ROM, a maximum of 16 colours, 160 × 96 high resolution graphic characters with 128 programmable graphic characters and 64 preset characters. The Colour Genie is priced at £199 including VAT, Lowe Electronics, Maltock, Derbyshire (0629 2430).

Oric I from Oric Products has been designed by Tangerine Computer Systems and is produced in two versions, both have 16 colours, one has 16K of RAM and is priced at £99 including VAT whilst the other has 48K of RAM and is priced at £169 including VAT. Oric I uses Microsoft basic, has a sound generator chip covering six octaves and a display resolution of 24 rows × 40 characters.

The Jupiter Ace which has been designed by two ex-Sinclair men uses a specially adapted version of the compiled language FORTH. The unit has 8K of ROM and 3K of RAM a memory mapped 32 × 24 character display, a programmable sound generator and a fast cassette interface.

Priced at £89·95 including VAT and p&p the Ace comes complete with a mains adapter, cassette and TV leads and a manual. Jupiter Cantab. 22 Foxhollow, Bar Hill, Cambridge.

ORIC I



The Colour Genie

The Dragon 32

Fujitsu Model 8

Jupiter Ace

POINTS ARISING ...

AUDIO ANALYSER
(August–October '81)

1. In Fig. 13, the orientation of the diode D1 is incorrect, and this component should be reversed. The circuit diagram is correct in this respect.
2. In Fig. 17, the component layout for the backplane, the orientation of C115 and C116 is incorrect. Both components should be reversed.
3. In Fig. 17, the component layout for the backplane, C114 is shown connected between rails 1 and 3 (the +7·5V supply), rather than between rails 1 and 2 (the +5V supply), as it should be connected.
4. In Fig. 29, the component layout for the microphone preamplifier, IC1 is shown incorrectly orientated, and should be rotated so that pin 1 is adjacent to C1. Also, the capacitor shown marked C7, and positioned near to IC1, should be marked C4.
5. In the parts list for the microphone preamplifier, C7 should be shown as 47µ 16V tantalum, and C8 as 4n7 disc ceramic.

MICROBUS (SEPT '82)

It is stated that the output of 0–255 corresponds to an analogue input of 0–5V; in this particular case this is not correct.

It can be seen from the circuit diagram that pins 7 and 8 of the ZN427 have been joined; this in effect brings into use the internal reference voltage of the chip which is 2·55V. The statement should therefore be "The output of 0–255 corresponds to an analogue input of 0–2·55V".

COMBO AMPLIFIER (Aug.–Oct. '82)

A complete set of semiconductors is available for this project from Hart Electronic Kits Ltd., Penylan Mill, Oswestry, Shropshire SY10 9AF. Tel: 0691 2894.

BECKMAN DMM's

Beckman Instruments has introduced two handheld digital multimeters; the $3\frac{1}{2}$ digit T100 and T110 models, both of which offer five d.c. voltage ranges from 200mV to 1000V, five a.c. voltage ranges from 200mV to 750V, six d.c. and a.c. current ranges from 200μA to 10A and six resistance ranges from 200 ohm to 20 Mohm.

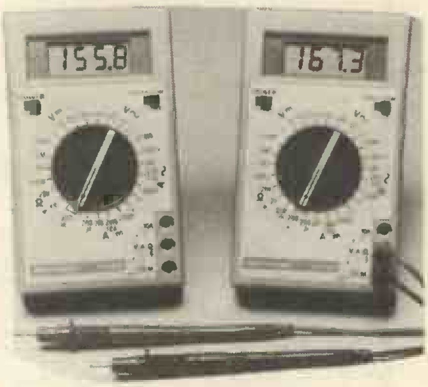
Of special interest is the direct 10A current range which obviates the need for external shunts. The resistance ranges can be switched to either low power for measuring in electronic circuits without turning on diodes and transistor junctions, or to high power for measuring resistances in electrical circuits or out of circuit. Both instruments also feature a special range for testing diodes and transistors which provides an accurate measure of the forward voltage drop in the diode junctions. Diodes and transistors can also be checked in or out of circuit. The T110 also incorporates a buzzer for continuity testing and circuit tracing.

A high 10 Mohm input impedance ensures that measurements are hardly affected by circuit loading, and effective RF shielding guards against external fields. Accuracies are guaranteed for one year, and eventual recalibration is very simple, as it only requires the adjustment of two potentiometers.

All functions and ranges are selected with a single rotary switch and the $3\frac{1}{2}$ digit l.c.d. features automatic decimal point positioning, polarity, overrange and low battery indication. The instruments will operate continuously for 200 hours from one standard 9V battery.

The two models T100 and T110 are priced at £49·00 and £59·00 respectively excluding VAT and p&p.

Beckman Instruments, Mylen House, 11 Wagon Lane, Shelden, Birmingham (021 742 77611).



Satellite TV Receiver

When you arrive at Alexandra Pavilion for the Electronic Hobbies Fair, the first thing you will see is a Luxor satellite TV receiver dish like the one shown opposite. The system with its two metre dish will be set up to receive programmes from the Russian Ghorizant-3 satellite in geostationary position 53 degrees E. The dish will be linked to a Luxor receiver system and TV inside the Pavilion so that visitors can see the results; this is just one of the special exhibits that is being arranged.

The other photo below was taken during the third International Road Racing Show. It gives a good impression of the inside of the hall. What is not apparent from this photo are the facilities available; these include three bars, two buffets, comprehensive toilet facilities—including a disabled toilet, first aid room and a baby changing room. Of course all these are purpose built and virtually brand new. In addition there will be extra cafeteria facilities with an additional area of tables and chairs, so no one should want for anything.

The largest supplier of components to the hobbyist—Maplin Electronic Supplies Ltd.—had this to say about the Fair: "The show coming in November is the one we are all excited about, here at Maplin. It's the Electronic Hobbies Fair, a brand new show, that is going to be very different from anything you've ever seen before. As well as the usual electronic stands, there will be computers, model control, amateur radio, CB and practical hi-fi.

"But the big plus about this show is that the organisers have really gone to town to provide you with dozens of extra exciting things to see and do."

Maplin will be devoting part of their stand to a bank of Atari computers, each running a different piece of software, so visitors will be able to play with them or just stand and watch.

Electronic Hobbies Fair, Alexandra Pavilion, November 18th to 21st. For more details and a 50p off voucher, see page 75. Keep watching PE for more details of the Fair; it will be the liveliest and most professionally organised event ever to be staged in this field.

Above: The Luxor satellite TV receiver dish
Below: Inside view of the new Alexandra Pavilion

17

ZON X-81 SOUND UNIT

A wide range of sound effects can be added to your ZX-81 with the ZON X-81 Sound Unit, now available form BI-PAK.

The unit is based on a three-channel-plus-noise sound chip and is so designed that the pitches and volumes of the three channels and the overall attack/decay envelope can be controlled by simple BASIC statements. By this means, piano, organ, bells, helicopters, lasers, explosions etc., can be simulated and easily added to existing programmes.

ZON X-81 is housed in a neat black plastic case with loudspeaker and manual volume control (in addition to programmed volume) and simply plugs in between the rear of the ZX-81 and its RAM pack and/or printer (if fitted). No dismantling, wiring, soldering, batteries, power supplies or leads are required.

An instruction booklet explains the operation of the unit and a number of example programs of useful sounds is also included.

The ZON X-81 is available from: BI-PAK Semiconductors, P.O. Box 6, Ware, Herts. 0902 3442 and is priced at £25·95 including postage and VAT.

Briefly...

Namal Electronics have developed a speech synthesizer which can be directly connected to the ZX81 or the Spectrum.

The synthesizer has a standard dictionary of about 600 words stored in an EPROM and the user can add to these by utilising the units 2K static RAM. The unit is programmed via the host computer, needing only two instructions per word.

Based on a phonetic speech synthesizer made by Votrax of Detroit the unit which measures 150 x 180 x 35mm comes complete with an integral loudspeaker, volume control and ribbon connector. There is also provision for driving an external loudspeaker or amplifier.

The Super Talker is priced at £49·95 for the ZX81 and £59·95 for the Spectrum (prices excluding VAT).

Namal Electronics, 25 Gwydir Street, Cambridge (0223 355404).

● ● ● ●

Readers may be interested to know that Premier Publications are intending to do for the Dragon what they have done for the UK101. They are already supplying Dragons, writing software and generally getting inside the unit in preparation for servicing and the design of various add on kits. This back up will no doubt add to the Dragons attraction. Premier Publications, 208 Croydon Road, Anerley, London SE20 7YX.

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The assets of EDA-Sparkrite Limited, which went into voluntary receivership in July 1982, have been acquired by STADIUM LTD. Sparkrite manufacture electronic ignition, car security systems and in-car computers and is based in Walsall, West Midlands.

This change of ownership is a major turning point for Sparkrite after the difficult circumstances of the last few months.

Sparkrite (A Division of Stadium Ltd.), 82 Bath Street, Walsall WS1 3DE. 0922 614791.

Countdown...

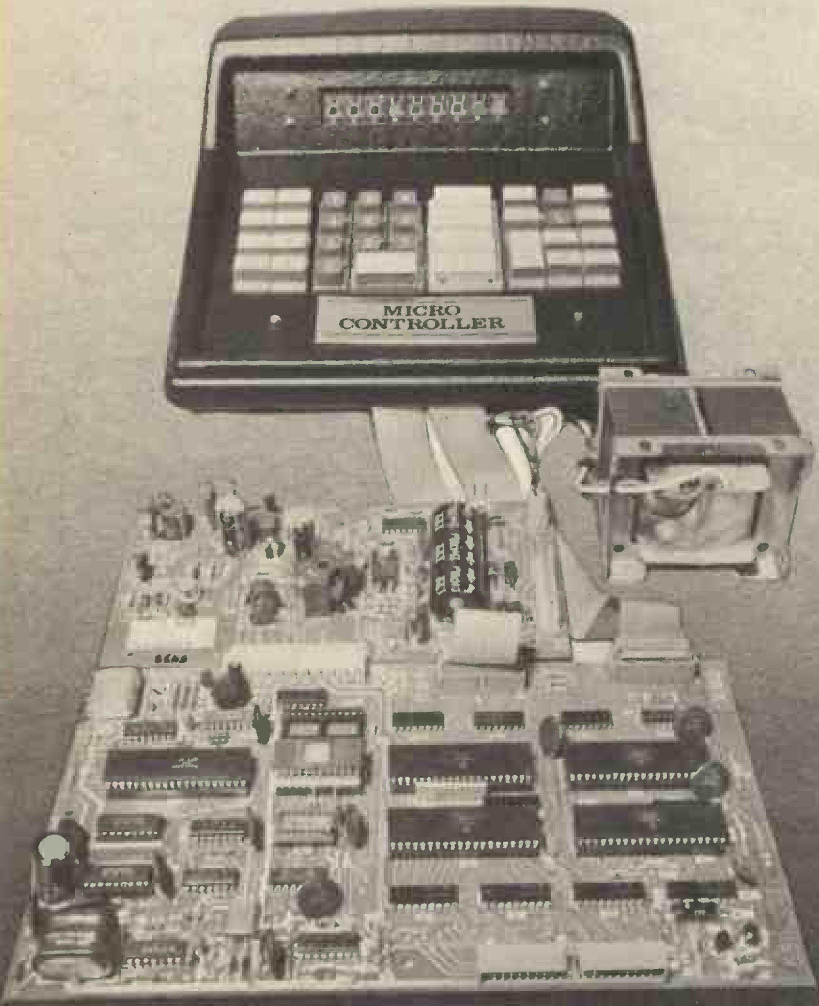
Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here.

Science and Technology in 19th Century Germany Oct. 15–Dec. 14 (weekdays 12–8pm and Sats. 10–1pm). Goethe Institut, 50 Princes Gate (Exhibition Road), London
Video Show Oct. 16–18. West Cntr. Hotel, London **Z1**
Computer Graphics Oct. 19–21. Royal Gdn. & Bloomsbury Cntr. London **O**
Testmex Oct. 26–28. Wembley Conf. Cntr. **T**
BEX Southampton Oct. 27–28. Polygon Hotel **K**
ISSEC (Safety, Security, Fire) Nov. 9–11. Royal Dublin Society Hall, Ireland **V**
BEX Plymouth Nov. 10–11. Holiday Inn **K**
Compec Nov. 16–19. Olympia **Z1**
Hobby Electronics Fair Nov. 18–21. Alexandra Pavilion, London **Z1**
INTRON Nov. 23–25. RDS Dublin, Ireland **V**
BEX Bristol Nov. 24–25. Holiday Inn **K**
Northern Computer Fair Nov. 25–27. Belle Vue, Manchester **Z1**
Christmas Holography (+ items for sale) Dec. 2–Mar. (1983) Light Fantastic Gallery, London **A8**
ElectroNORTH Dec. 7–9. Harrogate Supercentre **Q**
IT82 (Information Technology Year Conf.) Dec. 8–9. Barbican **O**
Continuous events at the National Microprocessor & Electronics Cntr. (nr. Tower of London) **L1**
Peripherals Feb. 2–4 1983. Cunard Int. Hotel, Hammersmith, London **Z1**
BEX Bournemouth Feb. 9–10 1983. The Pavilion **K**
Microsystems Feb. 23–25 1983. West Cntr. Hotel, Fulham, London **Z1**
CAD North Mar. 1–3 1983. Belle Vue Ex. Cntr. Manchester **Z1**
Mailing Efficiency Mar. 1–3 1983. Bloomsbury Cntr. Hotel, London **Z**
Local Networks Mar. 8–10 1983. Royal Lancaster Hotel, London **O**
Laboratory Edinburgh Mar. 16–17 1983. Assembly Rooms, George St. **E**
Brighton Electronics March 1983 **T**
BEX Leeds Mar. 16–17. Dragonara Hotel **K**
INSPEX Mar. 21–25 1983. National Exhibition Cntr. Birmingham International **Z1**
Sensors & Systems Mar. 22–24 1983. The Forum, Wythenshawe **T**
Compec Wales Mar. 22–24 1983. Cardiff University **Z1**
ETM (Electronic Test / Measurement) Mar. 22–24 1983. The Forum, Wythenshawe, Manchester **T**
Laboratory Manchester Mar. 23–24 1983. New Century Hall, Corporation St. **E.**
American Holography Mar.–June inc. Light Fantastic Gallery, Covent Garden, London **A8**
All Electronics Show April 19–21 1983. Barbican Cntr. London **E**

A8 Holographic Exhibitions ✆01-836 6423
E Evan Steadman ✆0799 22612
K Douglas Temple Studios ✆0202 20533
L1 World Trade Cntr., Europe Ho., London E1
O Online ✆09274 28211
Q Exhibitions For Industry ✆08833 4371
T Trident ✆0822 4671
V SDL Exhibitions ✆Dublin 763 871
Z BETA Exhibitions ✆01-405 6233
Z1 IPC Exhibitions ✆01-643 8040

MICRO CONTROLLER

MICHAEL TOOLEY B.A.
DAVID WHITFIELD M.A. M.Sc.



PART ONE

THE PE Microcontroller is an assembled project which is based around the 6800 micro.

Long term success for any product is usually assured if it is cost effective and if it can easily be adapted to meet any new requirements. The more adaptable the tool, the more successful and durable it is likely to be. Nature provides an example of a highly versatile tool in the human hand, which is capable of performing an extremely wide range of intricate tasks. It is, however, only with the advent of the microprocessor that the idea of the general purpose electronic controller has become a practical proposition. Such controllers still have a long way to go before they are able to rival the flexibility and ease of programming of the human hand. Programmable controllers are, nevertheless, now able to offer some significant advantages over the dedicated controllers of the last decade, and increasingly at prices which are acceptable to the home constructor.

This Microcontroller was originally designed to form the intelligent 'heart' of a mass produced commercial product. The basic design, however, followed conventional guidelines, and the final controller is a good example of a general purpose programmable controller. A wide range of control facilities are available within the basic controller, and users should have little difficulty in adapting it (often simply by writing a suitable control program) to a wide range of new applications. Practical applications will be discussed in later issues, together with details on how to program the 6800 microprocessor which is the CPU in the Microcontroller.

MICROCONTROLLERS

A microprocessor which is used to control a system (i.e. a microcontroller) must be capable of accepting input information, responding, and outputting appropriate signals to implement the required control action. A typical microcontroller arrangement is shown in the block diagram of Fig. 1.1. It can be seen from this figure that the input/output signals may require signal conditioning so that their forms and levels become compatible with the input/output interface elements. In many cases, however, no such conditioning is necessary, and indeed it is one of the aims of any general purpose microcontroller that the amount of conditioning circuitry is kept to a minimum. In the 6800 microprocessor family, interfacing is greatly simplified by the availability of a range of versatile and programmable interface adaptors, making the 6800 well suited to controller applications. The four parallel interface adaptors in the system can each provide up to 16 separately controllable input/output lines.

An important feature of any programmable controller is that its function may be changed by modifying its control program. Thus, in many situations, the age-old call of "Back to the drawing board", becomes "Back to the keyboard". This feature also allows the function of a controller to be modified during production without the need for any changes to be made to the hardware. This is one of the reasons that the use of erasable PROMS in early production units is

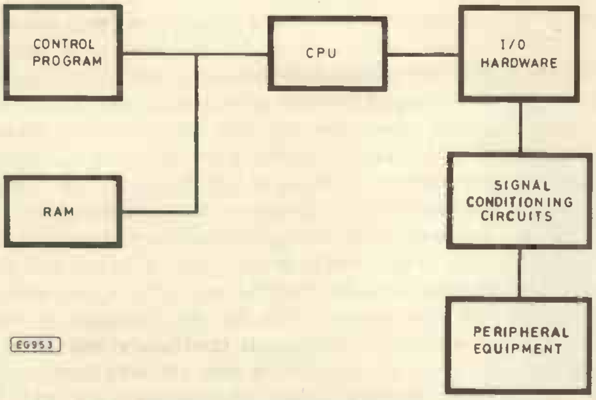


Fig. 1.1. Typical microcontroller arrangements.

so popular! Alternatively, the same hardware may be supplied to different customers, but with different control programs to enable them to perform significantly different tasks. An example of this is the way in which a manufacturer will market a range of pocket calculators all in the same case, using the same keyboard and internal hardware, but which are personalised for different applications (engineering, finance, surveying, etc.).

This system is rather more than a simple microcontroller. The keyboard and display which are provided may be used in two different ways. The first way uses them as part of the control application, with the keyboard for inputting commands, and the display for information output. The keyboard and/or display may alternatively be unplugged and different peripheral hardware substituted, in addition to that connected to the usual control ports. Such applications will have user-defined control programs to perform the necessary functions, e.g. central heating/lighting control, multi-program time switches, PROM programming, etc.

The second way in which the keyboard and display may be used is in conjunction with the DISBUG monitor program, which is supplied in permanent memory. This allows the user to develop his own applications control programs, and provides facilities to control the program execution, and to debug the program. The user program itself may then re-assign the keyboard and display for application-dependent functions. The DISBUG program cannot be overwritten by user programs, and the user can always return to DISBUG to continue debugging of an applications program which has run out of control.

The applications for the Microcontroller are therefore limited only by the ingenuity and imagination of the user; the best application offered for the unit is the subject of a competition details of which are given at the end of this article.

SYSTEM HARDWARE DESCRIPTION

The Microcontroller is a 6800 microprocessor-based system which is ideally suited to programmed control in a wide variety of applications. A block schematic for the Microcontroller is shown in Fig. 1.2. This diagram shows the 6800 configured in a conventional fashion with an 8-bit data bus, 16-bit address bus, and a control bus. The arrangement supports the full 64Kbyte addressing range of the 6800, while leaving scope for further expansion.

The 6800 is designed to use programmable memory-mapped peripheral devices. The system has four programmable interface adaptors (PIAs), each of which has 16 individually programmable input/output lines. One of these PIAs is dedicated to the keyboard, the second drives the gas discharge display, and the remaining two are available for user applications. The capabilities of the PIA devices are discussed in greater detail in a subsequent section, and at length in a later issue.

The Microcontroller has 1024-bytes of RAM, which is provided with integral battery back-up to safeguard against program loss in the event of power failure. The board has facility for the inclusion of a 32-byte ROM, originally intended for "personalising" units. This ROM is unused in the basic system. Permanent memory is provided for storage of the monitor program (DISBUG) by a 2048-byte EPROM. The circuit configuration does, however, allow the use of up to 8196 bytes of permanent memory.

An address map for the system is shown in Fig. 1.3. The addresses shown are all given in hexadecimal notation; areas shown with dotted line boundaries are available for use, but are not utilised in the basic unit. Users should be aware that full address decoding is not always employed, and that some address images do occur.

Two crystal controlled clocks are incorporated in the Microcontroller. The first is the master system clock which provides the basic timing for the microprocessor and the buses. In addition, it incorporates facilities for synchronising the start-up and reset sequences. The second oscillator is a real time clock, operating at 1Hz, which is connected to the display PIA. This clock may be configured under program

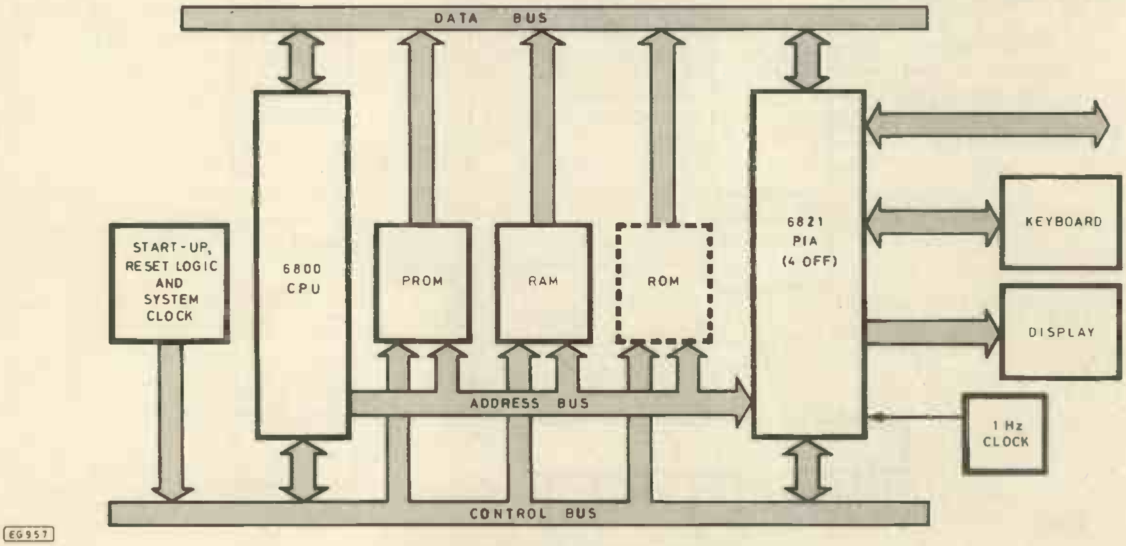


Fig. 1.2. Block schematic of the Microcontroller.

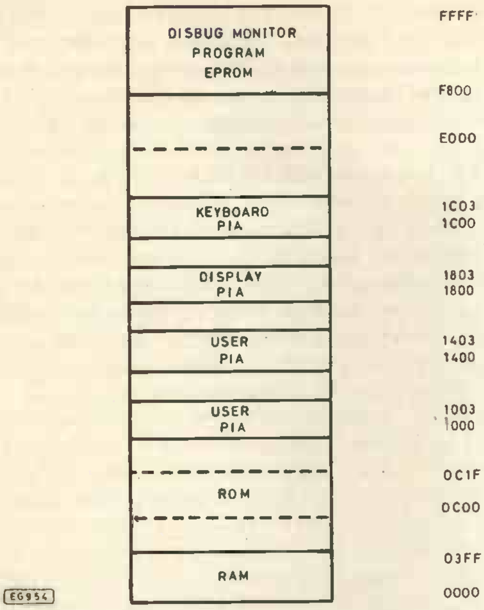


Fig. 1.3. Address map for the Microcontroller

control to provide regular interrupts, which are essential for any time dependent applications.

Separate from the main Microcontroller board are the gas discharge display, keyboard, power supply and mains transformer. Peripheral equipment to be controlled is connected to the main board by a multi-way ribbon cable.

ARCHITECTURE OF THE 6800 FAMILY

The 6800 is an 8-bit microprocessor whose internal architecture is shown in Fig. 1.4. The device is supplied in a 40-pin d.i.l. package, and requires only a single +5 volt supply. The main processor requires a 2-phase non-overlapping clock to control its operation. The basic processor cycle time is one quarter of the oscillator's crystal frequency.

The CPU device includes an 8-bit bidirectional buffer for the data bus, and a 16-bit unidirectional address bus buffer. These buffers will each drive a single TTL load; each standard peripheral device imposes a significantly lower load.

The programming model, given in Fig. 1.5, shows the registers which are available to the user. Two general purpose 8-bit accumulator registers (rA and rB) are provided for arithmetic and logic operations. A 16-bit index register (In) is available for indexed addressing modes of many instructions. The 16-bit program counter (PC) is maintained automatically by the CPU, and holds the memory address of the next instruction to be executed. The 16-bit stack pointer (SP)

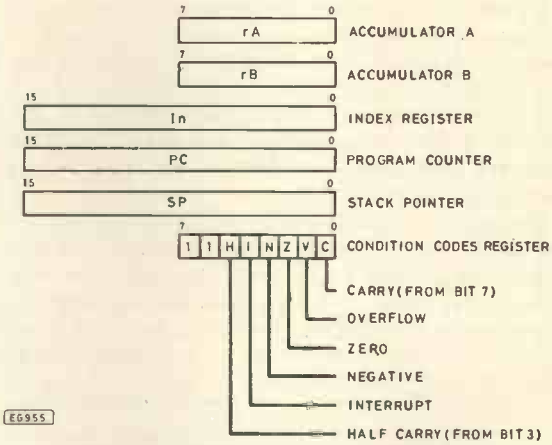


Fig. 1.5. 6800 programming model.

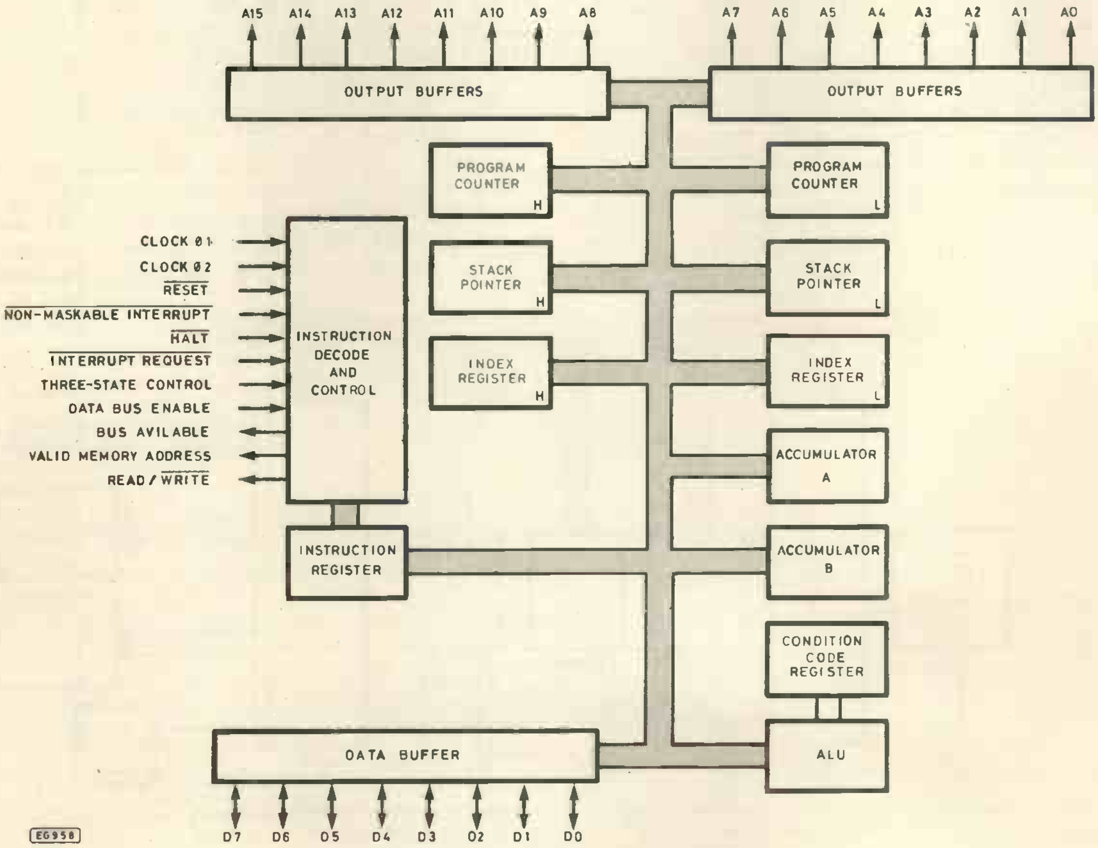


Fig. 1.4. Internal architecture of the 6800.

indicates the next free location on the push-down user stack. The stack pointer must be initialised by the user, but thereafter is maintained by the CPU. Finally, the condition code register (CCR) is used to indicate CPU and interrupt status. Only six bits of the CCR are used, the remaining two being permanently set HIGH.

Arithmetic and logic operations are performed by the arithmetic and logic unit (ALU). Operations may take one or two operands, depending on the instruction. Operands may be the contents of registers and/or memory locations. ALU operations set various bits within the CCR, depending on the instruction and the result of the operation.

The 6800 provides interrupt facilities for software interrupts, user interrupts, non-maskable interrupts and also for system reset. User interrupt requests may be masked under program control. The addresses of the interrupt service and reset service routines are defined as the top eight bytes of the 6800's memory. The Instruction decode and control unit handles interrupt requests, provides bus control signals and executes instructions. Details of programming the 6800 will be given next month.

The 6821 peripheral interface adaptor (PIA) provides a universal means of parallel interfacing to peripheral equipment. The PIA interface uses two 8-bit bidirectional buses and four control/interrupt lines. Fig. 1.6, shows the internal architecture of the 6821 PIA. The CPU sets up the PIA's functional configuration under program control. The peripheral data lines, PA0 to PA7 and PB0 to PB7, can each be configured either as an input or as an output. Consequently, any combination of inputs and outputs is possible, up to the maximum of 16 lines. The four control/interrupt lines, CA1, CA2, CB1 and CB2, may also be configured to act in one of several modes for handshaking with peripheral equipment. All PIA peripheral data lines may drive up to two TTL loads, with CMOS drive capability on PA0 to PA7.

Internally, the 6821 contains two independent sections each comprising an output register, control register, and data direction register. Separate interrupt status control is provided, together with an interface buffer, for each group of eight peripheral lines. Data is transferred to the output registers during a CPU WRITE operation via the data bus buffers and input register. Where a particular peripheral line has been programmed as an output, data will be transfered to this line. Where a particular line has been programmed as an input, data will be transferred to the system data bus from this line during a CPU READ operation. Multiple chip select lines simplify the selection of a particular PIA where several have been used. Timing is provided by an ENABLE signal derived from the 6800. Part of the address bus is externally decoded to select the required PIA, and usually the two least significant address bits are used to select the appropriate register within the PIA.

DISBUG MONITOR FACILITIES

A program of instructions is required by the CPU in order to make any use of the hardware facilities offered by an intelligent controller. It is this feature which distinguishes between dedicated and programmable controllers. The function of a programmable controller may be changed simply by the installation of a different control program; this may be

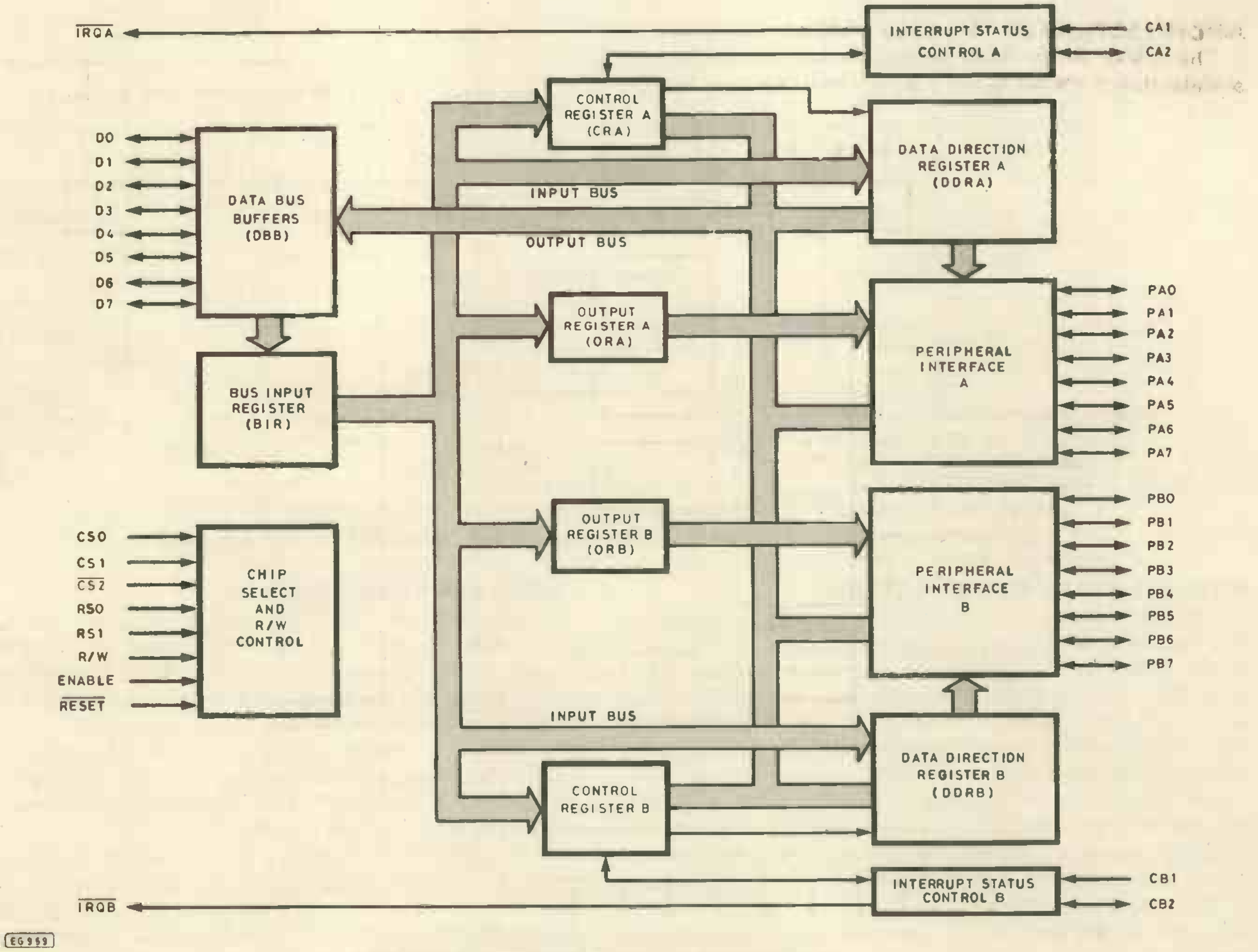


Fig. 1.6. Internal architecture of the 6821 PIA.

accomplished in a number of ways. In mass production applications, programs are written on development systems and then stored in the permanent memory of the controller. The function of the Microcontroller, however, is user-defined and therefore facilities must be provided to enable the user to develop his own control programs. These facilities are provided by the DISBUG monitor program which resides in permanent memory, and thus cannot be over-written. User programs are stored in the RAM area, allowing them to be developed in a modular fashion.

The facilities provided by a monitor program should include the following:—

1. An interface between the user and the system.
2. The means to input and modify programs.
3. The ability to control the execution of programs.
4. Debugging facilities.

The interface between the user and the system is provided by the keyboard and the display. The DISBUG monitor scans the keyboard for user commands, and uses the display to output results. The keyboard layout is shown in Fig. 1.7.

The keys are essentially divided into two major groups; numeric keys and command/control keys. The command/control keys are associated with five major groups of monitor functions:—

1. Memory examine and change.
2. Register examine and change.
3. Setting of breakpoints.
4. Memory presets.
5. User program control.

The facilities offered are outlined below and will be examined in detail in a later issue.

REGISTER EXAMINE AND CHANGE

The user may examine the contents of any of the 6800's registers after a breakpoint has been encountered. The REGISTER key is used to invoke the register editor, and changes may then be made before the program proceeds from the current breakpoint. Registers are displayed in a cyclic fashion, as shown in Fig. 1.8. The 16-bit registers are displayed in two stages, lower and upper bytes in turn. Other editing facilities are similar to those in the memory editor.

MEMORY PRESETTING

Areas of RAM may be present to user-defined values by using the preset editor. This facility is useful for initialising RAM to known values, e.g. all zeroes, filled with NOP instruction codes, etc. The preset editor is entered using the PRESET key, and pointers are then set up to indicate the bottom and top of the RAM area to be filled. The preset value is input, and this is then written to each location in the range specified, including the two extreme addresses.

SETTING BREAKPOINTS

Temporary halts or breakpoints are a useful aid to debugging user programs. They enable the programmer to split the program into convenient blocks so that each block may be tested separately. Breakpoints are set and reset using the breakpoint editor, which is entered by pressing the BREAKPOINT key. Up to four breakpoints may be set in the user program and, when a breakpoint is encountered, the user may examine the register contents using the register editor.

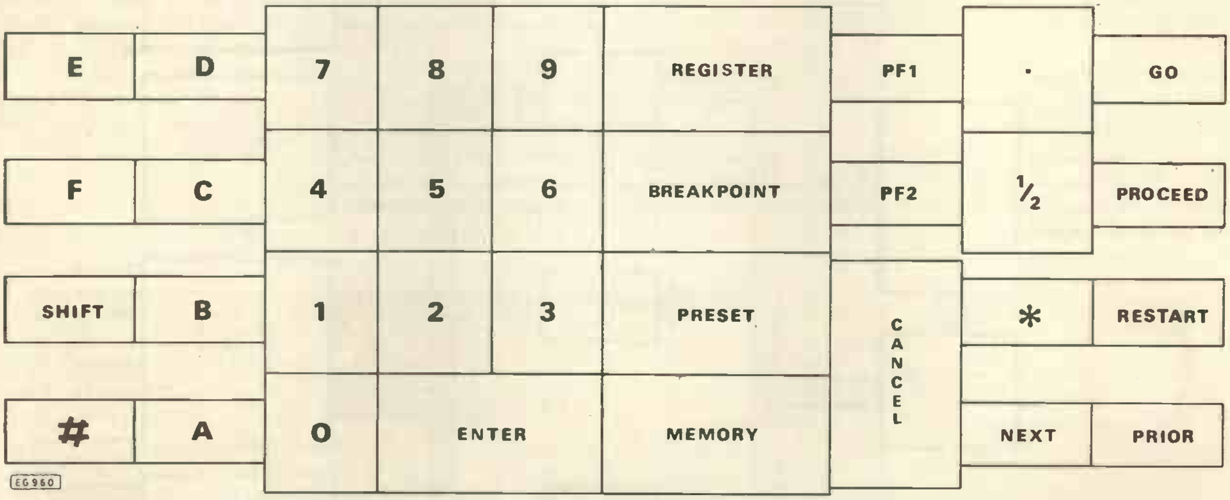


Fig. 1.7. DISBUG keyboard layout. Note this artwork can be cut out to label the user definable key tops.

MEMORY EXAMINE AND CHANGE

The contents of any memory location may be examined and (optionally) changed using the memory editor. This function is also used for entering programs into the user RAM area. The user may specify any address in the 6800 address space, i.e. 0000 to FFFF. Over-writing the DISBUG RAM area may have unforseen consequences, although writing to ROM addresses will have no effect.

The memory editor is invoked by pressing the MEMORY key, and the numeric keys 0 to F are then used to specify the four-digit memory address to be examined. The contents may then be changed, if required, and the editor then exited, or the next/previous memory location examined. The CANCEL key allows the user to abandon any uncompleted memory change.

USER PROGRAM CONTROL

GO: The user program is started using the GO function key. After pressing GO, the user enters the start address from which program execution should commence. The ENTER key is used to initiate execution, or CANCEL may be used to abandon the function.

PROCEED: The user program may be caused to continue from a breakpoint using the proceed function. After PROCEED is pressed, ENTER restarts program execution, or CANCEL abandons the command.

RESTART: The RESTART key is used to re-initialise the DISBUG monitor program. The DISBUG RAM area is reset to its initial values, and the welcome message appears. The user RAM is unaffected by this function. A restart has the same effect as entering DISBUG at power-up, but without

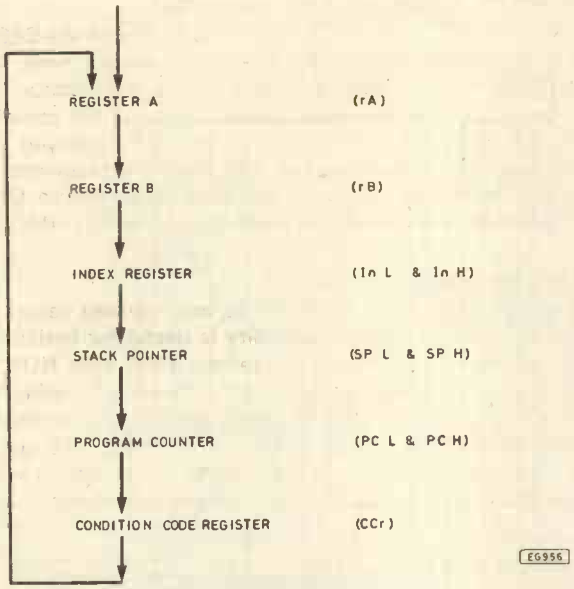


Fig. 1.8. Register display sequence.

the need to interrupt the mains supply. The CANCEL key may be used in place of the ENTER key to abandon a restart. This function is particularly useful for re-initialising the keyboard and display PIA's.

SOFTWARE FACILITIES

Various software aids are available within the DISBUG monitor program to assist the user in developing control programs. These aids are subroutines which may be called from RAM based code. The functions and interfaces for these routines will be described in a later issue.

CIRCUIT DESCRIPTION

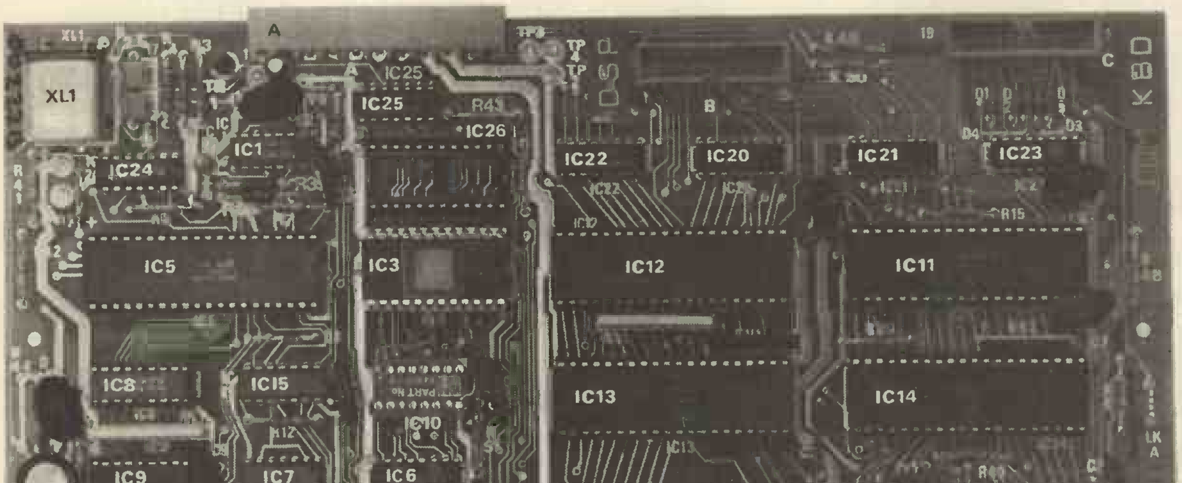
The circuit diagram for the Microcontroller is shown in two parts. The CPU, clocks, memory and the CPU side of the PIAs appear in Fig. 1.9. The keyboard, display, output drivers and the peripheral side of the PIAs are shown in Fig. 1.10. When interfacing in control applications, the primary concern is with the logic shown in the second of these drawings. Applications programs, and the monitor program used to enter and control these programs, reside in the memory and are executed by the hardware shown in the first figure.

A discrete Colpitts crystal oscillator, formed by TR1 and associated components, provides the master timing signal. The crystal operates in series resonant mode to produce a signal at 3·579MHz. The oscillator output is taken from the collector of TR1 and applied to the clock generator, IC1. The clock generator provides the necessary non-overlapping two-phase clock, producing a CPU cycle frequency of 894·75kHz, i.e. at one quarter of the frequency of the master timing signal. Outputs are also provided for memory synchronisation, and for the system reset signal.

The 6800 CPU is arranged in a conventional small system configuration, with no additional bus buffers required. Memory address decoding is provided by IC6 and IC25a. The $\overline{HALT}$ and $\overline{NMI}$ interrupt request lines are unused, and are therefore held HIGH by R7 and R5, respectively. The $\overline{IRQ}$ user interrupt request line is connected to the four PIAs, any one of which may assert this line, thereby causing a user interrupt request.

The four PIAs, IC11, IC12, IC13 and IC14, are all connected to the full width of the CPU data bus. Also connected to the PIAs are the system $\overline{RESET}$ signal from the clock generator, and the CPU R/$\overline{W}$ signal. The address decoder, IC6, provides an active low chip select ($\overline{CS}$) to a PIA when one of its register addresses is output by the CPU. Four of these chip select outputs from IC6 are connected to the appropriate $\overline{CS2}$ pin on the four PIAs. The CS0 and CS1 pins on all PIAs are unused, and are connected to +5 volts via R39. The two least significant lines of the address bus (A0 and A1) are connected to the register select inputs (RS1 and RS0, respectively) on the PIAs. The correspondence between the address value and the PIA register selected is shown in Table 1. A0 and A1 have no effect on the PIAs unless the $\overline{CS2}$ in the PIA in question is held LOW by the address decoder.

The 1Hz real time clock is provided by IC2. This device is a 24-stage frequency divider which incorporates a conven-



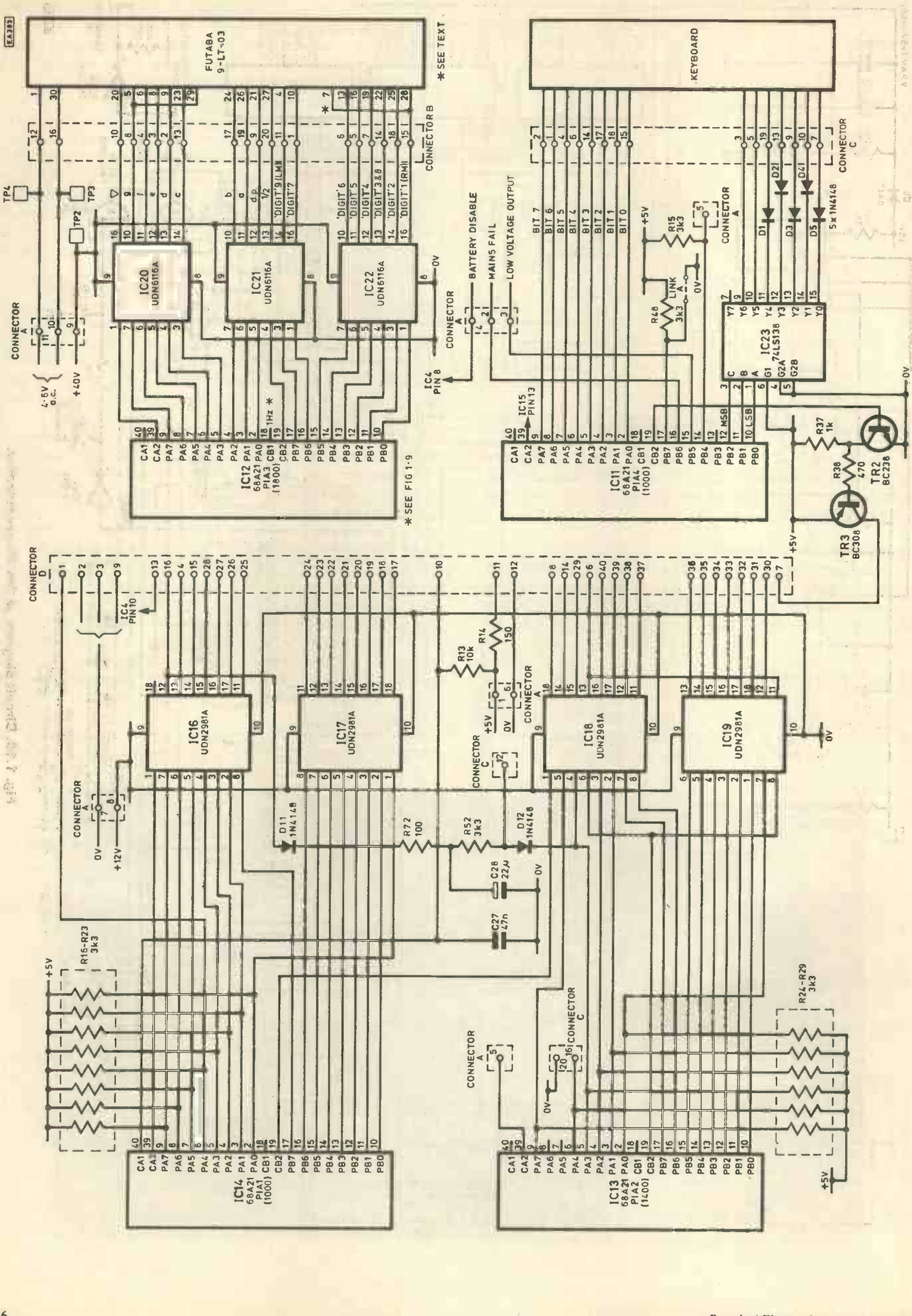


Fig. 1.9. Circuit diagram of the Microcontroller.

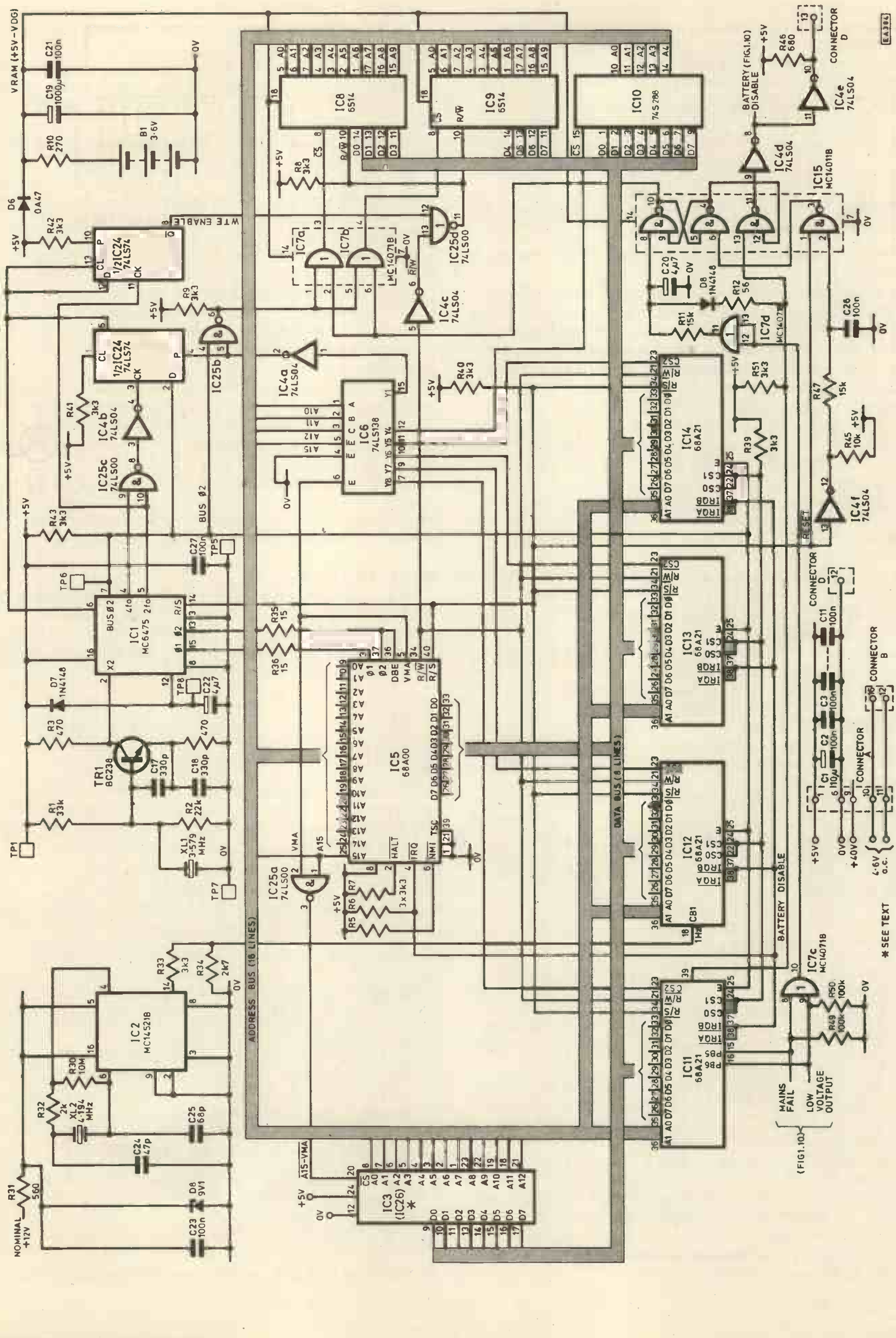


Fig. 1.10. Circuit diagram of the Microcontroller.

tional CMOS oscillator stage. A single inverting stage, biased into the linear region by R30, generates the fundamental clock at 4·194MHz. R32 reduces the crystal drive and improves the stability and accuracy of the oscillator. The oscillator output is set to standard logic levels by R33 and

A1 (RSO)	A0 (RS1)	PIA Register Selected
0	0	PIA output register A
0	1	PIA output register B
1	0	PIA control register A
1	1	PIA control register B

TABLE 1 Correspondence between address lines and PIA registers selected.

R34. The 1Hz output is applied to the CB1 line on the display PIA, IC12.

The RAM storage in the Microcontroller is provided by two 1024x4-bit very low power memory devices, IC8 and IC9. These are arranged to provide 1024 bytes of storage. The two RAM devices are de-selected whenever the main +5V supply is absent, thus preventing inadvertent memory corruption. The memory contents are retained by the on-board Ni-Cad battery supply, B1. This battery has a capacity of 90mA/h, and during normal operation it is trickle charged at a nominal 4mA rate by means of R10. Control logic devices IC7 and IC15 are also supplied from B1 during power failure.

The gas discharge display is connected to the display PIA, IC12, via three high voltage drivers, IC20, IC21 and IC22. The display unit is multiplexed in the conventional manner under software control.

The keyboard is connected as a matrix between the A and B halves of the keyboard PIA, IC11. The three-to-eight line decoder IC23, simplifies the software scanning of the keyboard.

The user PIAs, IC12 and IC14, are available at connector "D" via four 12V high current drivers, IC16 to IC19. The function of these PIAs is, of course, user definable.

INTERCONNECTIONS

1) Check that the thin blue and white wires on the mains transformer primary are connected together via an insulated connector block.

2) Remove the spade and tag connectors from the yellow, red, and green/yellow thin primary wires, N.B. do not remove the 4-way connector socket from the secondary wires.

3) Connect a good quality 3-core mains lead to the mains transformer, via a mains fuse (1 amp) and double pole on/off switch, as follows:

red = live
yellow = neutral
green/yellow = earth

The inclusion of a mains indicator neon, after the switch, is recommended.

4) Connect the mains transformer secondary lead to the power supply board by inserting the socket into the 4-pin connector labelled "C". Note that this connector will only mate correctly when properly inserted.

5) The power supply and Microcontroller boards should be linked together by mating the 11-way connectors marked "A" on the two boards.

6) Connect the 20-way ribbon cable from the display to plug "B" on the Microcontroller board, noting that the connectors are polarised.

7) Connect the 20-way ribbon cable from the keyboard to plug "C" on the Microcontroller board, again noting the polarisation of the connectors.

8) Connector "D" is utilised for interfacing the Microcontroller to the user's peripheral equipment.

HARDWARE MODIFICATIONS

To set up the Microcontroller the following steps should be carried out.

1) Obtain a good quality 24-pin d.i.l. socket and bend pins 18 and 21 outwards at right angles. Remove any PROMs which may be supplied fitted in IC3 and, on some units only, in IC26 positions.

2) Insert the modified d.i.l. socket into the existing holder for IC3, taking care to observe correct orientation.

3) Using a short length of tinned copper wire, connect pin 18 of the new socket to the 0V rail; this is the wide p.c.b. track which runs on the top of the board between IC3 and IC5 (the 6800 CPU).

4) Using a 0·25W 1 kohm miniature carbon resistor, connect pin 21 of the new socket to the +5V rail; this is the medium width p.c.b. track which runs on the top of the board between pin 24 of IC3 and one end of C4.

5) Insert the DISBUG monitor EPROM into the new socket in the IC3 position, taking care to observe correct orientation.

6) Turn the display board over. The display unit has pins which are numbered from 1 to 30, with pin 14 missing. Pin 1 is identified on the p.c.b. Connect a short length of insulated connecting wire between pin 7 (previously unused) and pin 22.

7) Remove the key tops marked "-" and "½" and replace them in the positions shown in Fig. 1.8. The key top which they replace should be relocated to fill the two gaps. The keys should all be labelled as shown in the diagram.

SWITCHING ON

1) Connect the mains supply, switch on and observe the DISBUG monitor "welcome" message on the display.

2) Should no display occur, check the voltages on connector "A" using a multimeter of 20 kohms/volt or better. Typical voltages expected are as follows:

A1	+5V	A5	+3·8V	A9	+42V
A2	+4·3V	A6	0V	A10	5V AC
A3	0V	A7	0V	A11	5V AC
A4	+4·2V	A8	+19V		

Any significant deviation from these values should be investigated. Also check that the DISBUG monitor EPROM has been correctly inserted, and that the voltage on pin 18 is 0V, and that the voltage on pin 21 is greater than +2V.

COMPETITION

The Microcontroller competition is being run by Display Electronics to find the most practical application for the system.

The winning entry, which will be considered for publication in *PE*, will receive £300 in cash or goods from Display Electronics to the value of £400.

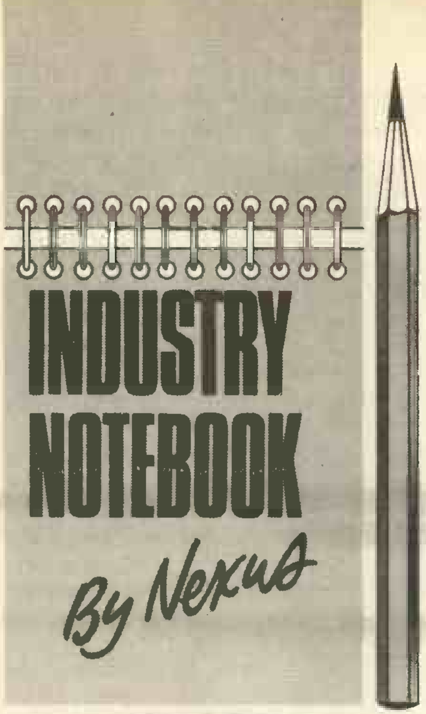
Full details of the competition together with an entry form and a copy of the rules are available from Display Electronics.

PRICES

The complete Microcontroller system (excluding the case) is available for £32·95 plus VAT and p&p or separately at the following prices: main board £10·95, p.s.u. board £7·75, keyboard £5·50, display board £4·75, Disbug £5·25, 40 way I/O cable £1·45 and 20 way I/O cable £1·25 . All prices exclude VAT and p&p.

Display Electronics, 64–66 Melfort Road, Thornton Heath, Surrey 01-689 7702. The case is available from West Hyde Developments, Unit 9, Park Street Industrial Estate, Aylesbury, Bucks.

NEXT MONTH: P.S.U., DISBUG and 6800 programming.



A Year to Go

Nudges and winks of a general election within a year, perhaps sooner, added little to the theatre which passes nowadays for a political conference. The stars of their respective shows, Michael, Tony, Roy, Shirley, David, Maggie, Willie, loved, despised, hated according to party taste, all performed competently. But however clearly they argued their case it still needed a small army of media pundits to clarify and re-interpret every word. Discussion and comment seemed endless, the end result negligible.

The struggles between the parties were less interesting than the struggles within them, enlivened by new entrant, SDP, in an as yet still uneasy alliance with the Liberals. Internal squabbles can be papered over but not totally concealed. They are in every party but never more so than in Labour where all the conciliating skill of Michael Foot appears to be unavailing.

Looking back over several conference seasons and their subsequent influence on events, very few of the hopes expressed have been achieved, particularly in the economy because politicians, like the rest of us, willy-nilly are victims of fundamental shifts in other economies which, by nature of our world trade, necessarily interact with our own.

An often overlooked fact is that the supposed hard-line present government continues to pour billions of subsidy into coal, steel, shipbuilding, railways, airlines and motor manufacture in the best socialist tradition. The National Health Service cost £7·7 billion in 1978–79. Today the government is trying to contain costs within twice that figure. This is the measure of the problem that this government, or any other, has to face. Now in its fourth year it has gone some way to arrest the downhill slide, in a few areas to reverse it. Painfully slow progress but progress nevertheless with electronics shining, the rest of industry remaining dull.

Spy Scare

The Japanese are nothing if not single-minded. For centuries theirs was an isolated nation, having no truck with foreigners. In this century they became dedicated to military conquest. Frustrated in this attempt they turned to industrial and trade war, so far with conspicuous success. No other nation has so mobilised itself to the single purpose of industrial supremacy on a world scale when military conquest has failed. The nearest parallel is equally defeated West Germany whose own 'economic miracle' is now faltering.

Every company likes to know what its competitors are doing and planning. But it still came as something of a shock that allegations are made that Hitachi and Mitsubishi have both been conspiring to obtain the trade secrets of IBM. Both companies have been indicted in US courts. Hitachi is reported to have admitted paying large sums (some £250,000) for information but denied knowing it had been stolen. Mitsubishi is reported to have denied unlawful conduct and will offer a vigorous defence against all charges.

Apparently the FBI set a trap by setting up a computer dealing company in Silicon Valley which looked genuine but was in fact bogus. Approaches were made to Japanese executives that confidential IBM documents could be provided—at a price. First contact, face-to-face, with an FBI undercover agent was, appropriately, in vice-city Las Vegas. The story, doubtless to be revealed more fully in court hearings, includes penetration of a building for photographic sessions and undercover payment in 100-dollar bills.

Whatever the outcome of these charges there is no question that they have opened another can of worms in the industry. For example it has re-opened the whole question of US technology leaking to other countries. One way of getting hold of a technology is by poaching engineering staff. A newly employed engineer should not, in theory, betray the secrets of his former employer, but even if he doesn't it is inevitable that ideas and techniques he has developed in his old job will be applied in his new employment. On a larger scale, another method is to buy a company outright or a big enough share to guarantee a place on the board. Examples are Philips buying Signetics and, more recently, Schlumberger's purchase of Fairchild. Then there are numerous cross-licensing deals which give a technology exchange between companies and also across national boundaries.

What worries the Americans is that US advanced technology can reach the Soviet Union through channels over which they have little or no control. If, say, a French company has acquired US know-how through acquisition of an American company, it can be regarded equally as French know-how and would need to be very sensitive (e.g. military security) not to be sold openly in the French manner, or indirectly through a third country acceptable to the West but having close links with the East.

So far, foreign ownership of electronics companies in the United States is mainly European and Japanese. But now, according to one report, the People's Republic of China has a half interest in a new semiconductor factory now building. It is hardly likely that the Soviet Union would be allowed equal access. But an awful thought remains. What if they have already done so through nominees? If the FBI can dupe the Japanese, why not the Soviets the USA?

Fifth Generation

The immediate practical objective in the secrets probe at IBM was to come to the market with plug-for-plug compatible products to sell to IBM users. A longer term objective could well have been fifth generation computers which are planned to have a high order of artificial intelligence and in specialist applications are already being described as expert systems. They should be with us in the 1990s, if not earlier.

Such machines will need to be 'friendly' in the sense of being uncomplicated to use. Most of the hardware is available today but capable of further development. Voice entry, for example, rather than keyboard, and voice response with optional print-out. Assume a medical expert system. A GP may address it, describing a patient's symptoms, and get an instant diagnosis and suggested course of treatment as if the GP is in conversation with a top consultant. Which, indeed, he or she would be because massive storage would house the accumulated experience and judgement of the best medical experts. The secret, as usual, will be in very advanced programming.

The snag lies in validation of the knowledge stored. In the medical example a mistake in programming could cost lives. And, of course, 'experts' are often proved wrong. The computer, with its phenomenal calculating power, programmed with the best economic models, has hardly been a success in management of our own and other nations' economies.

Nonetheless, expert systems are on the way and the Japanese are investing a reported £200 million of government funds in a ten-year development programme plus possibly £500 million or more from Japanese industry. It all sounds very ambitious until we are reminded, as happened at a recent conference on the topic, that IBM spends as much in a year on R&D as the whole Japanese ten-year programme.

Anyway, it would be foolish to ignore progress and although it would be difficult to match the level of investment of the Japanese or the Americans, there is no doubt that British engineers and companies will be involved in expert systems. On the commercial front Racal have been first to announce an Expert Systems Division which will initially concentrate on oilfield exploration requirements and later expanded to such applications as medicine, finance, energy, industry and defence.

The new breed of super programmers generating artificial intelligence also have a new name to distinguish them from run-of-the-mill hacks. They are to be knowledge engineers.

Ultimum Computer Interface Part 1

WATFORD ELECTRONICS

THE alarming rate at which personal computers have been introduced over the last couple of years *may* demonstrate a healthy growth market, but it doesn't help those who already took the plunge and are now left with a less capable machine. It matters little *when* you bought your computer, it is almost bound to be superceded by the next model in the range, and you are left with little or no support, and just like hi-fi five years ago, the only way out is to cut your losses and upgrade to one of the newer machines.

THE ULTIMUM!

The ULTIMUM has been designed to allow *almost any* 8 bit computer to be expanded into a much more flexible system. It is modular, which makes custom systems possible, and it offers features which should whet the most megalomaniac appetite.

The ULTIMUM itself is a seven slot expansion board which connects to your computer via a 40 way ribbon cable. A purpose built case is available which will house a power supply, man enough to handle a fully expanded system.

Over the coming months, we shall be introducing several daughter cards. Below is a brief summary of the range:

- ★ **A 16/64 KByte RAM card with paging.**
- ★ **A ROM/RAM/Battery back-up card allowing up to 20 Kbytes of RAM/ROM combinations.**
- ★ **A EPROM programmer with emulation facilities.**
- ★ **An *intelligent* floppy disk controller card, with its own processor allowing full control of disks from BASIC or M/C.**
- ★ **A port card with RS-232c, parallel and Centronics interfaces.**
- ★ **An analogue card with A>D and D>A capability.**
- ★ **A sound board providing up to nine voices, all independently programmable.**
- ★ **A speech card.**
- ★ **A terminal card which provides 80 column output and a keyboard interface.**
- ★ **A second processor card based on the 6809, for speed. This card can share the other cards on the ULTIMUM.**
- ★ **A prototype board, with pads and power tracks, for your own additions.**

THE MOTHERBOARD

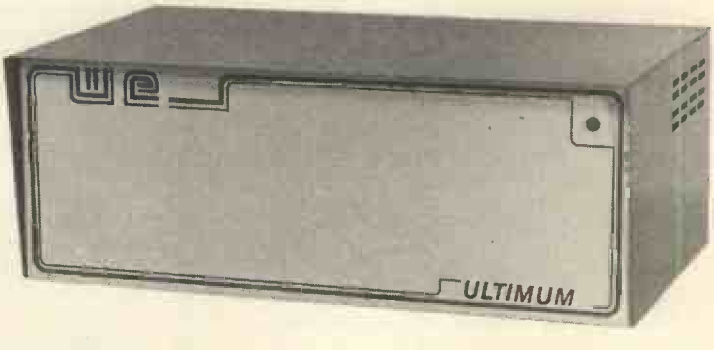
We begin with the motherboard. Fig. 1.1 gives the circuit diagram. IC1 to IC4 provide the full buffering of the data and address lines. Two basic bus standards are supported, the 65xx/68xx series and the Z80. These differ in their timing requirements and IC11 and IC12 (along with a few links) enable you to select either.

ICs 5,6,7,9 and 10 provide an on-board port, which makes paging and handshaking possible. This facility is not essential but makes the addition of large amounts of memory (256 Kbytes uses 4 slots) possible. The buffered signals are connected to each of the seven slots. IC8 is used to control the selection of the data buffer by collecting the select signals from the daughter cards. Cards can be moved around freely once set up, as all address decoding is done *off* the mother board.

There are three 40 ways d.i.l. sockets which enable you to connect to your computer from the side or from the back.

The board is well decoupled, with diodes to prevent rails from crossing over on switch on/off. The slots themselves make use of two-part connectors, which although a little more expensive, do ensure reliable, knock resistant connection to the daughter cards.

Interfaces are in preparation for the following machines: **Acorn Atom, Apple II, Atari, Commodore PET, Research Machines RML 380Z, Superboard, Spectrum, Superbrain, S100 Bus, UK101, Video Genie, ZX81.**



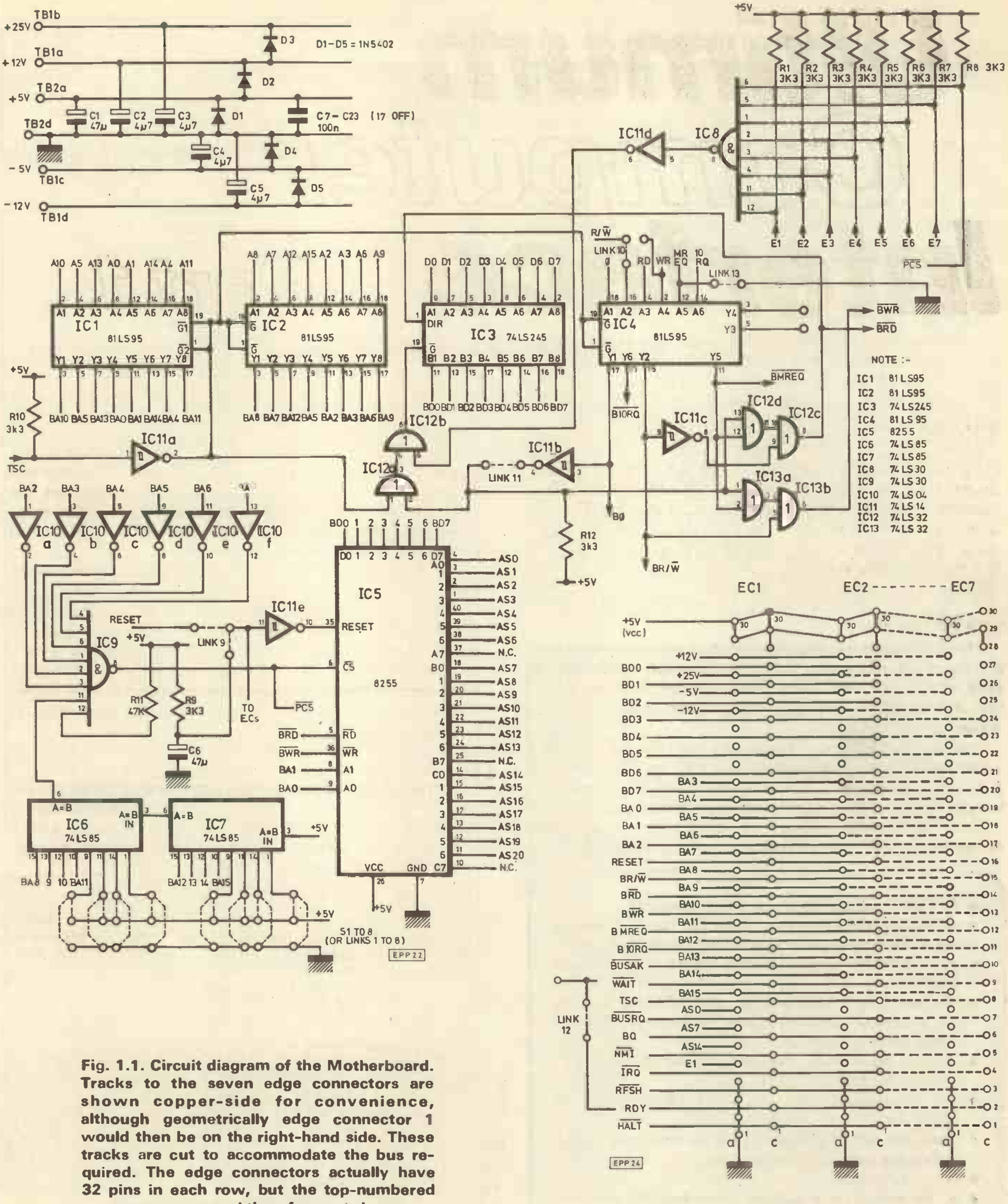


Fig. 1.1. Circuit diagram of the Motherboard. Tracks to the seven edge connectors are shown copper-side for convenience, although geometrically edge connector 1 would then be on the right-hand side. These tracks are cut to accommodate the bus required. The edge connectors actually have 32 pins in each row, but the top-numbered ones are n.c. and therefore not shown

THE *UNIVERSAL* INTERFACE

ASSEMBLY

You will need a fine tipped soldering iron. Referring to the component layout of Fig. 1.3 install the i.c. sockets first, then the discrete components and finally the connectors. The backplane connections are close together and you must be careful to avoid shorting the tracks. Put the i.c.s in last, checking orientation carefully.

The connection to your computer will, of course, vary from model to model. A manual is provided with the kit of parts (see constructors' note) which tells you how to interface with most machines. As a general guide, Table 1.1. gives the standard connection to Z80 based systems and Table 1.2 is for the 6502/6800 microprocessor family. These tables also describe how to set up the various links for each type.

TESTING THE 8255

The best way of testing that the board is wired correctly is to address the 8255 port i.c. The 8255 can be mapped to any 256 byte boundary by setting d.i.l. switches 1 to 8. Find an unused space and select it as shown in Table 1.3. The 8255 resets on power-on to its all input state. A set up routine (written in BASIC) is given in Table 1.4. which makes all the lines outputs, and then flips them from 1 to 0 approximately twice a second. You can observe this by looking on the port pins as laid out in Fig. 1.1. If nothing happens, check that you have set up the correct address and check your connections. If you use a multi-meter to check the outputs, make sure that it has an impedance of 5Kohms/volt or greater. Once the 8255 is working you can be fairly sure that any other faults are minor, and unlikely to damage the daughter cards.

COMPONENTS . . .

ULTIMUM MOTHERBOARD

Resistors

R1-R11	3k3 (11 off)
R11	47k
All resistors are ¼W 5%	

Capacitors

C1, C6	47μ/16V axial elect. (12 off)
C2-C5	4μ7/63V axial elect. (4 off)
C7-C24	100n disc ceramic (18 off)

Diodes

D1–D5	1N5402 (5 off)

Integrated Circuits

IC1, IC2, IC4	81LS95 (3 off)
IC3	74LS245 (8T245)
IC5	8255
IC6, IC7	74LS85 (2 off)
IC8, IC9	74LS30 (2 off)
IC10	74LS04
IC11	74LS14
IC12, IC13	74LS32 (2 off)

Miscellaneous

14 pin d.i.l. sockets (6 off)
16 „ „ „ (4 off)
20 „ „ „ (4 off)
40 „ „ „ (2 off)
S1–S4, S5–S8 4 way d.p.s.t. d.i.l. switch (2 off)
EC1, EC2 2 × 32 'A+C' DIN Euro Socket (straight pin) (2 off)
TB1, TB2 4 way p.c.b. terminal block (2 off)

Optional Extras

EC3–7 2 × 32 'A+C' DIN Euro Socket (straight pin) (5 off)
40 pin d.i.l. socket (2 off)

TABLE 1.1. 4Ø WAY CONNECTIONS TO Z8Ø SYSTEMS

1	INT	4Ø	MREQ
2	NMI	39	RESET
3	NC	38	HALT
4	DØ	37	NC
5	D1	36	D4
6	D2	35	D5
7	D3	34	D6
8	IORQ	33	D7
9	GND	32	NC
1Ø	NC	31	CLOCK
11	NC	3Ø	RD
12	A2	29	WR
13	A1	28	RFSH
14	AØ	27	A15
15	A3	26	A14
16	A4	25	A13
17	A5	24	A12
18	A6	23	A11
19	A7	22	A1Ø
2Ø	A8	21	A9

TABLE 1.2. 4Ø WAY CONNECTIONS TO 68/65xx SYSTEMS

1	IRQ	4Ø	NC
2	NMI	39	RST
3	NC	38	NC
4	DØ	37	RDY
5	D1	36	D4
6	D2	35	D5
7	D3	34	D6
8	NC	33	D7
9	GND	32	R/W
1Ø	NC	31	Q2
11	NC	3Ø	NC
12	A2	29	NC
13	A1	28	NC
14	AØ	27	A15
15	A3	26	A14
16	A4	25	A13
17	A5	24	A12
18	A6	23	A11
19	A7	22	A1Ø
2Ø	A8	21	A9

NC Means No Connection
Dn is Data bus
An is Address bus

TABLE 1.3.
SETTING THE 8255 ADDRESS SPACE

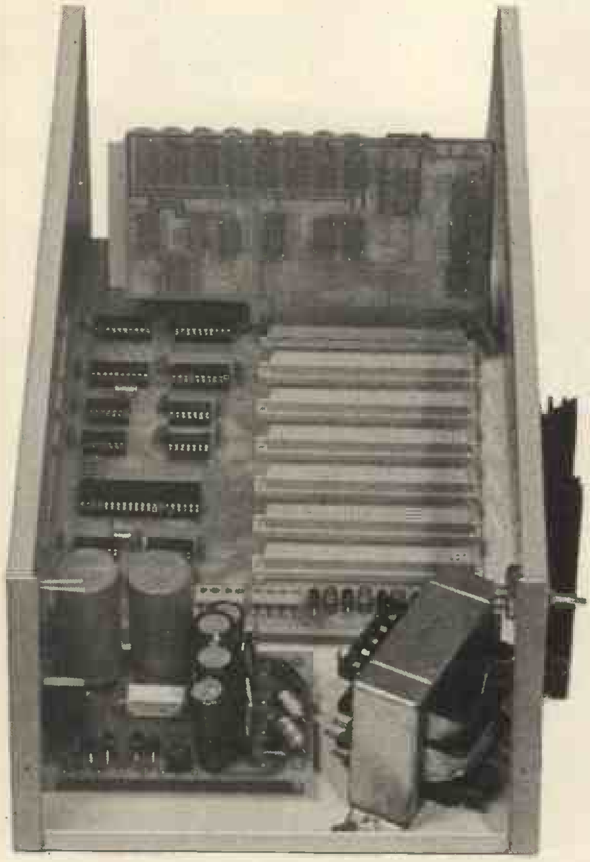
Link/switch	Mapped to . . . (hex)
8 7 6 5 4 3 2 1	
Ø Ø Ø Ø Ø Ø Ø Ø	ØØØØ
Ø Ø Ø Ø Ø Ø Ø 1	Ø1ØØ
Ø Ø Ø Ø Ø Ø 1 Ø	Ø2ØØ
Ø Ø Ø Ø Ø Ø 1 1	Ø3ØØ
. . . in 1ØØ hex increments	
Ø Ø Ø 1 Ø Ø Ø Ø	1ØØØ
Ø Ø Ø 1 Ø Ø Ø 1	11ØØ
Ø Ø Ø 1 Ø Ø 1 Ø	12ØØ
. . . in 1ØØ hex increments	
Ø Ø 1 Ø Ø Ø Ø Ø	2ØØØ
. . . etc.	
Ø Ø 1 1 Ø Ø Ø Ø	3ØØØ
. . . etc.	
1 1 1 1 1 1 1 1	FFØØ

Link	Switch
1 means link to Vcc	1 means ON
Ø means link to GND	Ø means OFF

TABLE 1.4.

```
1Ø    P = (8255 Address in decimal)
2Ø    POKE P + 3, 128 (Set all ports to output)
3Ø    POKE P,Ø
4Ø    POKE P + 1,Ø
5Ø    POKE P + 2,Ø
6Ø    GOSUB 12Ø
7Ø    POKE P,255
8Ø    POKE P + 1,255
9Ø    POKE P + 2,255
1ØØ   GOSUB 12Ø
11Ø   GOTO 3Ø
12Ø   FOR T = 1 TO 25Ø (Approx ½s delay)
13Ø   NEXT T
14Ø   RETURN
```

ULTIMUM
The ultimate motherboard?



Although the kit of parts will include d.i.l. switches for the setting up of address lines A8 to A15, we feel it is worthwhile pointing out the existance of an earlier option which the p.c.b. will accommodate. This is the use of prewired d.i.l. header plugs instead of switches, which can be changed quickly for different addressing. The tamper-proof nature of this option may be preferred.

The remaining links (refer to Fig. 1.3) should be wired as follows:

LINK 9
Link A-B for Z80 systems (allows reset from host computer)
Link B-C for 65/68 systems (gives on-board reset)

LINK 10 ($R/\overline{W}$, $\overline{WR}$ strapping link)
Link A-B for 65/68 systems (gives $R/\overline{W}$ to $R/\overline{W}$)
Link A-C for Z80 systems (gives $\overline{WR}$ to $R/\overline{W}$)

LINK 11
Link open for Z80 systems
Link closed for 65/68 systems

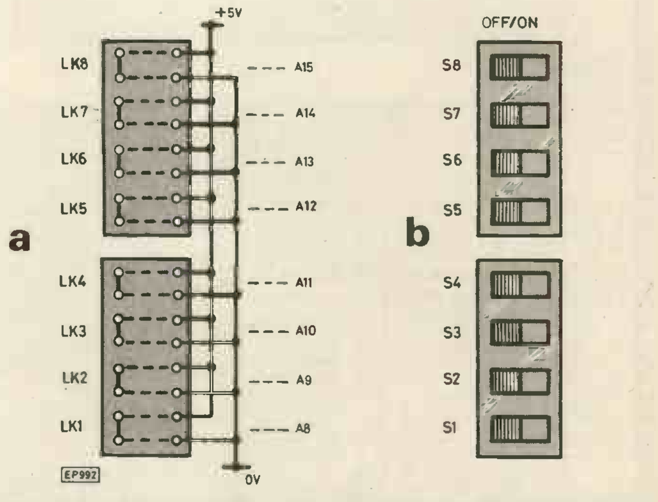


Fig. 1.2. Ultimum links, and methods of linking. (a) Using linked header plugs which can be swapped. (b) Using d.i.l. switches

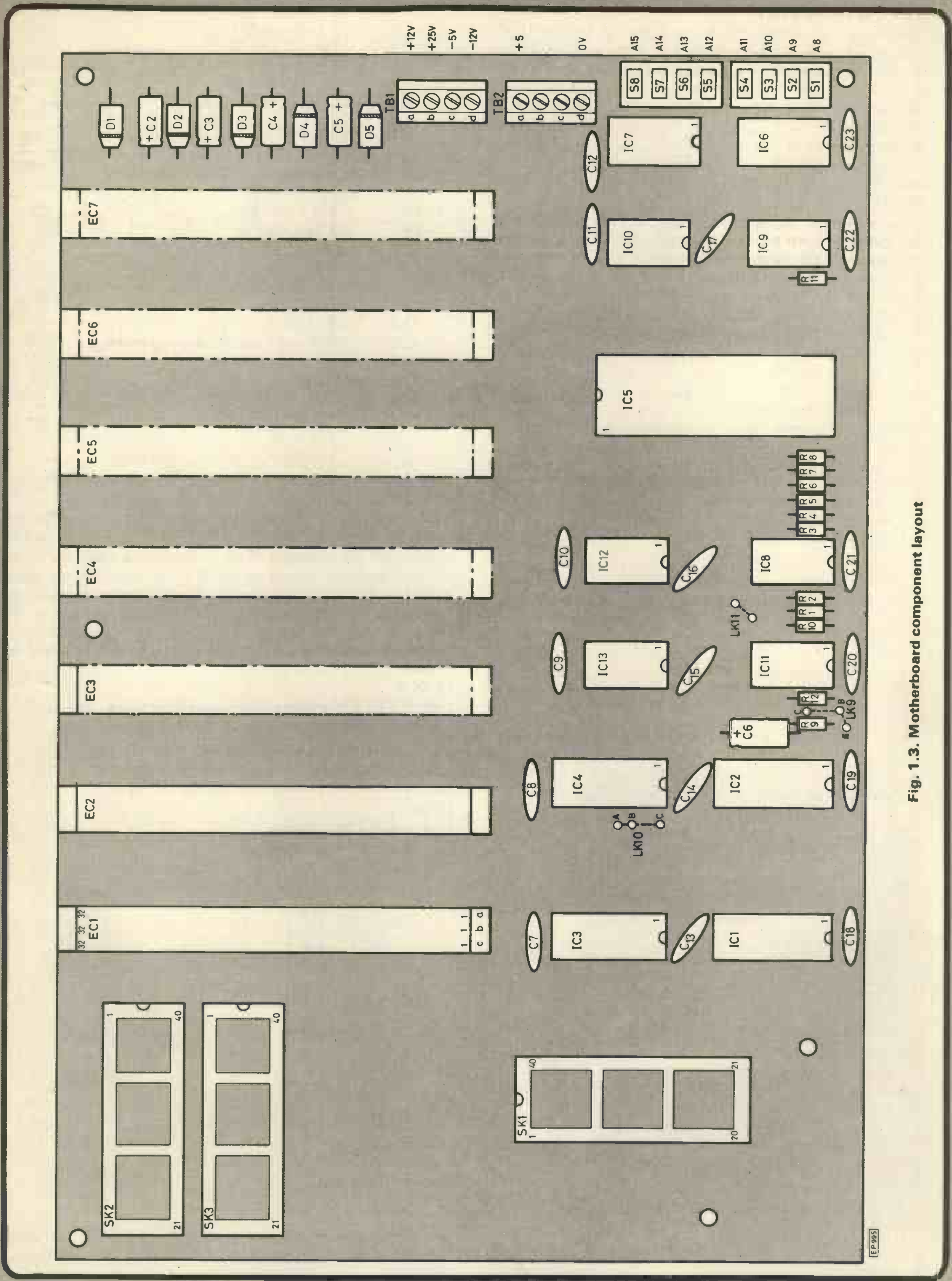


Fig. 1.3. Motherboard component layout

THE POWER SUPPLY

A special power supply has been designed for the ULTIMUM, which provides power rails for additions such as the disk drive and the EPROM programmer. The power supply will fit inside the ULTIMUM case or may be mounted separately.

The design of the power supply is given in Fig. 1.4. This is a standard design using current limiting, thermally protected i.c. regulators. The component layout is given in Fig. 1.5. Please observe the usual precautions when wiring mains equipment. How to fit the assembled unit into its housing is covered in a comprehensive manual (see constructors' note), available with the kit of parts, but construction of the power supply p.c.b. assembly is very straightforward. Follow the overlay given (Fig. 1.5) and the instructions below, being careful to note the polarity of components where appropriate. The construction sequence is as follows:

1) Fit p.c.b. pins in points A-G,M,I,J,L,K,N,O,P.
2) Fit diodes D1-D4.
3) Fit REC1 and heatsink—bolt heatsink to bridge REC1 and then mount this assembly to p.c.b.
4) Fit bridge rectifier REC2.
5) Fit R1—leave 5mm clearance between resistor and p.c.b. to allow heat flow around resistor.
6) Fit smoothing capacitors C1 and C2. Note that the dummy tag is used only to provide greater stability.
7) Fit smoothing capacitors C14,C7,C11,C8.
8) Fit ceramic capacitors C15,C6,C13,C10.
9) Fit capacitors C7,C12,C3.
10) Fit zener diode D5.
11) Fit IC5, IC2, IC4, IC3—note that the metal tabs stand towards the ceramic capacitors.

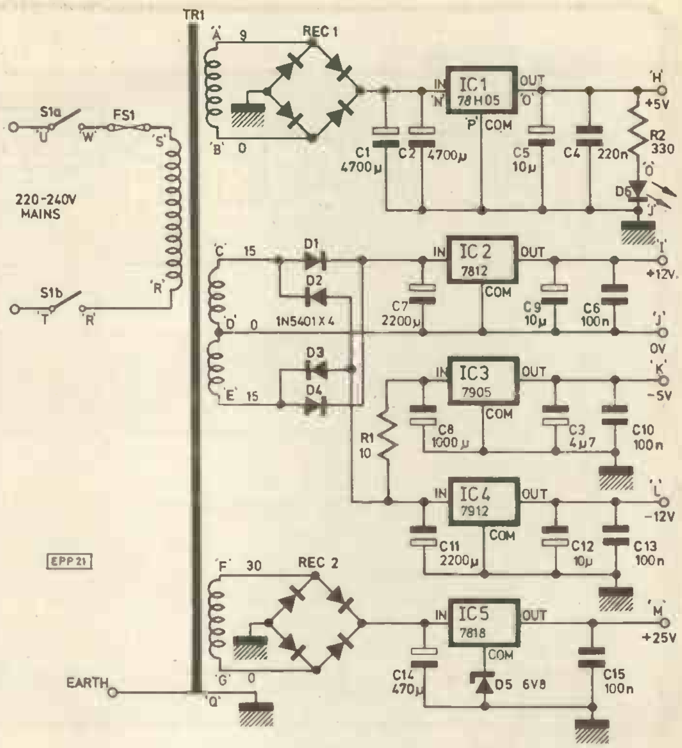
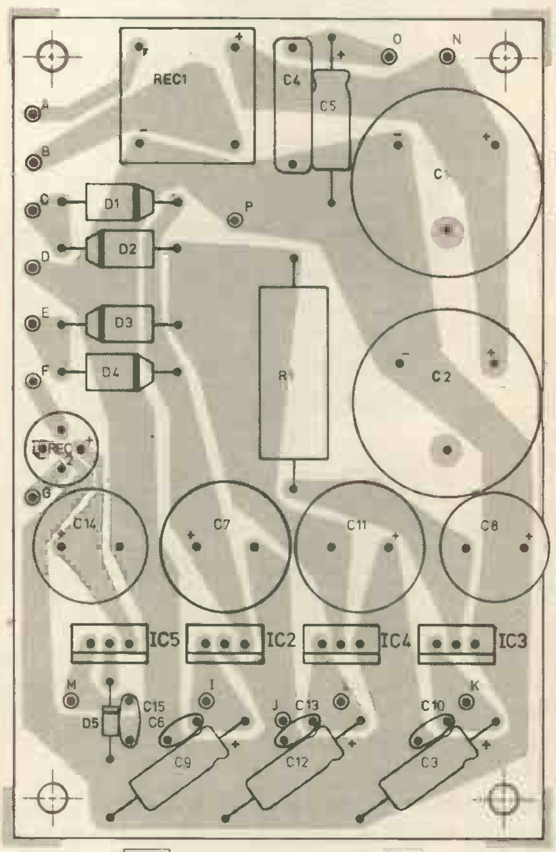
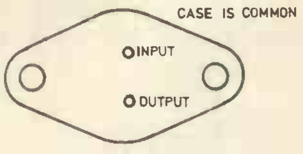


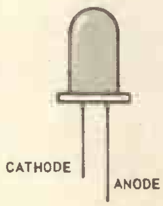
Fig. 1.4. PSU circuit diagram

Fig. 1.5. PSU component layout (copyright Watford Electronics)

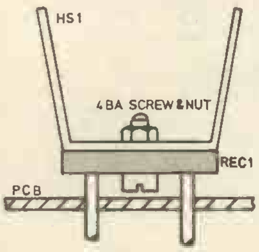


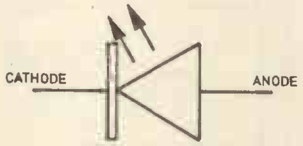


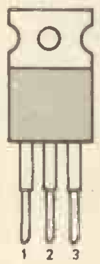
IC1 78H05 pin view



Physical details of D6







	1	2	3
IC2 7812	**Input**	**Common**	**Output**
IC3 7905	**Common**	**Input**	**Output**
IC4 7912	**Common**	**Input**	**Output**
IC5 7818	**Input**	**Common**	**Output**

Component pin-outs.

COMPONENTS . . .

MULTIRAIL POWER SUPPLY

Resistors

R1	10 or 12Ω 5W
R2	330Ω ½W

Capacitors

C1, C2	4700μ/25V tag elect. (2 off)
C3	4μ7/16V axial elect.
C4	220n polyester radial
C5, C9, C12	10μ/16V axial elect. (2 off)
C6, C10, C13, C15	100n disc ceramic (4 off)
C7, C11	2200μ/25V radial elect. (2 off)
C8	1000μ/16V radial elect.
C14	470μ/50V radial elect.

Discrete Semiconductors

D1-D4	1N5401 (4 off)
D5	6V8 1W3 Zener
D6	0·2 in. l.e.d.
REC1	6A/100V bridge rect.
REC2	1A/100V bridge rect.

Integrated Circuits

IC1	78H05 +5V/5A reg.
IC2	7812 +12V/1A reg.
IC3	7905 −5V/1A reg.
IC4	7912 −12V/1A reg.
IC5	7818 +18V/1A reg.

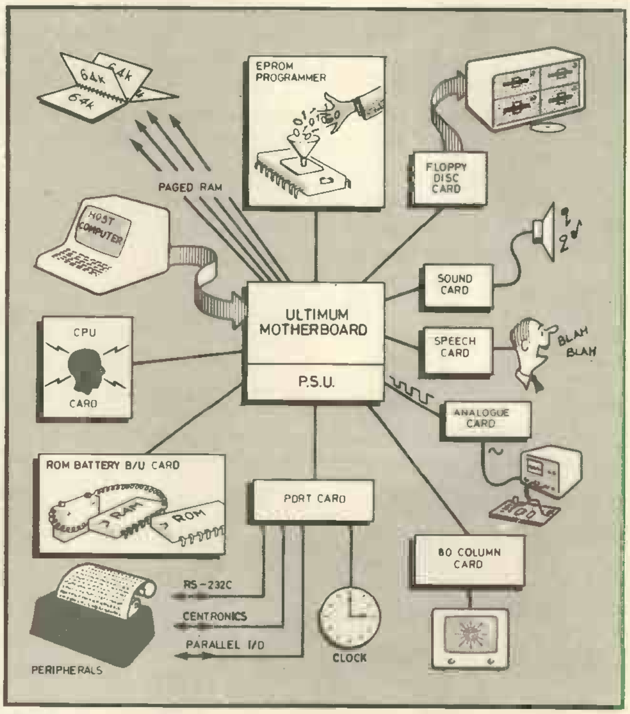
Miscellaneous

T1	Multitap transformer (0-15, 0-15, 0-30, 0-30, 0-9, 0-9@5A)
S1	2 pole 2 way sub min. toggle (mains)
FS1	20mm 1A A/S fuse plus 20mm panel fuse holder
P.c.b.	Watford PSU board
6BA stand-offs, nuts & screws for mounting p.c.b. (4 off each)	
Heatsink	Type TV4
Insulating kit	TO3
5A 3-core mains cable	2 metres
Grommet for above	
4BA ½in. bolts, and nuts (5 off each)	
Solder tag (2 off)	

CONSTRUCTORS' NOTE

Kits for the ULTIMUM are available from Watford Electronics (see advertisers' index). A limited number of ready-built units will be available. Please send SAE for price list of boards now available.

Because the system has so many applications, we feel sure, that people will want to exchange ideas. If this is the case, a users group will be formed to provide support for existing and future machines.



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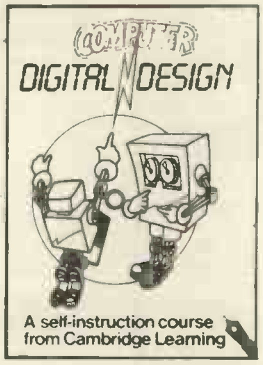

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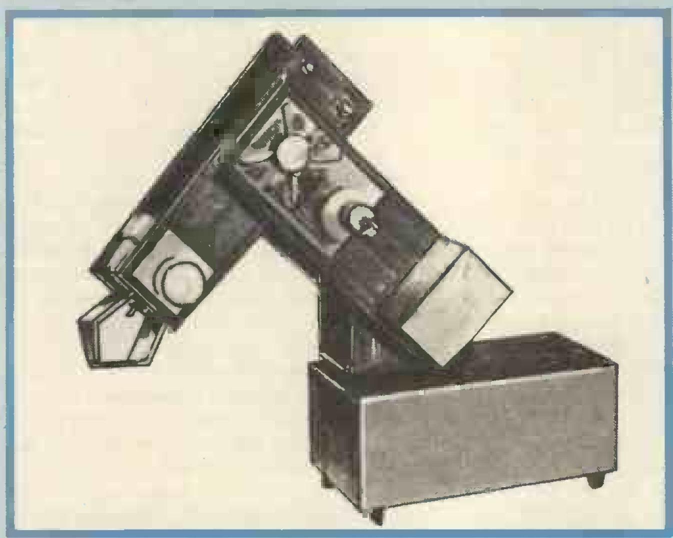

MICROGRASP

With the advancement of robotics into industry, some experience with robots becomes of increasing importance. The Genesis range of robots we published last Winter have achieved considerable penetration into industry and education. However, we have not been resting on our laurels! Next month we start Micrograsp, an ultra low cost electric robot. Even with full servo control and a universal computer interface board the price is under £200.

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4 PAGE PULLOUT

PE micro-file featuring 6800 6802

PRACTICAL

ELECTRONICS

DECEMBER ISSUE ON SALE FRIDAY, NOVEMBER 12

Space Watch...

SALYUT 6 AND COSMOS 1,267

The Soviet Space control ended the 58 month mission of this composite unit on July the 29th, 1982. Cosmos 1,267 was docked automatically with Salyut 6 for a mission of scientific experiments and another of the Russian feasibility studies dealing with permanently manned units in orbit. Up till the time that the composite unit was commanded to destruct into the Pacific Ocean, it had logged some 676 days of manned operations. These were in short and long periods. The short duration involved 11 crews and the long durations 5 crews. The reason given for the termination of the missions was that the programme had been completed and the consumable items such as the fuel for the control systems was near the planned exhaustion level. The total number of launches of Soviet vehicles since Sputnik 1 on October the 4th, 1957, has now reached more than 1,500.

The American authorities seem to have been somewhat worried as to whether some of these manned missions were in fact concerned with anti-satellite homing vehicles as a defensive activity against American satellites. It seems out of keeping with the manner of space research that so much worthwhile work in the cause of science for the benefit of mankind should be marred by wrong attitudes and suspicious undercurrents. Nothing but benefit can come from co-operation, now especially as so many independent countries are active in space technology.

LOOKING BELOW THE SURFACE OF THE LAND

The Shuttle imageing radar has shown that it is possible to provide adequate data of conditions and the character of sub-surface terrain. While it is, of course, possible for radar to 'see' below the surface, the imageing has always been regarded as useless. Now, after the data being analysed from the second Shuttle mission is considered, there are already plans for expeditions to the Sahara. Interest has extended to the re-examination of previous passes over arid areas. The JPL data is to be opened up for this purpose. Some of the Landsat data, like the multispectral scan over the Sahara, shows mostly sand but also a hint of rough terrain below the sand. These, however, were over the 'hyperarid' areas where rainfall comes every 30–50 years. Here, the very fine sand allowed the radar to penetrate. Generally, however, there is no clear indication that there are reliable visual formations that could be reported. However, the radar pictures returned by the second shuttle flight provides ample evidence that very considerable detail can be seen. The varied techniques growing in experience and skill show remarkable conditions. As an example, some of the evidence points to formations which must be at least 35 million years old. Under the sand are to be seen large, wide and dry river valleys extending for hundreds of miles. Indeed, some of the valleys resemble very closely the present Nile valley. Other conclusions that have been drawn indicate that there are extensive fault lines and rugged terrain; also there can be seen alluvial valleys and terraces. The expeditions to make direct examination of these areas will be putting a new look on archaeological digs, for now they will be looking not at recent but at remote periods of time. It is not surprising that renewed interest in the planet Mars is taking place. The arid surface of Mars could yield a great deal of information if the new imageing techniques could be applied from an orbiter. It could be possible to examine the terrain of Mars beneath the polar caps. These new techniques are already regarded as a great scientific advance and new missions for the shuttle are already being planned. It should also be proper that the person who first suggested that this sub-surface imageing capability existed should be rewarded. The Geological Survey and the JPL view this a major discovery and award the credit to a guest investigator Carol S. Breed with the Astrogeologic Branch.

However, while past history is a clue to the future, there are intensive matters of interest for the present. The ebb and flow of terrestrial changes on the crust of the Earth indicates periods of wet conditions and savana growth and periods of arid conditions. Geological features now to be examined below the surface will enable assessments to be made as to the possibility of water and oil recovery. Knowledge of places where possible human habitation may have been in existence as long ago as 200,000 years, offers evidence of the conditions then. So the priorities are already being set for future shuttle missions. Two special radar missions for radar surveys will have the benefit of the new techniques from the Geological SIR–B.

SIR-B radar is an improved and upgraded version of the initial imageing system and will be flown on the shuttle in 1984. This mission will use the same aerial, that is the L-band, but with the capability of variable incidence angle ranging from 15 to 65 deg. This will facilitate the assessment of the effects on the imageing content. The shuttle 1987 to 1988 missions will use a radar system that will have the facility of variable incidence and also variable polarisation.

At the Jet Propulsion Laboratory a study is being made for a radar sounder mission to try to penetrate the polar icecaps. This will be possible because water ice is transparent to the radar energy. Studies of the surface effects indicated that a great deal of surface information is to be obtained. Large wind patterns on the ocean surfaces were seen. In one section of the Aegean Sea it is thought that gravity waves have been detected, or at least the effect of such waves.

In enthusing about the imageing system it would be churlish not to deal with progress that is now being made with Landsat-D. The USA were intending to double the cost of the service of the distribution of data. These charges were $5 to $10 for a single coloured picture, and $200 for a length of binary tape which the purchaser had to process. Some countries have set up their own land stations, paying the USA annual fees for the right to intercept the data. They were able to sell their own data as they wished. Now with the new techniques the scene becomes almost a rescue. Landsat-D, which was launched in last July, carries the new cameras with much improved data acquisition and an improvement of nearly five to one with the new Thematic mapping. This is a far more efficient system and takes pictures both in the visible spectrum and in the infra-red. Areas of 1,000 square metres can be analysed, which adds to the detail that can be 'seen'. There are particular advantages in this for small areas and plantation study. Two teams are co-operating with NASA in Britain. These are the National Environment Council in Swindon and at Reading University. They will be doing this before the Landsat-D comes into official service next year.

There is a second improvement also available for this vehicle. It will be the first to use a new communications satellite to be launched by NASA in January, 1983. It is called the Data Relay Satellite and will orbit 36,000 km above the Earth and will be in the Western Hemisphere. The signals will be received from the Landsat-D and bounced down to the Goddard Spaceflight Center. This means that it will not be necessary for them to operate a large number of base stations to receive data. This will reduce operation costs considerably.

BRITAIN SHARES THE SPACE TELESCOPE WORK

British Aerospace will be delivering solar panels to NASA for the Space Telescope in September, 1983. The Bristol plant of British Aerospace are constructing what must be the largest solar panels so far destined for operation in space. The area of the panels are some 33 square metres. They are, in fact, so large that it is difficult to test the arrays in the Earth's gravity. Some 48,000 silicon cells will produce about 5·5 kilowatts of direct current.

The design of the panels is rather special. As the vehicle will have to be carried in the shuttle cargo bay, a compact package must be made. The solar panels will be wound around drums 20 centimetres in diameter. When the spacecraft is unloaded into orbit the two giant panels will unroll. The height at which the Telescope will orbit is comparatively low, only a few hundred kilometres.

These solar panels are likely to be the forerunners of still larger arrays. This will be necessary because power of 100kW will be required by the 1990's, and by the end of the century of the order of megawatts. The value of the contract to British Aerospace is worth some 11 million pounds.

PE

micro-file

R.W. COLES

INTRODUCTION

WE HAVE all been touched by the far reaching effects of the microprocessor revolution in our day to day lives, and there will soon be few households which do not have a microprocessor tucked away somewhere, in a TV game, a home computer, a washing machine or even a door bell!

Of course, as electronics enthusiasts, we have a special interest in the potential of the microprocessor, but although most of us are itching for a "piece of the action" it has *not* been easy to decide quite what we are supposed to do with this marvellous innovation. At the moment, even for electronic hobbyists, the main way "in" is to buy a basic home computer such as the Sinclair ZX81. But I suspect that for some this has been a frustrating experience. The problem is that using a home computer and programming it in BASIC is not necessarily a suitable replacement for the smell of solder flux and the burned fingers which we all enjoyed so much! Almost ten years since the first microprocessor appeared, it now seems that microprocessors are for *software* hobbyists and are much too complicated for us to use in the replacement of the transistors, gates, and pink wire with which we have been traditionally associated.

This situation cannot be allowed to continue. Microprocessors are crying out for the attentions of our soldering irons, and it is our contention that the use of these useful devices is not as difficult as it may appear at first sight. The problem we face is in the nature of an information explosion. We are surrounded by a bewildering array of microprocessor chips, support chips, memory chips and software, all apparently *very* complicated. If we want to build a simple system such as a music generator or a central heating controller, which chip do we choose? Is it powerful enough? Has it got the right features? Can we program it? Will it be obsolete next month? All questions not easy to answer, and enough to put us off the idea and return to building "traditional" projects or even turn our hand to writing a program to find all the prime numbers between 1 and 1000.

But all is not lost! The editorial team of *Practical Electronics* is determined that the electronic aspects of using microprocessors should not be delegated for ever to the professionals, and we are therefore launching the MICRO-FILE series to help reduce the confusion surrounding these powerful components. The series is an attempt to lay bare the essential characteristics of the most popular processors so that the interested may keep up to date, and the dedicated project designers can choose the correct processor for their needs. Those who already have microprocessors in personal computers or other units will also find the series useful if they wish to delve into the innards of their machine to interface with it, repair it, or even just understand it.

the micro scene...

There are currently about 40 different available microprocessor designs, although obviously not all of these can claim to be "winners". Even this daunting figure does not tell the whole story by any means. Many of the 40 basic chip designs come in several different versions which bumps the total up considerably, and nearly all the "popular" devices are produced by several manufacturers either by second sourcing under licence, or as functional copies which may not operate like the original in all respects. Add to this the fact that most micro based systems require additional family support chips to facilitate interfacing and the seeds of confusion have sprouted to form a forest!

Because of the kaleidoscopic nature of applications for the versatile microprocessor, it is not easy to create pigeon holes into which the various chips and their uses can be slotted, but some attempt has to be made to simplify things. Perhaps the best way to start is to split the spectrum of micro applications in two, with "data processors" on the one hand and "controllers" on the other. Data processors generally operate "off-line" under human supervision and require large programs usually written in a high level language such as BASIC. These systems require large arrays of read write memory and generally have at least one operator console. Personal computers are one example of a data processor application, word processors are another.

Controllers usually operate alone to control or monitor some process automatically and generally use smaller ROM based fixed programs which are usually written in assembly language machine code. For controller applications speed is often important, and transducers are required to sense the state of the process and to generate appropriate outputs. Burglar alarms, TV games and central heating systems are examples of applications where microprocessors are used as controllers.

CHOOSING A CHIP

Many microprocessor chips have special advantages which suit them either to data processor or to controller applications, but it is also true that many others are general purpose in nature.

Those best suited to data processing will have a word length of at least 8 bits and will have an address bus wide enough to access at least 64K words of memory. Their instruction sets should offer a rich variety of addressing modes and a family of interface devices should also be available. There is a very definite trend towards 16 bit processors with address ranges of 1 megabyte or more for most data processing tasks. These devices are at least as powerful as the minicomputers which they will soon replace, but the design of a hardware and software system to take advantage of their power is, unfortunately, a daunting prospect for the non-professional.

Microprocessors optimised for controller applications may have any word length from 4 bits upwards and should ideally be as self-contained as possible, even to the extent of being true "single chip" devices which pack RAM ROM and interface lines into a single package. Controller instruction sets should be compact and offer fast access to I/O and timing functions. Simple, on chip interrupt prioritisation is also an advantage, as is the availability of a multifunction peripheral chip family. Generally speaking, microprocessors which are optimised for control applications are simpler to design with in both hardware and software terms.

The author's view is that if your main interest lies in the data processing or personal computer field, then it is difficult to compete with the many ready-made offerings from Sinclair, Acorn, Commodore, Tandy, Apple, and a host of other suppliers. The main problem here is that the microprocessor is really only the tip of the iceberg in D.P. applications with software being the most important factor. It has been said, for example, that to make proper use of the new data processing orientated iAPX 432 microprocessor from Intel, the typical user will need to invest as much as ten *man-years* in software creation, even using a high level language!

If you wish to use a microprocessor to *control* things however, then hardware ingenuity is still very important and the required software can usually be created in weeks even when using machine code and without the benefit of expensive development systems. The message is clear. If your ambitions lie in designing a 16 bit personal computer with twin floppies, a megabyte of RAM and a Pascal compiler, then a stony road lies ahead! If, however, you wish to control your central heating or build a fuel consumption computer for your car, then pick a suitably simple control processor and have a go; you could have a lot of fun!

THE OBSOLESCENCE PROBLEM

One thorny problem for any budding designer is the very rapid progress in microprocessor technology which produces better, faster, and above all *cheaper* devices at a breakneck pace. There is therefore the ever present spectre of starting a project and then finding that before is is finished a new device has emerged which would do the job better and at a lower cost. This is especially true in the data processing field where development periods tend to be longer.

To avoid the worst of this problem, it is obviously necessary to choose a device which is not about to be superseded. Beware the bargain offer of a wheelbarrow full of National SC/MPs or Intel 8008s for a "Tenner!" At the same time it *is* necessary to choose a device which has been in-play for a sufficiently long period to establish its popularity and which can therefore be expected to have good support and a long life. You can expect the manufacturers to develop their success with popular chips by bringing out improved versions, and this can be an advantage because your "learning" investment can be put to good use on future projects using the enhanced devices when they are available. It is also necessary to remember that, say, a central heating controller may be required to operate for 20 years or more while the lifetime of the majority of microprocessors can be expected to be less than ten years—so remember to buy a spare!

SUPPORT DEVICES

If there *were* any such thing as a typical microprocessor system then in addition to the processor device itself we could expect to find RAM and ROM memory, a parallel I/O port, a serial I/O port, and at least one "special" device such as a disc controller, a maths chip, or an analogue to digital converter. Support devices are available to fill all these requirements and many more besides, and these have to be given serious consideration since they contribute almost as much as the processor itself to the success of any project.

Support devices can be part of a particular microprocessor "family" and these often have special features to simplify their use with that family. Also available are many general purpose devices which can be interfaced to most processors with the addition of a small amount of external logic. All have their part to play. The trend in support devices is towards complex and powerful chips which give a considerable boost to the basic performance of any processor by unloading from it a lot of the system "chores" which it would otherwise have to perform for itself. Prime examples here are the maths processor chips which give systems easy access to floating point arithmetic and high level math functions such as square roots and sines which would normally have to be provided by software routines. Many support devices rival the microprocessors which they serve in chip complexity, and so it is important not to underestimate the task of learning how to initialise and program these devices to perform the required function. Some support chips even have user manuals as thick as those of their attendant microprocessor!

MICRO-FILE FORMAT

Having set the scene, and perhaps frightened, but hopefully inspired many readers, we can now return to how the MICRO-FILE series has been designed to help!

To make any kind of objective assessment of a number of microprocessor devices it is normally necessary to purchase the relevant manuals, and these are not cheap. Having purchased the manuals, a period of intensive study is required to sort out the important characteristics and to come to any conclusion. Remember too, that the manuals are written by the manufacturer and are therefore unlikely to point out any shortcomings!

MICRO-FILE builds up month by month to provide a complete quick reference guide to the more popular microprocessors. Each MICRO-FILE entry consists of a quick reference fact sheet, designed for easy filing, and explanatory text which provides further information and application data. The sheets can be removed from the magazine and placed in a binder for filing.

This introductory article can form the binding "covers". At present there are plans to include about twelve of the most popular processors, but this may be extended later if necessary. So if you collect the whole series it will form a 48 page (or more) reference book on microprocessors plus this "cover" section.

The first FILESHEET considers the Intel 8080A and its successor the 8085A, two of the most popular processors so far, with the 8080A often considered to be the processor which really started the microprocessor revolution.

The reference fact sheet is intended to provide all the essential information about a processor or a processor family, including general background details, register arrangement, instruction set and software, system schematics, performance data, pin connections and basic support chip information. Using these sheets it will be possible to compare processors and to choose the best one for a particular application. Readers not interested in go-it-alone projects can use the sheets to assess the potential power of readily built systems using a particular processor, to help with system trouble shooting and interfacing, or simply to improve their knowledge of the subject.

PE micro-file

R.W.Coles

FILESHEET 1 8080A · 8085A

THE Intel 8080 8 bit NMOS microprocessor first appeared in 1973 as a successor to the more limited 8008 PMOS device. The 8080A was the first microprocessor to capture the imagination of designers and was a fundamental cog in the microprocessor revolution generating annual sales of over 2 million devices per year in its heyday. The success of this chip resulted in the spawning of two, more powerful successors, the Z80 from Zilog which had an enhanced instruction set but basically the same bus configuration, and the 8085A from Intel which had basically the same instruction set but a new multiplexed bus structure. Both of the newcomers appeared in 1977 and have now replaced the 8080A for all new applications with the Z80 being most popular for data processing and the 8085 being more successful as a controller.

In order to squeeze the maximum performance from the NMOS technology available in the early 1970s the 8080A was designed to use three supply rails of +5, −5 and +12 volts and had to have two additional support chips to provide clock generation and bus interface. The main competition to the 8080A in the early days was the Motorola 6800 which despite using only two chips and a single supply voltage was never as popular due to its lower overall performance.

The 8080A has a common instruction and data memory space of 64 kilobytes and a separate I/O space of 256 ports which, together with a good general purpose instruction set, made it useful for a wide range of applications in control and data processing.

The 8085 was an attempt by Intel to maintain the sales momentum created by the 8080A, although it could be argued that the competing Z80 from Zilog did a better job. The 8085 needs no support chips except for memory and I/O, and will run faster than the 8080A from a single 5V supply. To free extra interface pins the 8085A has a multiplexed data and address bus with the new connections being used for extra interrupts and serial I/O in addition to the necessary control and clock lines. Introduced at the same time as the 8085A were two special peripheral devices also in 40 pin packages. The 8155 provides 256 bytes of RAM, 22 parallel I/O lines and a 14 bit timer while the 8355 provides 2K bytes of ROM and 16 parallel I/O lines. Using the 8085A with these two peripherals it is possible to build a powerful processor system with RAM, ROM and comprehensive I/O using just three chips.

REGISTERS

The 8080A and the 8085A have an identical data register arrangement although the 8085A does have an additional register which is used in the control of its extra serial I/O and Interrupt lines. Both devices have eight addressable 8 bit registers which can be used as four 16 bit register pairs for many operations. Perhaps most important of these is the 8 bit Accumulator register which is the implied focus of many instructions including the memory reference, arithmetic, and I/O groups. For some operations this register is paired with the flag register which itself provides single bit status information about data in the accumulator after arithmetic and logical operations. Flag bits are provided to report on five possible status conditions as shown on the file sheet, with the remaining 3 bits being unused. The BC, DE and HL registers are essentially general purpose in nature and can be used as temporary storage for 8 and 16 bit data values, as 8 and 16 bit counters, or as 16 bit memory address pointers. The HL register is particularly important as a memory pointer since it is used by a number of memory reference instructions. It is also used as an "accumulator" for 16 bit arithmetic. A smaller number of instructions use the BC and DE pairs as pointers, and either of these register pairs can be added to the HL pair to give a limited 16 bit arithmetic capability.

In addition to the four register pairs already discussed there are two other 16 bit registers which have dedicated functions. The Program Counter register always points to the next instruction to be executed and therefore contains a 16 bit address. The Stack Pointer always points to the top of the last-in-first-out stack area maintained in read/write memory for the storage of subroutine return addresses and register values saved during interrupts or for other purposes. The Stack Pointer is decremented each time data is "pushed" on to the stack and is incremented each time data is "popped" off the stack.

The generous register set of the 8080 was one of the reasons for its success over the Motorola 6800, but the specialised uses of the BC, DE and HL pairs also had the effect of producing a less regular and "messy" instruction set making it necessary for the programmer to remember just what particular pairs can and cannot be used for. The more modern 16 bit processors overcome this problem by making their registers completely general purpose and non-specialised wherever possible. Lacking in the 8080/8085 is the useful feature of an index register such as that provided by the 6800, although this job can be performed by the register pairs at the cost of using extra instructions.

INSTRUCTION SET

As mentioned above, the 8080/8085 instruction set is rather "messy" due to the somewhat specialised nature of the large register array, but this does make these devices very powerful considering their small chip areas. The 78 basic instructions of the 8080 are used to move data between registers, between a register and memory, between a register and an I/O port, and to carry out arithmetic and logical operations. Instructions are also included to perform conditional and unconditional jumps and to control processor operation. Two additional 8085A instructions, RIM and SIM, are ingeniously used to provide access to, and control over, the extra serial I/O and interrupt features not present on the 8080.

A comprehensive array of arithmetic and logical operations are provided including 8 and 16 bit binary addition, 8 bit binary subtraction, binary coded decimal (BCD) arithmetic on packed BCD values, logical operations such as AND, OR, XOR and Compare, and a range of accumulator shifts and carry flag modifiers. One item missing from this group is the ability to set, test, and reset, individual accumulator bits which is a very useful feature for control applications. These operations can be performed by shifting the relevant bit into the carry flip-flop or by using logic instructions, however.

Four addressing modes are used as follows:—Direct, in which a memory address is specified as part of the instruction; Register, in which a register or register pair is specified; Register Indirect, in which the instruction specifies a register pair which itself contains a memory address; and Immediate, in which the instruction contains not a reference to a data area but the actual data itself. One particularly useful feature of the instruction set is the provision of a group of eight Restart instructions which cause an immediate jump to fixed vectors in low memory. These instructions use only a single byte and are used for hardware interrupt service or as software interrupts. Access to the separate I/O address space of 256 input and 256 output ports is provided by means of the instructions IN and OUT which are fast because they are only 2 bytes long. The separate I/O address space is useful because it does not encroach on main memory, but it is still possible to use memory mapping for I/O ports if required for a simple system not needing the full 64K memory address range.

8080A/8085A REFERENCE FILE SHEET

GENERAL

The 8080A was the first of the mid-range NMOS 8 bit processors and is certainly the most widely used. It has a good general purpose architecture and is very well supported with both hardware and software. The 8085A has essentially the same instruction set as the 8080A but needs only a 5V supply and has many additional features such as on-chip clock, serial I/O and four new interrupt lines. Extra pins for these functions have been made available by multiplexing the low order address bits with the data bus. A complete 8085A system with 2K bytes of ROM, 256 bytes of RAM, a timer and 38 I/O lines can be built with just three 40 pin chips by utilising the 8355 (ROM I/O) and the 8155 (RAM I/O TIMER) combination devices.

REGISTERS: The 8080/8085 has seven 8 bit general purpose registers. Six of these can be addressed as the three 16 bit pairs BC, DE, HL.

Notes
1) PSW = Processor Status Word
2) HL is used as memory pointer for register indirect addressing.

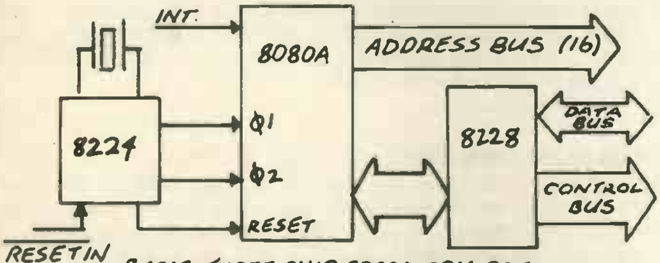
ACCUM	8	FLAGS	5	PSW
B	8	C	8	BC
D	8	E	8	DE
H	8	L	8	HL
STACK POINTER			16	SP
PROGRAM COUNTER			16	PC

FLAGS:

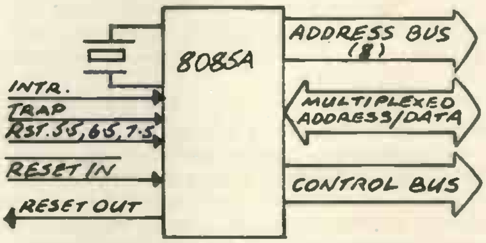
D7	D6	D5	D4	D3	D2	D1	D0
SIGN	ZERO		AUX. CARRY		PARITY		CARRY

INSTRUCTION SET AND SOFTWARE

The 8080 has 78 basic instructions and the 8085 has two more, RIM and SIM which support the additional interrupts and serial I/O. One, two and three byte instructions are used and Direct, Register, Register Indirect and Immediate addressing modes are available. Full binary and BCD arithmetic is possible on 8 bit bytes, and some 16 bit arithmetic is possible using the HL pair as an accumulator. A separate address space is available for I/O using the IN and OUT instructions. Very well supported with software including Tiny Basics and the CPM operating system.



BASIC THREE CHIP 8080A CPU CCT



BASIC SINGLE CHIP 8085A EQUIVALENT

PERFORMANCE DATA

PERFORMANCE DATA	8080A	8085A
MEMORY ADDRESS RANGE:	64K	64K
I/O ADDRESS RANGE:	256	256
CLOCK FREQUENCY:*	2MHz	3·125
POWER SUPPLIES:	+5, -5, +12V	+5V
INTERRUPTS:	INT.	INTR. TRAP RST5.5 RST6.6 RST 7.5

* NOTE: HIGH SPEED VERSIONS OF 8080A (3MHz) AND 8085A (5MHz) ALSO AVAILABLE

BENCHMARKS	8080A	8085A
ADD REGISTER TO ACCUM:	2μS	1·28μS
OUTPUT ACCUMULATOR TO PORT:	5μS	3·2μS
MOVE FROM MEMORY TO MEMORY:	8μS	5·12μS

PIN DIAGRAMS

8080A

A10	1	40	A11
GND	2	39	A14
D4	3	38	A13
D5	4	37	A12
D6	5	36	A15
D7	6	35	A9
D3	7	34	A8
D2	8	33	A7
D1	9	32	A6
D0	10	31	A5
-5V	11	30	A4
RESET	12	29	A3
HOLD	13	28	+12V
INT	14	27	A2
Ø2	15	26	A1
INTE	16	25	A0
DBIN	17	24	WAIT
WR	18	23	READY
SYNC	19	22	Ø1
+5V	20	21	HLDA

8085A

X1	1	40	VCC
X2	2	39	HOLD
RESET OUT	3	38	HLDA
SOD	4	37	CLK OUT
SID	5	36	RESET IN
TRAP	6	35	READY
RST 7.5	7	34	IO/M
RST 6.5	8	33	S1
RST 5.5	9	32	RD
INTR.	10	31	WR
INTA	11	30	ALE
AD0	12	29	S0
AD1	13	28	A15
AD2	14	27	A14
AD3	15	26	A13
AD4	16	25	A12
AD5	17	24	A11
AD6	18	23	A10
AD7	19	22	A9
VSS	20	21	A8

MANUFACTURERS

ORIGINATOR—INTEL

2nd Sources 8080A: SIEMENS, AMD, NEC. NATIONAL, SIGNETICS, HITACHI

2nd. Sources 8085A: AMD, SIEMENS, NEC

SUPPORT CHIPS

8080A Needs 8224 and 8228 and has a large family of support devices including: 8251 (USART), 8255 (Parallel I/O) 8253 (Timer) 8259 (Interrupt Control) 8257 (DMA)
8085A has two special combination I/O memory chips 8355 and 8155 in addition to above devices.

TABLE 8. INSTRUCTION SET SUMMARY

Mnemonic	Description	Instruction Code[1] $D_7 D_6 D_5 D_4 D_3 D_2 D_1 D_0$	Clock[2] Cycles
MOVE, LOAD, AND STORE			
MOVr1 r2	Move register to register	0 1 D D D S S S	4
MDV M r	Move register to memory	0 1 1 1 0 S S S	7
MOV r M	Move memory to register	0 1 D D D 1 1 0	7
MVI r	Move immediate register	0 0 D D D 1 1 0	7
MVI M	Move immediate memory	0 0 1 1 0 1 1 0	10
LXI B	Load immediate register Pair B & C	0 0 0 0 0 0 0 1	10
LXI D	Load immediate register Pair D & E	0 0 0 1 0 0 0 1	10
LXI H	Load immediate register Pair H & L	0 0 1 0 0 0 0 1	10
LXI SP	Load immediate stack pointer	0 0 1 1 0 0 0 1	10
STAX B	Store A indirect	0 0 0 0 0 0 1 0	7
STAX D	Store A indirect	0 0 0 1 0 0 1 0	7
LDAX B	Load A indirect	0 0 0 0 1 0 1 0	7
LDAX D	Load A indirect	0 0 0 1 1 0 1 0	7
STA	Store A direct	0 0 1 1 0 0 1 0	13
LDA	Load A direct	0 0 1 1 1 0 1 0	13
SHLD	Store H & L direct	0 0 1 0 0 0 1 0	16
LHLD	Load H & L direct	0 0 1 0 1 0 1 0	16
XCHG	Exchange D & E, H & L Registers	1 1 1 0 1 0 1 1	4
STACK OPS			
PUSH B	Push register Pair B & C on stack	1 1 0 0 0 1 0 1	12
PUSH D	Push register Pair D & E on stack	1 1 0 1 0 1 0 1	12
PUSH H	Push register Pair H & L on stack	1 1 1 0 0 1 0 1	12
PUSH PSW	Push A and Flags on stack	1 1 1 1 0 1 0 1	12
POP B	Pop register Pair B & C off stack	1 1 0 0 0 0 0 1	10
POP D	Pop register Pair D & E off stack	1 1 0 1 0 0 0 1	10
POP H	Pop register Pair H & L off stack	1 1 1 0 0 0 0 1	10
POP PSW	Pop A and Flags off stack	1 1 1 1 0 0 0 1	10
XTHL	Exchange top of stack, H & L	1 1 1 0 0 0 1 1	16
SPHL	H & L to stack pointer	1 1 1 1 1 0 0 1	6
JUMP			
JMP	Jump unconditional	1 1 0 0 0 0 1 1	10
JC	Jump on carry	1 1 0 1 1 0 1 0	7/10
JNC	Jump on no carry	1 1 0 1 0 0 1 0	7/10
JZ	Jump on zero	1 1 0 0 1 0 1 0	7/10
JNZ	Jump on no zero	1 1 0 0 0 0 1 0	7/10
JP	Jump on positive	1 1 1 1 0 0 1 0	7/10
JM	Jump on minus	1 1 1 1 1 0 1 0	7/10
JPE	Jump on parity even	1 1 1 0 1 0 1 0	7/10
JPO	Jump on parity odd	1 1 1 0 0 0 1 0	7/10
PCHL	H & L to program counter	1 1 1 0 1 0 0 1	6
CALL			
CALL	Call unconditional	1 1 0 0 1 1 0 1	18
CC	Call on carry	1 1 0 1 1 1 0 0	9/18
CNC	Call on no carry	1 1 0 1 0 1 0 0	9/18
CZ	Call on zero	1 1 0 0 1 1 0 0	9/18
CNZ	Call on no zero	1 1 0 0 0 1 0 0	9/18
CP	Call on positive	1 1 1 1 0 1 0 0	9/18
CM	Call on minus	1 1 1 1 1 1 0 0	9/18
CPE	Call on parity even	1 1 1 0 1 1 0 0	9/18
CPO	Call on parity odd	1 1 1 0 0 1 0 0	9/18
RETURN			
RET	Return	1 1 0 0 1 0 0 1	10
RC	Return on carry	1 1 0 1 1 0 0 0	6/12
RNC	Return on no carry	1 1 0 1 0 0 0 0	6/12
RZ	Return on zero	1 1 0 0 1 0 0 0	6/12
RNZ	Return on no zero	1 1 0 0 0 0 0 0	6/12
RP	Return on positive	1 1 1 1 0 0 0 0	6/12
RM	Return on minus	1 1 1 1 1 0 0 0	6/12
RPE	Return on parity even	1 1 1 0 1 0 0 0	6/12
RPO	Return on parity odd	1 1 1 0 0 0 0 0	6/12
RESTART			
RST	Restart	1 1 A A A 1 1 1	12
INPUT/OUTPUT			
IN	Input	1 1 0 1 1 0 1 1	10
OUT	Output	1 1 0 1 0 0 1 1	10
INCREMENT AND DECREMENT			
INR r	Increment register	0 0 D D D 1 0 0	4
DCR r	Decrement register	0 0 D D D 1 0 1	4
INR M	Increment memory	0 0 1 1 0 1 0 0	10
DCR M	Decrement memory	0 0 1 1 0 1 0 1	10
INX B	Increment B & C registers	0 0 0 0 0 0 1 1	6
INX D	Increment D & E registers	0 0 0 1 0 0 1 1	6
INX H	Increment H & L registers	0 0 1 0 0 0 1 1	6
INX SP	Increment stack pointer	0 0 1 1 0 0 1 1	6
DCX B	Decrement B & C	0 0 0 0 1 0 1 1	6
DCX D	Decrement D & E	0 0 0 1 1 0 1 1	6
DCX H	Decrement H & L	0 0 1 0 1 0 1 1	6
DCX SP	Decrement stack pointer	0 0 1 1 1 0 1 1	6
ADD			
ADD r	Add register to A	1 0 0 0 0 S S S	4
ADC r	Add register to A with carry	1 0 0 0 1 S S S	4
ADD M	Add memory to A	1 0 0 0 0 1 1 0	7
ADC M	Add memory to A with carry	1 0 0 0 1 1 1 0	7
ADI	Add immediate to A	1 1 0 0 0 1 1 0	7
ACI	Add immediate to A with carry	1 1 0 0 1 1 1 0	7
DAD B	Add B & C to H & L	0 0 0 0 1 0 0 1	10
DAD D	Add D & E to H & L	0 0 0 1 1 0 0 1	10
DAD H	Add H & L to H & L	0 0 1 0 1 0 0 1	10
DAD SP	Add stack pointer to H & L	0 0 1 1 1 0 0 1	10
SUBTRACT			
SUB r	Subtract register from A	1 0 0 1 0 S S S	4
SBB r	Subtract register from A with borrow	1 0 0 1 1 S S S	4
SUB M	Subtract memory from A	1 0 0 1 0 1 1 0	7
SBB M	Subtract memory from A with borrow	1 0 0 1 1 1 1 0	7
SUI	Subtract immediate from A	1 1 0 1 0 1 1 0	7
SBI	Subtract immediate from A with borrow	1 1 0 1 1 1 1 0	7

TABLE 8. INSTRUCTION SET SUMMARY* (Continued)

Mnemonic	Description	Instruction Code[1] $D_7 D_6 D_5 D_4 D_3 D_2 D_1 D_0$	Clock[2] Cycles
LOGICAL			
ANA r	And register with A	1 0 1 0 0 S S S	4
XRA r	Exclusive Or register with A	1 0 1 0 1 S S S	4
ORA r	Or register with A	1 0 1 1 0 S S S	4
CMP r	Compare register with A	1 0 1 1 1 S S S	4
ANA M	And memory with A	1 0 1 0 0 1 1 0	7
XRA M	Exclusive Or memory with A	1 0 1 0 1 1 1 0	7
ORA M	Or memory with A	1 0 1 1 0 1 1 0	7
CMP M	Compare memory with A	1 0 1 1 1 1 1 0	7
ANI	And immediate with A	1 1 1 0 0 1 1 0	7
XRI	Exclusive Or immediate with A	1 1 1 0 1 1 1 0	7
ORI	Or immediate with A	1 1 1 1 0 1 1 0	7
CPI	Compare immediate with A	1 1 1 1 1 1 1 0	7
ROTATE			
RLC	Rotate A left	0 0 0 0 0 1 1 1	4
RRC	Rotate A right	0 0 0 0 1 1 1 1	4

Mnemonic	Description	Instruction Code[1] $D_7 D_6 D_5 D_4 D_3 D_2 D_1 D_0$	Clock[2] Cycles
RAL	Rotate A left through carry	0 0 0 1 0 1 1 1	4
RAR	Rotate A right through carry	0 0 0 1 1 1 1 1	4
SPECIALS			
CMA	Complement A	0 0 1 0 1 1 1 1	4
STC	Set carry	0 0 1 1 0 1 1 1	4
CMC	Complement carry	0 0 1 1 1 1 1 1	4
DAA	Decimal adjust A	0 0 1 0 0 1 1 1	4
CONTROL			
EI	Enable interrupts	1 1 1 1 1 0 1 1	4
DI	Disable Interrupt	1 1 1 1 0 0 1 1	4
NOP	No-operation	0 0 0 0 0 0 0 0	4
HLT	Halt	0 1 1 1 0 1 1 0	5
EXTRA 8085A INSTRUCTIONS			
RIM	Read Interrupt Mask	0 0 1 0 0 0 0 0	4
SIM	Set Interrupt Mask	0 0 1 1 0 0 0 0	4

NOTES: 1. DDD or SSS: B=000. C 001. D 010. E 011. H 100. L 101. Memory 110. A 111.
2. Two possible cycle times. (6/12) indicate instruction cycles dependent on condition flags.

SOFTWARE

The 8080/8085 family is probably better supported in software than any of the other microprocessors. There is so much software available that it would be quite impossible to list it all. The key to 8080/8085 software is the CP/M disc operating system produced by Digital Research of Pacific Grove, California. Since its introduction, CP/M has become the standard microprocessor operating system and has therefore encouraged large numbers of software writers to produce Interpreters, Compilers, Word processors, games, and utilities. CP/M itself is quite basic but is written in 8080 code so that it is directly compatible with 8080, 8085 and Z80 based systems. So popular is it, that personal computers based on other processors, such as the Apple which uses a 6502, are often upgraded to CP/M compatibility by the addition of an extra 8080 or Z80 processor card so that access to CP/M compatible software is possible.

Of course, not all systems can use discs, and in this case standalone software is desirable. Software distribution is more difficult in this case, but a number of 8080/8085 Tiny Basic Interpreters have been published and there are several books with software listings available. I can recommend the inexpensive Scelbi books which give listings for an 8080 Monitor, Editor, and Assembler.

INTERFACING

The 8080A and 8085A interface to both memory and I/O devices by means of READ and WRITE machine cycles which each have an associated control line output ($\overline{RD}$ and $\overline{WR}$ respectively). An additional control line IO/$\overline{M}$ informs bus users whether the cycle applies to a memory or an I/O device. The main difference between the two processors is the multiplexed bus structure of the 8085A where the eight low order address bits (A0–A7) share the same pins as the data bus and are therefore labelled AD0–AD7. The special purpose 8085A interface chips, the 8155 RAM/IO/TIMER and the 8355 ROM/IO, have internal demultiplexing circuitry so that they can work directly from the 8085 bus. Other devices including general purpose ROM and RAM chips, and interface chips such as the UART, need a non-multiplexed bus and this can be easily achieved by using an external 8 bit latch such as the 74LS373. The 8085A provides a special signal, ALE, to cause the low address data to be latched. With this latch in use, the bus structures of the 8080A and 8085A are virtually identical.

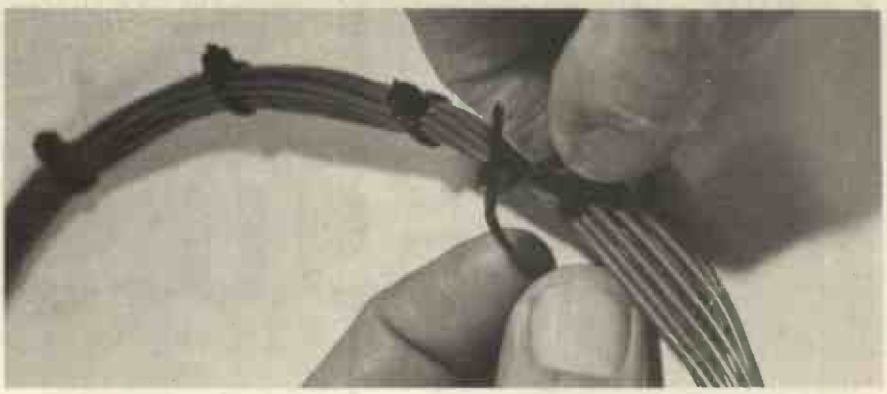
The most versatile interrupt line, INT on the 8080A and INTR on the 8085A can cause a vector to any location in memory with the use of external hardware to force a CALL (Jump to subroutine) instruction on to the bus. This three byte instruction is best generated by the 8259A interrupt controller which will provide separate interrupt vectors for up to eight interrupts. A much simpler scheme can also be used to generate single byte RESTART instructions instead, but of course these vector to fixed locations in low memory. In addition to this general purpose interrupt, the 8085A has four additional fixed vector interrupt lines which do not need any external hardware support. These inputs, RST 5.5, RST 6.5, RST 7.5 and TRAP, cause the processor to vector to locations in low memory positioned between the RESTART vectors which remain available. The TRAP interrupt puts right one criticism of the 8080A by providing a non-maskable interrupt which cannot be ignored. This is useful for important occurrences such as power failure.

One major strength of the 8080A/8085A family is the very wide range of directly compatible interface devices available. In addition to the 8259A Interrupt controller there is the 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART), the 8255A Programmable Parallel Interface (PPI), the 8271 Floppy Disc Controller, the 8278 Programmable Keyboard Interface and many, many more, including devices made for this family by other manufacturers such as N.E.C. Both processors are compatible with a wide range of standard memory components including static and dynamic RAM, ROM, EPROM, and EEPROM.

APPLICATIONS

Unless you are an existing 8080A fan, there would seem to be little point in using this processor for new applications since both the Z80 and the 8085A are actually cheaper and, of course, more powerful. The 8085A still has a part to play in controller applications which can make good use of its extra Interrupts, Serial I/O lines, and the useful 8155A peripheral device, but it is really best suited to applications which are too "big" for one of the single chip processors like the 8748, but not so big that they need one of the newer 16 bit devices. For data processing applications the Zilog Z80 is probably a better choice. Perhaps the main obstacle to using the 8085A in home projects is the inability to use the 8355A masked ROM and I/O device and the consequent need to use a standard EPROM such as the 2716 which therefore makes the use of a bus demultiplexer latch necessary.

Using Your 6 FREE CABLE TIES



BY NOW you will no doubt have found the 6 Ty-It cable ties attached to the front of this issue. Just in case you don't know what to do with them (!) here are a few suggestions, some buying information and details of other related products. Even if you don't build any of our projects the ties will be useful in a number of other applications.

Many of the devices in current use which have been designed for the specific purpose of securing electrical cables employ plastics, either wholly, or as a covering for stronger materials such as stainless steel or aluminium. Our free Ty-It ties are made of nylon and are from the Hellermann Insuloid range.

Broadly, the range can be divided into harnessing ties, with the cables only tied to one another, and fixing ties which hold single cables or bundles of wires to chassis, cabinet, machine or cable tray. A third class provides a solid anchorage for a flexible lead—say into a domestic appliance—sometimes with the added feature of a block terminal.

Ties and fastenings which were once pieces of string and insulated staples, are now almost exclusively produced as plastic mouldings. Some flat metal types are made in stainless steel or aluminium, but these are normally plastic covered. Nylon 66 is a commonly used standard material with a high tensile strength. For outside use where weather resistance is needed there is a special 2 per cent carbon black grade and there is also a heat stabilised grade which extends the life at 150 degrees C.

STANDARD TIES

The Ty-It ties are made in tough, flexible nylon 66. They are offered in various lengths and with alternative types of fixing heads. The size range covers 2·5mm to 7·6mm strap width with lengths from 120 to 540mm. Note that the length can be extended in an emergency by joining ties.

It is in the field of flexible ties that the greatest variety of designs is found, simply because of the infinite variety of applications such as TV receivers, business machines, motor cars, commercial vehicles, machine tools, switchgear and telecommunications, each of which can present different problems of accessibility, the concealment of fastenings and the panel material or chassis wall.

There is a variety of mounting bases or cradles designed for fixing to panels and walls before anchoring down the loom, these being arranged to accept standard nylon ties. Rivet fixing is possible for releasable and permanent ties where corrosion-proof anchorage and a sealed hole are sought. A bolted-on version is available for restricted spaces and there is a further version which lifts the loom clear of the panel surface and is recommended for tropical and high humidity conditions.

Quickly installed and often very convenient is an adhesive base cradle, which also takes a standard tie. The adhesive should be checked in the case of high temperature installations.

CLIPS

Successor to the insulated staple perhaps and useful for domestic appliances, radio and automotive work are moulded PVC clips. Screwed down or self-adhesive (Stiki-Clips) versions are made for single core cables, pairs or flat twin cables. These clips save time in securing cables and harnesses particularly where fixing holes are impractical.

APPLICATIONS

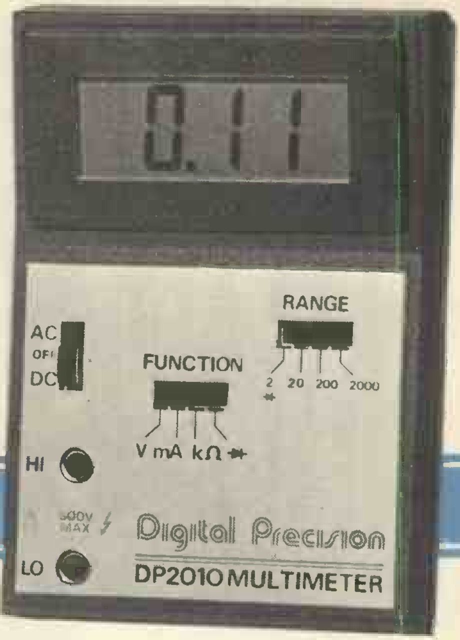
For every cable and every situation there is a potential tying and fixing problem, but one that has probably been solved before and its solution entered into the standard repertoire of the tie maker. Sometimes cable routing has to be chosen to suit available fixing methods—for instance to avoid having to drill holes that will appear on external surfaces—but even this problem is now disappearing with the adoption of self-adhesive devices.

Cable ties have many other uses outside the original field of electrical wiring. The securing of large or heavy components to a p.c.b. and the fixing of light pneumatic or fluidic tubing are obvious ones, but in virtually any application where a piece of tape or string can be used a cable tie will probably do it better. With this wide range of fasteners the only limitation is the ingenuity of the designer in choosing and applying the right one.

Ty-It ties and Stiki-Clips are available from stores throughout the country. For further details contact Hellermann Insuloid, Sharston Works, Leestone Road, Wythenshawe, Manchester M22 4RH. Tel 061-998 5415-8.

Ty-It Releasable Ties, available in 140mm and 250mm sizes; Ty-It Non-Releasable Ties, available in 100mm, 150mm and 200mm sizes; Stiki-Clips for 6mm, 13mm and 18mm maximum overall diameter

DMM



MARTIN KENT

A compact multimeter with digital read-out

THIS compact multimeter features twenty-one ranges with six functions. L.c.d. read-out gives excellent readability with extended battery life. The complete instrument calibration is by one multi-turn trimming potentiometer.

BOARD DESCRIPTIONS

The instrument comprises of two printed circuit boards. The display unit is a self-contained panel meter with l.c.d. read-out, which measures voltages within the range 0–200mV. It displays the magnitude and polarity of the applied voltage. The other board contains the conditioning circuitry to change all inputs into a voltage output in range 0–200mV.

PANEL METER MODULE

The heart of the meter is the 7126 i.c. which is a complete dual-slope integration analogue to digital convertor. It consumes typically only 50μA and drives the l.c.d. directly. Components R25 and C6 determine the integrator time constant, and C7 reduces the susceptibility to noise of the auto-zero circuit. The l.c.d. has an auto-zero feature which gives a zero reading when the analogue input is zero volts.

An input filter is formed by R27 and C8 and assists with overload protection. The frequency of the internal oscillator is determined by C10 and R28 and provides typically three samples per second. The module has a full scale reading of 199·9mV. IC3 is a high stability reference and a potential divider is formed across this so that VR1 can be adjusted to produce a V_{ref} of 100mV. A low-battery detection circuit is included to provide advance warning of battery failure directly on the display.

A potential divider is formed across the supply by R31 and R33 and when the supply voltage falls below a threshold level, the collector of TR1 goes high. EX-OR gate IC4a then acts as an invertor to provide the required drive signal for the LO BAT warning. EX-OR gate IC4b output may be used to drive the decimal points.

CONDITIONING BOARD

The circuit diagram of the multimeter 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 the 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 multimeter 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 shunt resistors R6 to R9, each of which should develop 200mV with full scale current input. The value of R9 is chosen to allow for the effect of switch 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 D1 and D2 protect the instrument from the application of high input voltages.

SPECIFICATION

Function	F.s.d.	Resolution	Accuracy	Protection
Volts	2V	1mV	1% ± 1 digit	500V for one
(d.c.)	20V	10mV	1% ± 1 digit	minute
	200V	100mV	1% ± 1 digit	
	500V	1V	1% ± 1 digit	
Current	2mA	1μA	1% ± 1 digit	1A/250V
(d.c.)	20mA	10μA	1% ± 1 digit	
	200mA	100μA	3% ± 1 digit	
	2A	1mA	5% ± 1 digit	
Volts	2V	1mV	2% ± 5 digit	500V for one
(d.c.)	20V	10mV	2% ± 5 digit	minute
	200V	100mV	2% ± 5 digit	
	500V	1V	2% ± 5 digit	
Current	2mA	1μA	2% ± 5 digit	1A/250V
(d.c.)	20mA	10μA	2% ± 5 digit	
	200mA	100μA	4% ± 5 digit	
	2A	1mA	7% ± 5 digit	
Resistance	2k	1	1% ± 1 digit	260V r.m.s.
	20k	10	1% ± 1 digit	
	200k	100	1% ± 1 digit	
	2M	1k	1% ± 1 digit	
Diode Test	2V	1mV	1% ± 1 digit	260V r.m.s.

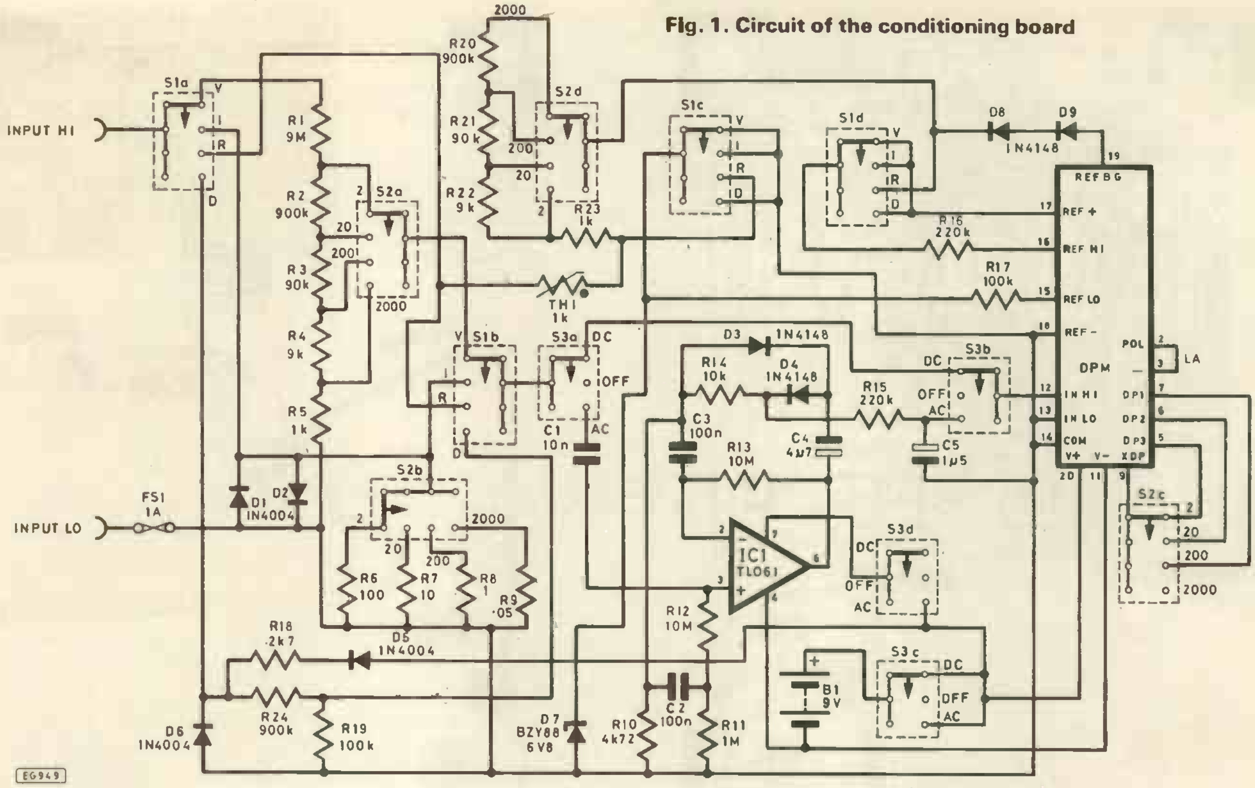


Fig. 1. Circuit of the conditioning board

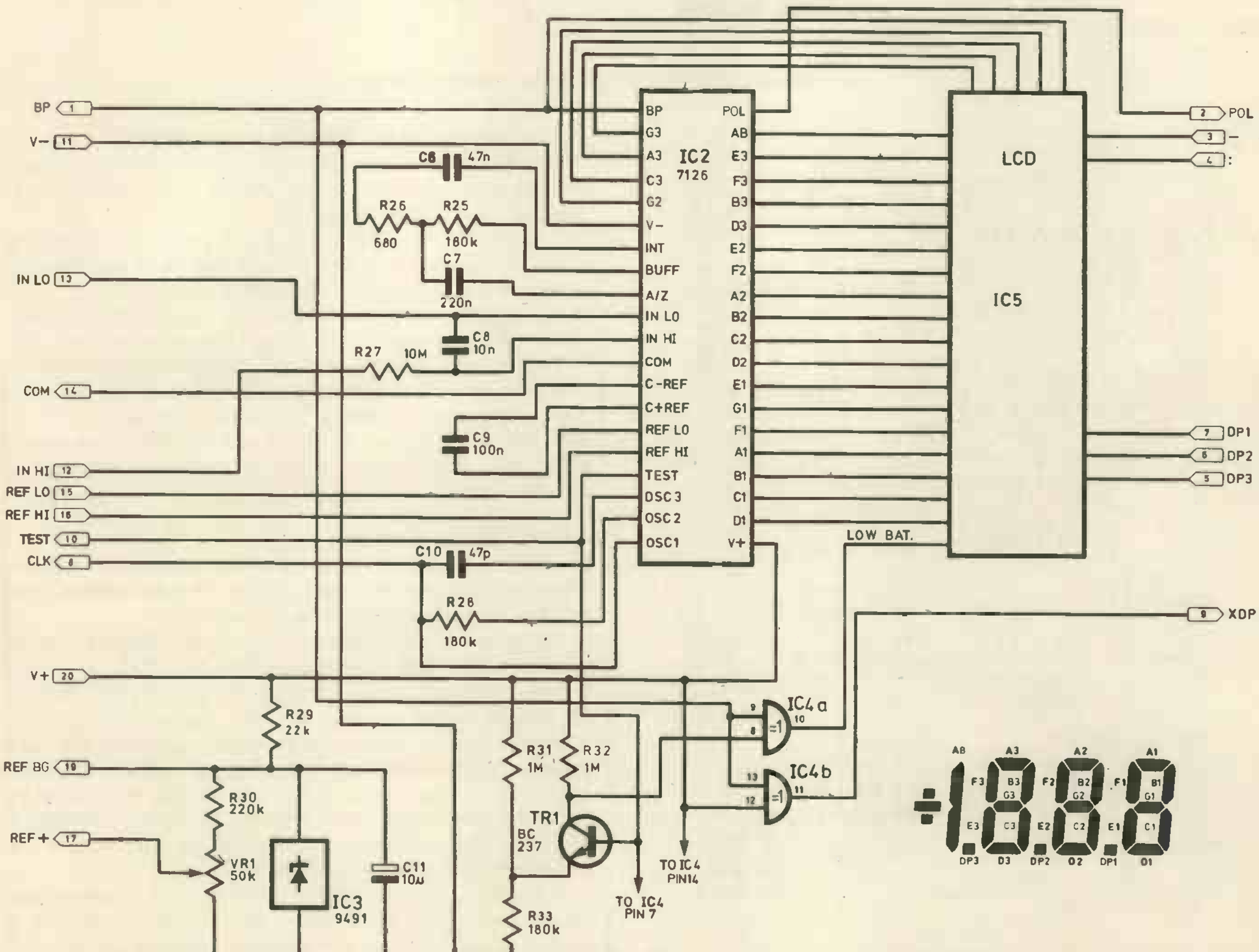


Fig. 2. Circuit of the display board

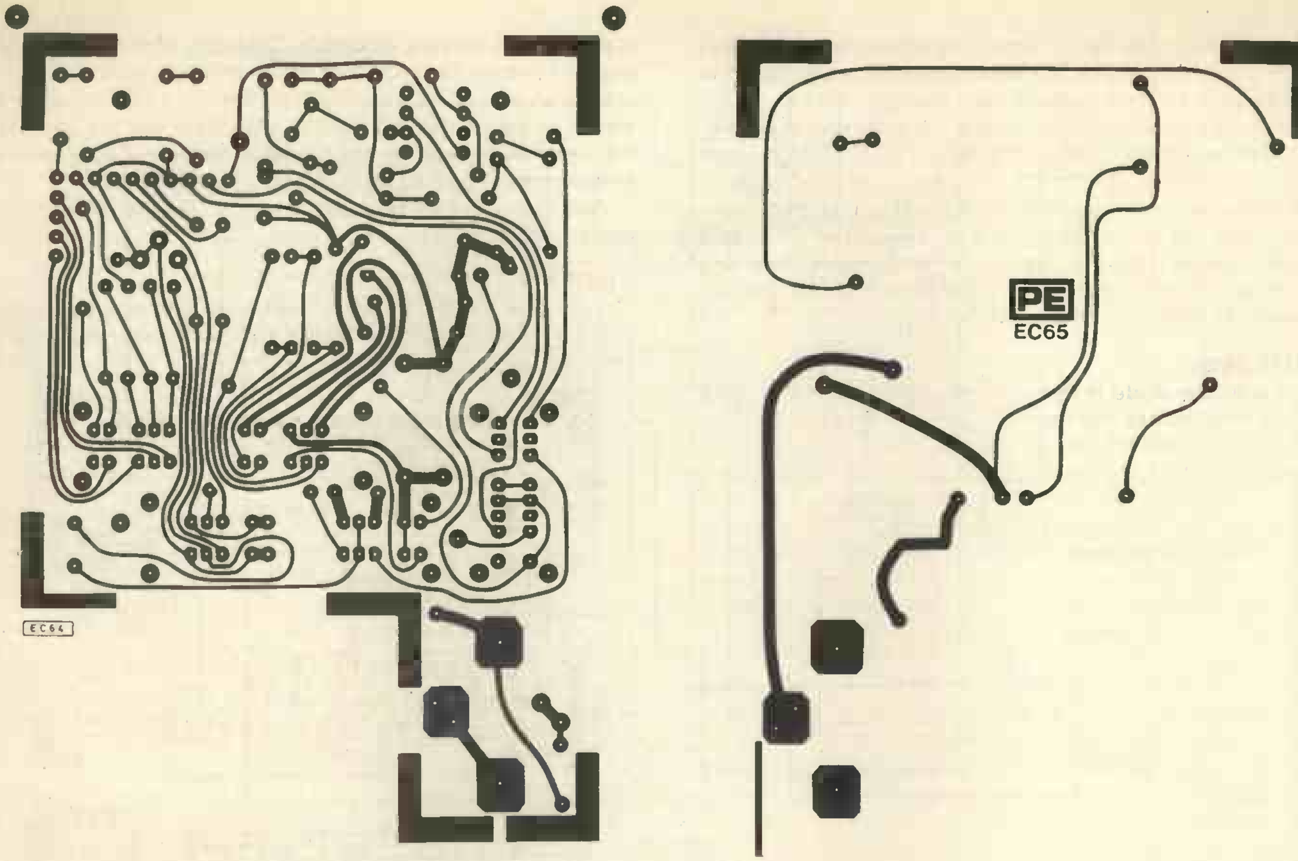


Fig. 3. Double sided p.c.b. design for the Multimeter

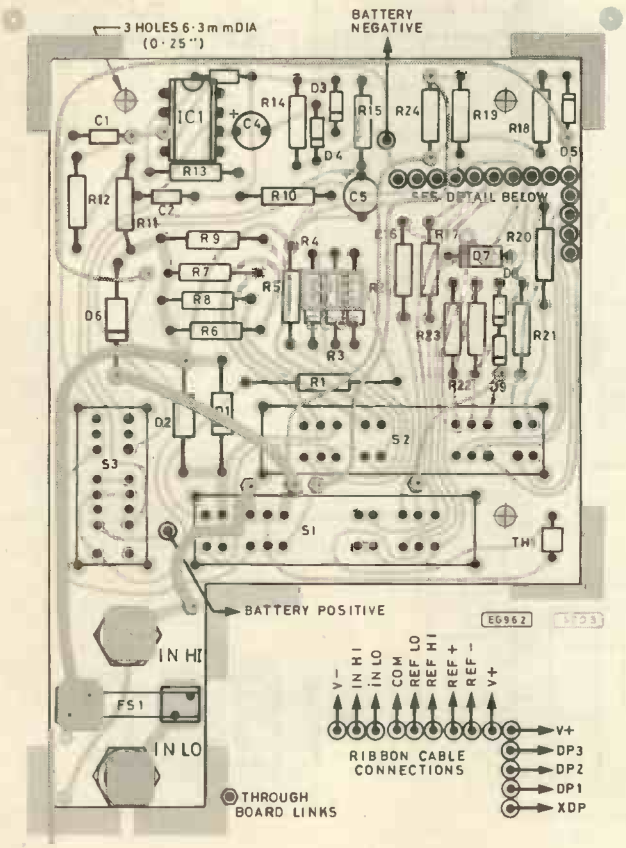


Fig. 4. Component layout for the p.c.b.

A.C. VOLTAGE AND CURRENT RANGES

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 R13 and filtered by R15 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 R14 and R10 and use of the values indicated will eliminate the need for calibration. Alternatively, a 10k potentiometer could be substituted for R10.

RESISTANCE RANGES

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

For all other multimeter functions, the voltage reference within the module is employed and the 100mV 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 voltage 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 = 1000 Rx/Rr.

Metal film resistors R20 to R23 are used as references. It would have been possible to use the resistors from the voltage attenuator 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. Thermistor TH1 has a nominal value of 1k at room temperature and diode D7 will turn on at approximately 6·8V to shunt the applied voltage. When D7 draws current through TH1 the thermistor temperature rises and due to the positive temperature coefficient the resistance increases so limiting the input current.

DIODE TEST

When a silicon diode is forward-biased into conduction the voltage drop across the device is approximately 0·6V. The 200mV full scale of the module is however too low to measure this voltage drop. When S1 selects the 'Diode Test' function, biasing from the battery is available via D5 and R18. When the applied diode is forward-biased the voltage drop will be attenuated by a factor of 10 by R24 and R19 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 D6 will protect the instrument from the application of high negative input voltages which would otherwise be shunted onto the supply by D5. Positive input voltages are held off by D5 and safely attenuated by R24 and R19.

CONDITIONING MODULE

Components should be checked against the component list and assembly commenced by soldering the through-board pins in place. As assembly proceeds, the solder pads on the top surface of the p.c.b. should be soldered to ensure circuit continuity.

Solder 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. The fuse clips and fuse may now be fitted followed by the p.c. mounting terminals, battery connector leads, and ribbon cable. The other end of the ribbon cable may now be soldered to the panel meter module.

CONSTRUCTION

A plated-through-hole p.c.b. is used for the digital precision multimeter to simplify assembly. Soldering of components is required only on the underside of the printed circuit board.

Link LA should be inserted first. Resistors and capacitors should be positioned followed by VR1, TR1 and the i.c.s. As the l.c.d. is required to sit over IC1 and capacitors, these components should be arranged tight to the p.c.b.

The display should be carefully positioned and all components soldered in place.

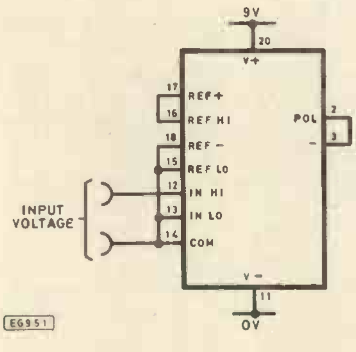


Fig. 5. Module connections for measuring a floating voltage source with 200mV full scale and autopolarity indication implemented

TESTING

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

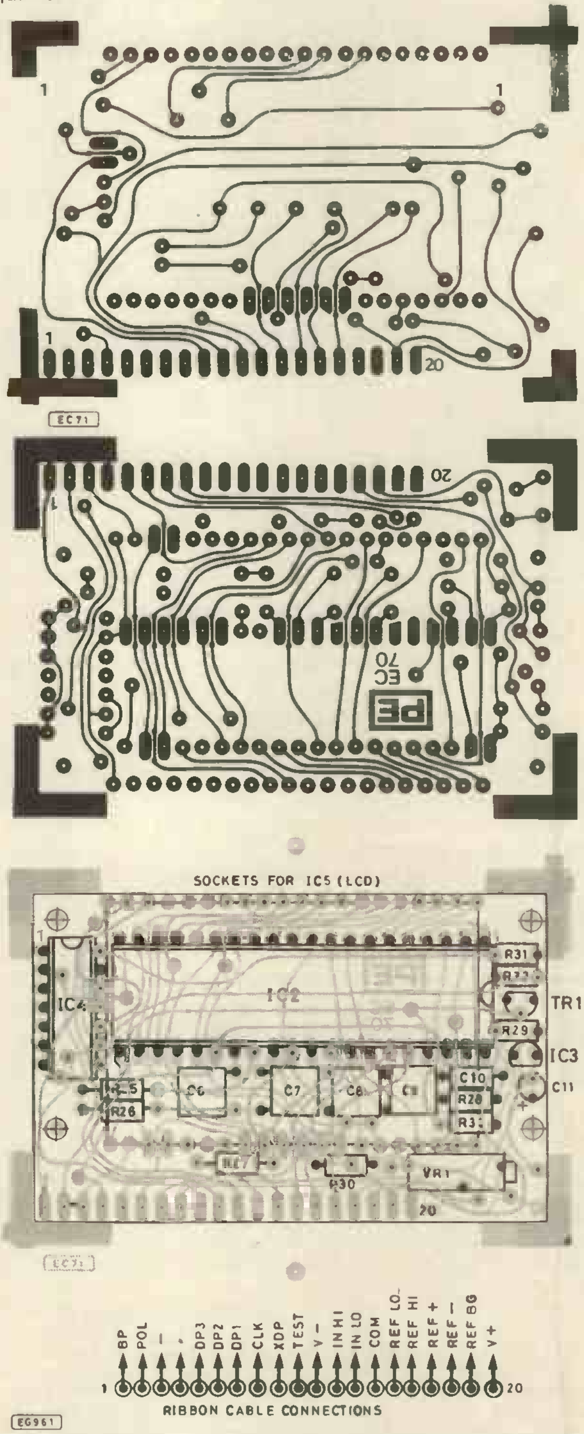


Fig. 6. Double sided p.c.b. and component layout for the display board

COMPONENTS . . .

Resistors

R1	9M metal film
R2, R20, R24	900k (3 off) metal film
R3, R21	90k (2 off) metal film
R4, R22	9k (2 off) metal film
R5, R23	1k (2 off) metal film
R6	100 metal film
R7	10 metal film
R8	1 metal glaze
R9	0·05 wirewound
R10	4k72 metal film
R11	1M carbon film 5%
R12, R13	10M (2 off) carbon film 5%
R14	10k metal film
R15, R16	220k (2 off) carbon film 5%
R17	100k carbon film 5%
R18	2k7 carbon film 5%
R19	100k metal film
TH1	thermistor PTC 1k 260V a.c.
R25	miniature 180k carbon film 5%
R26	680 carbon film 5%
R27	10M carbon film 5%
R28	miniature 180k carbon film 5%
R29	miniature 22k carbon film 5%
R30	miniature 220k carbon film 5%
R31, R32	miniature 1M (2 off) carbon film 5%
R33	miniature 180k

Semiconductors

D1, D2	1N4004 (2 off)	IC2	7126
D3, D4, D8, D9	1N4148 (4 off)	IC3	9491
D5, D6	1N4004 (2 off)	IC4	4070
D7	BZY88 6V8	IC5	3½ digit LCD
IC1	TL061CP	TR1	BC237

Capacitors

C1	10n polyester 100V
C2, C3	100n polyester 100V (2 off)
C4	4µ7 elect. 16V
C5	1µ5 elect. 16V
C6	47n polyester
C7	220n miniature polyester
C8	10n miniature polyester
C9	100n miniature polyester
C10	47p polystyrene
C11	10µ elect. 16V

Switches

S1, S2	4 pole 4 way slide (2 off)
S3	4 pole 3 way

Miscellaneous

Case
2 p.c.b.s
20mm p.c.b. fuse clips
20mm fuse 1A
PP3 battery connector
4mm terminals (2 off)
Through board pins (6 off)
Ribbon cables (10 way + 4 way)

A kit of parts is available from **Lascar Electronics Ltd., Oakland House, Reeves Way, South Woodham Ferrers, Chelmsford, Essex CM3 5XQ** at £19.95 including p/p and VAT

Fig. 5 demonstrates 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 2·8V and battery consumption about 200µA. When the IN HI and IN LO connections are sorted together, the display should be 000. With a 100mV source connected between IN HI and IN LO the display should read 1000 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 0·00 and the voltage between Input LO and battery positive should be approximately 2·8V. The voltage between pins 5 and 6 of the module should be 100mV. Apply a 10V input and adjust VR1 until the display reads 10·00. Switch to 20mA d.c. and check the reading with a 10mA source connected. 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 over-range 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.

BAZAAR

WANTED ultrasonic cleaner, small size suitable small components, must be good condition. Reasonable price. G. A. Chappel, 'Auchenreoch', Arrochar, Dunbartonshire.

TOKUDEN eight inch twin cone speakers. Eight ohms, seven watts max. unused £7 the pair. N. Wakeling, 8 Milton Park, Aviemore, Inverness-shire, Scotland. Tel: (0479) 810 818.

PRE-AMP kit. Already made with ILP transformer. No time to test. £40. Tel: Gravesend 23119. Steven Kwan, 28 Ferguson Avenue, Gravesend, Kent.

16K NASCOM 2 with Gemini RAM card, p.s.u. graphics ROM. Fully operational mounted in 19 inch rack. £395. A. Gifford, Little Pundells, Bartley, Southampton SO4 2LN. Tel: 042 127 2392 (Evenings).

PRACTICAL Electronics Sep. '77 to date. E.T.I. April '78 to June '81. Everyday Electronics Feb. '75 to Aug. '77 offers. Mr. A. Pettitt, 2 Caburn View, Firle, Nr. Lewes, Sussex. Tel: Glynde 492.

WANTED push pull output transformer to match N78 valves for HMV car radio model 4200. Mr. G. W. Nickolds, 15 Cambridge Rd., Lee-on-Solent, Hants. Tel: 550963.

AVO Model 8 MKIII small crack on case but fully working £60. Phone: Tamworth 896522.

ZX81 16K full size keybord leads p.s.u. User Manual, excellent value £90 o.n.o. D. Richardson, 26 Kelvin Road, Bellshill, Lanarkshire ML4 1LN.

UK101 8K CEGMON, numeric keypad, P.S.G., 300/600 Baud, R.T.S. output, cased, fan. Lots software £165 o.n.o. Brian Andrews, 77 Valiant Hse., Valley Grove, Charlton S.E.7. Phone after 6p.m. 853 4171.

WANTED coil winder, hand or motor driven for transformer winding. H. E. Enfield. Phone 412058. "Springtime", Withies Lane, Midsomer Norton, Avon, BA3 2JE.

P.E. STRING ENSEMBLE, only needs wiring up. Complete £90 ono. Pair of 38 radio sets—offers. L. Fletcher, 21 Shakespeare Avenue, Andover, Hants SP10 3DR. Tel: Andover 65368.

WILL PERSON from Aylesbury, who sent cash for book, my recent advert send name and address. G. A. Noble, 50 Crofthill Road, Slough, Berks SL2 1HF.

UK101, 8K, cased, 300/600 Baud, lots s/ware, computer mags. £120 o.n.o. Tel: (0384) 75168 (after 4.00 p.m.). Ian Lavender, 288 Stourbridge Road, Holly Hall, Dudley, West Midlands.

WANTED ZX80 with manual and circuit diagram. 94 The Straits, Dudley, West Midlands DY3 3BH.

UK101 8K 2MHz. Four premier cassettes. Malik invaders and fruit machine. Many programs from magazines £110. T. C. Smith, c/o T. M. Craig, 129 High St., Dumbarton, Strathclyde (Mornings).

WANTED service manual or circuit diagram for Tektronix type 561A Oscilloscope. Mr. J. Bowen, 41 Lower Gardiner Street, Dublin 1, Ireland. Tel: 01-74 52 00.

CB Synthesiser

DUNCAN HEAD
B.Sc.(Hons)

AT LAST after a five month long wait the Sanyo LC7137 PLL synthesiser has become generally available in the UK. (No explanation by Sanyo or their distributors for this delay, although one may hazard a guess.)

This device has been utilised in the following circuitry and is capable of producing the required frequencies for receiving and transmitting 27MHz FM CB signals. The circuitry is very versatile indeed and has a multiplicity of inputs/outputs that may be combined with crystal controlled portables (such as the *PE* Ranger), FM communications receivers and FM transceivers operating in the 26MHz to 28MHz band.

The solution is a great deal more straightforward than employing the synthesiser techniques adopted by some companies which may use up to three separate i.c.s plus two or three different crystals.

The LC7137 is a 20-pin CMOS i.c. that forms a single crystal PLL system. It may be programmed via a 6-bit BCD input using an encoded switch or BCD logic. The receive local oscillator is generated directly with a 10·695MHz (low) IF offset; however, this may be mixed with the 10·24MHz crystal frequency to produce the local oscillator output with a 455kHz (low) IF offset. The transmit frequency is generated at half the output frequency. This is because the maximum input frequency of the programmable divider is 20MHz and at this lower frequency the modulation characteristics are more linear.

HAVE YOU HAD YOUR PLL?

Phase-Lock-Loop frequency synthesisers have become standard in all 40 channel CBs and communications receivers. These techniques have eliminated the use of separate crystals for every channel. The actual concept stems from as early as the 1930s but until it became available in an i.c. its use was not generally cost effective. Many of the earlier PLL devices were of the analog type, but the advanced types such as the LC7137 and its hierarchy are digital in operation. We must thank the American CB market for the development of the PLL over the last ten years. The first generation synthesisers employed as many as nine i.c.s; however, the availability of LSI (Large Scale Integration) devices over the last few years has reduced the number to not more than two.

IT'S ALL DONE WITH FREQUENCY

Fig. 1 shows the equivalent block diagram and external components. The important features are an on-board crystal oscillator, reference divider, programmable divider with associated ROM decoding logic and phase detector.

The reference frequency of 5kHz (5·000226kHz) is derived from the 10·2405MHz crystal frequency by dividing down by 2048. In practice a standard 10·24MHz crystal may be trimmed to this frequency. The reference frequency is not exactly 5kHz since the programmable divider uses only 4 decades to achieve the UK 27MHz CB specifications with the 1·25kHz "offset"; however, the final frequencies are well within the tolerances and this error will not affect the transceiver performance.

A BCD signal is applied via the channel data inputs, D1–D6, to the internal ROM. Table 1 shows the program data against the channel number and internal divisor ratio. Data lines D1–D4 form the "units" digit of the channel code (D1 = LSB) and D5 and D6 form the "tens" digit of the code (D6 = MSB), the next two bits of the "tens" code being unnecessary.

The internal memory decodes this data and changes the divisor ratio depending on the channel and if RX or TX is required. The ratio of the RX to TX divisor values is due to the RX freqencies being generated with the 10·695MHz IF offset and the TX frequencies being generated at half the output frequency.

For example, channel 20, RX frequency = 27·79125MHz-10·695MHz
TX frequency = 27·79125MHz/2
thus RX/TX = 1·23033
Ratio of actual divisor ratio = 3419/2779
= 1·23029

These ratios are not exactly correct as described earlier; however, this error is very small indeed and does not significantly change the receive frequency.

The programmable divider thus divides down the input frequency to approximately 5kHz. This is then compared with the 5kHz reference signal in the phase detector. This, as with most of the other internal circuitry, is achieved digitally. In this application the phase detector has three possible conditions of its output circuit, i.e. it provides three states to the following circuit, the loop filter. These are, an off state, a negative going state and a positive going state. When the loop is locked, i.e. the VCO is running at the correct frequency and the divided down input frequency and reference frequency are exactly in phase, the detector is in the off state and no error signals are generated. When the divided down input frequency lags behind the reference frequency the detector's output pulses are negative going, and when it leads the reference frequency the output pulses are positive going. These output pulses are inverted and amplified in an active integrator stage between the detector and VCO to provide the proper direction of bias change on the varicap diode controlling the VCO.

40 CHANNELS FOR ALL

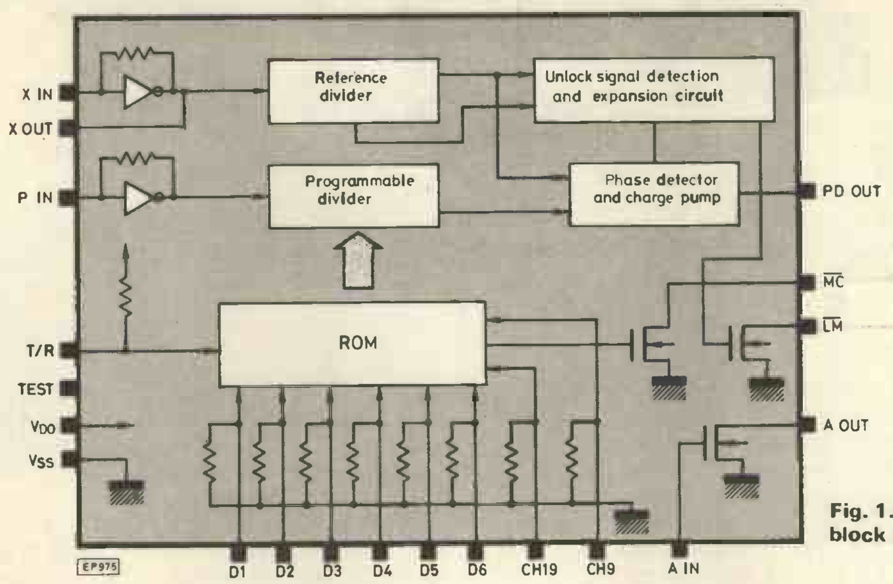


Fig. 1. Equivalent circuit block diagram

CH	Channel Frequency	Program Code D_1	D_2	D_3	D_4	D_5	D_6	RX (T/R = 1) Divisor	RX (T/R = 1) VCO Freq.	TX (T/R = 0) Divisor	TX (T/R = 0) VCO Freq.
1	27·60125	1	0	0	0	0	0	3381	16·9057	2760	13·8006
2	27·61125	0	1	0	0	0	0	3383	16·9157	2761	13·8056
3	27·62125	1	1	0	0	0	0	3385	16·9257	2762	13·8106
4	27·63125	0	0	1	0	0	0	3387	16·9357	2763	13·8156
5	27·64125	1	0	1	0	0	0	3389	16·9457	2764	13·8206
6	27·65125	0	1	1	0	0	0	3391	16·9557	2565	13·8256
7	27·66125	1	1	1	0	0	0	3393	16·9657	2766	13·8306
8	27·67125	0	0	0	1	0	0	3395	16·9757	2767	13·8356
9	27·68125	1	0	0	1	0	0	3397	16·9857	2768	13·8406
10	27·69125	0	0	0	0	1	0	3399	16·9957	2769	13·8456
11	27·70125	1	0	0	0	0	1	3401	17·0057	2770	13·8506
12	27·71125	0	1	0	0	1	0	3403	17·0157	2771	13·8556
13	27·72125	1	1	0	0	1	0	3405	17·0257	2772	13·8606
14	27·73125	0	0	1	0	1	0	3407	17·0357	2773	13·8656
15	27·74125	1	0	1	0	1	0	3409	17·0457	2774	13·8706
16	27·75125	0	1	1	0	1	0	3411	17·0557	2775	13·8756
17	27·76125	1	1	1	0	1	0	3413	17·0657	2776	13·8806
18	27·77125	0	0	0	1	1	0	3415	17·0757	2777	13·8856
19	27·78125	1	0	0	1	1	0	3417	17·0857	2778	13·8906
20	27·79125	0	0	0	0	0	1	3419	17·0957	2779	13·8956
21	27·80125	1	0	0	0	0	1	3421	17·1057	2780	13·9006
22	27·81125	0	1	0	0	0	1	3423	17·1157	2781	13·9056
23	27·82125	1	1	0	0	0	1	3425	17·1257	2782	13·9106
24	27·83125	0	0	1	0	0	1	3427	17·1357	2783	13·9156
25	27·84125	1	0	1	0	0	1	3429	17·1457	2784	13·9206
26	27·85125	0	1	1	0	0	1	3431	17·1557	2785	13·9256
27	27·86125	1	1	1	0	0	1	3433	17·1657	2786	13·9306
28	27·87125	0	0	0	1	0	1	3435	17·1757	2787	13·9356
29	27·88125	1	0	0	1	0	1	3437	17·1857	2788	13·9406
30	27·89125	0	0	0	0	1	1	3439	17·1957	2789	13·9456
31	27·90125	1	0	0	0	1	1	3441	17·2057	2790	13·9506
32	27·91125	0	1	0	0	1	1	3443	17·2157	2791	13·9556
33	27·92125	1	1	0	0	1	1	3445	17·2257	2792	13·9606
34	27·93125	0	0	1	0	1	1	3447	17·2357	2793	13·9656
35	27·94125	1	0	1	0	1	1	3449	17·2457	2794	13·9706
36	27·95125	0	1	1	0	1	1	3451	17·2557	2795	13·9756
37	27·96125	1	1	1	0	1	1	3453	17·2657	2796	13·9806
38	27·97125	0	0	0	1	1	1	3455	17·2757	2797	13·9856
39	27·98125	1	0	0	1	1	1	3457	17·2857	2798	13·9906
40	27·99125	0	0	0	0	0	0	3459	17·2957	2799	13·9956

Table 1. Program data versus divisor ratio and frequency

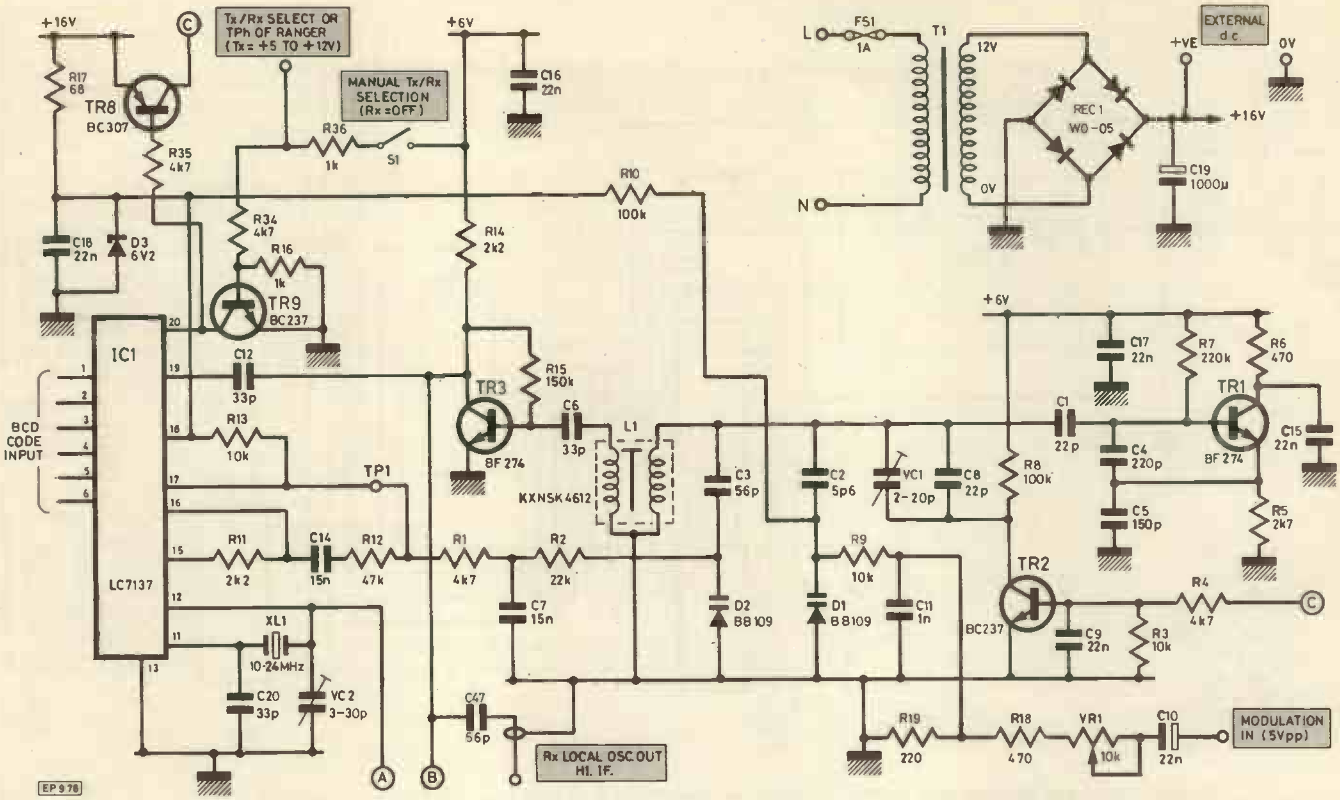


Fig. 2a. 40 Channel CB Synthesiser circuit diagram. Diode D6 should be shown directly in the output from pin 20 of IC1 (anode towards pin 20, cathode towards R35/TR9). C20 may need to be 47pF

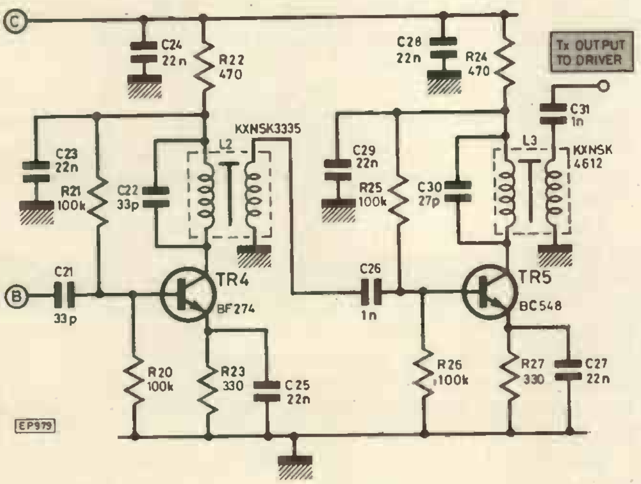


Fig. 2b. Tx × 2 multiplier (TR4) and r.f. amplifier (TR5)

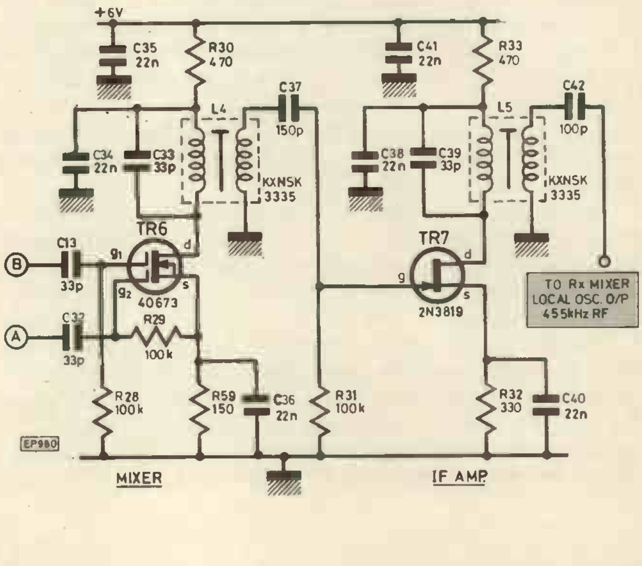


Fig. 2c. Mixer (TR6) and i.f. amplifier (TR7)

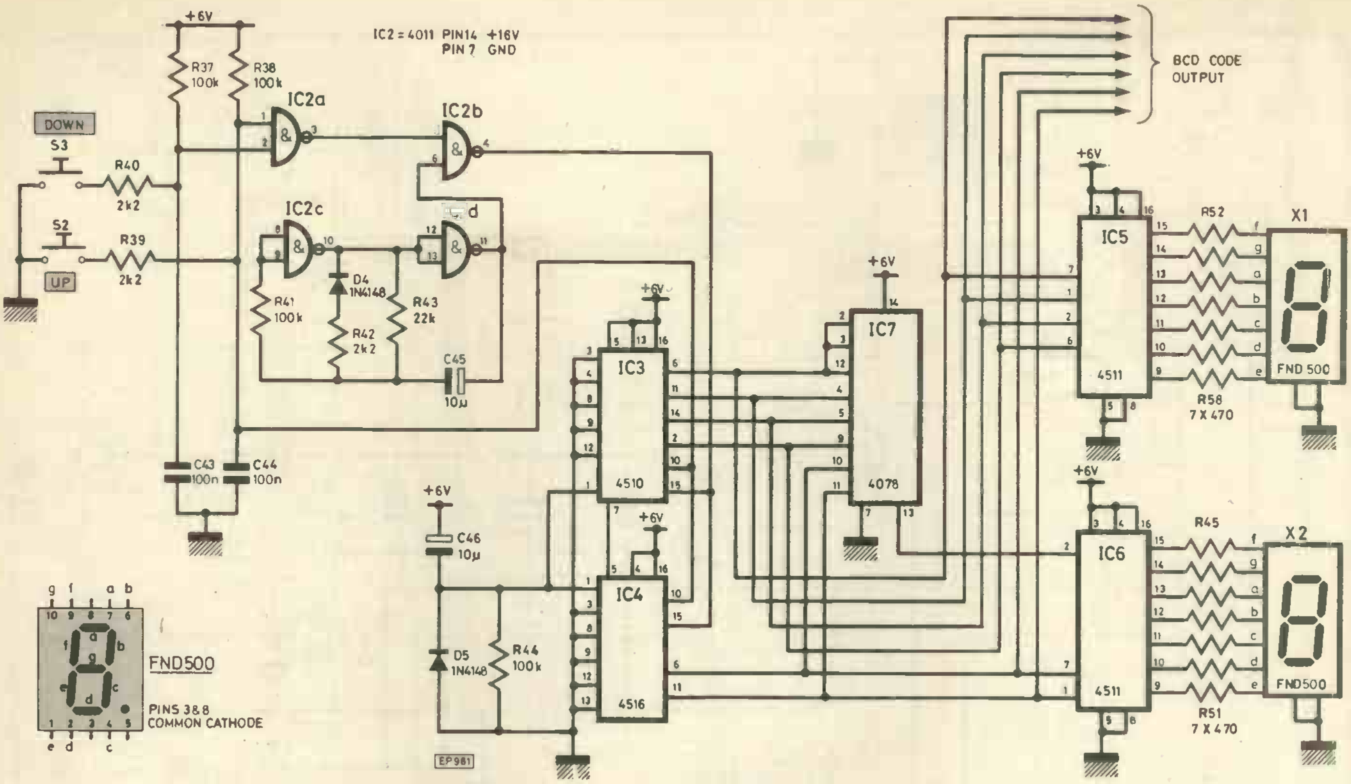


Fig. 2d. Display and BCD generator section. Pins 6 of IC3 and IC6 are connected to 0V

A loop filter follows this stage in order to smooth the phase detector output so that a d.c. voltage can be fed to the varicap diode. Thus, as the VCO frequency drifts slightly, the phase detector will sense this and will counteract this change by subsequently changing the bias on the varicap diode.

OPERATION

The VCO comprises TR1 (see Fig. 2) which is biased in such a way as to oscillate at a frequency determined by the equivalent series load inductance and capacitance present between the base and emitter connections. This comprises C1, L1 and the series loading of C3 and C2 with D1 and D2. The frequency is changed by altering the bias on D2, the varicap diode. This semiconductor device exhibits the property of changing capacitance when the reverse bias voltage is altered. The varicap diode is chosen to have a high Q, low reverse leakage and linear characteristics. The series capacitors C2 and C3 alter the relative effects of the varicap on the oscillator frequency. The output of the VCO is fed from L1 via C6 to a buffer amplifier TR3, and then into the PLL i.c. The loop output of the i.c. is amplified and then fed via R1 to a final filter comprising R2 and C7. The d.c. bias is then fed to D2.

On TX the VCO changes from approximately 17MHz to 13·5MHz, half the final TX output frequency. To achieve optimum linearity and keep the VCO and PLL locked the VCO frequency is pulled down to this range by switching in VC1 and C8 by turning on TR2.

The modulation input, which only requires to deviate the VCO frequency by a few kHz, is fed via C10 and R9 to D1. Note the different value of series capacitance, C2 compared to that of C3, required to tune the VCO over the complete band. The buffered output of the VCO is fed via C13 or C21 to the RX mixer section and TX RF driver section. To prevent any interference the TX circuitry is only powered up during transmit. TR8 and TR9 are used to switch the supply to the TX circuitry and change the logic on pin 20 of IC1, the RX/TX select. This input is TTL and CMOS compatible.

Transistor TR4 forms a frequency doubler circuit where the collector is tuned to 27MHz by L2 and C22. The output, rich in harmonics, is fed to a further amplifier stage consisting of TR5. The output of this stage is also tuned to 27MHz by L3 and C30.

TR6, a dual gate f.e.t., is employed in the receive circuitry to mix the VCO output with the 10·24MHz reference signal to produce the local oscillator output with a 455kHz IF offset. This section of the circuit may be omitted if an IF frequency of 10·695MHz is to be used. Again, as with the previous circuitry, the loads are tuned to remove as many harmonics and unwanted mixer products as possible. TR7 forms a buffer amplifier producing roughly 0·5V to 0·8V of RF signal.

The BCD channel coding is formed by two up-down counters, IC3, a BCD type and IC4 a binary type. The reason that IC4 is binary and not BCD coded is that as only the two LSBs of the counter are utilised no special reset lines are necessary to reset the counters from 39 to 00 on the up count and vice-versa on the down count. IC7 converts the BCD signal, 0000 0000 to 0100 0000 so that channel 40 is displayed corresponding to the BCD code 0000 0000. Refer to Table 1 for coding. The up-down select and clock pulses are produced by IC2, a quad two input NAND gate. Two gates form a pulse generator with a duty cycle determined by R42, R43 and D5. The other two gates form an enabling circuit which allows the pulses to clock the counters and select up or down. On power-up the counters are preset with the BCD number corresponding to channel 14. IC5 and IC6 decode the BCD signals and drive the 7-segment displays.

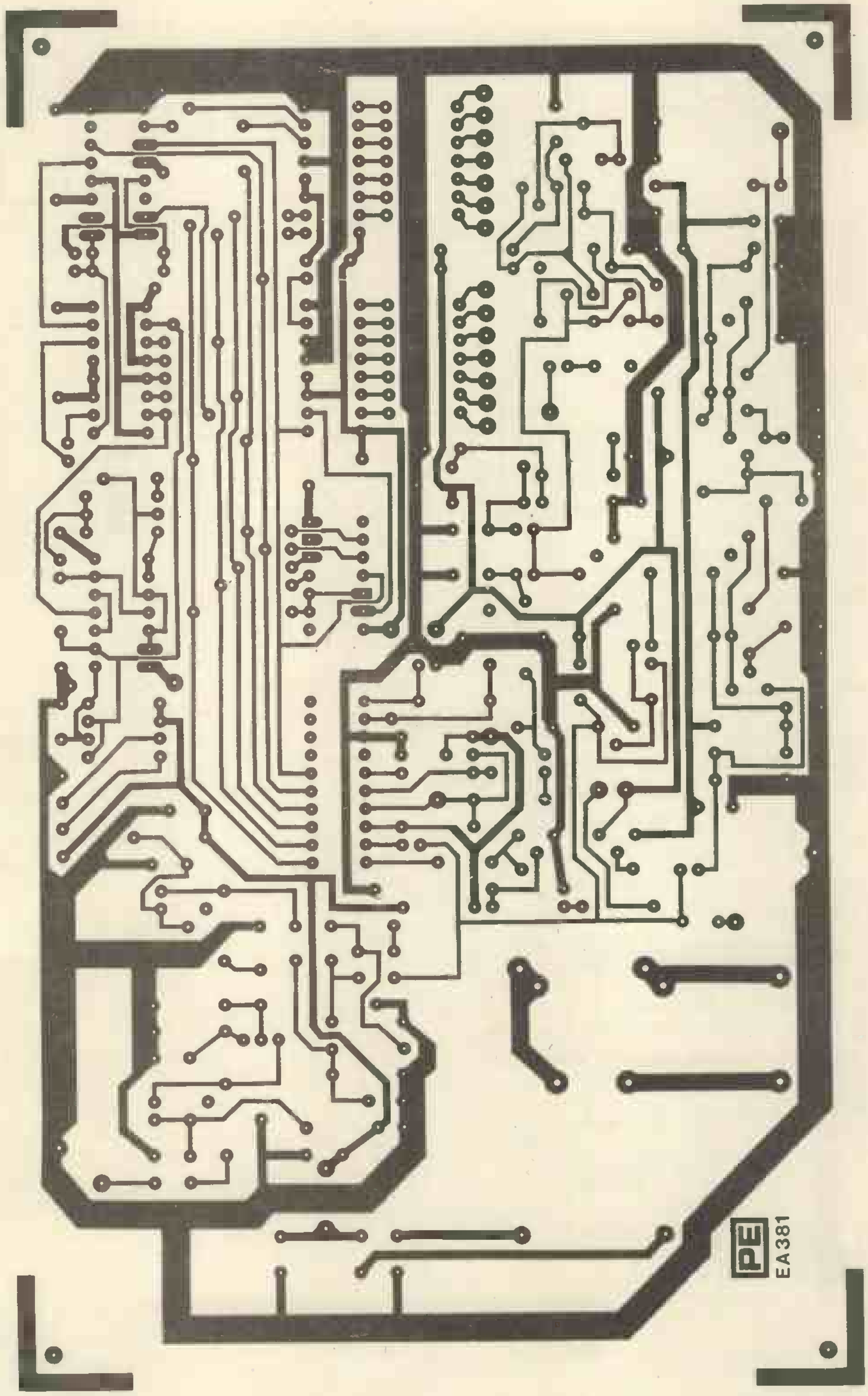


Fig. 3a. Printed circuit layout (actual size)

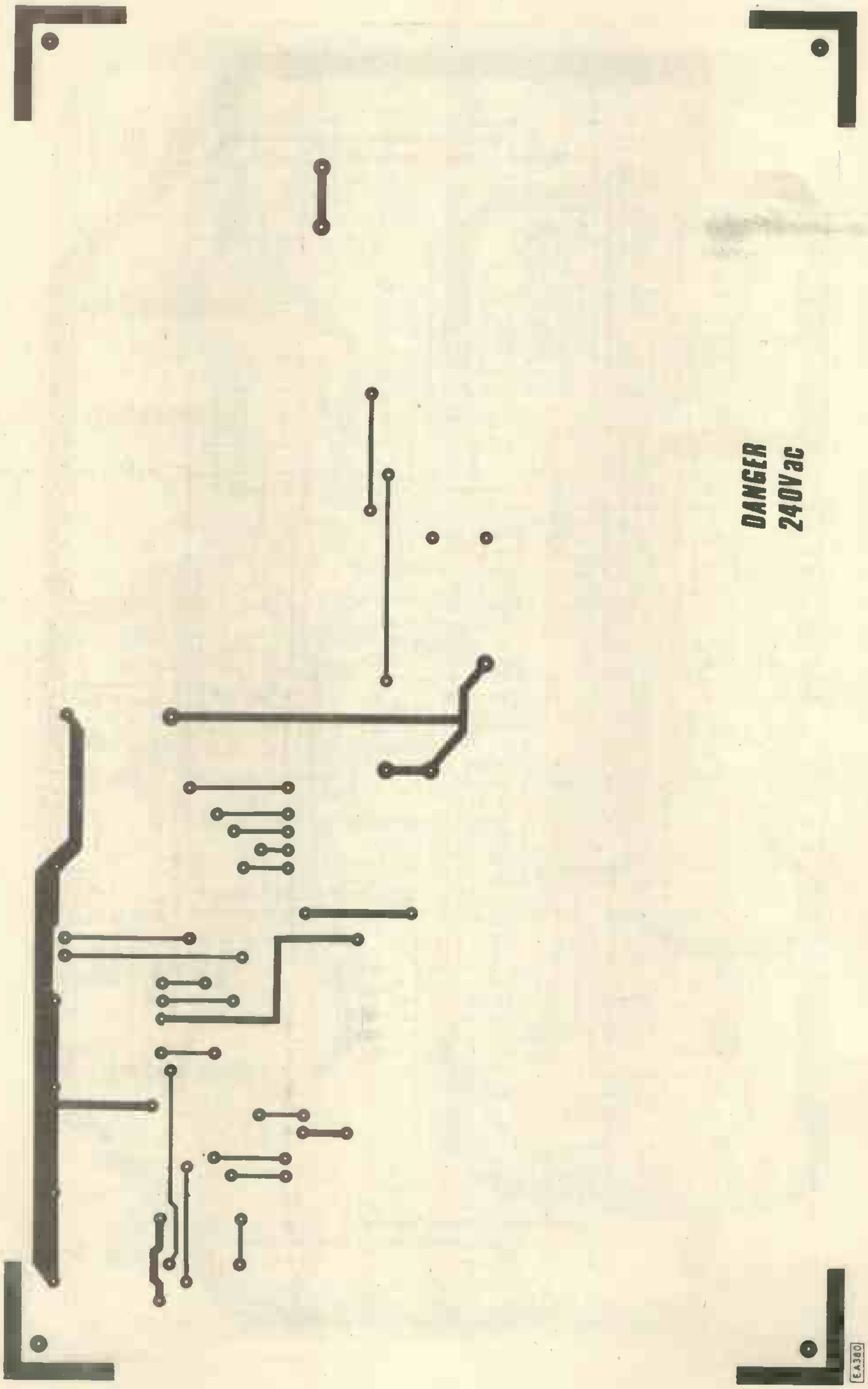


Fig. 3b. Printed circuit layout (actual size)

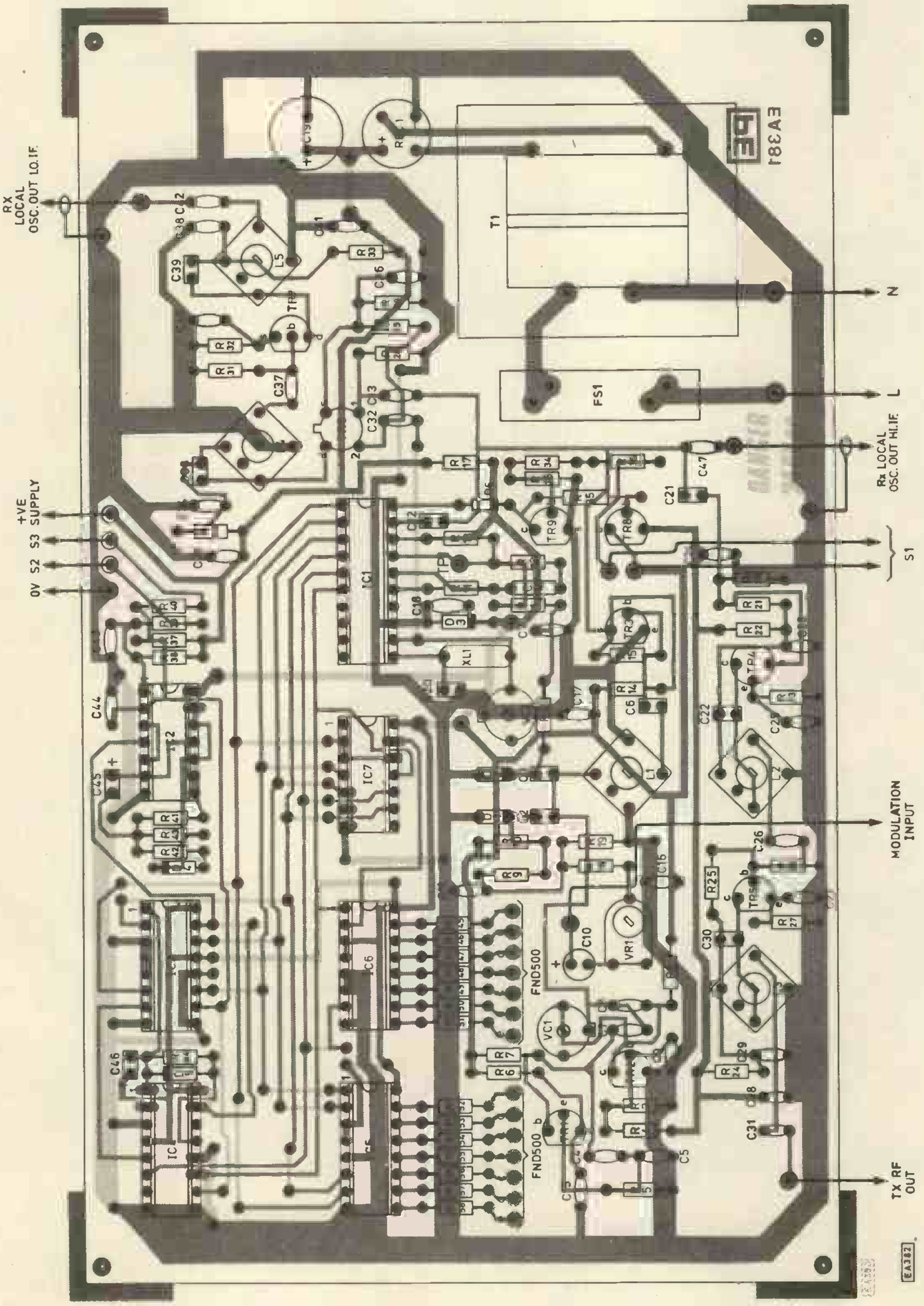


Fig. 4. Component layout

COMPONENTS . . .

Integrated Circuits

IC1	LC7137
IC2	4011
IC3	4510
IC4	4516
IC5,IC6	4511 (2 off)
IC7	4078

Crystal

XL1	10·24MHz

Variable Capacitors

VC1	2–20p
VC2	3–30p

Potentiometers

VR1	10k

Inductors

L1	KXNSK4612
L2–L5	KXNSK3335 (4 off)

Transistors & Diodes

D1,D2	BB109 (2 off)
D3	6V2 400mW
REC1	W005
D4–D6	1N4148 (3 off)
TR1,TR3,TR4	BF274 (3 off)
TR2	BC237
TR5	BC548
TR6	40673
TR7	2N3819
TR8	BC307
TR9	BC237

Resistors

R1,R4,R34,R35	4·7k (4 off)
R2,R43	22k (2 off)
R3,R9,R13	10k (3 off)
R5	2·7k
R6,R18,R22,R24,R30,R33	470 (6 off)
R7	220k
R8,R10,R20,R21,R25, R26,R28,R29,R31,R37, R38,R41,R44	100k (13 off)
R11,R14,R39,R40,R42	2·2k (5 off)
R12	47k
R15	150k
R16,R36	1k (2 off)
R17	68
R19	220
R23,R27,R32	330 (3 off)
R45–R58	470 (14 off)
R59	150

Capacitors

C1,C8	22p (2 off)
C2	5·6p
C3, C47	56p (2 off)
C4	220p
C5,C37	150p (2 off)
C6,C12,C13,C20,C21,C22, C32,C33,C39	33p (9 off)
C7,C14	15n (2 off)
C9,C15–C18,C23–25, C27–29,C34–36,C38, C40,C41	22n (17 off)
C10	22µf
C11,C26,C31	1n (3 off)
C19	1000µf
C30	27p
C42	100p
C43,C44	100n (2 off)
C45,C46	10µf (2 off)

Miscellaneous

T1	12V 3VA p.c.b. mounting transformer
S1	Toggle switch spst
S2	Push button switch
S3	Push button switch
LED display FND 500 (2 off)	X1, X2
P.c.b.	
Case	
Mains socket	
Mains lead	
Fuse 20mm 1A	
Fuse holders	
50 ohm coax	
BNC sockets (2 off)	

Constructor's Note

LC7137 may be purchased from **Anglia Components Ltd,** Burdett Road, Wisbech, Cambs PE13 2PS (Tel 0945 63281) for the sum of £8.74 inc VAT and p/p.

T1, the case and the mains connector/lead may be purchased from **Modus Systems Ltd,** Park Drive, Baldock, Herts SG7 6EW (Tel 0462 894848) for the sum of £0.79, £1.99 and £1.35 respectively. VAT and 35p p/p should be added to each order.

ADAPTION

The circuitry shown may be used in conjunction with several different types of equipment as discussed in the introduction. IF frequencies should be injected into the appropriate mixer section of the receiver. The higher 10·695 MHz IF frequency should always be used if possible to give the highest value of image rejection. Note that any existing inputs to the receiver's mixer should be inhibited or spurious outputs will cause serious interference.

On TX the input waveform should preferably be from a speech processor, i.e. amplitude and band limited to prevent over modulation and non-linearity distortion. The TX output should be connected to the pre-amplifier stage of the transmitter, which should be tunable to 27MHz.

The circuitry may also be connected to the *PE* Ranger. The modulating input should be connected to test point j, the output of the speech processor. To facilitate 40 channels, one of the 6 channel selections in the Ranger must be inhibited, i.e. the TX and RX crystals shorted or switched out of circuit to prevent interference. The two RF connections to the synthesiser board from TR3 (base) and IC101 (pin 1) should be via 50 ohm screened coax. terminated with BNC or other suitable miniature RF connectors at the cases. The TX/RX sense is connected to test point h.

TESTING AND ALIGNMENT

The unit is fairly simple to align. After it has been constructed and fully checked it should be powered up with a 9V to 12V supply. The channel display should indicate channel 14. If not, the load inputs to IC3 and IC4 (pins 3, 4, 12, 13) and the preset enable lines (pins 1) should be checked. On depressing the up or down switch the display should toggle at a reasonable rate. If not check IC2 and associated components. Assuming this is all correct check with the aid of an oscilloscope that the VCO and reference oscillators are working (TR3 collector and IC1 pin 12). With S1 in the off position, i.e. RX selected, measure the d.c. voltage at TP1 and adjust the core of L1 to produce a range of approximately 2V to 3V from channel 1 to 40. If the voltage at TP1 is either high or low continuously then check the BCD code input to IC1 and the associated components of IC1 and the VCO. Switch S1 on, i.e. TX selected, and adjust VC1 to produce the same voltage range at TP1 from channel 1 to 40. Repeat the alignment again and re-adjust L1 if necessary. With S1 off tune L4 and L5 for maximum local oscillator output. Re-tune when connected to a receiver for maximum receiver sensitivity. With S1 selected and a 50 ohm dummy load on the output socket tune L2 and L3 for maximum RF output, with least visible harmonic content. With a frequency counter connected to the Tx RF output, and with Tx selected, adjust VC2 to give the correct channel frequency (as shown in Table 1) to five places over the whole range. VR1 should now be adjusted to give adequate audio modulation. This is best checked with the use of a FM CB monitor or CB rig. Remember that over-modulation (<±2·5kHz) will not only cause distortion on some FM receivers and/or cross channel interference, but is a contravention of the Home Office regulations. ★

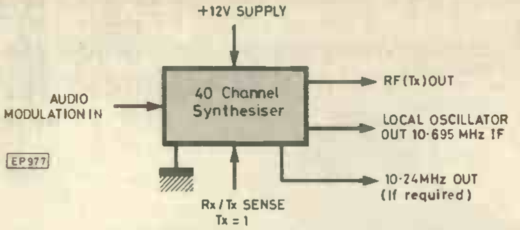


Fig. 5. Connection to a communications receiver/transceiver

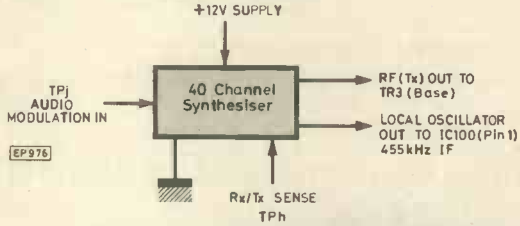
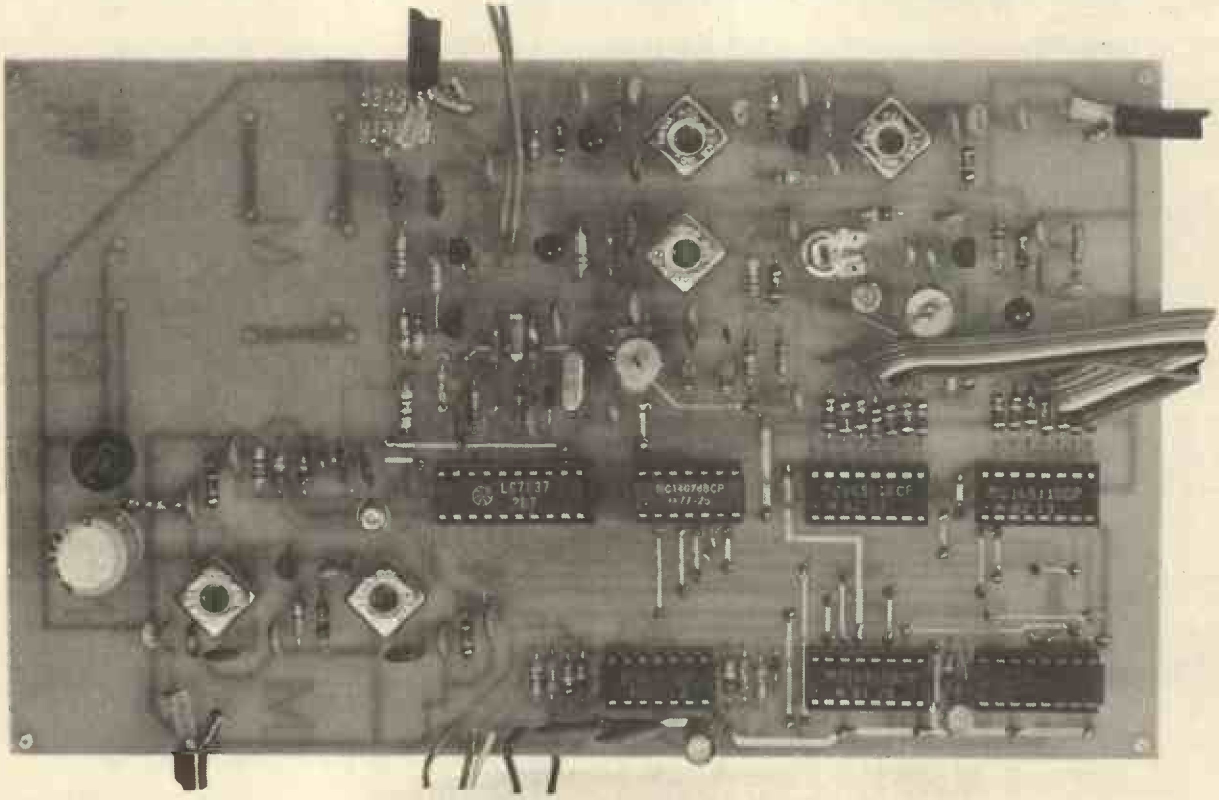


Fig. 6. Connection to a PE Ranger

Due to the nature of this circuitry, the author cannot accept any responsibility whatsoever for the specifications of any system that may be used in conjunction with the described article.



SEMICONDUCTOR UPDATE

R.W.Coles

FEATURING IMS26000 X2816A X2804A S3610 S3620

INMOS WINNER

Inmos, the world-class semiconductor memory manufacturer set up and largely funded by the British Government, is continuing to expand its share of the memory market by introducing new devices which are, quite simply, *better* than those produced by either the American or the Japanese competition. This is a deliberate policy designed to allow Inmos to join the memory race as a market leader without the need to make vast quantities of the common-or-garden memory components already supplied by all the longer established manufacturers such as Texas, Motorola, Intel, N.E.C. and others. One day Inmost expect to compete directly in those markets too, and already they have a new production facility in South Wales to add to their design centre in Bristol and their first production unit in Colorado, but for the moment Inmos are concentrating on the premium memory market where profits are higher and quantities lower. After success with their high speed 16K static parts, Inmos have now released their long awaited 64K dynamic, and it does seem to have been worth the wait! Their brand new IMS26000, organised as 64Kx1-bit, is the fastest dynamic RAM available anywhere, and it offers features which show it to be a second generation approach to the 64K DRAM design problem.

Most important in the long run may be the CAS before RAS refresh feature which has the effect of releasing a package pin so that upwards compatibility with the next generation 256K devices is possible. To get a 64K memory into a 16 pin package the 16-bit address is multiplexed as two 8-bit bytes strobed by the Row Address Strobe RAS, and the Column Address Strobe CAS. Normally CAS follows RAS and these signals are produced by an external dynamic RAM controller chip which also has the job of issuing a sequence of refresh cycles which interleave with normal memory cycles to prevent the capacitor storage cells from "forgetting." The refresh addresses are generated by an on-chip counter activated via pin 1 which unfortunately will be needed for A8 in the 256K chip when it appears. To keep pin 1 spare, Inmos detect the use of CAS before RAS to signify a refresh cycle, since this sequence is not used during a normal read or write access. The result is that circuit boards can be laid out now for 64K chips with a drop-in upgrade to 256K possible later.

Another IMS26000 innovation is "nibble mode" which allows the already fast 100 nanosecond access time of the chip to be reduced to only 55 nanoseconds for sequential four bit "nibbles". This feature is made possible by the internal memory organisation which actually gains access to four bits at a time even though only one of the four available is selected for output. With the IMS26000 a sequence of four CAS pulses will allow all four bits to be shifted out at high speed if required.

ROM THAT THINKS IT'S A RAM

After the EPROM, which had to be erased with U.V. light, came the EEPROM which can be erased and reprogrammed electrically by the application of high voltage pulses. EPROMs are still cheaper than EEPROMS; also, having to have high voltages and programming components on the circuit board can be a nuisance, and so the apparently more convenient EEPROM devices are nowhere near as popular as their EPROM predecessors. If, as is likely, the cost advantage of the EPROM is maintained in the future, the EEPROM will never replace it for normal program memory use and will be restricted only to those applications where the rewriting of non-volatile memory data is an especially desirable feature in itself.

Even if the price advantage of EPROMs cannot be removed, it *is* at least possible to overcome the *technical* disadvantages of the EEPROM technology as Xicor have demonstrated with a pair of new devices coded X2816A and X2804A. The great advantage of these two devices is that they do not require either the high voltages or the special programming circuitry needed by previous EEPROMs, and this makes them especially easy to use. In fact, these new chips appear to the rest of the system like RAM chips, and are actually pin compatible with byte-wide RAMs such as the Mostek 4802, with the main difference being that you can remove the power supply from the EEPROM without disturbing the stored data!

The X2816A and the X2804A can be read just like RAM chips, in 300 nanoseconds. Writing new data takes much longer at 10 milliseconds, but the "spanner" which this might otherwise throw into the works of RAM compatibility is avoided by having address and data latches within the package. The system carries out a normal (fast) write cycle, but this is stretched internally by the EEPROMs to provide the required 10 milliseconds. The only restriction placed on the system is that the software should not try to program another location until at least 10 milliseconds has elapsed, although during the pause other system activities can take place if required.

Now if you lay out your microprocessor board to take 24 or 28 pin memory sockets it is possible to decide later whether you plug in a static RAM (for short term data storage), an EPROM (to contain the program) or an EEPROM (to store long term but alterable data). All three options will work from a single 5 volt supply and will not require special programming or refresh circuitry.

The Xicor X2816A has a 2Kx8 format and the X2804A provides 512x8.

NATURAL VOICE

According to information theory, you need to take at least two samples during the period of the highest frequency when attempting to encode analogue signals digitally. For speech, this means a sampling rate of about 8kHz, so if we assume 8 bits per sample to give a reasonable quality we can predict the need for a 64K bit ROM to store just *one second* of speech.

ROM devices are getting cheaper all the time of course, but they will have to get a good deal cheaper *and* bigger to make simple sampling a viable method of digital speech encoding. Fortunately, ways have been found to encode speech with fewer bits by the elimination of the redundant information which speech signals contain. By this means, the size of the store required can be reduced by a factor of about one hundred. Linear Predictive Coding (LPC) is one such encoding technique which was championed by Texas Instruments and used, for example, in their "Speak and Spell" learning aid. If you have used the "Speak and Spell" you will be rightly impressed by the great benefits that digitised speech can bring, but you may also be less than happy about the clarity of the speech.

A new device from AMI Microsystems which uses a modified LPC technique, is claimed to provide a higher quality speech signal than has hitherto been possible with ordinary LPC. The manufacturers call their new speech technique "Natural Voice" and are currently making it available on two chips, the S3610 which has an internal 20K ROM for 17 seconds of speech, and the S3620 which can use an external 128K ROM (the S3630) to give up to 110 seconds. Apart from the promised advantages of the "Natural Voice" technique which I haven't been able to sample yet, the thing which appeals to me is AMI's "one-chip" approach to speech synthesis. The S3610 for example has an internal 30 milliwatt audio amplifier and needs only two capacitors and a cheap crystal to add speech to any instrument or toy. No doubt these chips will soon be available with a standard vocabulary so that we can all have a go. The chips are made in CMOS, run from a single 5 to 8 volt supply, and have a great deal to say for themselves!

SEMI-PROFESSIONAL MIXING DESK

Part Two

Tim Orr

THE p.c.b. designs for the input, output and auxiliary channels are shown in Figs. 1, 2 and 3 respectively with their component layouts shown in Figs. 4, 5 and 6. Note that the p.c.b.s are shown in two sections and should be joined along the X-X axis making sure that the tracks are aligned properly. Each p.c.b. should be assembled by first fitting the wire licks then the resistors, i.c. sockets, semiconductors and capacitors.

Take care that the jack sockets and potentiometers fit flush with the p.c.b. as these parts have to mate up with the metal work. The push switches can now be inserted but they should not be soldered. After the module panel has been fitted to the p.c.b. and the potentiometer retaining nuts tightened the push switches should be adjusted so that they do not interfere with the metal work. When the switches have been adjusted they can be soldered into position.

The slider switches should be mounted last on the input and output channels along with the mounting socket SK1. On the auxiliary channel the microphone and pre-fade listen jack socket wires should be twisted before being soldered to the p.c.b. Tinned copper wire can be used for wiring the talk back switch.

After all the channel boards have been soldered carefully check each one for any solder splashes or incorrectly placed components.

The p.c.b. design for the bus board is shown in Fig. 7, the thick tracks are for power supplies and the thin tracks for signals. The number of bus boards required depends upon the number of channels incorporated into the mixer, one bus board is required for every six channels used. Ten way pin blocks are used to connect the power supplies and signals to and from the bus board to each channel. After the pin blocks have been soldered onto the board (Fig. 8) trim off the excess pin lengths on the underside. The bus board can now be fitted into the case using spacers to prevent the pins being shorted to the chassis.

Make certain that the 4 signal tracks are facing the front of the mixer. If more than one bus board is used they should be joined together using 24s.w.g. tinned copper wire covered with rubber sleeving. The mains supply lead should be connected to the bus board as shown in Fig. 9.

TESTING

The input channels are relatively simple circuits; only 4 op amps are used to perform the amplification and tone control functions. Inject a 1Vpp sinewave into the line input, select LINE operation. The output signal seen at the SEND jack can be varied from 0·3Vpp to 18Vpp (with FLAT selected) by rotating the GAIN control pot. Now select the MIC mode and inject a 10mVpp signal into the MIC jack. The signal seen on the send jack should be variable over a range of 63mV to 6·3Vpp. In all cases the output signal should be free from distortion and clipping. Note that the LEVEL DETECTOR l.e.d. should come on and stay on when the SEND level exceeds +4dBm (3·5Vpp). The noise performance of the input amplifier can be measured, but only if you have the use of the equipment shown in Fig. 10. The procedure is as follows. Remove all inputs and select MIC operation and maximum gain. Also select FLAT operation and measure the noise voltage at the SEND jack. The theoretical input noise is 1·46μVr.m.s. which when multiplied by the MIC gain of 56dB results in an output noise voltage of 0·9mV r.m.s. If the input noise is significantly bigger than this then check that the gain is actually 56dB. Wrong resistor values may give you a high preamplifier gain, and hence more apparent noise. Also IC1 may be more noisy than other devices. It is not uncommon to select the input op amp for low noise operation. If noise is a problem then check for dry joints or other microphonic faults. When using the MIC input at full gain you will hear the preamplifier noise, this is not a fault. The important parameter in all audio equipment is the signal to noise ratio and not the absolute noise level. If the microphone input signal level is 1·46mV r.m.s. then the signal to noise ratio will be 60dB, which is not very much worse than most semi-professional tape recorders. A microphone signal level of 1·46mV r.m.s. is quite a small signal level. In cases like this the best advice is to move the microphone nearer to the object being recorded!

TONE CONTROLS

The tone controls can be tested either with test equipment or by listening to pre-recorded music through them. Inject a sinewave source into the LINE input, set S2 to EQ and monitor the signal at the SEND jack. The frequency response can be plotted out by varying the sinewave frequency and recording the gain changes. These responses should conform to those shown in Fig. 2 last month. However, no one would want laboriously to plot the frequency responses of 18 tone control units using this method! The best method for determining a circuit's frequency response is to inject a swept sinewave and to monitor the output waveform on an oscilloscope. However, if you do not have access to this equipment, then a listening test is quite adequate. Note that the TONE CONTROL section actually provides gain and so it is possible to amplify the system noise. If any of the controls

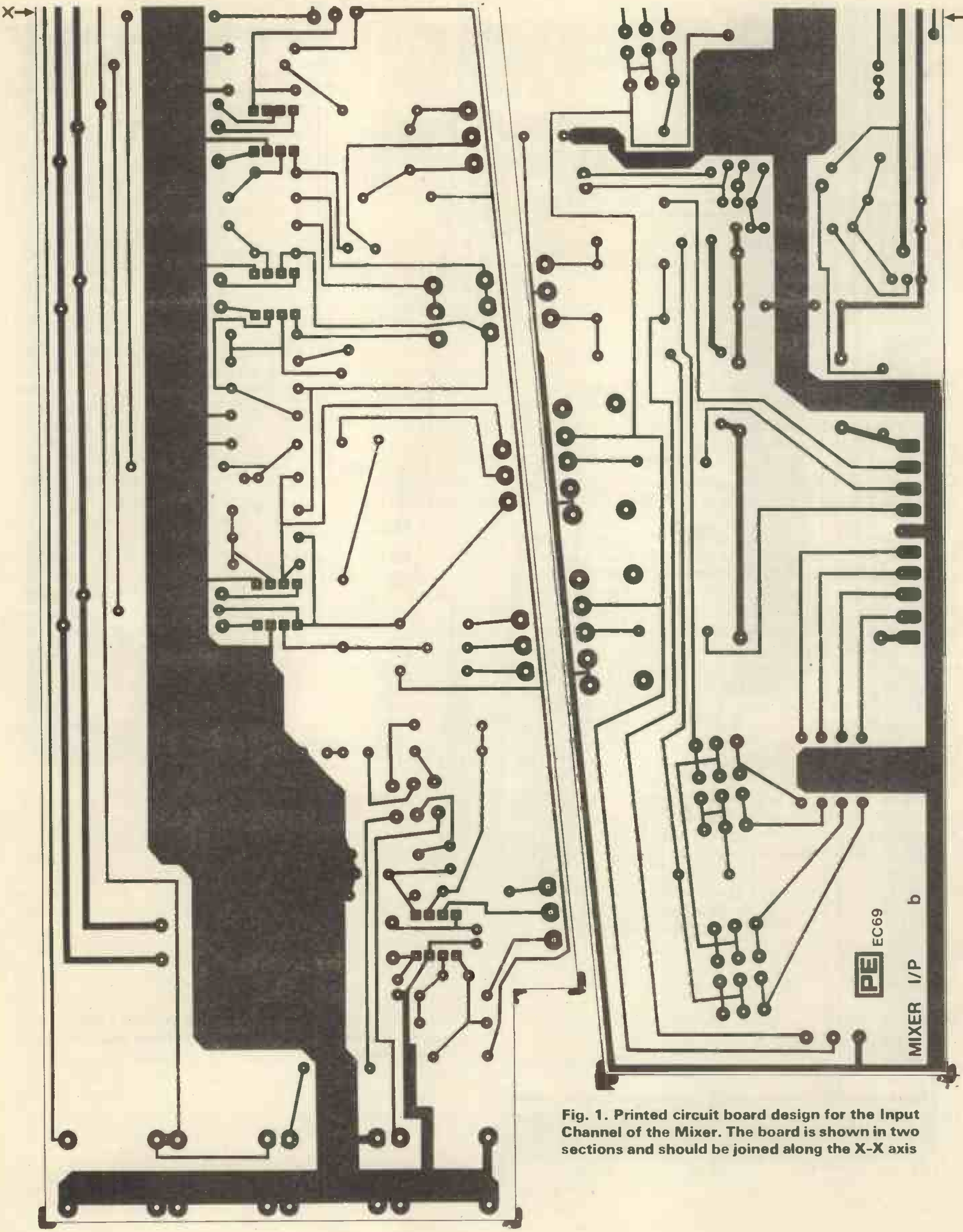


Fig. 1. Printed circuit board design for the Input Channel of the Mixer. The board is shown in two sections and should be joined along the X-X axis

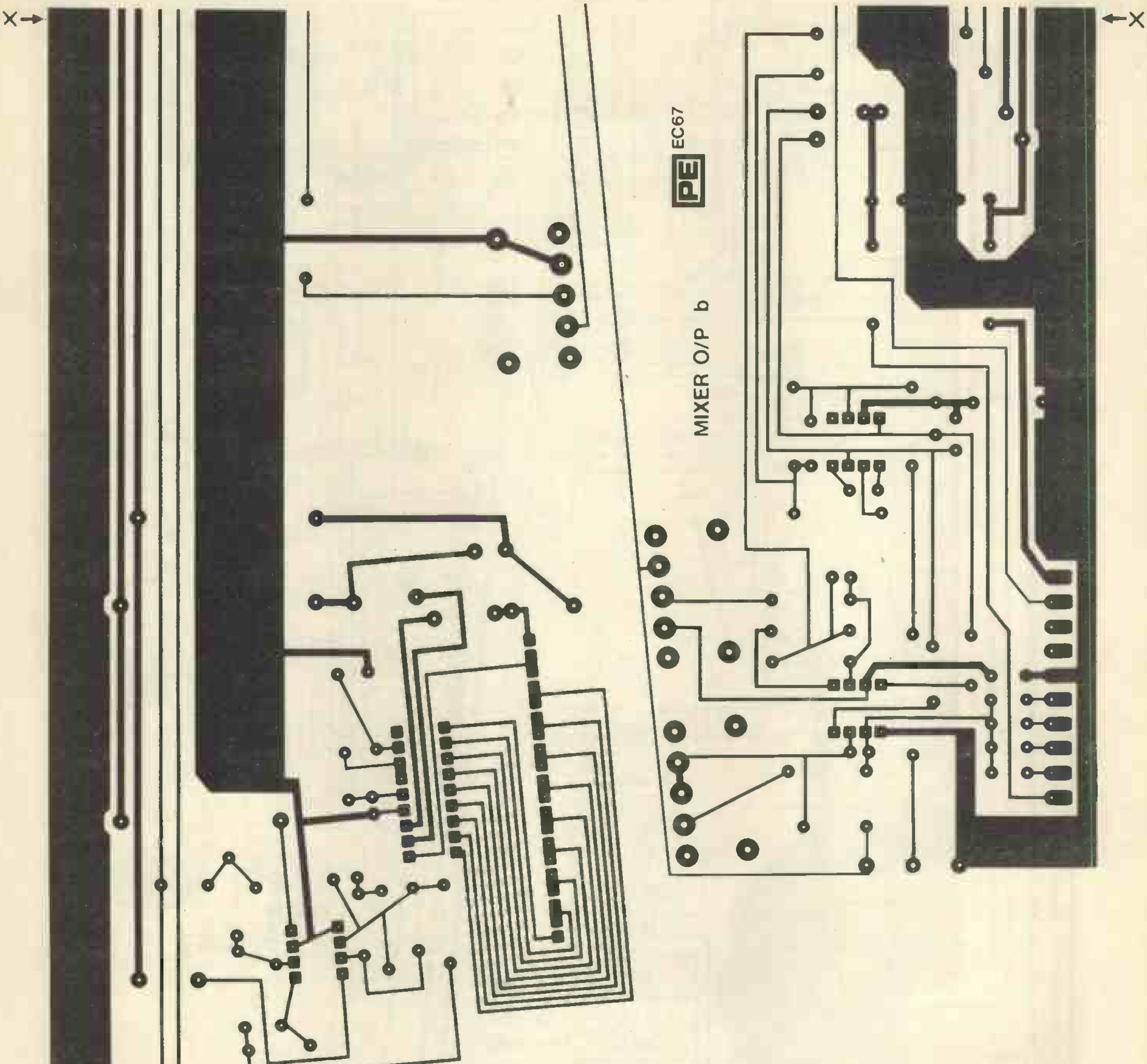


Fig. 2. Printed circuit board design for the Output Channel. The board is shown in two sections and should be joined along the X-X axis

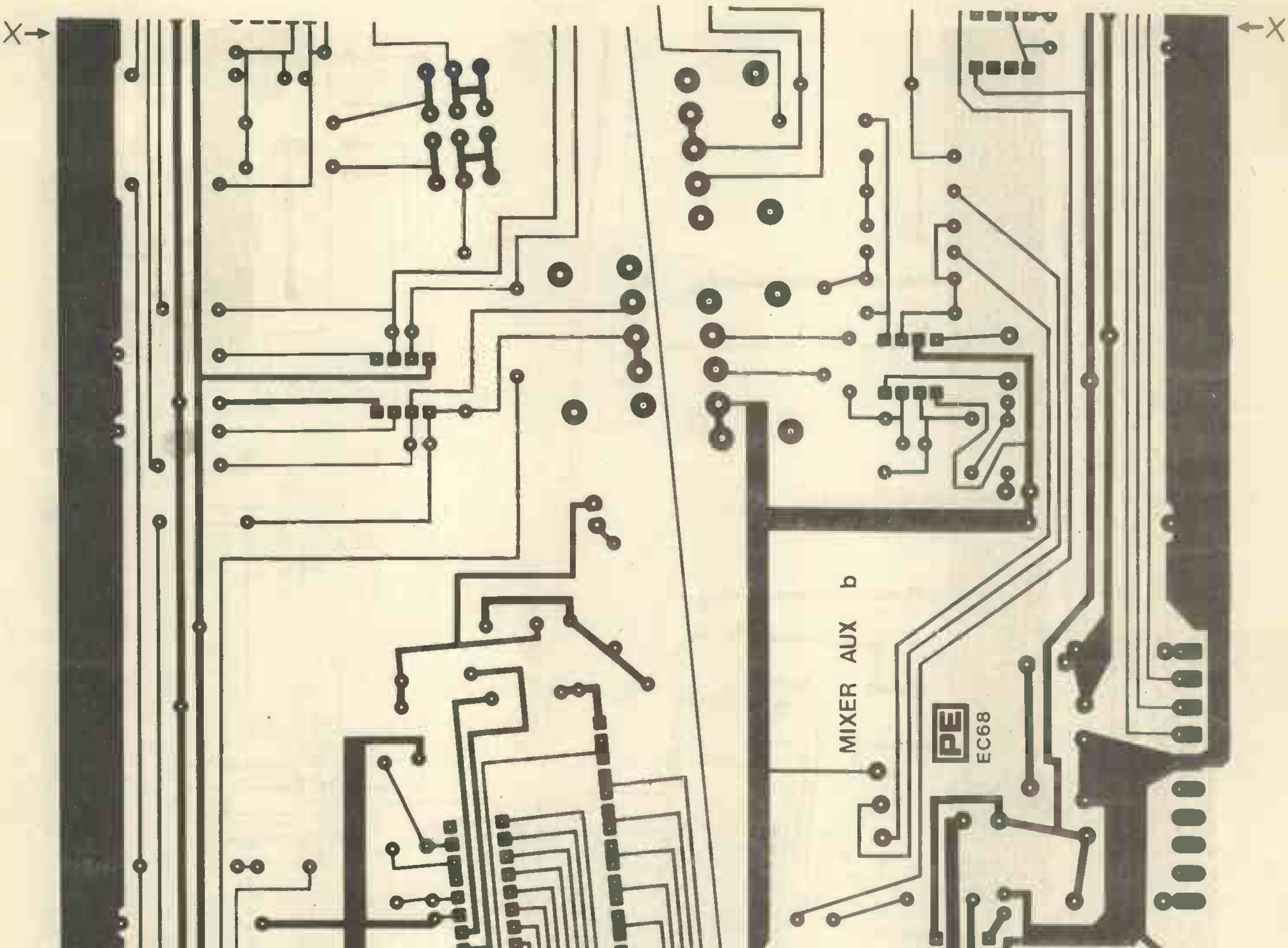


Fig. 3. Printed circuit board design for the Auxiliary Channel. The board is shown in two sections and should be joined along the X-X axis.

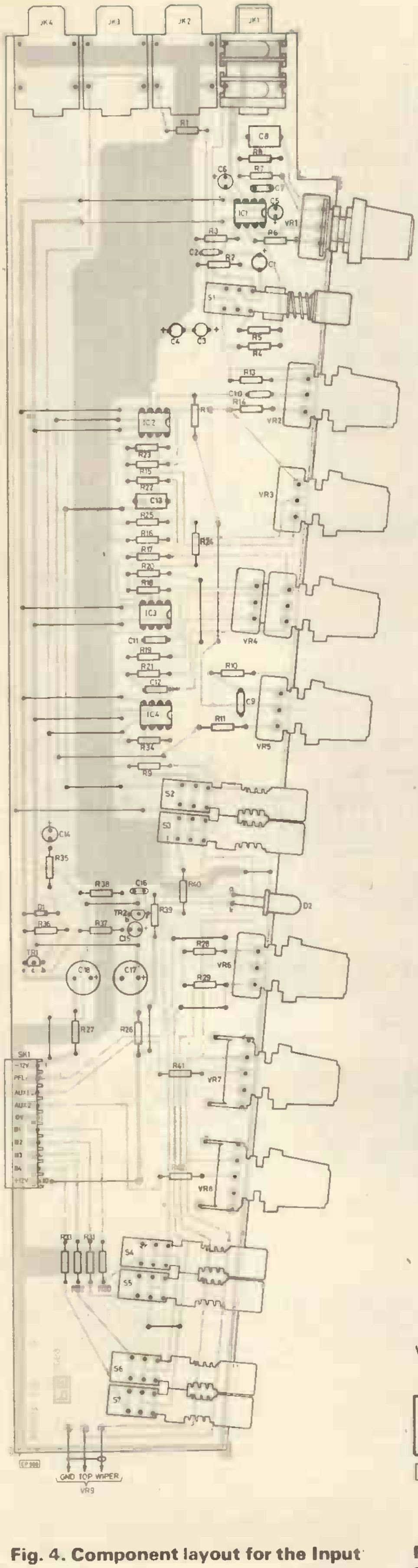


Fig. 4. Component layout for the Input Channel

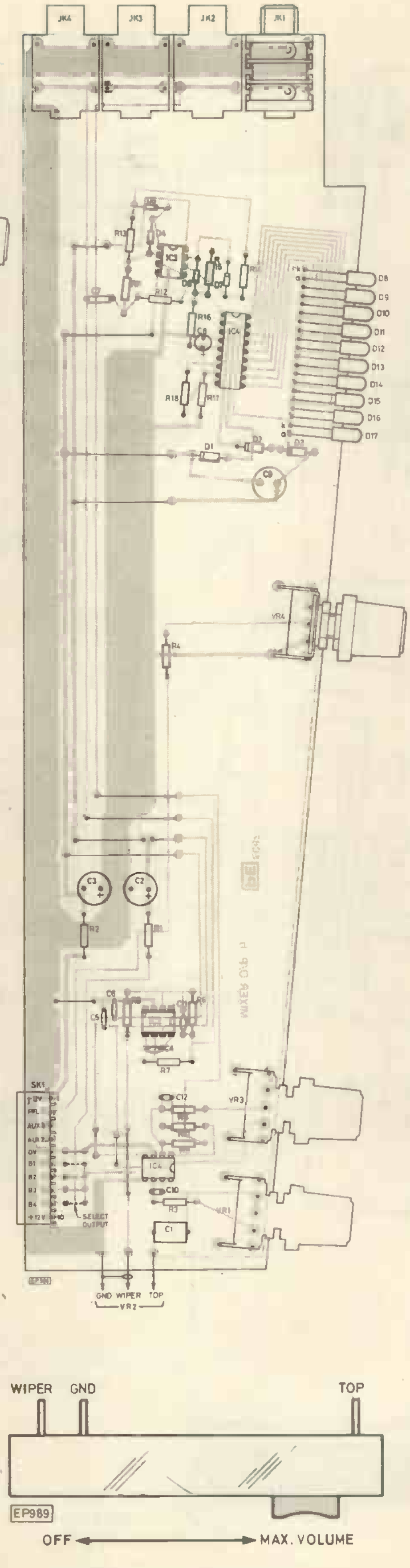


Fig. 5. Component layout for the Output Channel

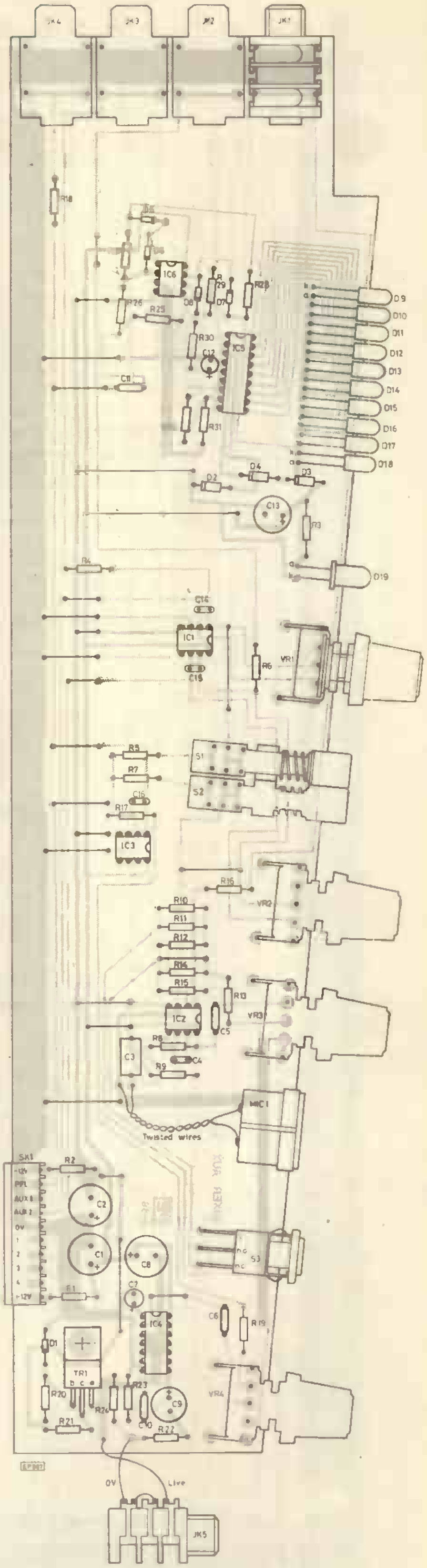


Fig. 6. Component layout for the Auxiliary Channel

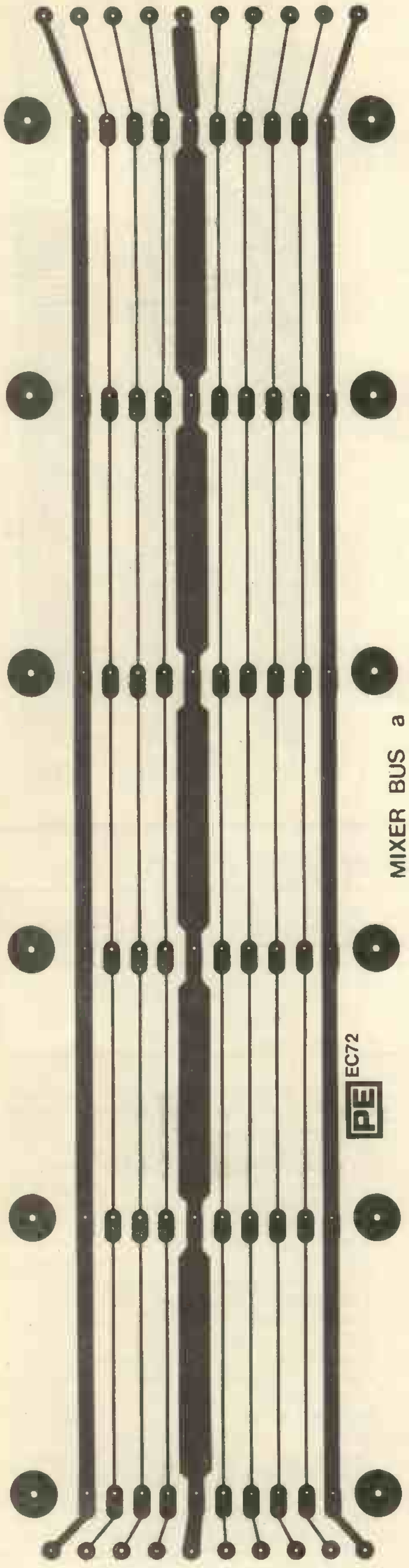


Fig. 7. Bus bar p.c.b. design

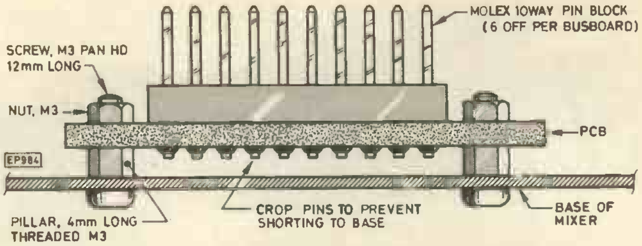


Fig. 8. Mounting details for the bus blocks

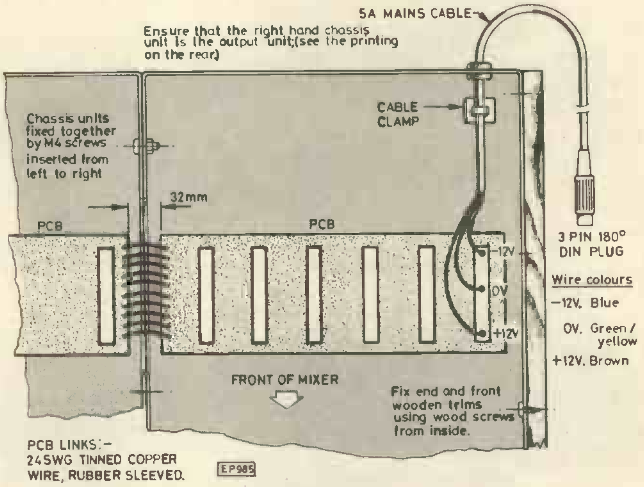
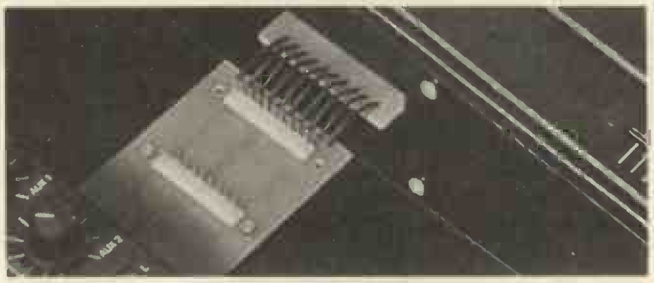


Fig. 9. Wiring and layout for the Bus boards



Bus board link wiring

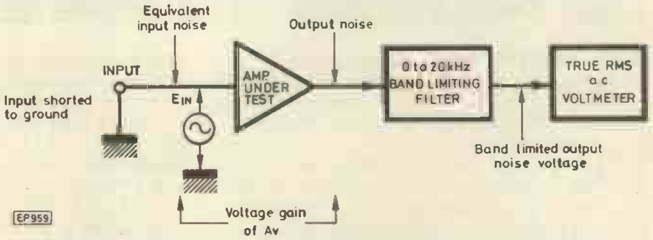
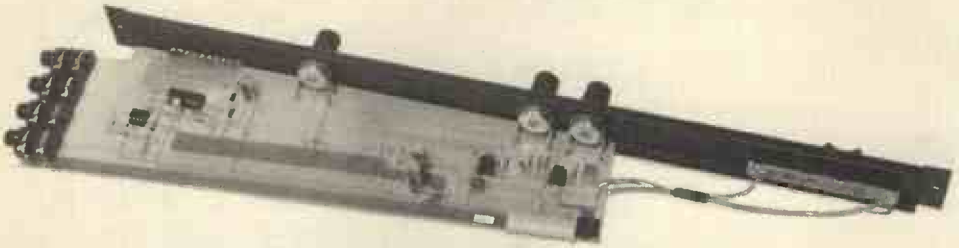


Fig. 10. Arrangement for measuring the equivalent input noise

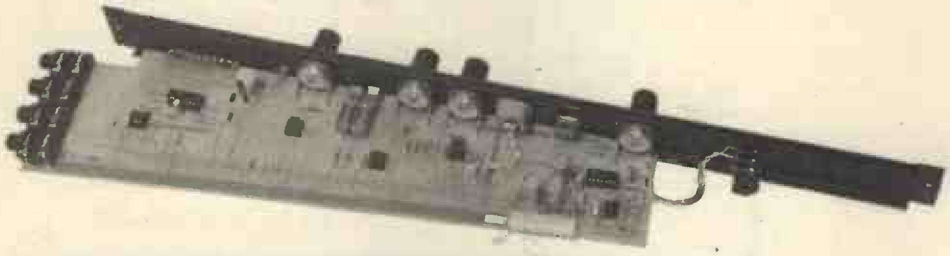
operate at the wrong frequency or produce a wrong gain change then check the circuit for correct component values. All the pots and switches in the input channel should be almost noiseless and clickless when operated. If this is not the case then check the circuit for correct components or mechanically faulty pots.

The input channels consume about 15mA from each rail rising to nearly 30mA when the LEVEL l.e.d. comes on. All the op amps should have very little d.c. offset on their outputs. Typically the offset will be ±10mV. Larger offsets may well cause crackle when control pots are rotated. The two integrators in the MIDDLE tone control may have larger offsets but this will not degrade the performance.

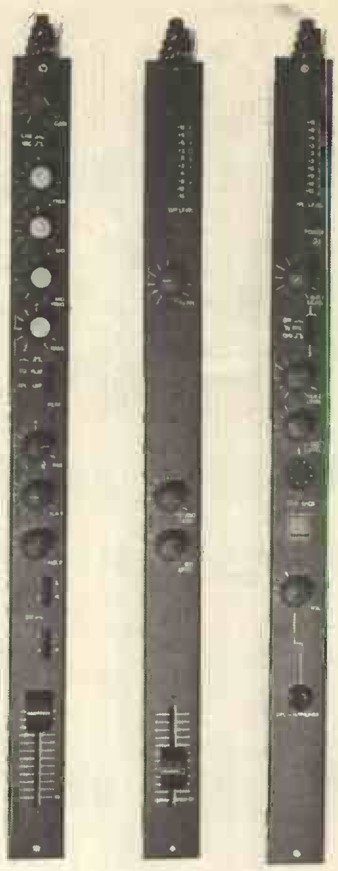
Input Channel with the front panel layout shown in (a)



Output Channel with the front panel layout shown in (b)



Auxiliary Channel with the front panel layout shown in (c)



(a) (b) (c)

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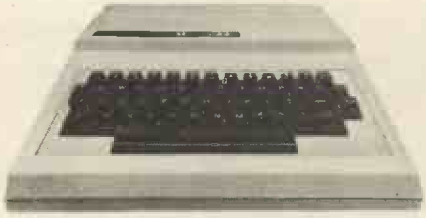

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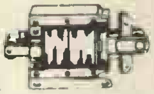

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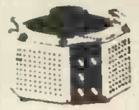

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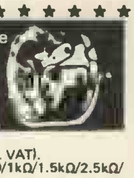

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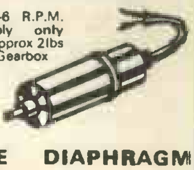

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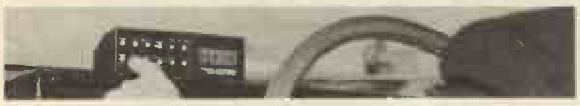

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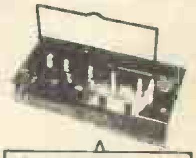

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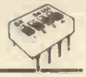

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74LS240	65p
74LS241	55p
74LS242	55p
74LS243	55p
74LS244	55p
74LS245	70p
74LS251	30p
74LS253	30p
74LS257	30p
74LS258	35p
74LS259	55p
74LS260	25p
74LS266	20p
74LS273	60p
74LS279	30p
74LS280	100p
74LS283	40p
74LS292	£5
74LS293	40p
74LS294	£5
74LS295	90p
74LS297	900p
74LS298	90p
74LS299	180p
74LS323	160p
74LS324	150p
74LS348	90p
74LS352	60p
74LS353	60p
74LS356	140p
74LS363	140p
74LS364	140p
74LS365A	27p
74LS367A	27p
74LS368A	27p
74LS373	55p
74LS374	55p
74LS375	45p
74LS377	70p
74LS378	70p
74LS390	45p
74LS393	45p
74LS395	120p
74LS399	200p
74LS445	110p
74LS640	100p
74LS641	100p
74LS642	100p
74LS643	100p
74LS644	200p
74LS642	100p
74LS643	100p
74LS644	100p
74LS645	100p
74LS668	100p
74LS669	100p
74LS670	120p

74S SERIES	
74S00	30p
74S02	30p
74S04	30p
74S05	60p
74S08	60p
74S10	40p
74S11	50p
74S20	40p
74S22	50p
74S30	40p
74S32	70p
74S37	60p
74S74	75p
74S85	450p
74S86	90p
74S112	90p
74S113	90p
74S114	90p
74S124	300p
74S132	110p
74S133	60p
74S138	120p
74S139	120p
74S157	250p
74S163	400p
74S174	250p
74S175	320p
74S188	150p
74S189	150p
74S194	350p
74S200	450p
74S201	320p
74S225	550p
74S241	300p
74S244	300p
74S251	250p
74S257	250p
74S258	250p
74S260	70p
74S261	300p
74S262	850
74S287	225p
74S288	150p
74S373	400p
74S374	400p
74S471	650p
74S474	400p
74S571	620p
74S573	900p

74C SERIES	
74C00	28p
74C04	20p
74C08	28p
74C10	28p
74C14	90p
74C20	28p
74C42	95p
74C48	143p
74C73	57p
74C74	59p
74C76	57p
74C85	134p
74C90	99p
74C95	106p
74C107	127p
74C151	255p
74C157	229p
74C160	140p
74C161	115p
74C162	115p
74C163	115p
74C164	108p
74C173	90p
74C174	90p
74C175	90p
74C192	115p
74C193	115p
74C194	120p
74C195	106p
74C221	120p
74C902	90p
74C912	800p
74C922	450p
74C923	500p
74C925	400p
74C928	600p

4000 CMOS	
4000	10p
4001	10p
4002	12p
4006	50p
4007	14p
4008	36p
4009	24p
4010	24p
4011	11p
4012	16p
4013	20p
4014	48p
4015	40p
4016	20p
4017	32p
4018	45p
4019	25p
4020	48p
4021	40p
4022	45p
4023	13p
4024	32p
4025	13p
4026	80p
4027	20p
4028	40p
4029	45p
4030	15p
4031	125p
4032	80p
4033	125p
4034	140p
4035	45p
4036	275p
4038	110p
4040	40p
4041	40p
4042	40p
4043	40p
4044	40p
4045	105p
4046	50p
4047	45p
4048	50p
4049	24p
4050	24p
4051	45p
4052	60p
4053	50p
4054	90p
4055	90p
4056	90p
4059	450p
4060	65p
4063	90p
4066	27p
4067	225p
4068	14p
4069	14p
4070	14p
4071	14p
4072	14p
4073	14p
4075	14p
4076	48p
4077	16p
4078	16p
4081	14p
4082	15p
4086	55p
4089	125p
4093	24p
4094	90p
4095	75p
4096	70p
4097	290p
4098	90p
4099	100p
40102	150p
40103	180p
40105	120p
40106	40p
40109	100p
4501	28p
4502	60p
4503	45p
4504	75p
4506	35p
4507	35p
4508	130p
4510	45p
4511	45p
4512	48p
4514	110p
4515	110p
4516	55p
4518	40p
4520	50p
4521	90p
4522	120p
4526	60p
4527	60p
4528	50p
4532	70p
4534	400p
4536	270p
4538	90p
4539	70p
4543	75p
4553	245p
4555	35p
4556	35p
4557	300p
4560	120p
4566	160p
4568	250p
4569	170p
4572	30p
4583	90p
4584	40p
4585	75p
40014	40p
40085	90p
40097	45p
40163	60p
40174	60p
40175	75p
40193	75p
14495	400p
14599	290p

LINEAR I.Cs	
AN103	200p
AY1-0212	700p
AY1-1313	668p
AY1-1320	225p
AY1-5050	140p
AY3-8910	440p
AY3-8912	625p
AY5-1350	£4
AY5-4007D	520p
CA3019	80p
CA3028A	110p
CA3046	70p
CA3048	220p
CA3059	285p
CA3080E	70p
CA3086	48p
CA3089E	200p
CA3090AQ	375p
CA3130E	90p
CA3140E	40p
CA3160E	100p
CA3161E	150p
CA3162E	450p
CA3189E	300p
CA3240E	110p
CA3280G	200p
DAC1408-8	200p
HA1366	300p
HA1388	250p
ICL7106	700p
ICL7660	£2
ICL8038	300p
LC7120	300p
LC7130	350p
LF347	150p
LF351	48p
LF353	95p
LF356P	95p
LF357	110p
LM10C	325p
LM301A	25p
LM310	300p
LM311	70p
LM318	150p
LM319	215p
LM324	30p
LM335Z	140p
LM339	50p
LM348	65p
LM358P	60p
LM377	175p
LM380	75p
LM381AN	180p
LM382	120p
LM386	90p
LM387	120p
LM389	95p
LM393	100p
LM394CH	300p
LM709	36p
LM710	50p
LM711	100p
LM725	300p
LM733	100p
LM741	18p
LM747	70p
LM748	35p
LM1871	300p
LM1872	300p
LM1886	700p
LM1889	350p
LM2917	200p
LM3302	75p
LM3900	50p
LM3909	85p
LM3911	125p
LM3914	200p
LM3915	200p
LM3916	225p
LM13600	110p
M51513L	230p
M51516L	500p
M83712	200p
MC1310P	150p
MC1413	75p
MC1458	36p
MC1495L	350p
MC1496	70p
MC3340P	120p
MC3401	50p
MC3403	65p
MK50938	635p
ML920	800p
MM57160	620p
NE531	140p
NE555	16p
NE556	45p
NE564	420p
NE565	120p
NE566	155p
NE567	140p
NE570	410p
NE571	400p
NE5534A	125p
PLL02A	500p
RC4136	70p
RC4151	200p
RC4558	60p
S5668	225p
SAD1024A	850p
SFF96364	800p
SL490	350p
SN76477	480p
SN76488	450p
SP8515	750p
TA7120	150p
TA7204	150p
TA7205	90p
TA7222	150p
TA7310	150p
TBA621AX1	275p
TBA6418X1	300p
TBA800	80p
TBA810	100p
TBA820	80p
TBA920	200p
TBA950	225p
TC9109	750p
TCA210	350p
TCA220	350p
TCA940	175p
TDA1004A	300p
TDA1008	320p
TDA1010	200p
TDA1022	500p
TDA1024	120p
TDA1170	300p
TDA2002V	325p
TDA2003	325p
TDA2020	320p
TL071/81	25p
TL072/82	45p
TL074	100p
TL084	90p
TL094	200p
TL170	50p
TL430C	70p
UAA170	170p
UA2240	120p
ULN2003A	75p
UPC1156H	300p
XR2206	300p
ZNA234	£9
ZN414	80p
ZN419C	180p
ZN424E	130p
ZN425E	340p
ZN427E	590p
ZN428E	410p
ZN1034E	200p
ZN1040E	670p

VOLTAGE REGULATORS FIXED PLASTIC

1A	+ve		−ve	
5V 1A	7805	•40p	7905	45p
12V 1A	7812	•40p	7906	45p
15V 1A	7815	•40p	7912	45p
18V 1A	7818	•40p	7915	45p
24V 1A	7824	•40p	7918	45p
5V 100mA	78L05	30p	7924	45p
12V 100mA	78L12	30p	79L05	65p
15V 100mA	78L15	30p	79L12	70p
			79L15	70p

OTHER REGULATORS			
LM309K 1A 5V	135p	78HGKC	600p
LM317K	325p	78HO5KC	550p
LM317T 1A Adj	200p	78MGT2C	140p
LM337T	225p	78GUIC	200p
LM323K 3A 5V	450p	79GUIC	225p
LM723 150mA Adj	37p	79HGKC	700p
TL494	400p	TL497	300p
78S40	300p	LM305H	250p

OPTO-ELECTRONICS			
2N5777	45p	ORP60	120p
OCP71	180p	ORP61	120p
ORP12	120p	TIL78	55p

OPTO-ISOLATORS			
ILD74	130p	TIL 111	70p
MCT26	100p	TIL 112	70p
MCS2400	190p	TIL 113	70p
ILQ74	240p	TIL 116	70p

LEDS			
0.125"		0.2"	
TIL32	55p	TIL220 Red	10p
TIL209 Red	10p	TIL222 Gr	12p
TIL211 Gr	12p	TIL228 Yel	15p
TIL212 Ye	15p	Rectangular LEDs (R, G, Y)	20p
TIL216 Red	18p		

DISPLAYS			
3015F	200p	NSB5881	670p
DL704	140p	TIL311	600p
DL707 Red	140p	TIL312/3	110p
FND357	120p	TIL321/2	130p
FND500	90p	TIL330	140p
FND507	90p	7750/60	200p
MAN3640	175p		
MAN4640	200p		

DRIVERS	
9368	250p
9370	300p
UDN6118	320p
UDN6184	320p

CPUs	
1802CE	650p
2650A	£12
6502	350p
6502A	500p
6800	225p
6802	250p
68B02	700p
6809	650p
6809E	£12
68809	£12
8035	350p
8039	£3
8080A	250p
8085A	350p
INS8060	£11
TMS9980	£20
Z8	£24
Z80	290p
Z80A	320p
Z80B	£12
8088	£18

SUPPORT DEVICES	
3242	800p
3245	450p
6520	280p
6522	310p
6522A	550p
6532	600p
6551	650p
6821	100p
68821	220p
6840	375p
68840	£6
6850	110p
68B50	220p
6852	250p
6854	£7
6875	570p
8154	950p
8155	350p
8156	350p
8205	225p
8212	110p
8216	100p
8224	110p
8226	250p
8228	220p
8243	280p
8250	850p
8251	250p
8253	380p
8255	255p
8256	£36
8257	£4
8259	£4
8279	440p
8284	350p
8288	£11
TMS9918	£60
Z80PIO	250p
Z80APIO	280p
Z80CTC	250p
Z80ACTC	250p
Z80ADART	£7
Z80ADMA	£10
Z80SIO-0/1/2	£9

CRT CONTROLLER	
CRT6545	900p
CRT5027	£18
CRT5037	£18

EF9365	£45
EF9366	£48
MC6845	650p
MC6847	650p
SFF96364	£8
TMS9918	£60
TMS9927	£18
TMS9928	P.O.A.

ZIF SKTS (TEXTOOL)	
24 pin	£6
28 pin	£8
40 pin	£10

MEMORIES	
2101A	400p
2102-3L	120p
21078	500p
2111A	300p
2112-A	300p
2114-2L	100p
2147	450p
4027-3	300p
4044-45	450p
4116-15	100p
4116-20	90p
4118-3	500p
4118-4	450p
4164-2	£6
4816AP-3	280p
5101	300p
5516	950p
6116P-3	550p
6116LP	750p
6514-45	£3
6810	120p
7489	210p
74S189	325p
74S201	350p
74S289	325p
93415	600p
93425	600p

ROMs/PROMs	
74S188	150p
74S287	225p
74S288	150p
74S387	350p
74S471	650p
74S473	650p
74S474	400p
74S570	650p
74S571	620p
74S573	900p

EPROMs	
2516 (+5V)	250p
2532	380p
2564	£15
2708	250p
2716 (+5V)	250p
2732	450p
2716 (350ns)	500p
2732 (300ns)	750p
TMS2716	750p

UARTs	
AY-3-1015P	300p
AY-5-1013P	300p
COM8017	300p
IM6402	450p
TR1602	300p

INTERFACE ICs	
AD558CJ	775p
AD561J	£14
AM25S10	350p
AM25LS2521	£2
AM26LS31	125p
AM26LS32	125p
COM8116	800p
DAC80	£28
DM8131	275p
DP8304	250p
DS8830	140p
DS8831	140p
DS8832	250p
DS8833	225p
DS8836	150p
DS8838	225p
LF13201	450p
MC1488	55p
MC1489	55p
MC3418	950p
MC3446	300p
MC3480	850p
MC3486	500p
MC3487	300p
MC4024	325p
MC4044	325p
MC14411	675p
MC14412	750p
ULN2003A	90p
75107	90p
75110/12	90p
75114/15	160p
75121/22	140p
75150P	120p
75154	140p
75182	90p
75324	375p
75361	150p
75363	150p
75365	150p
75451/2	72p
75453/4	72p
75491/2	65p
8T26	120p
8T28	120p
8T95/96	80p
8T97/98	80p
81LS95	80p
81LS96	80p
81LS97	90p
81LS98	90p
9602	220p
9637AP	160p
ZN425E-8	350p
ZN426E-8	350p
ZN427E-8	650p
ZN428E-8	500p

DISC CONTROLLERS	
FD1771	£20
FD1791	£22
FD1793	£23
FD1795	£28
FD1797	£28
WD1691	£15
WD2143	550p
8271	£65

CHARACTER GENERATORS	
RO-3-2513UC	750p
RO-3-2513LC	700p
SN74S262AN	£10
MC66760	750p

CRYSTALS	
32·768KHz	100p
100KHz	250p
200KHz	280p
1·0MHz	290p
1·008MHz	275p
1·5MHz	450p
1·8432MHz	210p
2·00MHz	225p
2·45760MHz	210p
2·5MHz	250p
2·662MHz	250p
3·276MHz	150p
3·5795MHz	100p
3·686MHz	300p
4·00MHz	150p
4·194MHz	200p
4·43MHz	110p
4·608MHz	250p
4·9152MHz	250p
5·00MHz	175p
6·00MHz	150p
6·144MHz	150p
7·00MHz	150p
7·168MHz	175p
8·00MHz	175p
8·86MHz	175p
10·00MHz	175p
10·50MHz	250p
10·70Hz	150p
12.00MHz	150p
14·318M	175p
14·756MHz	250p
15·00MHz	200p
16·00MHz	200p
18·00MHz	200p
18·432MHz	150p
19·968MHz	150p
20·000MHz	200p
26·690MHz	150p
27·145MHz	200p
38·6667MHz	175p
48·0MHz	175p
55·5MHz	400p
116MHz	300p
145.80MHz	250p

KEYBOARD ENCODER	
AY-5-2376	700p
74C922	420p
74C923	500p

MODULATORS	
6MHz UHF	400p
8MHz UHF	450p

BAUD RATE GENERATOR	
MC14411	675p
COM8116	700p
47028	750p

TELETEXT DECODER ICs	
SAA5020	£6
SAA5030	£9
SAA5041	£16
SAA5050	£9

REAL TIME CLOCK	
MM58174	850p
MCM66760	700p

WIRE WRAP SOCKETS BY TEXAS					
8 pin	25p	18 pin	50p	24 pin	70p
14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

LOW PROFILE DIL SOCKETS BY TEXAS					
8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	18p	28 pin	26p
16 pin	11p	22 pin	22p	40 pin	30p

TRANSISTORS	
AD161/2	45p
BC107/8	13p
BC109C	14p
BC169C	12p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC337	16p
BC338	16p
BC461	25p
BC477/8	30p
BC516/7	40p
BC547B	14p
BC548C	12p
BC549C	16p
BC557B	14p
BC559C	16p
BCY70	18p
BCY71/2	22p
BD131/2	75p
BD135/6	40p
BD139	40p
BD140	40p
BD189	60p
BD242	60p
BD379	60p
BD380	60p
BF244B	35p
BF256B	60p
BF257/B	32p
BF259	36p
BF337	30p
BFR39	25p
BFR40/1	25p
BFR79	25p
BFR80/1	25p
BFX29	40p
BFX30	27p
BFX84/5	40p
BFX88	27p
BFX89	150p
BFY50	24p
BFY51/2	24p
BFY56	33p
BFY90	80p
BRY39	45p
BSX19/20	24p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
BUX80	600p
J310	50p
MJ802	400p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJE340	60p
MJE2955	100p
MJE3055	70p
MPF102	40p
MPF103/4	30p
MPF105	30p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
TIP29A/C	35p
TIP30A/C	38p
TIP31A/C	40p
TIP32A/C	48p
TIP33A/C	70p
TIP34A/C	90p
TIP35A/C	120p
TIP36A/C	140p
TIP41A/C	50p
TIP42A/C	60p
TIP54	160p
TIP120	75p
TIP122	90p
TIP142	120p
TIP147	120p
TIP2955	78p
TIP4055	70p
VN10KM	100p
VN66	80p
ZTX108	12p
ZTX300	13p
ZTX500	15p
ZTX502	18p
ZTX504	18p
2N697	25p
2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	36p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	25p
2N2222A	25p
2N2369A	25p
2N2484	25p
2N2646	45p
2N2904/5	25p
2N2906A	25p
2N2907A	25p
2N2926	9p
2N3053	25p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3584	250p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	300p
2N3819	25p
2N3820	40p
2N3823	50p
2N3866	90p
2N3902	700p
2N3903/4	16p
2N3905/6	16p
2N4037	65p
2N4123/4	27p
2N4125/6	27p
2N4401/3	27p
2N4427	90p
2N4871	60p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5194	90p
2N5245	40p
2N5296	60p
2N5401	50p
2N5457/8	32p
2N5459	32p
2N5460	60p
2N5485	44p
2N5875	250p
2N6027	48p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1172	150p
2SC1306	150p
2SC1307	150p
2SC1957	90p
2SC2969	198p
2SC2028	120p
2SC2029	250p
2SC2078	200p
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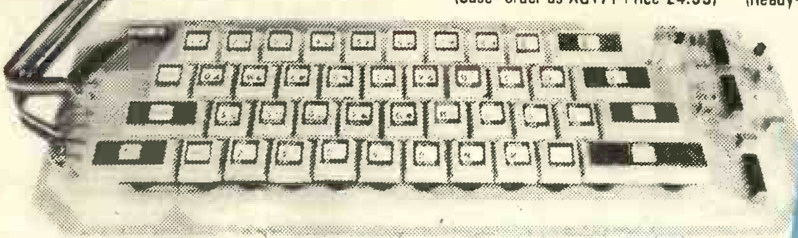

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