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ELECTRONICS

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PE ROBOTICS MICROS ELECTRONICS INTERFACING

ISSN 0032-6372

VOLUME 21 Nº 4 APRIL 1985

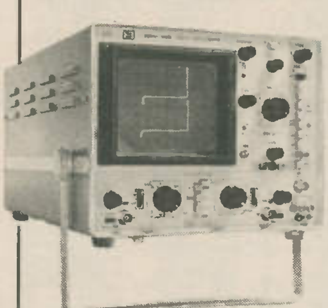
CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

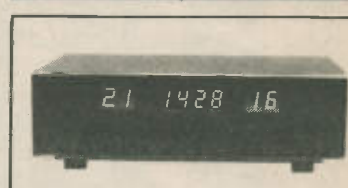
NEWS & COMMENT

This month's cover shows a digitised photograph, designed and created by Alex Kempkens, of a National Semiconductor 32-bit microprocessor. The Series 32000 Family from National includes the first commercially available 32-bit c.p.u.

SCOPE OFFER . . .



. . . See Page 26



OUR MAY ISSUE WILL BE ON SALE FRIDAY, APRIL 4th, 1985 ***(see page 43)***

WATFORD ELECTRONICS

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

ELECTROLYTIC CAPACITORS (Values in µF). **500V:** 10µF **52p**; 47 **78p**; **63V:** 0·47, 1·0, 1·5, 2·2, 3·3, **8p**; 4·7 **9p**; 10 **10p**; 15, 22 **12p**; 33 **15p**; 47 **12p**; 68 **16p**; 100 **19p**; 220 **26p**; 1000 **70p**; 2200 **99p**; **50V:** 68 **20p**; 100 **17p**; 220 **24p**; **40V:** 6·8 **15p**; 22 **9p**; 33 **12p**; 330, 470 **32p**; 1000 **48p**; 2200 **90p**; **25V:** 4·7, 10, 22, 47 **8p**; 100 **11p**; 150 **12p**; 220 **15p**; 330 **22p**; 470 **25p**; 680, 1000 **34p**; 1500 **42p**; 2200 **50p**; 3300 **76p**; 4700 **92p**; **16V:** 2·5, 40 **8p**; 47, 68, 100 **9p**; 125 **12p**; 220 **13p**; 330 **16p**; 470 **20p**; 680 **34p**; 1000 **27p**; 1500 **31p**; 2200 **36p**; 4700 **79p**.

TAG-END TYPE: 64V: 4700 **245p**; 3300 **145p**; 2200 **120p**; **50V:** 3300 **155p**; 2200 **95p**; **40V:** 4700 **160p**; 2200 **70p**; 3300 **85p**; 4000, 4700 **75p**; 10,000 **250p**; 15,000 **270p**; **16V:** 2200 **200p**; **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 **36p** 33, 47 **50p** 100 **95p** 220 **100p** **10V:** 15, 22 **26p** 33, 47 **50p** 100 **75p**.

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

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

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm track
5KΩ-500KΩ Single gang **80p**

PRESET POTENTIOMETERS

0·1W 50Ω-2·2M Mini Vert. & Horiz.	**8p**
0·25W 220Ω-4M7 Vert. & Horiz.	**12p**

RESISTORS Hi-stab, Miniature, 5% Carbon.

	RANGE	Val.	1-99	100+
0·25W	2Ω2 - 4·M7	E24	3p	1p
0·5W	2Ω2 - 4·M7	E12	3p	1p
1W	2Ω2 - 10M	E12	6p	4p
1% Metal Film 51Ω-1M		E24	8p	6p

SILVER MICA (pf)
2, 3·3, 4·7, 6·8, 8·2, 10, 12, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180 **15p**. 220, 250, 270, 330, 360, 390, 470, 600, 800 & 820pF **21p**.
1000, 1200, 1800 **30p each**
3300, 4700 **60p each**

SIEMENS mulitlayer miniature capacitors.
250V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 8n2, 10n, 15n, 22n, 27n, 33n, 47n **8p**; 39n, 56n, 68n **9p**, 100nF **11p**.
100V: 100n, 120n, **10p**; 150n **11p**; 220n **13p**; 330n **18p**; 470n **23p**; 680n **30p**; 1MF **34p**; 2M2 **50p**.

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

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

RESISTDRS S.I.L. Package: 7 Commoned, 100Ω, 470Ω, 680Ω, 1K, 2K2, 4K7, 10K, 47K, 100K **24p**.
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K, 100K **26p**.

TRANSISTORS

AC127/8	35
AC141/2	35
AC176	35
AC187/8	35
AC188	35
AD142	120
AD149	79
AD161/2	42
AF118	95
AF139	40
AF239	55
BC107/8	12
BC107B	14
BC108B	14
BC108C	14
BC109	12
BC109B	14
BC109C	14
BC114/5	30
BC117/8	25
BC140	38
BC142/3	38
BC147/8	12
BC147B	15
BC148C	10
BC149	12
BC149C	15
BC153/4	30
BC157/8	14
BC159	11
BC167A	14
BC168C	12
BC169C	12
BC171/2	12
BC173	15
BC177/8	16
BC179/81	20
BC181	30
BC182/3	10
BC184	10
BC182L	10
BC183L	10
BC184L	10
BC186/7	28
BC212/3	12
BC212L	10
BC213L	12
BC214	10
BC214L	12
BC237/8	15
BC307B	15

BC308B	16
BC327/8	16
BC337/8	15
BC441	34
BC461	34
BC477/8	40
BC516/7	40
BC547/8	12
BC549C	15
BC556/7	15
BC558/9	15
BCY41/42	30
BCY70	18
BCY71	20
BCY72	25
BCY78	30
BD131/2	65
BD133	60
BD135	45
BD136/7	40
BD138/9	40
BD140	40
BD158	68
BD245	65
BD434	70
BD695A	150
BD696A	150
BF115	45
BF154/8	30
BF167	35
BF173	35
BF177	35
BF178	35
BF179	40
BF194/5	12
BF198/9	18
BF200	30
BF224	40
BF244A	28
BF244B	29
BF245	50
BF256B	50
BF257/8	32
BF259	40
BF394	40
BF451	40
BF494/5	40
BF594/5	30
BFR39/40	25
BFR41/79	25
BFR80/81	25

BFR98	105
BFX29/84	35
BFX84	35
BFX85/86	35
BFX87/88	28
BFY50/51	30
BFY52	30
BFY53	35
BFY55	35
BFY56	35
BFY64	40
BFY90	80
BRY39	50
BSX20	30
BSX29	45
BSY26	35
BSY95	35
BU105	180
BU205	190
BU206	200
BU208	200
MJ2955	90
MJE340	54
MJE371	100
MJE2955	99
MJE3055	70
MPF102	40
MPF103/4	30
MPF105	30
MPSA05	30
MPSA06	25
MPSA08	30
MPSA12	32
MPSA55	30
MPSA56	30
MPSA70	40
MPSU02	58
MPSU05	60
MPSU06	60
MPSU52	65
MPSU55	60
MPSU56	60
OC23	170
OC28/36	220
OC41/42	75
OC70	40
OC72	50
OC75/76	55
OC76	50
OC81/82	50
OC83/84	70
TIP29A	32
TIP29C	38
TIP30A	35

TIP30C	37
TIP31A	38
TIP31C	45
TIP32A	43
TIP32C	45
TIP33A	70
TIP33C	75
TIP34A	85
TIP34C	105
TIP35A	120
TIP35C	130
TIP36A	130
TIP36C	140
TIP41A	50
TIP41B	52
TIP42A	55
TIP42B	58
TIP120	70
TIP121	73
TIP141	120
TIP142	120
TIP147	120
TIP2955	70
TIP3055	70
TIS43	50
TIS44	45
TIS88A	50
TIS90	30
TIS91/93	32
VK1010	99
VN10KM	70
VN46AF	95
VN66AF	110
VN88AF	120
VN89AF	120
ZTX107/8	12
ZTX109	12
ZTX212	28
ZTX300	13
ZTX301/2	16
ZTX303	25
ZTX304	17
ZTX320/26	30
ZTX500/1	14
ZTX502/3	18
ZTX504	25
ZTX531	25
ZTX550	25
2N696	30
2N697	23
2N698	40
2N699	48
2N706A	25
2N708	25

2N914/5	32
2N918	40
2N930	20
2N1131/2	40
2N1303/4/5	
2N1307	70
2N1613	30
2N1671B	160
2N2160	325
2N2219A/20A/	
21A/22A	25
2N2369A	18
2N2646	45
2N2846	80
2N2904A/05A/	
06A/07A	26
2N2926G	10
2N3053	25
2N3054	55
2N3055	50
2N3442	140
2N3615	199
2N3663	20
2N3702/3	10
2N3704/5	10
2N3706/7	10
2N3708/9	10
2N3710	10
2N3771	179
2N3772	195
2N3773	210
2N3819	35
2N3820	60
2N3822/3	60
2N3866	90
2N3903/4	15
2N3906/5	15
2N4037	60
2N4058	15
2N4061/2	15
2N4264	30
2N4286	25
2N4289	25
2N4400	25
2N4427	80
2N4859	78
2N5135	30
2N5138	25
2N5172	25
2N5180	45
2N5191	75
2N5194	80
2N5305	24
2N5457	30

2N5458/9	30
2N5485	36
2N5777	45
2N6027	32
2N6109	60
2N6290	70
2SA636	250
2SA671	250
2SA715	75
2SC495/6	85
2SC1061	250
2SC1096	85
2SC1162	45
2SC1172/3	125
2SC1306	100
2SC1307	150
2SC1449	95
2SC1679	190
2SC1678	140
2SC1923	65
2SC1945	225
2SC1953	90
2SC1957	90
2SC1969	165
2SC2028	85
2SC2029	200
2SC2078	170
2SC2091	85
2SC2166	165
2SC2314	85
2SC2335	200
2SC2465	125
2SC2547	40
2SC2612	200
2SD234	75
2SK45	90
2SK288	225
2SJ83	225
2SJ85	225
3N128	118
3N140	115
40251	150
40311	60
40313	130
40361/62	70
40408	76
40412	90
40467	130
40468	85
40594	105
40595	110
40603	110
40673	70
40871/2	90

LINEAR IC's

555 CMOS	95
702	75
709C 8 pin	35
710	48
741	16
747C 14 pin	70
748C 8 pin	30
753 8 pin	185
810	159
9400CJ	375
ADC0808	£10
AY-1-1320	225
AY-1-5050	99
AY-1-6720	210
AY-3-8910	390
AY-3-8912	500
AY-5-1317A	630
CA3011	130
CA3012	175
CA3014	275
CA3018	86
CA3019	90
CA3020	210
CA3023	210
CA3028A	110
CA3035	255
CA3036	270
CA3043	275
CA3045	365
CA3046	70
CA3048	220
CA3059	325
CA3075	213
CA3080E	70
CA3081	190
CA3085	160
CA3086	60
CA3089E	200
CA3090AQ	375
CA3123	165
CA3130	90
CA3140	45
CA3160	90
CA3161E	180
CA3162	525
CA3189	275
CA3240	110
HA1366	175
HA1388	235
ICL7106	675
ICL7107	975
ICL7611	99
ICL7660	248
ICL8038CC	345
ICL8211	225
ICM7205	1150
ICM7215	1050
ICM7216A	£22
ICM7217A	£11
ICM7224	£11
ICM7240	300
ICM7555	105
ICM7556	150
LA3350	250
LA4031P	340
LA4032	295
LA4400	350
LA4422	320
LC7120	300
LC7130	320
LC7137	350
LF347	150
LF351	60
LF353	90
LF355	90
LF356	90
LF357	100
LF398	495
LM10	325
LM301A	30
LM307	45
LM308	75
LM311	60
LM318	150
LM319	180
LM324	45
LM334Z	150
LM335Z	135

LM337	275
LM339	40
LM348	60
LM349	125
LM358	50
LM377	210
LM379	495
LM380	115
LM381N	175
LM382	200
LM384	225
LM386	90
LM387	200
LM389	160
LM393	85
LM394CH	380
LM558	170
LM725CN	300
LM733	65
LM1871	300
LM1889	400
LM2907	395
LM3900	70
LM3909	85
LM3911	185
LM3914	300
LM3915	345
LM3916	300
LM13600	150
LS7220	280
M51513L	230
M51515L	320
M51516L	475
MB3712	200
MB3756	440
MC1204	250
MC1301	90
MC1303	98
MC1304P	260
MC1310P	150
MC1445	250
MC1455	50
MC1458	35
MC1469	300
MC1494	694
MC1495	350
MC1496L	70
MC1596	225
MC1648	290
MC3302	75
MC3401	50
MC3403	95
MC3404	85
MC3405	150
MC3442	00
MC3423P	80
MC3487	00
MC4016	00
MF10	300
MFC6040	75
ML924	275
NE515	275
NE529	225
NE531	140
NE543	225
NE544	200
NE555	25
NE556DB	65
NE558	170
NE560	350
NE562B	410
NE564	420
NE565A	120
NE566	155
NE567	140
NE570	410
NE571	400
NE5532	150
NE5534	160
OM335	650
RC4136D	60
RC4558	55
S566B	225
SAB3209	425
SAB3210	325
SAB3271	485
SAB4209	595
SG3402	295

SL490	350
SL924	00
SL6270	170
SN76033	350
SN76488	525
SP0256AL	625
TA7120	140
TA7130	125
TA7204	150
TA7205	90
TA7222	150
TA7310	00
TAA900	395
TAA661	190
TAA700	275
TAD100	159
TBA120S	70
TBA540	275
TBA550Q	330
TBA641	290
TBA651	190
TBA800	80
TBA810S	95
TBA820	80
TBA920Q	200
TBA990	350
TCA270	350
TCA280A	220
TCA940	175
TCA950	00
TCA965	180
TDA1008	310
TDA1010	235
TDA1022	499
TDA1024	115
TDA1034	350
TDA1054	00
TDA1490	350
TDA2002	325
TDA2003	250
TDA2004	270
TDA2006	320
TDA2020	320
TDA2030	190
TDB0791	420
TL061CP	40
TL062CP	65
TL064CN	95
TL071CP	40
TL072CP	75
TL074CN	130
TL081CP	35
TL082CP	55
TL083CP	75
TL084CP	110
TL091CP	60
TL170	50
TL430C	90
TL507	110
TL509	110
UA2240	120
UA78540	230
UAA170	180
UAA180	180
ULN2003	90
ULN2004	90
ULN2283	150
ULN2803	190
UPC556	00
UPC575	275
UPC1025H	375
UPC1156H	295
UPC1181	00
UPC1182	425
UPC1366	195
XR2206	375
XR2207	400
XR2211	575
XR2216	675
XR2266	360
ZN414	80
ZN423E	130
ZN424E	130
ZN425E-8	345
ZN426E-8	200
ZN427E-8	600
ZN428E	450
ZN429E-8	240
ZN459	245
ZN1034E	200

ZN1040E	665
ZNA234E	925

COMPUTER IC's

2102L	160
2114	275
2147-3	£3
2516	350
2532-4	400
25L32	450
2564	£6
27L08	450
2716-5V	350
2732	£4
2764-250	470
27C64	£10
26501	75
27128/250n	£13
256K DRAM	£25
3242	675
4027	95
4116	140
4164-150	395
4416-2	425
4532-3	250
4816-100ns	200
4864-15	425
5514	250
6116-150	350
6116L-120ns	350
6117-100n	575
6167-6	795
6264L-15	£14
63A03	£14
6402	350
6502 CPU	325
6502A	545
6503	650
6504	600
6505	650
6520	175
6522 VIA	340
6530 RRIOT	£11
6532 RIOT	650
6545 CRTC	899
6551 ACIA	650
6592	00
6800	220
6802	275
6803	850
6805	670
6808	520
6809E	680
6810	150
68B21	220
6821	150
6840	375
6843	800
6845	650
6845SP	750
6846	625
6847	650
6850	120
6852	250
6854	625
68B54	750
6875	500
68000	£25
8035	350
8080A	400
8085A	600
8088	£15
81LS95	140
81LS96	170
81LS97/98	140
8123	160
8131	475
8150	800
8154	750
8155	400
8156	400
8202	£25
8212	220
8214	495

8216	150
8224	£3
8226	£3
8228	310
8243	290
8250	£11
8251	350
8253	370
8255	400
8256A	£15
8257A	400
8259	400
8271	£50
8272	£15
8279	750
8282	450
8283	450
8284	550
8288	£11
8748	£45
8T26A	99
8T27	150
8T31	350
8T95N	90
8T97N	90
9364AP	550
9602	220
AM26LS31C	125
AM26LS32A	125
AM26LS33	150
AM7910	£30
AY-3-1015	300
AY-5-1013	300
AY-5-1350	388
AY-5-3600	750
CD4724	150
COM8017	275
COM8116	700
DM8131	275
DP8303	450
DP8304BN	350
DS3647	00
DS3691N	£5
DS8820	110
DS8830	140
DS8831	125
DS8832	200
DS88LS120	395
E9364	800
E9365	£28
FD1691	£15
FD1771	£15
FD1791	£22
FD1793	£23
FD1795	£28
FD1797	£28
HD26501	75
HM6845	755
IM6402	350
INS8060N	1250
M58174	825
MC1488	60
MC1489	60
MC14411	675
MC14412	725
MC3242	590
MC3446	250
MC3447P	315
MC3486	175
MC3487	175
MK3886-2M	£7
MM5280D	695
MM5303	635
MM5307	1275
MM5387A	865
MM58174	875
RO-3-2513L	700
RO-3-2513U	650
SAA5050	875
SFF96364E	800
SP0256AL2	495
TCM3101J	£13
TMS2716-3	725
TMS4047	100
TMS4164-15	395
TMS4416-2	595
TMS4500A	£12
TMS4532-3	350
TMS5100	600
TMS6011	500

TMS9914	895
TMS9927	£14
TMS9928	£16
TMS9929	£16
TMS9980	£12
TMS9995	£12
ULN2003	75
UPD7002	725
UPD7007	725
WD1691	£14
WD1770	£19.95
WD2143	850
Z80CPU 2·5	295
Z80ACPU4M	380
Z80ACTC	310
Z80B	£8
Z80DART	650
Z80ADART	800
Z80ADMA	900
Z80DMA	795
Z80P10	250
Z80AP10	315
Z80S10-1	850
Z80AS10	900
Z80AS10-2	£9
Z8002CPU	00

74S

74S00	40
74S02	40
74S03	40
74S04	40
74S05	40
74S08	40
74S09	40
74S10	40
74S11	40
74S15	60
74S20	40
74S30	60
74S22	40
74S30	40
74S32	50
74S37	50
74S38	70
74S40	40
74S51	40
74S64	40
74S65	40
74S74	70
74S85	295
74S86	100
74S112	100
74S113	100
74S114	100
74S124	300
74S132	90
74S133	50
74S134	60
74S135	110
74S138	170
74S139	170
74S140	60
74S151	140
74S153	140
74S157	200
74S158	190
74S162	300
74S163	300
74S168	00
74S169	00
74S174	250
74S175	300
74S181	00
74S182	00
74S188	200
74S189	225
74S194	280
74S195	275
74S196	00
74S197	300
74S201	250
74S225	500
74S226	500
74S240	375
74S241	375
74S244	474
74S251	225
745257	225
745258	225

74S260	70
74S262	£10
74S274	00
74S275	00
74S280	00
74S281	00
74S283	00
74S287	200
74S288	180
74S289	200
74S299	540
74S301	350
74S365	250
74S373	375
74S374	375
74S412	380
74S470	325
74S471	600
74S472	400
74S473	00
74S474	400
74S475	425
74S571	300
74S573	450

75

75107/8/9	95
75110	90
75121	00
75150	125
75154	195
75158	150
75159	140
75160	420
75162	650
75182/3	99
75188/9	100
75322	140
75353	00
75361	00
75365	00
75376	00
75450	86
75451/2	52
75454	70
75491/2	65

TTL 74

7400	25
7401	25
7402	25
7403	25
7404	30
7405	30
7406	40
7407	40
7408	25
7409	25
7410	25
7411	25
7412	25
7413	50
7414	60
7416	25
7417	35
7420	25
7421	50
7422	40
7423	35
7425	35
7426	40
7427	35
7428	35
7430	25
7432	30
7433	30
7437	30
7438	40
7440	30
7441	90
7442	65
7443	100
7444	100
7445	110
7446	110
7447	95
7448	110
7450	30
7451	30

7453	30
7454	30
7460	30
7470	50
7472	50
7473	50
7474	45
7475	55
7476	45
7480	60
7481	175
7482	100
7483	100
7484	105
7485	100
7486	40
7489	200
7490	55
7491	70
7492	110
7493	50
7494	100
7495	60
7496	75
7497	200
74100	175
74104	70
74105	70
74107	45
74109	70
74110	55
74111	55
74112	170
74116	160
74118	100
74119	160
74120	90
74121	45
74122	65
74123	75
74125	60
74126	60
74128	55
74132	70
74136	50
74141	85
74142	235
74143	250
74144	250
74145	100
74147	160
74148	130
74150	170
74151	60
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74154	130
74155	75
74156	90
74157	75
74159	170
74160	100
74161	100
74162	100
74163	100
74164	100
74165	100
74166	130
74167	250
74170	190
74172	400
74173	130
74174	100
74175	100
74176	100
74177	110
74178	130
74179	130
74180	100
74181	300
74182	120
74184	170
74185	170
74186	70
74188	75
74190	120
74191	120
74192	120
74193	120
74194	100
74195	75

74196	120
74197	100
74198	200
74199	200
74221	200
74246	130
74247	120
74248	145
74249	175
74251	90
74259	150
74265	260
74273	180
74276	130
74278	160
74279	80
74283	100
74284	440
74285	300
74290	80
74293	80
74297	175
74298	160
74351	180
74365	70
74366	70
74367	70
74368	70
74376	120
74390	100
74393	100
74425	60
74426	60
74490	100

74C

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

74LS

LS00	25
LS01	25
LS02	25
LS03	25
LS04	25
LS05	25
LS08	25
LS09	25
LS10	25
LS11	25
LS12	25
LS13	35
LS14	50
LS15	25
LS19	45
LS20	25
LS21	25
LS22	25
LS24	50
LS26	25
LS27	25
LS28	25
LS30	25
LS32	50
LS33	25
LS37	25
LS38	25
LS40	25
LS42	50
LS47	80
LS48	90
LS49	100
LS51	25
LS52	25
LS54	25
LS55	25
LS63	55
LS73	30
LS74	35
LS75	45
LS76	40
LS78	40

LS83	70
LS85	70
LS86	35
LS90	50
LS91	90
LS92	55
LS93	55
LS95	70
LS96	90
LS107	40
LS109	45
LS112	45
LS113	40
LS114	40
LS122	70
LS123	100
LS124	125
LS125	100
LS126	50
LS132	60
LS133	50
LS135	28
LS136	45
LS138	60
LS139	60
LS145	95
LS147	165
LS148	130
LS151	70
LS153	70
LS154	155
LS155	70
LS156	70
LS157	60
LS158	60
LS160	70
LS161	70
LS162	70
LS163	70
LS164	75
LS165	110
LS166	150
LS168	140
LS169	100
LS170	140
LS173	100
LS174	75
LS175	70
LS181	190
LS183	190
LS190	85
LS191	85
LS192	100
LS193	100
LS194	75
LS195	75
LS196	85
LS197	85
LS221	85
LS240	80
LS241	80
LS242	95
LS243	95
LS244	80
LS245	120
LS247	105
LS248	105
LS249	105
LS251	75
LS253	75
LS256	120
LS257	75
LS258	75
LS259	125
LS260	70
LS261	100
LS266	60
LS273	120
LS275	350
LS279	70
LS280	180
LS283	80
LS290	80
LS292	880
LS293	80
LS294	999
LS295	140
LS297	850
LS298	100
LS299	225

LS320	210
LS322	360
LS323	400
LS324	150
LS325	150
LS326	290
LS327	290
LS347	120
LS348	140
LS352	110
LS353	110
LS355	220
LS356	200
LS363	150
LS364	150
LS365	50
LS366	50
LS367	50
LS368	50
LS373	100
LS374	100
LS375	70
LS377	130
LS378	95
LS379	130
LS380	310
LS382	310
LS384	460
LS385	330
LS386	50
LS390	60
LS393	100
LS395	110
LS396	300
LS398	195
LS399	140
LS445	125
LS447	80
LS465	140
LS467	120
LS490	150
LS540	140
LS541	140
LS624	155
LS629	130
LS640	200
LS641	150
LS645	195
LS668	90
LS669	90
LS670	170
LS673	890
LS674	800
LS682	250
LS684	350
LS687	350

CMOS

4000	20
4001	25
4002	25
4006	70
4007	25
4008	60
4009	45
4010	45
4011	25
4012	25
4013	35
4014	60
4015	60
4016	40
4017	60
4018	60
4019	58
4020	80
4021	58
4022	67
4023	30
4024	50
4025	22
4026	90
4027	40
4028	50
4029	75
4030	35
4031	130
4032	70
4033	130
4034	140

4035	70
4036	275
4037	115
4038	75
4039	280
4040	60
4041	57
4042	50
4043	42
4044	50
4045	110
4046	60
4047	60
4048	55
4049	38
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4051	70
4052	60
4053	60
4054	85
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4056	85
4057	£10
4059	435
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4061	£5
4062	995
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4069	25
4070	25
4071	25
4072	25
4073	26
4075	25
4076	68
4077	25
4078	25
4081	25
4082	25
4085	60
4086	60
4089	125
4093	37
4094	70
4095	95
4096	100
4097	275
4098	80
4099	75
4160	95
4161	99
4162	99
4163	99
4174	99
4175	105
4194	105
4408	850
4409	850
4410	725
4411	750
4412	805
4415	590
4419	280
4422	770
4433	770
4435	850
4440	999
4450	350
4490	450
4500	395
4501	38
4502	60
4503	40
4504	99
4505	385
4506	100
4507	45
4508	130
4510	55
4511	55
4512	55
4513	150
4514	115
4515	125
4516	65
4517	275
4518	48

4519	32
4520	53
4521	115
4522	125
4526	60
4527	65
4528	70
4529	150
4530	90
4531	130
4532	65
4534	400
4536	275
4538	80
4539	90
4541	95
4543	70
4544	150
4549	400
4553	245
4554	180
4555	35
4556	55
4557	250
4558	120
4559	395
4560	160
4561	104
4562	350
4566	165
4568	250
4569	175
4572	45
4580	255
4581	125
4582	99
4583	100
4584	60
4585	70
4599	155
40097	45
40098	42
40100	215
40101	130
40102	140
40103	412
40104	120
40105	220
40106	60
40107	55
40108	325
40109	100
40110	235
40114	240
40161	194
40163	75
40174	75
40175	75
40181	220
40192	75
40193	95
40194	90
40195	80
40244	195
40245	195
40257	198
40373	220
40374	220

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BI-PAK BARGAINS

HIGH QUALITY MODULES FOR STEREO, MONO & OTHER AUDIO EQUIPMENT

Audio Amplifiers

O/No.	POWER O/P R.M.S.	MAX SUP. VOLTAGE	PRICE
AL 30A	10 Watts	30V	£4.95
AL 60	25 Watts	30-50V	£5.92
AL 80	35 Watts	40-60V	£8.75
AL 120	50 Watts	50-70V	£15.22
AL 250	125 Watts	50-80V	£20.60

Stabilised Power Supplies —

Output current 2.5 Amps

O/No.	AC Input	Price
SPM 120/45	40-48V	£8.05
SPM 120/55	50-55V	£8.05
SPM 120/65	60-65V	£8.05

Mono Pre-Amplifiers – Operating Vtg. 40-65V

O/No.		Price
MM 100	Suitable for Disco Mixer	£14.75
MM 100G	Suitable for Guitar Pre-Amp Mixer	£14.75

Magnetic Cartridge Pre-Amplifier
O/No. MPA30. Sup Vtg. 20-30V. Price £4.29

Monographic Equaliser
GE 100 MKII 10 Channel OUR PRICE ONLY £20.00

Full Specifications and Data available on request.
Please send self-addressed envelope.

VALUE PACKS

Pak No	Qty	Description	Price
VP1	300	Assorted Resistors Mixed Types	£1.00
VP2	300	Carbon Resistors ¼-½ Watt Pre-Formed	£1.00
VP3	200	⅛ Watt Min Carbon Resistors Mixed	£1.00
VP4	150	½ Watt Resistors 100 ohm-1M Mixed	£1.00
VP5	200	Assorted Capacitors All Types	£1.00
VP6	200	Ceramic Caps Miniature – Mixed	£1.00
VP7	100	Mixed Ceramics Disc. 1pf – 56pf	£1.00
VP8	100	Mixed Ceramic Disc. 68pf – .015pf	£1.00
VP9	100	Assorted Polyester/Polystyrene Caps	£1.00
VP10	60	C280 Type Caps Metal Foil Mixed	£1.00
VP11	50	Electrolytics – All Sorts	£1.00
VP12	60	Bead Type Polystyrene Min Caps	£1.00
VP13	50	Silver Mica Caps Ass. 5.6pf – 150pf	£1.00
VP14	50	Silver Mica Caps Ass. 180pf – 4700pf	£1.00
VP15	25	.01uF 250v Min. layer metallised Polyester Capacitors	£1.00
VP16	50	Wirewound Res. 9W (avg) Ass. 1 ohm – 12K	£1.00
VP17	50	Metres PVC Covered Single Strand Wire Mixed Colours	£1.00 £1.00
VP18	30	Metres PVC Covered Multi Strand Wire Mixed Colours	£1.00
VP19	40	Metres PVC Single/Multi Strand Hook-Up Wire Mixed	£1.00
VP20	6	Rocker Switches 5 Amp 240v	£1.00
VP21	15	2in. high bright RED LEDs in plastic encapsulation–Large area light source	£1.00
VP22	200	Sq. Inches Total, Copper Clad Board Mixed Sizes	£1.00
VP23	20	Assorted Slider Pots. Mixed Values	£1.00
VP24	10	Slider Pots. 40 mm 22K 5 × Log. 5 × Lin	£1.00
VP25	10	Slider Pots. 40 mm 47K 5 × Log. 5 × Lin	£1.00
VP26	15	Small .125" Red LED's	£1.00
VP27	15	Large .2" Red LED'S	£1.00
VP28	10	Rectangular .2" RED LED'S	£1.00
VP29	30	Ass. Zener Diodes 250mW – 2W Mixed Vlts. Coded	£1.00
VP30	10	Ass. 10W Zener Diodes Mixed Vlts. Coded	£1.00
VP31	10	5 Amp SCR's TO-66 50-400v Coded	£1.00
VP32	20	3 Amp SCR's TO-66 Up To 400v Uncoded	£1.00
VP33	200	Sil. Diodes Switching Like IN4148 DO-35	£1.00
VP34	200	Sil. Diodes Gen. Purpose Like OA200/BAX13/16	£1.00
VP35	50	1 Amp IN4000 Series Sil. Diodes Uncoded All Good	£1.00
VP37	8	Black Instrument Type Knobs With Pointer ¼" Std	£1.00
VP42	10	Black Heatsinks To Fit TO-3, TO-220 Ready Drilled	£1.00
VP43	4	Power-Fin Heatsinks 2 × 10-3 2 × TO-66 Size	£1.00
VP45	50	BC107/8 Type NPN Transistors Good Gen. Purpose Uncoded	£1.00
VP46	50	BC177/8 Type PNP Transistors Good Gen. Purpose Uncoded	£1.00
VP47	10	Silicon Power Trans. Similar 2N3055 Uncoded	£1.00
VP140	50	Precision Resistors. 2-1% tol.	£1.00
VP141	40	1N4002 Sil. Rects. 1A 100v preformed pitch	£1.00
VP142	4	40A Power Rectifiers Silicon TO48 300PIV	£1.00
VP143	5	BY187 12KV Sil. Diodes in carriers 2.5mA	£1.00
VP144	4	100K 1in. Multi-turn pots ideal vari cap tuning	£1.00
VP145	10	Assorted pots. inc. Dual & Switched types	£1.00
VP146	25	Solid Tantalum Caps. Mixed Values	£1.00

TRANSISTOR PACKS

VP150	20	BC183B Sil. Trans. NPN 30v 200mA Hfe240+ TO92	£1.00
VP151	25	BC171B Sil. Trans. NPN 45v 100mA Hfe240+ TO92	£1.00
VP152	15	TIS90 Sil. Trans. NPN 40v 400mA Hfe100+ TO92	£1.00
VP153	15	TIS91 Sil. Trans. PNP 40v 400mA Hfe100+ TO92	£1.00
VP154	15	MPSA56 Sil. Trans. PNP 80v 800mA Hfe50+ TO92	£1.00
VP155	20	BF595 Sil. Trans. NPN eqvt. BF184 H.F. TO92	£1.00
VP156	20	BF495 Sil. Trans. NPN eqvt. BF173 H.F. TO92	£1.00
VP157	15	ZTX500 Series Sil. Trans. PNP Plastic	£1.00
VP158	15	ZTX107 Sil. Trans. NPN eqvt. BC107 Plastic	£1.00
VP159	15	ZTX108 Sil. Trans. NPN eqvt. BC108 Plastic	£1.00
VP160	20	E5024 Sil. Trans. PNP eqvt. BC214L TO92	£1.00
VP161	25	BC183L Sil. Trans. NPN 30v 200mA TO92	£1.00
VP162	5	SJE5451 Sil. Power Trans. NPN 80v 4A Hfe20+	£1.00
VP163	2	NPN/PNP pairs Sil. Power Trans. like SJE5451	£1.00
VP164	4	2N6289 Sil. Power Trans. NPN 40v 40w 7A Hfe30+	£1.00
VP165	6	BFT33 NPN Sil. Trans. 80v 5A Hfe50-200 TO39	£1.00
VP166	5	BFT34 NPN Sil. Trans. 100v 5A Hfe50-200 TO39	£1.00
VP167	1	BUY69C NPN TO3 VCB 500 10A 100w Hfe15+	£1.00
VP168	10	BC478 eqvt. BCY71 PNP Sil. Trans. TO18	£1.00
VP169	10	BXS21 eqvt. BC394 NPN Sil. Trans. 80v 50mA TO18	£1.00
VP170	10	Assorted Power Trans. NPN/PNP Coded & Data	£1.00
VP171	10	BF355 NPN TO-39 Sil. Trans. eqvt. BF258 225v 100mA	£1.00
VP172	10	SM1502 PNP TO39 Sil. Trans. 100v 100mA Hfe100+	£1.00

TRANSISTORS

100 Silicon NPN Transistors. All Perfect. Coded Mixed. Types With Data And Eqvt. Sheet No Rejects. Fantastic Value. O/No. BP38 **£3.00**

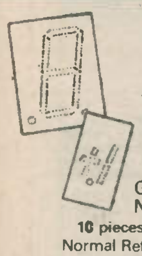
100 Silicon PNP Transistors. All Perfect Coded. Mixed. Types With Data and Eqvt. Sheet. No Rejects. Real Value. O/No. BP39 **£3.00**

The best known Power Transmitter in the world 2N3055 NPN 115W. Our Bi-Pak Special Offer Price.

10 off	50 off	100 off
£3.50	£16.00	£30.00

BD312 COMPLIMENTARY PNP POWER TRANSISTORS TO 2N3055. Equivalent MJ2955 BD312 TO3. Special Price **£0.70** each. 10 off **£6.50**

HYBRID LED COLOUR DISPLAYS



Red, Green, Yellow – .3/.5/.6 inch Mixed types and colours NUMERIC & OVERFLOW Common Anode/Cathode. GaAsP/GaP. Brand New. Full Data incl.

10 pieces (our mix) . . . £4.00
Normal Retail Value Over £10.00
Order No. VP58

SEMICONDUCTORS FROM AROUND THE WORLD

100 A collection of Transistors, Diodes, Rectifiers & Bridges, SCRs, Triacs, I.C.s & Opto's all of which are current every day useable devices. Guaranteed Value Over £10 Normal Retail Price. Data etc. in every pack. Order No. VP56

Our Price £4.00

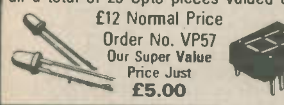
TRANSISTOR CLEARANCE

100 All Sorts Transistors. A mixed bag NPN-PNP Silicon & Germ. Mainly Uncoded You To Sort Pack includes instructions for making Simple Transistor Tester, Super Value.
Order No. VP60. **£1.00**

150 De-soldered Silicon Transistors from boards 10mm leads all good. O/No. VP173 **£1.00**

BI-PAK'S OPTO SPECIAL

A selection of large and small sized LED's in various shapes, sizes & colours, together with 7 Segment Displays both anode & cathode plus photo transistors emitters and detectors. Cadmium Cell ORP12 and Germ. photo transistor OCP71 included. In all a total of 25 Opto pieces valued over £12 Normal Price



Order No. VP57
Our Super Value Price Just
£5.00

OPTICALLY COUPLED MODULES

1 pair SD1/131 Consisting 1 × LS600 Silicon Light Sensor & 1× Matched Gallium Arsenide Light Source – Type TIL23, on ready mounted fibre glass board. Including Data. Ideal Alarm projects etc. O/No. VP147.

BI-PAK Price ONLY £0.60 pr.

TECASBOTY

THE ELECTRONIC COMPONENTS AND SEMICONDUCTOR BARGAIN OF THE YEAR!

This collection of Components and Semiconductors for the hobbyist is probably the most value-packed selection ever offered, it consists of Resistors, carbon and wirewound of various values. Capacitors: All types, sorts and sizes including electrolytics. Potentiometers – single, dual, slider and preset. Switches, Fuses, Heatsinks, Wire, P.C.B. Board, Plugs, Sockets etc., PLUS a selection of Semiconductors for everyday use in popular Hobby Projects. These include: SCR's, Diodes, Rectifiers, Triacs & Bridges as well as a first class mix of Transistors and I.C.'s. In all, we estimate the value of this in current retail catalogues to be over £25! So, help yourself to a great surprise and order a Box TODAY – ONLY at BI-PAK. Remember, stocks are limited so hurry! You can call us on 0920 3182/3442 and order with your Barclaycard or Access Card – 24hr Answerphone Service NOW. Order No. VP 85.

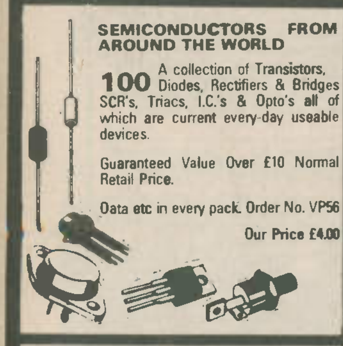
just £7.00

LED DISPLAYS

VP130	6	RED 7 Seg. CC 14mm × 7.5mm RDP FND353	£2.00
VP131	4	GREEN 7 Seg. CA .6" LDP XAN6520	£2.00
VP132	5	RED 7 Seg. CC .6" LDP XAN6940	£2.00
VP133	6	RED Over-flow .6" 3 × CA 3 × CC 6630/50	£2.00
VP134	5	GREEN Over-flow .6" CA XAN6530	£2.00
VP135	5	RED 7 Seg. CA .3" XAN3061	£2.00
VP136	3	DUAL RED 7 Seg. .5" CA DL527 DPR	£2.00
VP137	3	DUAL RED 7 Seg. .51" CA DL727 DPR	£2.00
VP138	20	Assorted LED Displays – Our mix with Data	£5.00

RDP = Right Hand Decimal Point — CC = Common Cathode
LDP = Left Hand Decimal Point — CA = Common Anode

SEMICONDUCTORS FROM AROUND THE WORLD



100 A collection of Transistors, Diodes, Rectifiers & Bridges SCR's, Triacs, I.C.'s & Opto's all of which are current every-day useable devices.

Guaranteed Value Over £10 Normal Retail Price.

Data etc in every pack. Order No. VP56

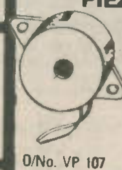
Our Price £4.00

ANTENNA SWITCH 2 and 3 WAY

Co-axial switch for one transceiver to two antennae or one antenna to two transceivers. Dims: 86 × 55 × 32mm (Body).
O/No. VP 113 **£4.50**

As above but 3-way.
O/No. VP 114 **£4.75**

PIEZO BUZZERS



PIEZO
Miniature round piezo-electric buzzer. White plastic. Low consumption.
Frequency: 4kH approx.
Output: 70dB (A) @ 1, typ.
Power: 12Vd.c. 4mA.
Dims: 22 (dia.) × 11.5mm.
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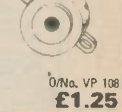

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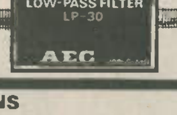
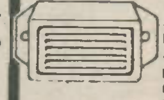


ELECTRONIC BUZZER



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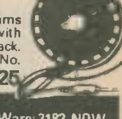

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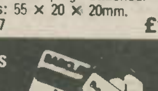

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PE VOLUME 21 Nº 4 APRIL 1985

BANG GOES THE BOOM

While the computer boom appears to be over and a price battle under way, interest in our computer projects is showing a steady increase. We believe that many thousands of computers have been bought by people with little real interest in them and virtually no idea of what to do with them apart from play games. It is likely that many good computers will appear on the secondhand market quite soon; that some of the manufacturers will go out of business or move out of the computer market-place and that as many as half the software houses will disappear during the next year.

With such a down-turn in the industry why are our readers more interested in 'computer projects'? Our projects either add extra facilities, abilities or aid the understanding and testing of computer systems. It seems therefore that a significant number of hobby computer owners are what we might call serious users. They are interested in getting past the game playing, giving their computer a more educational role or putting it to use in control applications.

PE readers want to know how the system functions, how to interface it, how to control mains loads or how to provide mechanical ability. Many of you already have the ability to write software of a high standard, to blow your own EPROMS and connect your c.p.u. to other peripherals.

With all this in mind we have developed PE to meet your needs and we have planned some interesting projects and features for future months. They are not all directly aimed at computer buffs, indeed we will still be retaining our strong interest and involvement in all other areas, but items like switched mode power supplies, logic analysers and even sound effects units are all related to the wider area of computers these days.

For those that want more information on micro-computer systems, without perhaps wanting to buy a home computer or even to ever use one, we are planning an excellent introduction series for later in the year. We will also be widening our horizons and hopefully yours in the area of low cost educational robotics. While many readers have shown considerable interest in robotics, the relatively high initial outlay has been a stumbling block. We have been working on ways to overcome this and a series of educational ideas and designs, coming soon, is the result. We also have a mobile robot project designed to be developed in 'easy' stages which will soon be manoeuvring into our pages.

Mike Kenward

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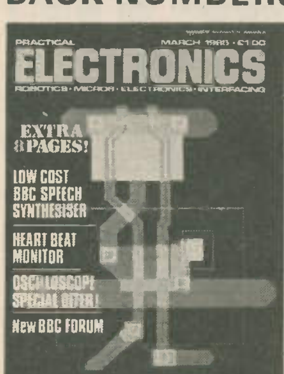

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We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in PE. All letters requiring a reply should be accompanied by a stamped addressed envelope, or addressed envelope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

Components are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Old Projects

We advise readers to check that all parts are still available before commencing any project in a back-dated issue, as we cannot guarantee the indefinite availability of components used.

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We regret that lengthy technical enquiries cannot be answered over the telephone.

SECOND PROCESSOR

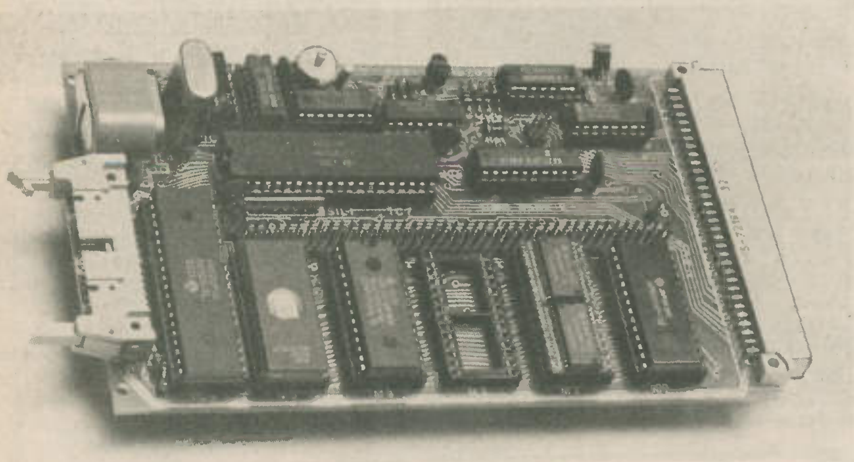
Cambridge Microprocessor Systems has developed a 'second processor' that will really open up the outside world for BBC micro owners. Via the tube interface the CMS 6502 2nd processor is programmed using BBC Basic (or using any other BBC language ROM) then disconnected from the machine to run as the 'hub' of a completely separate microprocessor system suitable for an unlimited range of control applications with a large analogue or digital I/O capability.

Feasibly such systems as intelligent alarms, machine control, experimental and domestic monitoring, etc. can be developed.

Relatively inexperienced programmers can write, develop and test application programs in BBC Basic and run them in the target environment before transferring the program to the 2nd processor's EPROM.

The real time calendar clock provides time of day, month, and year, interval timing and alarm facilities, and can also be configured as non-volatile battery backed-up RAM (8k). In the event of power failure, correct operation of the clock circuitry is maintained and the on-board battery is automatically recharged from the 5V power supply. PROM decoding allows the memory map to be re-defined.

The 64-way bus connector allows the user direct access to a comprehensive range of interface boards, all are Eurocard size (100mm x 160mm) and a complete racking system is available. The CMS 6502 costs £229 inc. VAT and the tube interface board £90 inc. VAT. Contact: Cambridge Microprocessor Systems, 44a Honson Street, Cambridge, CB1 1NL (0223 324141).



The Diamond Anvil

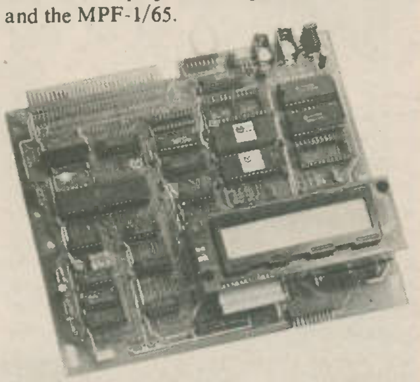
Take two diamonds, then squeeze them together with such incredible force so as to recreate the pressure levels at the centre of the earth. Using this method American scientists are reported to be close to a breakthrough in semiconductor technology.

Theoretically under these pressures (around 2·5 million atmospheres) hydrogen would be transformed into a metallic state that would be retained, even when normal conditions were resumed. Furthermore the resultant metal would possess superconductive properties, enabling the conduction of electricity at the speed of light, without generating any heat caused by resistance.

Present technology can only employ the superconductive properties of metals by operating them at extremely low temperatures which is proving to be prohibitively expensive. The machine being used by the researchers at the Carnegie Institution of Washington has been nicknamed the 'diamond anvil'; so far it has managed to maintain the enormous pressures for forty consecutive days.

BYTE BY BYTE MICRO AID

Flight Electronics has a fine reputation in the field of microprocessor based learning aids, and has recently introduced two new products to their *microprofessor* range—the MPF-1/88 and the MPF-1/65.



The MPF-1/88 is a learning kit based on the Intel 8088 microprocessor, it teaches the 'fundamentals' of 16-bit microprocessing. The unique design approach enables the user to open the case and see the components, which aids hardware as well as software understanding. Three informative manuals are supplied ranging from an introduction for beginners to a complete specification.

The MPF-1/65 deals in a similar way with the 6502 microprocessor. Once again a comprehensive approach has been adopted and all aspects of hardware and software are dealt with. Both the Users Manual and the Monitor Program Source Listing Manual are written with both beginner and professional in mind.

These new products follow in the footsteps of their popular predecessors—the MPF-1B and the MPF-1 Plus, the subject of a review by M. Tooley in *PE April 1984*.

A catalogue containing more detailed information, full specifications and prices (including accessories) can be obtained free of charge from, Flight Electronics Ltd., Quayside Road, Bitterne Manor, Southampton SO2 4AD (0703 34003).

MARKET PLACE

VIDEO HEAD SWOP KIT

Whether it's Star Wars or Raiders of the Lost Ark, or even home-recorded re-runs, they all have one thing in common—slowly but surely they cause the video tape head to wear.

It is unlikely that most of us will adhere to the service industry's advice and replace our video heads 'every two or three years (or 1000hrs)'. It is likely, however, that sooner or later the job will have to be done. To have this work done professionally could cost over £100.

Monolith Electronics have an option for those of us who might like to do the job ourselves, in the form of a video head replacement kit. It is not an understatement to say that this kit is very comprehensive as the following list of inclusions will prove. The kit's storage box contains a novel head-concentricity gauge for the alignment of Betamax heads to an accuracy of better than three hundredths of a millimetre, a stroboscopic tacho disc which verifies the head speeds of VHS machines, a pair of handling gloves, a cross-head screwdriver, an anti-static cloth, cleaning fluid and shaped spatulas, replacement service labels, and last but not least a mains soldering iron with solder.

A step-by-step instructions and stock list of available heads is also provided, and customers can make use of the telephone advisory service. The VMC–02 video head replacement and maintenance kit costs £22.45 inc VAT and p&p. The average cost of Monolith's replacement heads are—VHS £41 and Betamax £53, prices inc VAT. For further details contact, Monolith Electronics Co. Ltd., 5–7 Church Street, Crewkerne, Somerset (0460 743210).

LAST CHANCE FOR 11 YEARS

In these times of regular space travel most of us know what weightlessness 'looks' like having witnessed much television coverage of the Space Shuttle crews.

It is a little known fact, however, that once in every eleven years we can actually experience a level of weightlessness right here on earth.

At exactly 8.17 a.m. on Monday 1st April the planet Pluto will pass directly behind the planet Jupiter, bringing about a strong, albeit momentary, increase in the combined gravitational pull. At the precise moment when the planets are in exact spacial alignment, a sense of elation can be felt. Indeed jumping into the air at this exact moment will bring about a real sensation of weightlessness.

This phenomenon was originally discovered in 1899 when a Mr. Y. S. Dilloss made an incredible high jump of 3·47 metres, a record incidentally that has never been broken.

Countdown . . .

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

The Northern Computer Show April 16–18. Belle Vue, Manchester. **K2**
British Electronics Week (includes: All Electronics, Circuit Technology & Fibre Optics) April 30–May 2. Olympia. **E**
IFSSEC (fire/security) April 15–19. Earls Court, London. **S**
Cast (Cable & Satellite) April 16–18. NEC, Birmingham. **F5**
Communications April 23–25. Olympia. **I**
Photoworld April 23–May 6. Earls Court. **I**
CAD April 26–28. Metropole, Brighton. **K2**
Fibre Optics & Lasers April 30–May 2. Olympia. **E**
Custom Electronics & Design Techniques April 30–May 2. **E**
All Electronics Show/ECIF April 30–May 2. Olympia 2. **E**
Field Service & Repairs April 30–May 2. Olympia 2. **E**
Automan (manufacturing) May. NEC. **T1**
IBM Computer User May 14–16. NEC B/ham. **O**
Business Telecom May 21–23. Barbican, London. **O**

A1	Institute Electronics ✆ 0706 43661
E	Evan Steadman ✆ 0799 26699
F2	Pontefract Am. Rad. Soc. N. Whittingham ✆ 0977 792784
F5	✆ 01-487 4397
I	ITF ✆ 021-705 6707
K2	Reed Exhibitions, Surrey Ho., 1 Throwley Way, Sutton, Surrey
M	Montbuild ✆ 01-486 1951
O	Online ✆ 01-868 4466
S	✆ 01-387 5050
S2	Fairs & Exhibitions Ltd., ✆ 01-831 8981
T1	Cahners ✆ 0483 38085

Power Control Interface

R. A. PENFOLD

SIMPLE on/off control using a computer is a relatively straightforward affair with a digital output being used to control the load by way of a relay, triac, or other power switching device. Proportional power control, where intermediate power levels as well as on and off are required, represents a more difficult proposition, especially where a mains powered load is concerned. The high voltages involved with the mains supply do not in themselves represent a real difficulty since high voltage semiconductor control devices are readily available at quite reasonable prices. However, proper isolation of the computer from the mains supply is an important factor and one which must be adequately taken care of. This is not just to ensure that the computer comes to no harm, but is also necessary to safeguard the user against an electric shock.

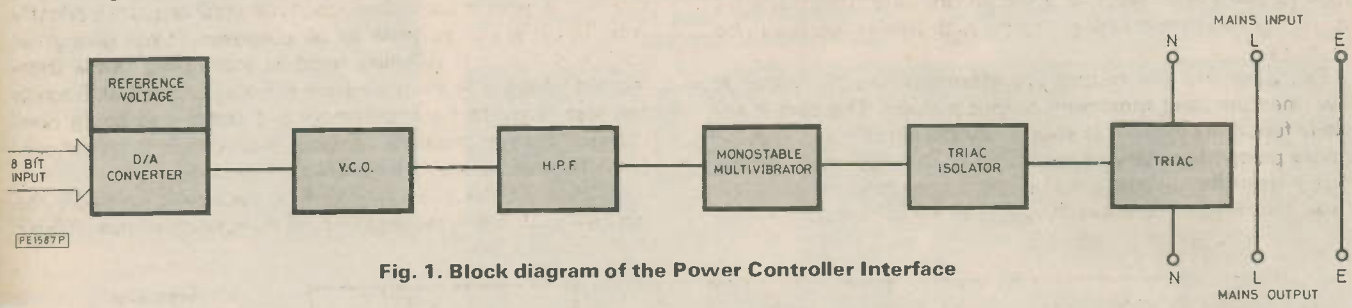


Fig. 1. Block diagram of the Power Controller Interface

POWER CONTROL

The power controller circuit described here gives proportional control over a mains load, and with the specified triac which has a current rating of 10 amps (provided suitable heatsinking is used) the unit can handle loads of up to about 2 killowatts or so. A triac-isolator (a form of opto-isolator device) ensures that the connections to the computer are properly isolated from the mains supply. As the unit is digitally controlled it does not give an infinite number of output power levels, but the use of an 8 bit input gives some 256 different power levels (including zero and maximum), and this should be more than adequate for the vast majority of practical applications. The simple method of power control used in the unit does preclude its use with some type of equipment, but it is suitable for use with a heating element, which was the principal application in mind when the interface was designed. The interface is ideal for use in a high quality computer based thermostat.

Normally thermostats use simple on/off switching of the heating element, but with a proportional set up, a more sophisticated approach is possible, with the heat from the element being adjusted to match the heat loss from the system. This gives better stabilisation than is possible using a simple on/off thermostat.

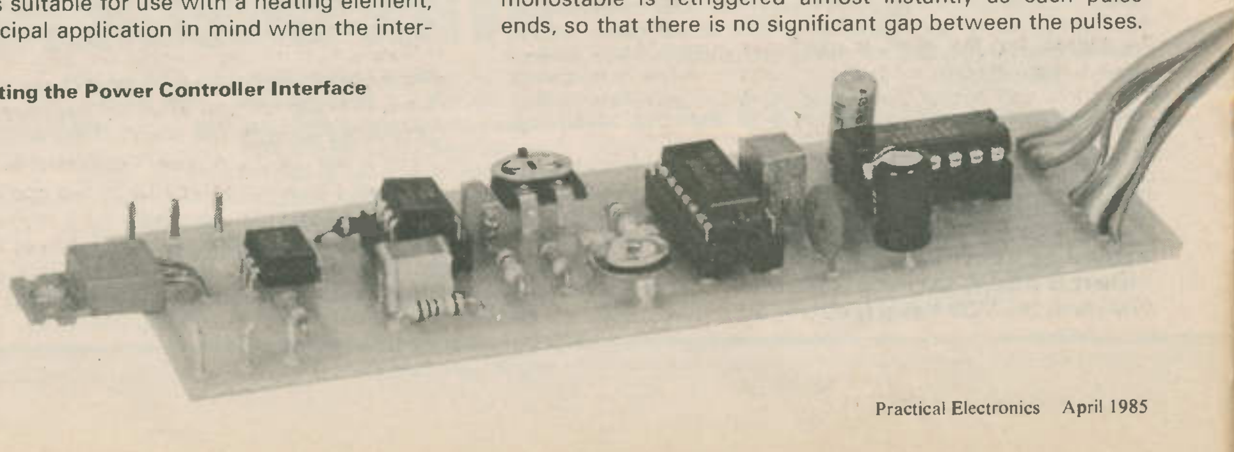
SYSTEM OPERATION

The block diagram of Fig. 1 shows the arrangement used in the power controller.

A digital to analogue converter is fed from an 8-bit latching output of a computer. Several home computers, including the BBC model B, VIC-20, Commodore 64, and Memotech MTX500 have a user port which provides a suitable output. For use with some machines, such as the Sinclair Spectrum and ZX81, the unit would have to be driven via an add-on parallel port. The converter requires a precision reference voltage, and in this case the built-in 2·55 volt reference source of the converter chip is used.

The 0 to 2·55 volt output of the digital to analogue converter is used as the control voltage for a VCO. The latter has an output frequency that is roughly proportional to the control voltage, with no output when the control voltage is zero. The squarewave output of the VCO is processed by a simple highpass filter circuit to give a series of brief positive and negative pulses. The negative pulses trigger a monostable multivibrator. With maximum control voltage to the VCO the monostable is retriggered almost instantly as each pulse ends, so that there is no significant gap between the pulses.

Photograph illustrating the Power Controller Interface



Lower control voltages and frequencies give greater gaps between pulses, and with zero control voltage the monostable is not triggered at all.

TRIAC ISOLATOR

The positive output pulses from the monostable multivibrator operate a triac-isolator. This is similar to a conventional opto-isolator where an infra-red light emitting diode drives a phototransistor, but the phototransistor is replaced by a triac. The gate terminal of the triac is not externally accessible though. When the l.e.d. is not activated and the triac is in darkness, the device is switched off and passes only small leakage currents. If the l.e.d. is provided with a suitably high current it produces sufficient "light" output to cause large leakage currents to flow in the triac. These currents produce a regenerative action that cause the device to conduct strongly, just as if it had been switched on in the normal way by a gate current. The triac remains in conduction for as long as the l.e.d. is activated, and like an ordinary triac, it will also remain in conduction until the current flow between the MT1 and MT2 terminals falls to a very low level (usually just a few milliamps).

The triac section of the triac-isolator has a current rating of only 100 milliamps, which represents just 24 watts with the 240 volt a.c. mains supply. This is obviously not sufficient for most power controller applications, but it is very easy to use the isolator to drive an ordinary triac having a much higher current rating so that high power loads can be controlled.

Fig. 2. shows the output waveforms of the controller at low, medium, and maximum output powers. The circuit actually functions in what is essentially the same way as an ordinary pulsed type power controller of the type that is commonly used for the control of small d.c. electric motors. The output waveform consists of bursts of a.c. signal rather than d.c. pulses, but the effect is much the same. At low output powers there is no output for the majority of the time, giving a low average output power. At medium power levels the power is switched on for about half the time, giving an average output power of about 50 per cent. At maximum output the current is switched on for virtually all the time. There are actually brief gaps in the signal, but these are too small to significantly reduce the output power, and for most practical purposes can be ignored.

There is a limitation to this system in that it can only work properly if the VCO has a fairly low maximum frequency so that the mains signal is chopped up into bursts of several half cycles. It will not give the desired result if a higher VCO frequency is used, since the circuit can not chop up each half mains half cycle. This would not work because of the hold-on characteristic of a triac, which causes it to remain in conduction until the current flow through the device falls to a low level. Once switched on the triac must therefore remain in conduction until virtually the end of each mains half cycle.

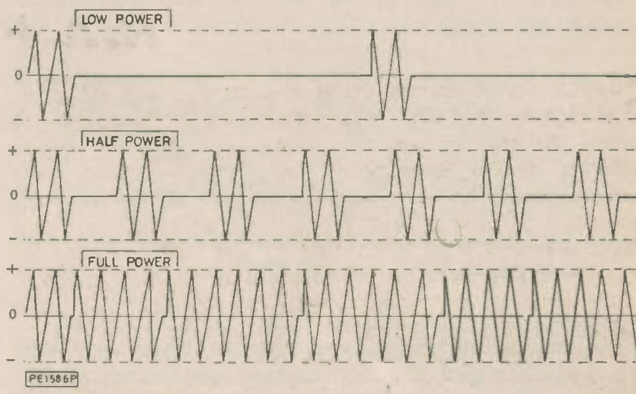


Fig. 2. Output waveforms at various power levels

In most practical power controller applications the simple method of power control adopted here will operate perfectly well, but it is not suitable for all purposes. It will give good results if the unit is being used in something like a thermostat where a heating element is being controlled. Results are less likely to be satisfactory if a lamp was being controlled, since at medium and low powers there would certainly be very noticeable flickering of the lamp.

As is often the case, it would be possible to simplify the hardware at the expense of more complicated and difficult software. In this case it would be quite feasable to drive the triac isolator from a digital output of the computer, with the software being used to generate an output signal of suitable frequency and mark-space ratio.

For those who are more interested in hardware than in software the adopted approach has the obvious attraction of requiring very simple driving software with only one value to be written to the appropriate address in order to set the required output power. The alternative approach outlined above would make an interesting project for someone who is software orientated.

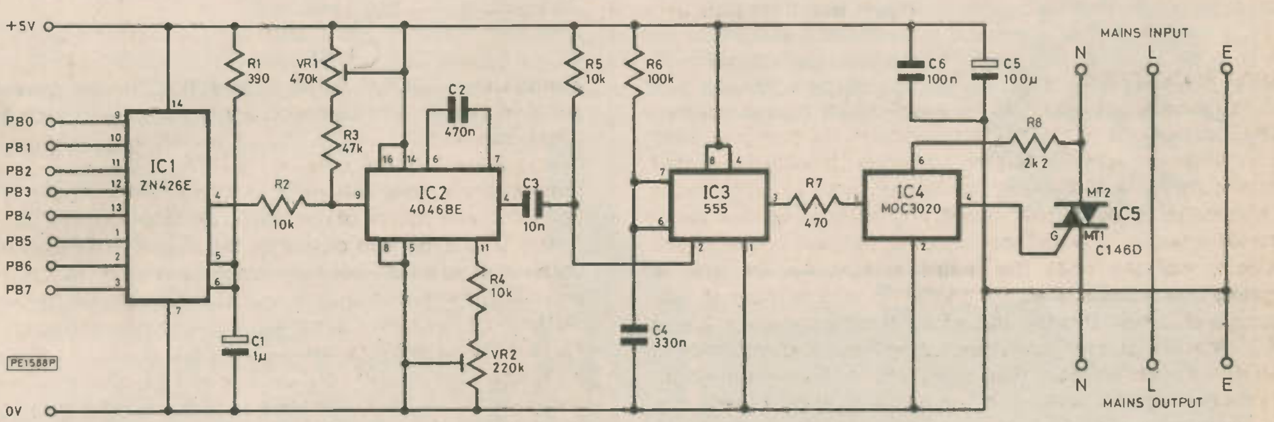


Fig. 3. The complete circuit diagram of the Power Controller Interface

CIRCUIT OPERATION

The circuit is reasonably simple, as can be seen by refering to the circuit diagram which appears in Fig. 3.

IC1 is the digital to analogue converter, and this is a Ferranti ZN426E low current consumption type. This is a conventional converter having an R-2R resistor network and a bank of eight electronic switches. The integral 2·55 volt reference source requires load resistor R1 and decoupling capacitor C1. These are the only discrete components needed by the ZN426.

The VCO is the oscillator section of a CMOS 4046BE low power phase locked loop (IC2). The phase comparators and other sections of IC2 are not used in this circuit. C2, R4, and VR2 are the timing components for the oscillator. R2 couples the output of the digital to analogue converter to the control input of IC2, and VR1 with R3 are used to give a small positive bias to the control input. Without this bias all values from about 0 to 50 would give zero output from the VCO, and therefore from the controller as well. With the correct bias added the circuit gives greatly improved results with low values giving low output powers.

TIMING

The monostable multivibrator uses a 555 timer device, IC3 in the standard 555 monostable configuration. R6 and C4 are the timing components for the monostable, and these set the output pulse duration at approximately 50 milliseconds. IC3 is triggered by taking pin 2 to less than one third of the supply voltage. However, the trigger pulses must be very brief as the monostable is a retriggerable type, and long trigger pulses could result in the output pulses being extended.

R5 is used to bias the trigger input of IC3 to the positive supply rail, and C3 couples the output signal of IC2 to this input. IC2 has a squarewave output signal, but the highpass filtering provided by C3 and R5 modifies this to a short positive pulse on each rising edge of the squarewave, and a brief negative pulse on each trailing edge. These negative pulses provide a suitable trigger signal for IC3.

IC3 has more than adequate current drive to operate the l.e.d. in the triac-isolator, and R7 is in fact needed to provide current limiting here. The triac section of the isolator is used to trigger the main triac via R8 which limits the gate current to a safe level.

CONSTRUCTION

The component layout and full-size track pattern for the printed circuit board are shown in Fig. 4. Construction of the board does not present any real difficulties, but as the mains supply is involved it is obviously essential to take great care to avoid errors, and to thoroughly check the finished board.

If desired the interface could be constructed as a self contained unit with the board fitted in a case with a multiway input socket and a mains outlet for the controlled equipment. Alternatively, it could be built into a larger system. This is something that must be varied to suit individual requirements. In either case the triac will need a heatsink if it is to control currents of more than about two amps, and for high currents of around six to eight amps a substantial heatsink (about 2·5°C per watt or better) with adequate ventilation would be needed. Bear in mind that the heat-tab of the triac connects to the MT2 terminal, and that the heatsink will therefore be connected to the mains supply unless it is properly insulated from the triac.

DRIVING THE UNIT

For use with the VIC-20, Commodore 64, and BBC model B computers the 8-bit input of the interface is fed from the eight data lines of the user port (PB0 to PB7). The 0V and 5V lines of the port are also connected to the interface. The two Commodore machines require a 2 by 12 way, 0·156 inch pitch edge connector, and as you are unlikely to be able to obtain a connector which has the appropriate polarising key, care must be taken to fit it to the computer the right way round. It is advisable to clearly label the top and bottom edges of the connector so that mistakes are avoided. Connections to the user port of the BBC model B computer are made by way of a 20 way IDC header socket. Connection details for the user ports of all three computers are provided in the relevant manuals.

Before data can be written to the interface the lines of the user port must be set as outputs. This is achieved by writing 255 to the appropriate address, as detailed below:—

?&FE62=255 (BBC model B)
POKE 37138,255 (VIC-20)
POKE 56579,255 (CBM 64)

Data is then written to address &FE60 in the case of the BBC model B, 37136 for the VIC-20, and 56577 for the CBM 64.

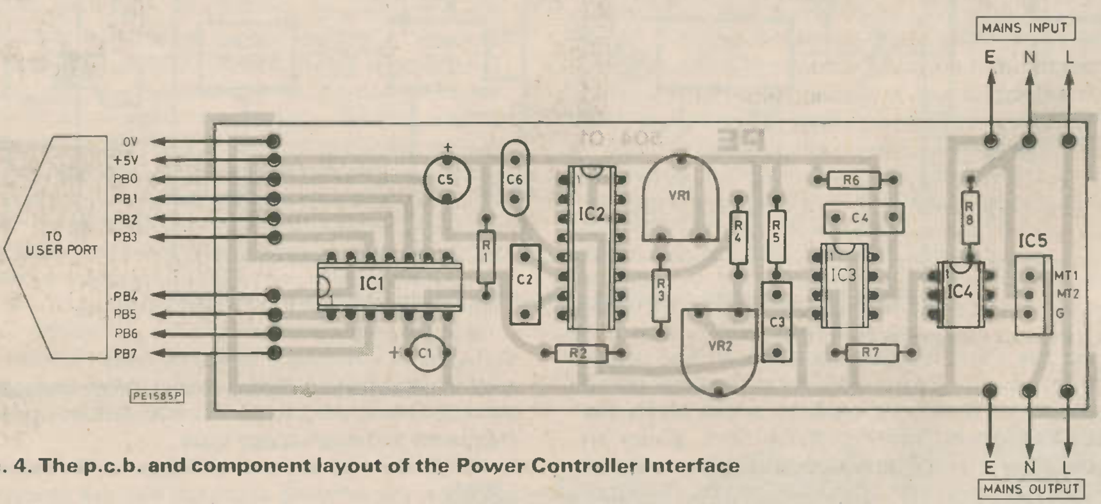


Fig. 4. The p.c.b. and component layout of the Power Controller Interface

The circuit requires a single 5 volt supply and has a current consumption of about 30 milliamps or so. The user or expansion port of most computers is capable of supplying this.

The connections to the user port of the Memotech MTX-500/512 computers (the 20 pin d.i.l. i.c. socket on the printed circuit board) are made via a d.i.p. plug. Rather than PB0 to PB7 lines POT0 to POT7 are used. These do not

COMPONENTS . . .

Resistors

R1	390
R2,R4,R5,	10k (3 off)
R3	47k
R6	100k
R7	470
R8	2k2

All resistors $\frac{1}{4}$W 5% carbon

Potentiometers

VR1	470k 0·1W horizontal preset
VR2	220k 0·1W horizontal preset

Capacitors

C1	1µ 63V radial elect
C2	470n carbonate
C3	10n carbonate
C4	330n carbonate
C5	100µ 10V radial elect
C6	100n ceramic

Semiconductors

IC1	ZN426E D to A converter
IC2	4046BE phase locked loop i.c.
IC3	NE555 timer i.c.
IC4	MOC3020 Triac-Isolator
IC5	C146D (400V 10A) or similar Triac

Miscellaneous

Printed circuit board (PE 504-01)
Heatsink (see text)
Computer connector and cable
16 pin d.i.l. i.c. holder
14 pin d.i.l. i.c. holder
8 pin d.i.l. i.c. holder
Veropins, wire, etc.

require any setting up software to set them as outputs, but the OTSTB line must be linked to the 0V line in order to take the outputs into the active state. Data for the interface is sent from BASIC using the OUT instruction, and the user port is at address 7.

ADJUSTMENT

When setting up the interface ready for use it does not need to be connected to the mains supply, and in the interest of safety it is probably best not to do so. Write a value of 0 to the interface, and then adjust VR1 for the lowest resistance that does not produce oscillation from IC2 (i.e. set it as far in an anticlockwise direction as possible without oscillation occuring). An oscilloscope, audio amplifier, or a crystal earphone can be used to detect the output pulses at pin 4 of IC2.

Next write 255 to the interface, and use a multimeter set to a low voltage range (about 5 or 10 volts f.s.d.) to monitor the output voltage at pin 3 of IC3. With VR2 set fully clockwise there should be only a fairly low voltage present, but adjusting VR2 in an anticlockwise direction should result in the voltage rising. Adjusting VR2 too far will cause the voltage to suddenly drop to about half its peak level. VR2 should then be backed off slightly to reinstate the peak reading. After repeating this procedure a couple of times the unit is ready for use. ★

Sequential Logic Techniques Part 7

M.TOOLEY BA and D.WHITFIELD MA MSc C Eng MIEE

WE conclude our series on **Sequential Logic Techniques** with a brief look at binary full-adders. This topic was first introduced in our earlier series (Introduction to Digital Electronics) which described the characteristics and basic gate arrangements of both half and full-adders. As with most popular gate arrangements, the TTL chip designer has come to our aid with d.i.l. packaged devices which provide the complete function of a full-adder. We shall examine one such device which can be readily cascaded to cope with binary words of any desired length.

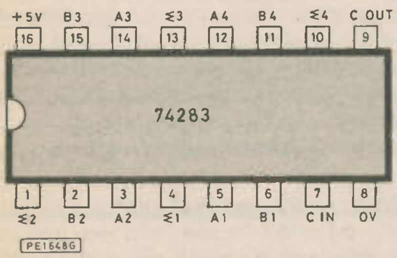


Fig. 7.1. Pin connections for the 74283

THE 74283 BINARY FULL-ADDER

The 74283 is a high speed 4-bit binary full-adder with internal carry 'look-ahead', the pin connections and internal logic of which are respectively shown in Figs. 7.1 and 7.2.

The 74283 accepts two 4-bit binary words (A1 to A4 and B1 to B4) and a carry input (Cin). The sum of the two 4-bit words is combined with the carry input and presented as four sum outputs (Σ1 to Σ4) and a carry output (Cout). This arrangement permits cascading of the device.

We shall begin our investigation of the 74283 with the simple full-adder shown in Fig. 7.3. This arrangement uses only three inputs; A1, B1 and Cin. The 'sum' output appears as Σ1 whilst the 'carry' output appears as Σ2.

The 74283 should be inserted into socket E of the Logic Tutor (taking care to align pin-1 with E1) and the following links should then be made:

E1	to D3	(D3 shows the state of Σ1)
E4	to D4	(D4 shows the state of Σ2)
E5	to S1	(A1 input)
E6	to S2	(B1 input)
E7	to S3	(carry input)
E8	to 0V	(common)
E16	to +5V	(supply)

(a total of 7 links)

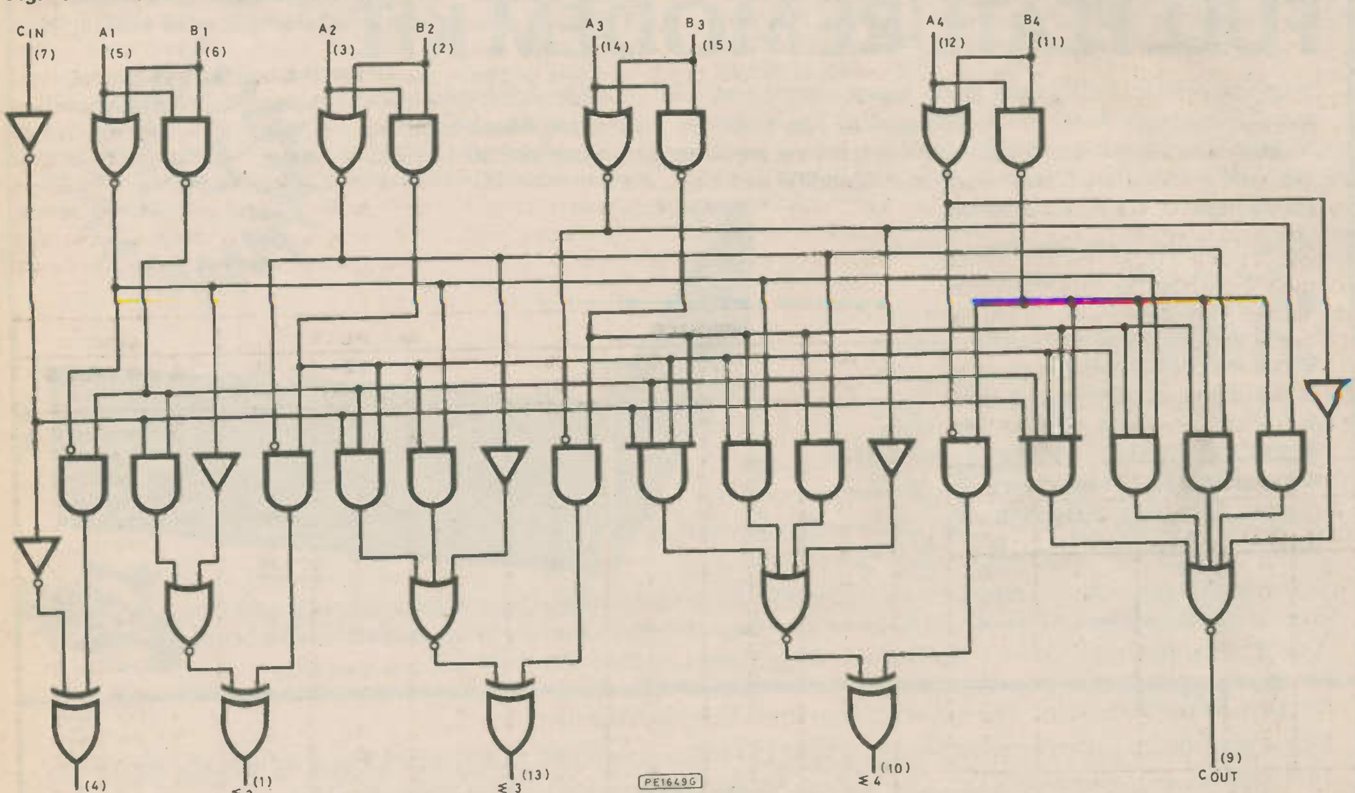


Fig. 7.2. Internal logic of the 74283

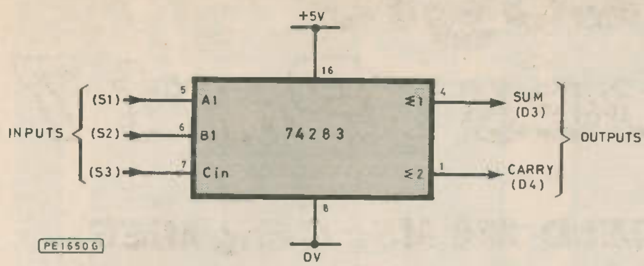


Fig. 7.3. Simple full-adder arrangement using the 74283

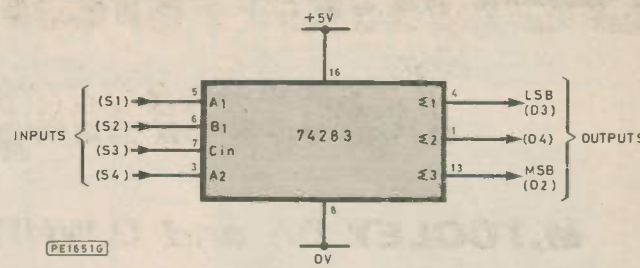


Fig. 7.4. A full-adder arrangement using all four logic Tutor switches as inputs

Logic Tutor switches S1, S2 and S3 should all be initially adjusted to produce logic 0 inputs on A1, B1 and Cin. In this condition D3 and D4 should both be extinguished showing that the 'sum' and 'carry' outputs are both at logic 0. Now depress, and hold down, momentary action switch, S1. This produces a logic 1 at the A1 input. D4 will then become illuminated whilst D3 should remain extinguished showing that the 'sum' is 1 whilst the 'carry' is 0.

S1 should now be released and S2 held down to produce logic 0 and logic 1 on the A1 and B1 inputs respectively. This should again produce 'sum' and 'carry' outputs of 1 and 0 respectively.

S2 should now be released whilst latching action switch S3 should be depressed. This produces a logic 1 on the carry input whilst the A1 and B1 inputs remain at logic 0. D4 will become illuminated whilst D3 should remain extinguished, again indicating 'sum' and 'carry' ouputs of 1 and 0 respectively.

S3 should now be depressed a second time so that the carry input reverts to logic 0. S1 and S2 should now be held down to produce logic 1 on both A1 and B1. D4 should become extinguished whilst D3 should become illuminated. This shows a 'sum' output of 0 and a 'carry' ouput of 1.

S3 should now be depressed a third time in order to produce a logic 1 carry input. Now depress first S1 and then S2. Notice that both of these input conditions result in a 'sum' output of 0 and a 'carry' output of 1.

Finally, hold down both S1 and S2 to produce a logic 1 on all three inputs, A1, B1 and Cin. In this condition D3 and D4 will both be illuminated indicating that both the 'sum' and 'carry' outputs have become logic 1. The results of the investigation are summarised in Table 7.1.

Having shown how the 74283 can be used as a simple full-adder let's extend the arrangement to provide a fourth input derived from the remaining unused Logic Tutor switch, S4. Make the following extra connections:

E3 to S4 (A2 input)
E13 to D2 (D2 shows the state of Σ3)

This modified arrangement is shown in Fig. 7.4. and uses Σ1 and Σ3 to respectively denote the least (LSB) and the most (MSB) significant bits of the sum.

All four Logic Tutor switches should initially be adjusted for logic 0 inputs. D2 and D4 will be extinguished but D3 will have become illuminated to indicate a result of '010'. Clearly we must have forgotten something!

Unused inputs of TTL devices normally float 'high' thus, with the B1 input left unconnected, the B1 input receives a logic 1. We shall therefore need to 'hard-wire' this input to logic 0 using the following additional link:
E2 to logic 0

All three output indicators should now be extinguished showing that the sum is '000'. Readers should experiment with all possible input combinations (there are sixteen of them!) and confirm that the arrangement conforms to the truth table that is shown in Table 7.2. It should be noted that the A2 and A1 inputs are the MSB and LSB of the two-bit number generated by S4 and S1 respectively, and that the remaining switches, S2 and S3, generate single bit inputs. For clarity, the equivalent decimal sum is also shown in the truth table with the leftmost digit corresponding to the two-bit A input.

A SIMPLE ADDING MACHINE

We shall conclude with an extension of the previous arrangement which forms a simple 'adding machine' and incorporates several of the techniques and devices introduced in the series. This simple arrangement accepts a 4 binary input (derived from the Logic

INPUTS			OUTPUTS	
A1 (S1)	B1 (S2)	Cin (S3)	Carry (Σ2)	Sum (Σ1)
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Table 7.1. Truth table for the simple full-adder of Fig. 7.3

INPUTS				OUTPUTS			SUM
A2 (S4)	A1 (S1)	B1 (S2)	Cin (S3)	Σ3 (D2)	Σ2 (D4)	Σ1 (D3)	A + B + C = S
0	0	0	0	0	0	0	0 + 0 + 0 = 0
0	0	0	1	0	0	1	0 + 0 + 1 = 1
0	0	1	0	0	0	1	0 + 1 + 0 = 1
0	0	1	1	0	1	0	0 + 1 + 1 = 2
0	1	0	0	0	0	1	1 + 0 + 0 = 1
0	1	0	1	0	1	0	1 + 0 + 1 = 2
0	1	1	0	0	1	0	1 + 1 + 0 = 2
0	1	1	1	0	1	1	1 + 1 + 1 = 3
1	0	0	0	0	1	0	2 + 0 + 0 = 2
1	0	0	1	0	1	1	2 + 0 + 1 = 3
1	0	1	0	0	1	1	2 + 1 + 0 = 3
1	0	1	1	1	0	0	2 + 1 + 1 = 4
1	1	0	0	0	1	1	3 + 0 + 0 = 3
1	1	0	1	1	0	0	3 + 0 + 1 = 4
1	1	1	0	1	0	0	3 + 1 + 0 = 4
1	1	1	1	1	0	1	3 + 1 + 1 = 5

Table 7.2. Truth table for the arrangement shown in Fig. 7.4

Tutor switches) and displays the resulting sum on a seven segment l.e.d. display.

The circuit of the 'adding machine' is shown in Fig. 7.5. The binary output from the 74283 adder, IC1, is fed to a 7447 seven segment decoder, IC2. Since only three bits are used, the fourth input to the 7447 must be wired to logic 0. The seven active low outputs of IC2 are connected to the display by means of a series resistor network comprising seven 150 ohm resistors contained within a single d.i.l. package. Where readers have difficulty in obtaining such a device, seven discrete 0·25W 150 ohm resistors may be substituted. These should be connected from B1 to B16, B2 to B15, B3 to B14, and so on, ending with B7 to B10. The pin-outs and characteristics of the 7447 and seven segment d.i.l. indicator were described in Parts One and Two and thus will not be repeated here.

The 74283 should be left in socket E of the Logic Tutor and the remaining devices inserted as follows: the 7447 in socket A, the 150 ohm d.i.l. resistor network in socket B, and the seven segment common anode l.e.d. indicator in socket C. The usual convention for connectiong these devices should be observed.

The following links are required:

A1 to E1
A2 to E13
A6 to logic 0
A7 to E4
A8 to 0V (common)
A9 to B5
A10 to B4
A11 to B3
A12 to B2
A13 to B1
A14 to B7
A15 to B6
A16 to +5V (supply)

B10 to C13
B11 to C2
B12 to C7
B13 to C10
B14 to C12
B15 to C15
B16 to C1

C16 to +5V (common anode supply)

E2 to logic 0
E3 to S4
E5 to S1
E6 to S2
E7 to S3
E8 to 0V (common)
E16 to +5V (supply)

(A total of 28 links)

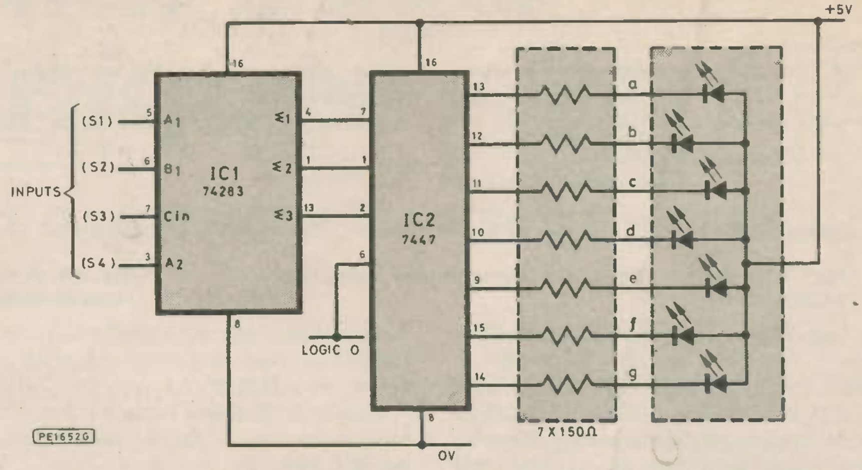


Fig. 7.5. The simple adding machine

Readers should confirm that the 'adding machine' produces a decimal indication of the sum of the two-bit number generated by switches S4 and S1, and the two one-bit numbers generated by switches S2 and S3.

This concludes our series on Sequential Logic Techniques. Readers wishing to progrees further will, no doubt, be interested to learn that we shall be returning in the autumn with a new series designed to provide an introduction to microprocessor systems.★

INDEX

DISC DRIVE PSU

J.R.W. BARNES BSC

THE advantages of using a disc drive over a cassette recorder have been covered in great depth elsewhere and are well known. To obtain full benefit from the BBC computer a disc drive is essential. The cheapest, and the most popular solution is to add a single drive and power this from the computer's internal power supply. Whilst this arrangement is satisfactory under most circumstances, the addition of a second drive and or a large number of sideways ROMs may result in the power supply being overloaded.

The unit described here is intended to provide the power for the extra disc drive. There is nothing particularly special about the power supply and constructors may find other uses for it. The prototype was made as a stand-alone unit but it may also be built inside a suitable disc drive housing.

REQUIREMENTS

The majority of disc drives require two power supply voltages, five volts for the logic integrated circuits and 12 volts for the various motors. The load on the five volt output is reasonably constant but, the load on the 12 volt output varies considerably depending whether the drive is idle or running. The output current required will also vary depending on the make and vintage of the drives. According to the label on the bottom of the BBC micro, 1·25A is available for the operation of external equipment. So as to allow a margin of safety this unit has been designed to provide 2A at each output.

Provision has been made so that the current limit can be reduced by changing the value of a resistor. The output voltages are variable by 10% either side of their nominal value.

CIRCUIT DESCRIPTION

The complete circuit diagram of the unit is shown in Fig. 1. The circuit can be split into two sections, the five volt output and the 12 volt output. These two sections are very similar in their mode of operation but there are some important differences.

Regular readers of PE will be surprised by the absence of three terminal regulator integrated circuits. While these can be used to provide simple regulated power supplies, those with high output current capability are relatively expensive and only the very expensive ones have facilities for being able to adjust the output voltage and current limit setting. The discrete arrangement as used here tends to offer better thermal stability. The reason for this, is that the series pass transistor dissipates a large amount of power raising the chip's temperature. In this discrete design the voltage reference and the pass transistor are in thermal isolation.

CIRCUIT OPERATION

The control circuits used in both outputs are examples of classic feedback systems. The differences arise because in the five volt case, the required output voltage is less than the reference voltage, and in the 12 volt case the output is greater than the reference. Both regulators are based on the LM723 i.c.

The mains transformer, T1 has two output windings; a nine volt winding for the five volt supply and a 16 volt winding for the 12 volt output. The two bridge rectifiers, D1–D4 and D5–D8 convert the a.c. to d.c., and smoothing is provided by C1 and C2.

Consider the 12 volt output first. TR1 and TR2 are connected in the Darlington configuration and are used as an emitter follower. An emitter follower provides current gain only, i.e. the output voltage is the same as the input voltage minus ($2 \times V_{be}$). This is used to boost the output capability of the control i.c. Resistors R4 and R5 together with the preset potentiometer VR2 form a voltage divider and feed a percentage of the output voltage to the inverting input of the error amplifier.

VR2 allows the output voltage of the power supply to be adjusted to cope with small variations in the reference voltage. The non-inverting input is connected to the voltage reference output of IC1. This configuration provides negative feedback resulting in the output of the power supply being held constant for varying load conditions. The capacitor C3 provides frequency compensation for the error amplifier.

SHORT CIRCUIT PROTECTION

A constant current type of short circuit protection is implemented. R6 is used as a shunt to sense the output current. When the voltage across this resistor equals 0·7 volts the control i.c. reduces its output voltage to keep the current constant. Since V = IR it is possible to select the maximum current by a suitable choice of R6.

$$R6 = 0{\cdot}7/I_{output\ max}$$

In the prototype the maximum output current was set to 3A. As with all linear regulators, short circuiting the output will cause the dissipation in the series pass transistor to rise. This will lead to the junction temperature of the transistor rising and may lead to its eventual destruction. Whilst the power supply will withstand short term overloads it is not recommended that power supply is shorted for long periods.

Operation of the five volt output is very similar. The power supply for the control i.c. is derived from C1, this enables the five volt output to operate with a lower input to output voltage difference and leads to higher efficiency.

Constructors' note:—
T1—Mains transformer 9 volt and 16 volt secondaries on 50 V/A Core. (Available from **Samsons Electronics Ltd., 9–10 Chapel Street, Marylebone Road, London NW1.** Note that this transformer has been specially designed.

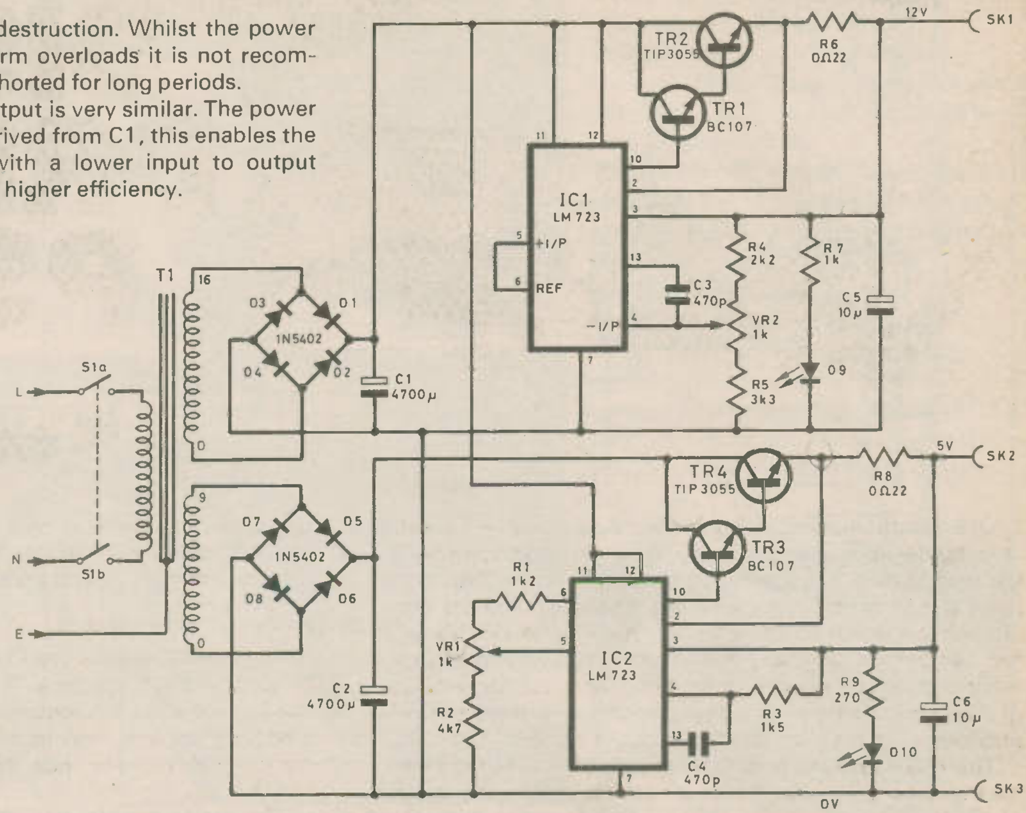


Fig. 1. The complete circuit diagram of the Disc Drive PSU

Because the desired output voltage is lower than the voltage reference a different configuration is employed. R1, R2 and VR1 act as a voltage divider on the reference voltage, the output of which is fed to the non-inverting input of the error amplifier. VR1 allows fine adjustment of the five volt output. The output voltage of the power supply is fed back via R3 to the inverting input of the error amplifier. The output of the control i.c. is boosted by the Darlington consisting of TR3 and TR4.

Current limiting is provided by R9 in an identical way to the 12 volt output, and the two l.e.d.s and their limiting resistors give an indication that the outputs are on.

COMPONENTS . . .

Resistors

R1	1k2
R2	4k7
R3	1k5
R4	2k2
R5	3k3
R6,R8	0Ω22 3 watt WW(2 off)
R7	1K 0·5 watt carbon
R9	270 0·5 watt carbon

All resistors $\frac{1}{4}$W ± 5% unless stated otherwise

Potentiometers

VR1, VR2	1k sub. min. pre-set pot. (2 off)

Capacitors

C1,C2	4700μ 25 volt elect. axial (2 off)
C3,C4	470p disc ceramic (2 off)
C5,C6	10μ 25 volt elect. radial (2 off)

Semiconductors

D1–D8	IN5402 (8 off)
D9–D10	0·2 inch l.e.d.s with panel mounting clips (2 off)
TR1,TR3	BC107 silicon npn (2 off)
TR2,TR4	TIP3055 silicon npn plastic power transistors (2 off)
IC1,IC2	LM723 voltage regulator i.c.s (2 off)

Miscellaneous

S1	d.p.s.t. rotary mains switch
SK1–SK3	Binding posts colour to suit (3 off)

T1 Transformer, 9V and 16V secondaries
Verobox
P.c.b. PE 504-02
Knob for S1
Heatsink
Fixing screws
Captive grommet
Connecting wire
Insulating kits for TR2, TR4 (2 off)

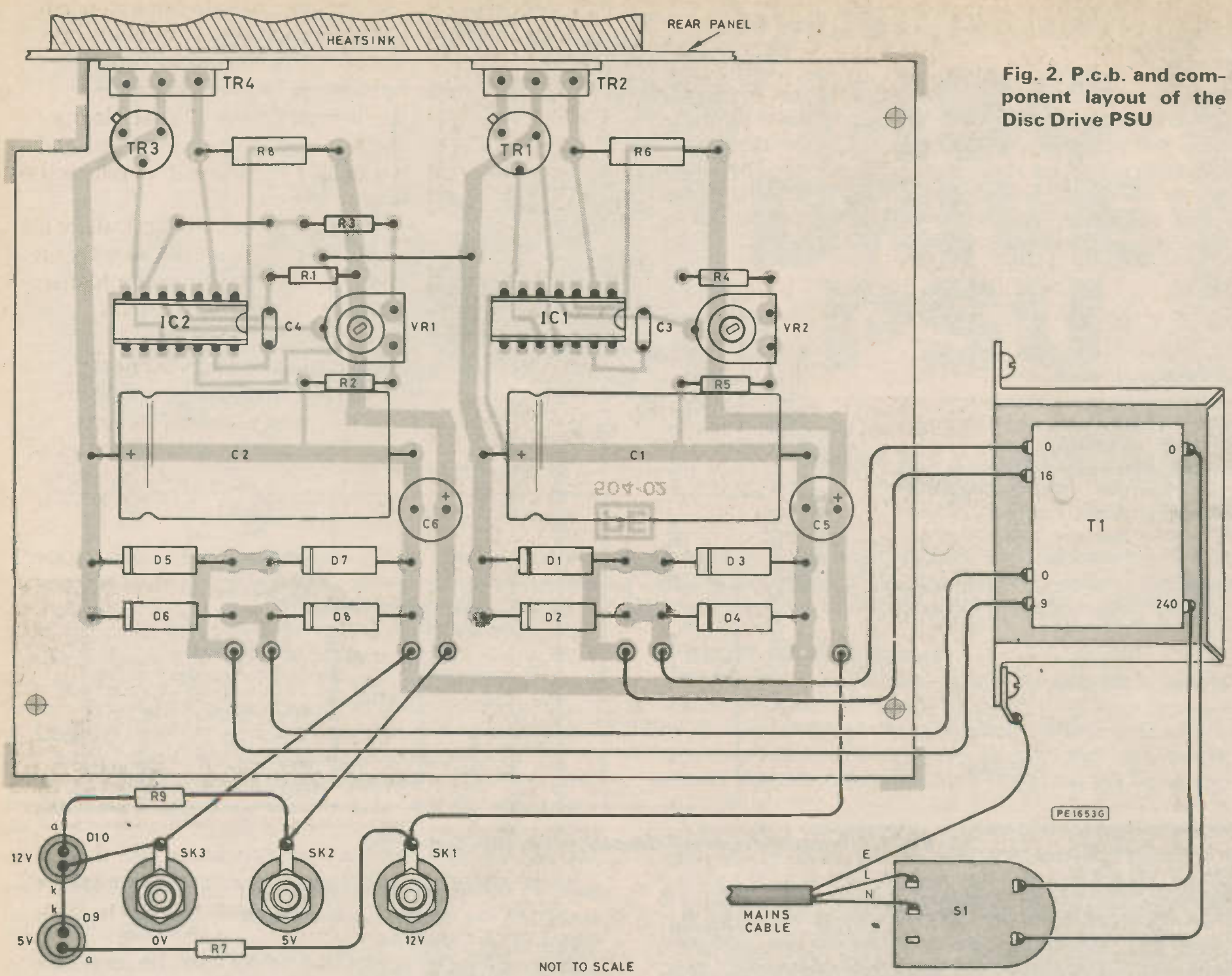


Fig. 2. P.c.b. and component layout of the Disc Drive PSU

CONSTRUCTION

With the exception of the mains transformer all the components are mounted on a single p.c.b. and front panel. The printed circuit board track layout is shown in Fig. 2. The design can be transferred to the circuit board by any of the usual methods and subsequently etched and drilled.

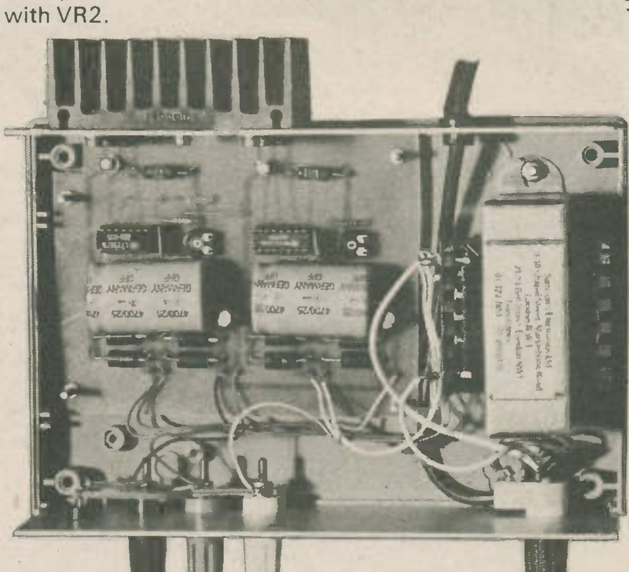
To allow some of the components to be mounted some of the holes may need to be enlarged. The normal practice of constructing circuit boards should be followed. The Veropins if used should be fitted first, then the wire links and the smaller components. It will assist if the bulky electrolytic capacitors are left till last. Care should be taken to ensure that all the polarised components such as capacitors and diodes are correctly orientated. Constructors are advised to use sockets for the two i.c.s.

The prototype was built in a Verobox and before the transformer can be bolted in position, it is essential to remove some of the internal mouldings. This can be done with a large twist drill and then any remaining plastic should be removed using a sharp knife.

ADJUSTMENT

Before the power supply is connected to a disc drive it is essential to test it and adjust the output voltage. Connect an accurate volt meter to the five volt output and turn the unit on. The meter should read approximately five volts, adjust VR1 until the output is exactly five volts, switch off. Set the meter to a range greater than three amps d.c. and connect this across the output and turn the unit on. If all is well the meter should read about 3A.

Repeat for the 12 volt output, but this time set the voltage with VR2. ★

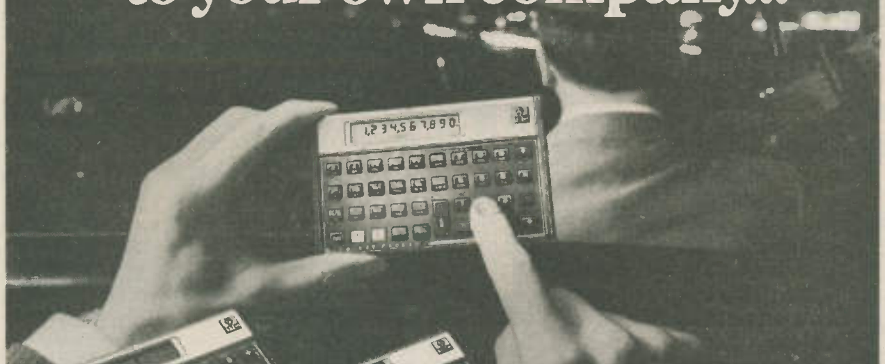


Internal details of the Disc Drive PSU

From your student days...

to your first job...

to your own company...



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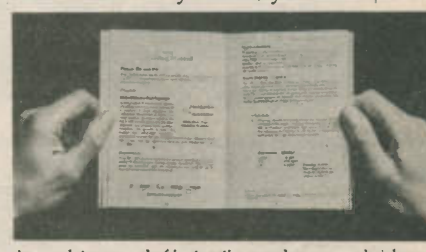

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HEWLETT PACKARD

MODULAR AUDIO POWER SYSTEM

PART 3

M.TOOLEY BA
D.WHITFIELD MA MSc CEng MIEE

In the series thus far we have assumed that all of the ancillary modules described have derived their d.c. supplies from an associated power amplifier module. Whilst this arrangement is convenient when pre-amplifier and power amplifier modules are assembled together within a common external enclosure, it is less attractive when the power amplifier module is remotely located.

A somewhat simpler, and far more flexible solution is that of including a 'local' power supply within the pre-amplifier enclosure, thus obviating the need to provide three additional conductors in order to convey the positive and negative supply rails and common earth.

Such a supply need only be capable of delivering a few tens of milliamps from symmetrical output voltage rails of between 15V and 30V. Furthermore, there is no need for electronic regulation of the d.c. output voltage as shunt Zener stabilisation is incorporated within each ancillary module.

The complete circuit diagram of the power supply module is shown in Fig. 1. This relatively straightforward arrangement is capable of supplying up to five parallel connected ancillary modules and employs a mains transformer, T1, having either two series connected 12V windings or a single centre tapped secondary of nominally 24V. In either case, a conventional plastic encapsulated bridge rectifier, REC1, is employed.

The power supply is built on a single sided p.c.b. measuring approximately 65mm × 115mm (i.e. identical in size to all other modules). The component overlay is shown in Fig 2.

Components should be assembled on the p.c.b. in the following sequence: terminal pins, transformer, resistors, capacitors, and bridge rectifier. As always, care should be taken to ensure the correct orientation of the polarised components (including the bridge rectifier).

When the p.c.b. wiring is complete, the underside of the board should be carefully checked for solder bridges and dry joints whereas the component side should be examined paying particular attention to the correct placement and orientation of components.

Although the power supply will normally be mounted in the same enclosure as that used for the pre-amplifier module (see last month) some constructors may prefer to use a separate enclosure. In such cases the authors strongly

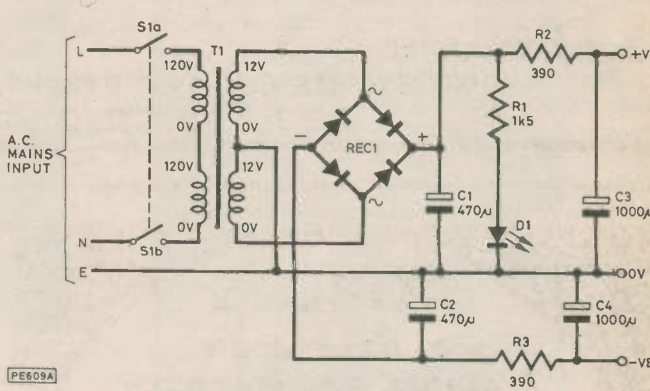


Fig. 1. Circuit diagram of the power supply module

COMPONENTS . . .

POWER SUPPLY

Resistors

R1	1k5 0·25W 5%
R2, R3	390 0·5W 5% (2 off)

Capacitors

C1, C2	470µ 50V p.c. electrolytic (2 off)
C3, C4	1000µ 16V p.c. electrolytic (2 off)

Semiconductors

REC1	50V 1A bridge rectifier
D1	Red l.e.d.

Miscellaneous

P.c.b.
Terminal pins (8 required)
T1 3VA mains transformer with 2 × 120V primaries and 2 × 12V secondaries each rated at 120mA
D.p.s.t. mains switch
Mains connector

Power amplifier module

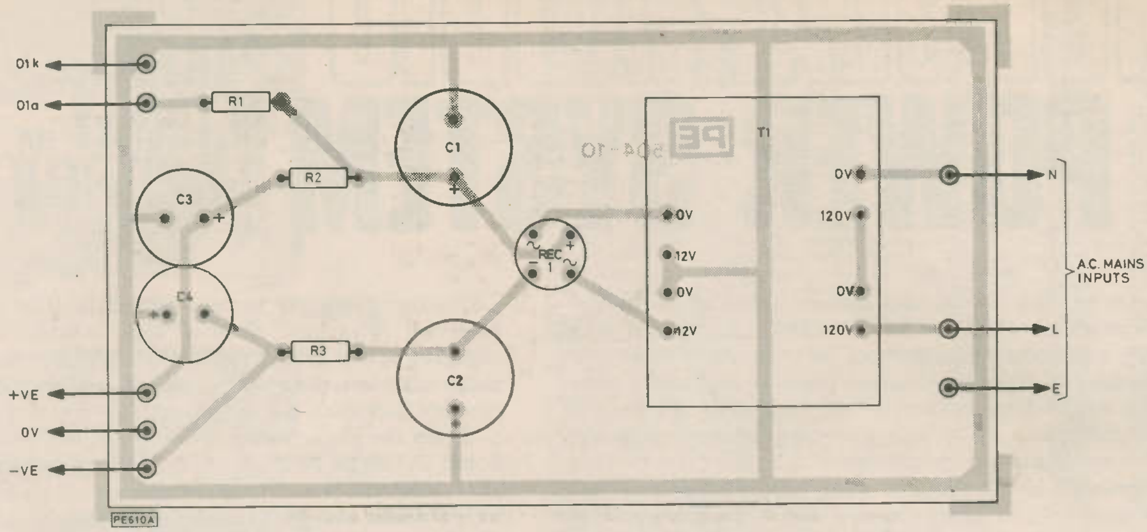


Fig. 2. Component layout of the power supply module

recommend the use of a small diecast box, being both neat and robust. Ventilation of such an enclosure will not normally be required.

TEST SIGNAL SOURCE

This final ancillary module generates a sinusoidal signal of reasonable purity at a frequency of approximately 1kHz. It thus not only provides a means of testing the complete power amplifier system but also enables a realisitic measurement of the r.m.s. output power when used in conjunction with the test load described previously.

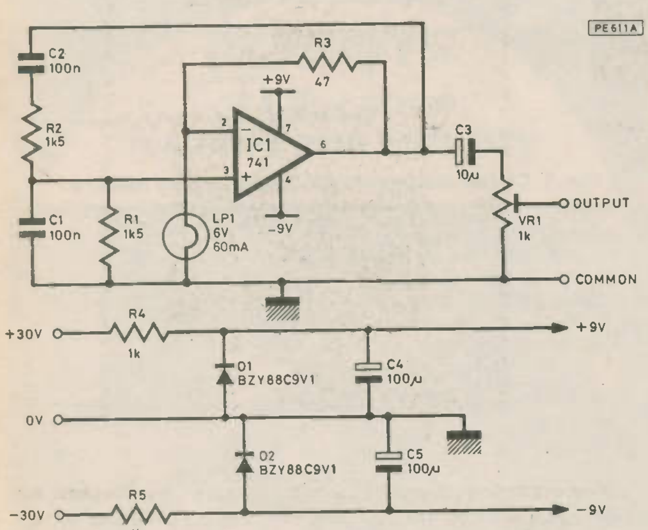


Fig. 3. Circuit diagram of the test signal source

The test signal source is based on a 741 operational amplifier and its complete circuit diagram is shown in Fig. 3. The oscillator uses a simple Wien bridge network, R1, C1 and R2 C2, with negative feedback amplitude control provided by means of R3 and LP1. This arrangement ensures reasonable purity without the need to use a more expensive thermistor device in the feedback network.

With the component values shown, the frequency of

COMPONENTS . . .

TEST SIGNAL SOURCE

Resistors

R1, R2	1k5 (2 off)
R3	47
R4, R5	1k 0·5W (2 off)
VR1	1k horizontal mounting min. skeleton pre-set

Unless otherwise stated, all fixed resistors are 0·25W 5%

Capacitors

C1, C2	100n polyester (2 off)
C3	10µ 16V p.c. electrolytic
C4, C5	100µ 16V p.c. electrolytic (2 off)

Semiconductors

IC1	741
D1, D2	BZY88 C9V1 (2 off)

Miscellaneous

P.c.b.
Terminal pins (5 required)
LP1 6V 60mA wire ended pilot lamp
8-pin low profile d.i.l. socket

Pre-amplifier

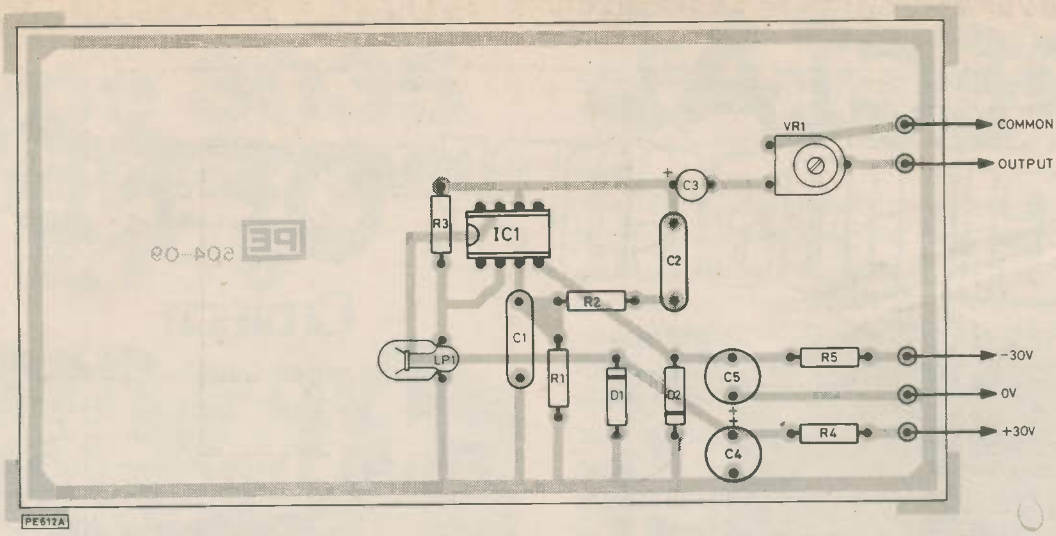
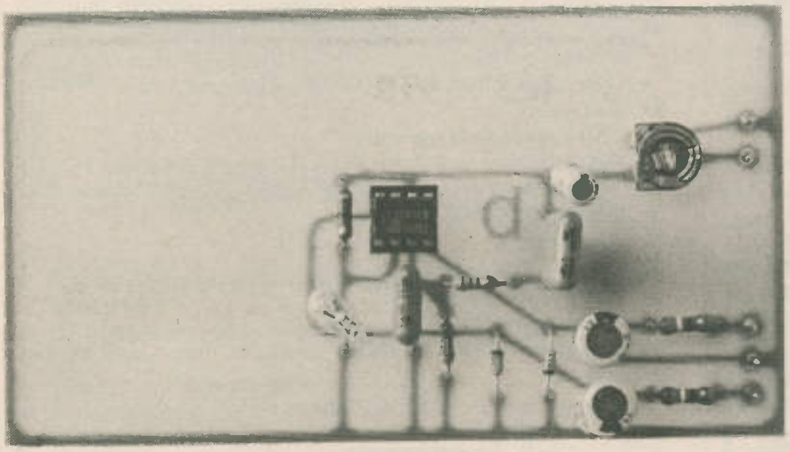
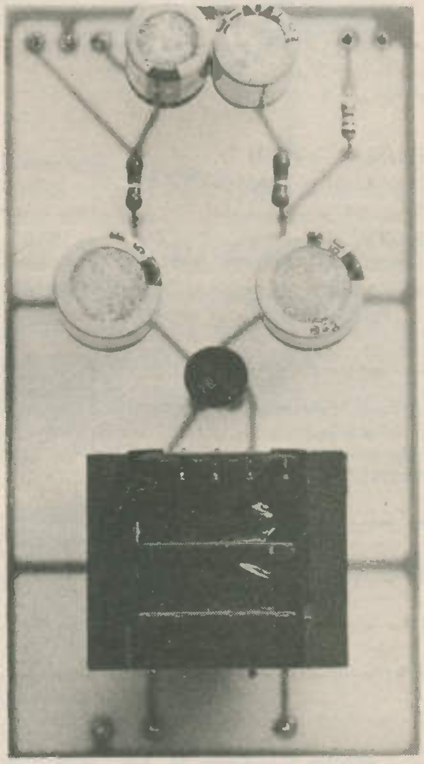


Fig. 4. Component layout for the test signal source





The photograph shown above is of the test signal source p.c.b. whilst the power supply p.c.b. is shown on the right.

operation is approximately 1kHz. If desired, however, constructors may readily change the frequency of oscillation by altering the values of R1, R2 and C1, C2. The frequency of oscillation is given by:

$$f = \frac{159}{C \times R} (\text{kHz})$$

Where C = C1 = C2 (expressed in μF) and R = R1 = R2 (expressed in kohm).

Adjustment of the output voltage level is provided by means of VR1. With this control in mid-position, the output voltage produced will be of the order of 1V pk-pk. As mentioned previously, simple Zener diode shunt regulators, D1 and D2, are provided to stabilise the incoming positive and negative supply rails.

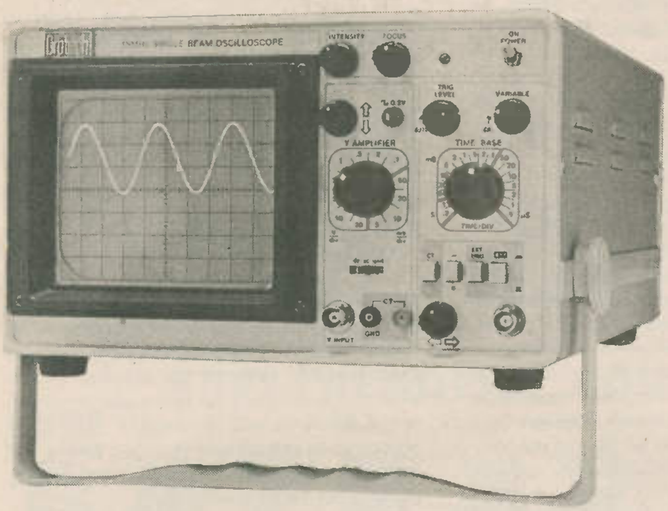
The test signal source is again built using a single sided p.c.b. measuring approximately 65mm × 115mm. The component overlay is shown in Fig. 4. Components should be assembled on the p.c.b. in the following sequence; terminal pins, i.c. holder, resistors, capacitors, diodes, variable resistor and filament lamp. This latter component should be secured to the p.c.b. using a small drop of epoxy resin based adhesive.

When complete, the p.c.b. should be carefully checked for solder bridges, dry joints, and correct orientation of all polarised components. The test signal source may be tested by simply connecting its output to the input of any of the other modules and listening for a signal output from the system. If available, an oscilloscope may be used both to confirm that the output waveform is sinusoidal and to accurately set the level of the output signal.

In a practical system the output of the test signal source may either be made available at a standard jack or d.i.n. connector so that it may be 'patched' into the system when required or may be switched directly to any of the inputs of the pre-amplifier/line driver or pre-amplifier-mixer modules described last month. ★

Crotech

Type 3035 Single Trace 15MHz £199



★ 5mV/division to 20V/division (12 steps) calibrated sensitivity (± 3%)
★ DC–15MHz bandwidth (–3dB). Rise time 23ns.
★ X–Y operation
★ 130mm cathode ray tube
★ 200ns/division to 0.2s/division (18 steps) timebase (±5%)
★ 6 trigger functions
★ Triggering to 20MHz
★ 10 x 8 division display
★ Component tester
★ Measures 160H x 265W x 317D (mm), weight 6kg (approx.)

PRICES INCLUDE VAT AND DELIVERY

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★ DC–15MHz bandwidth (–3dB). Rise time 23ns.
★ X–Y operation
★ 95mm rectangular cathode ray tube
★ 200ns/division to 0.2s/division (18 steps) timebase (± 5%)
★ 6 trigger functions
★ Triggering to 20MHz
★ 10 x 8 division display
★ Component tester
★ Measures 125H x 240W x 335D (mm), weight 4.6kg (approx.)

PRACTICAL ELECTRONICS is pleased to be able to offer these quality CROTECH oscilloscopes to readers at special discount prices which include VAT and delivery. The 'scopes can be purchased using Access to spread the load.

Any of these three items would be an invaluable addition to the test gear used by an amateur or professional engineer. Each unit is supplied with an input lead, instruction manual and a free copy of "Getting The Best From Your Scope". Additional probes and accessories are also available.

The 'scopes have the additional facility of a built-in component comparator or tester which allows in-circuit testing of both passive and active devices and, on the 3132 direct comparison of components. Each 'scope employs regulated internal supplies and features a 1KHz, 200mV P-P calibration output.

THESE CROTECH PRODUCTS ARE ALL COVERED BY A TWELVE MONTH GUARANTEE.

Unfortunately we can only make this offer to UK readers due to delivery problems overseas.

DARK RINGS

Using a C.C.D. (Charge-Coupled Device) on the 100-inch reflector at the Las Campanas Observatory, in Chile, the American astronomers Richard Terrile and Bradford Smith have succeeded in imaging the rings of Uranus, together with all five known satellites (Miranda, Ariel, Umbriel, Titania and Oberon). Infra-red images have been obtained by D. A. Allen and J. Crawford from the Siding Spring Observatory in New South Wales, but this is the first record of them at visual wavelengths.

The rings are quite unlike those of Saturn; instead of being bright and icy, they are made up of material which is as dark as coal-dust.

Meanwhile, occulation observations by F. Vilas and L. Elicer at the Cerro Tololo Observatory, also in Chile, give the first indications that the outermost giant planet, Neptune, may also have a dark ring. Previously no signs of a Neptunian ring had been found, and it had been thought that none might exist because of the presence of Triton, a large satellite with retrograde motion. The Chilean observations are far from conclusive, but they are certainly very interesting.

Russia's two *Vega* probes to Halley's Comet are now on their way, first to rendezvous with Venus and then to encounter the comet in March 1986—at about the same time as the Japanese *Planet A*, and shortly before the European probe, *Giotto*, is scheduled to pass right into the heart of the comet on March 13, 1986.

HORSE SENSE

There has been an interesting suggestion with respect to the famous Horse's Head Nebula in Orion, which is spectacular when photographed and really does give the impression of a knight's head in chess—though it is hard to see visually (with my 15-inch reflector I always find it an excessively difficult object). B. Reipurth of Denmark and P. Bouchet of France suggest that it may be an embryo Bok Globule.

These Globules, named in honour of the late Bart J. Bok (who first drew attention to them) are formed when strong radiation from very hot stars strips away all but the compact centres of large interstellar clouds, and are believed to form into stars of rather low mass.

In the case of the Horse's Head, the radiating star is Sigma Orionis. Reipurth and Bouchet believe that eventually the Horse's Head will emerge from the surrounding nebulosity and become typically spherical in form, though obviously the process will be a very slow one indeed.

MERCURY

March this year is the best time for seeing the rather elusive planet Mercury, which reaches its greatest eastern elongation (18 degrees) on the 17th. It is well north of the celestial equator, and should be visible above the horizon for about half an hour after sunset. On the evening of the 22nd, Venus, Mercury and the 30-hour-old crescent Moon will be almost in a straight line, pointing downward and to the left—photographic enthusiasts, please note!

The phase of Mercury decreases from almost 90 per cent at the beginning of the month to less than 12 per cent at the end. Mercury passes through inferior conjunction on April 3, about eight hours before Venus does so—though the two planets are not in conjunction with each other until April 18.

Ordinary telescopes will show practically nothing on Mercury apart from the characteristic phase. Maps of the surface were drawn by G. V. Schiaparelli in 1881–9 and by E. M. Antoniadi in 1934. Antoniadi, who used the great 33-inch refractor at Meudon Observatory, was probably the best planetary observer of his time, and his maps of Mars have proved to be remarkably accurate, but he was less successful with Mercury, and showed only some rather vague shadings.

He also believed that there could be an appreciable atmosphere, and that the rotation was synchronous—that is to say, equal to the planet's revolution period or 'year', amounting to 88 Earth-days. This would have meant that

THE SKY THIS MONTH

Several planets are on view this month, though only Mercury and Venus are well placed. Venus continues to dominate the western sky after sunset, and its magnitude at the beginning of the month is –4.3, far brighter than any other planet and about three magnitudes brighter than Sirius, the most brilliant star in the sky.

However, Venus sets earlier and earlier as the month progresses, and the phase decreases from 25 per cent on March 1 to only 4 per cent on March 30. Inferior conjunction is reached on April 3.

This is a good time to see whether the phase of Venus can be seen with the naked eye. Very keen-sighted people can do so (though I certainly cannot!) and of course binoculars will show the phase easily.

Telescopically, this is also the right time to look for the Ashen Light, or faint luminosity of the night side of the planet. Observations of it have been made so often that it can hardly be dismissed as a contrast effect—though we can hardly agree with the last-century German astronomer Franz von Paula Gruithuisen that it is due to fires lit on the planet's surface by the local inhabitants to celebrate the election of a new Government! More probably it is due to electrical effects in the upper atmosphere of Venus.

Mars, in the evening sky, is now only of magnitude 1½. Jupiter rises well before the Sun by mid-March, and so does Saturn, but both are low, as they are well to the south of the celestial equator. The Moon is full on March 7, and new on the 21st.

Halley's Comet, brightening steadily, is still beyond the range of any but very powerful telescopes; however, its nucleus is already showing marked signs of activity, and we may hope that the comet will be rather more of a spectacle than was originally feared. For the record: the position on March 1 is R.A. 4h 56m, dec. N.13°35'; on March 31, R.A. 4h 51m, dec. N.14°49'. This is close to the boundary between Orion and Taurus—roughly midway between Aldebaran and Betelgeux.

Orion, of course, is still the most striking constellation on view, though by the end of the month it is starting to run into the evening twilight. (Do not forget that Summer Time starts on March 31.) Capella is still very high, which means that Vega is low in the north and may not be seen at all even though it never actually sets over Britain.

The Great Bear, Ursa Major, is high in the north-east, and Leo, the Lion, has become prominent; to locate Leo it is helpful to use the Pointers in the Great Bear 'the wrong way' (that is to say, away from the Pole Star). Regulus, leader of Leo, is at the foot of a curved line of stars making up the pattern known as the Sickle.

Below Leo the sky appears rather blank; this is the region of Hydra, the Watersnake, whose only bright star, the reddish Alphard, may be found by using the Twins, Castor and Pollux, as direction indicators. Alphard is often nicknamed 'the Solitary One' because of its somewhat isolated position. It is of the second magnitude, but has been suspected of variability.

part of Mercury would be in constant sunlight and another part in constant darkness, with only a narrow 'twilight zone' in between over which the Sun would bob up and down over the horizon.

Antoniadi was wrong on both counts, though he can hardly be blamed. The Mercurian atmosphere is negligible, and the rotation period is only 58.6 days, two-thirds of the planet's 'year'—which means that each time Mercury is best placed for observation from the Earth, the same regions are turned in our direction.

MISSION ACCOMPLISHED

Virtually all our detailed knowledge of Mercury comes from a single space-probe, *Mariner 10*, which made three active passes of the planet: in March and September 1974 and March 1975. Since Mercury, with a diameter of 3030 miles, is not a great deal larger than the Moon, it was expected that the surface features would be basically of lunar type, and this proved to be correct. There are craters, mountains, valleys, scarps and ridges; some of the craters have central peaks, and some are the centres of systems of bright rays. In fact, the first crater to be identified as *Mariner 10* drew in toward Mercury is a ray-centre; it has been named Kuiper, in honour of the late Dutch-American astronomer G. P. Kuiper, who placed such an important role in the early days of planetary probe research.

The most imposing formation is the Caloris Basin, which is a huge ringed structure. Unfortunately we have mapped only part of it. Each time *Mariner 10* by-passed Mercury the same regions of the planet were in sunlight, so that a large area remains unknown, though there is no reason to believe that these regions are basically different from those which we have been able to study.

Though the crater distribution on Mercury follows the same laws as on the Moon, with smaller formations breaking into larger ones instead of vice versa, there are no smooth 'seas' comparable with the lunar Mare Imbrium or Mare Serenitatis, and there are inter-crater plains of a type not found on the Moon.

One distinct surprise was that Mercury, unlike Venus, Mars or the Moon, has a detectable magnetic field, with a strength about 1/30 of that of the Earth's field. The field is dipolar, with two equal magnetic poles of opposite polarity aligned with the rotational axis of the planet—which is almost perpendicular to the plane of the orbit.

Moreover, Mercury is about as dense as the Earth, with a specific gravity of 5.5. Presumably it has a large iron-rich core, which may in fact be larger than the whole globe of the Moon.

HOSTILE WORLD

Contact with *Mariner 10* was finally lost on 24 March 1975, though no doubt the probe is still in solar orbit and still makes regular close approaches to Mercury. No further missions have been announced as yet, though new launchings will probably be made in the foreseeable future.

Obviously Mercury is a very hostile world, and there is no chance of any life there; neither does it seem likely that manned landings will be practicable for a long time. However, it is always worth seeking out this curious, elusive little planet, and March this year provides an excellent opportunity.

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HEWLETT Packard signal generator HP606A 50kHz-65MHz. Handbook. Offers, or exchange radio control equipment. Chelmsford 59033. J. H. Gooday, 53 Lawn Lane, Chelmsford, Essex.

PHILIPS 1700 video for spares also 40 tapes and manual. Offers. Tel: 041 632 5408.

WANTED Bogen ¼ track erase heads type UL296 or address of supplier. Mr. B. Langmead, Bowd Cottage, Sidmouth, E. Devon EC10 0ND. Tel: 03955 3328.

WANTED manual or circuit diagram to repair Sinclair R3000 amplifier. K. J. Steward, 8 Langley Close, Church Crookham, Aldershot GU13 0PX.

WANTED circuit diagrams on quality pre-amps and mosfets and Bipolar and p.c.b.s and special offer on components and 2 N3773 etc. Contact: A. Larrc, 56 Becher St., Derby DE3 8NN.

FULL size keyboard from NCR accounting machine £20. Sinclair ZX80 complete with instruction book £20. Mr. W. E. Ames, 33 Beach Rd. West, Portishead, Bristol. Tel: 0272 848273.

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PRINTER BUYER'S GUIDE....

UNTIL recently, printers for computers were large, noisy and expensive pieces of equipment. This picture has changed, however, with the introduction of increasingly powerful small computers in business and the home. The different needs of these new groups of computer users have brought about a re-think in printer design, resulting in desktop printers which meet the needs, and fall within the price range of today's small computer systems. This month's printer survey looks at the wide range of printers currently on the market at around £500 or less. Before we do this, however, we will take a look at some of the basic features of these printers, and suggest some points to consider when choosing a printer.

WHO NEEDS A PRINTER

The need for a printer is not something which is immediately obvious when 'The Computer' first arrives in the home. If your computer is to be more than just a passing fancy, however, the pre-packaged games used to get things started will soon give way to an urge to 'have a go' yourself. Copying programs from magazines is usually the first step, but one which soon shows itself to have a few hidden snags. These usually take the form of the almost inevitable typing mistakes; the well-known 'finger trouble' syndrome. Tracking down these bugs can be a nightmare of "is that a '1' or is it a 'l'?", particularly if you are restricted to debugging on a shimmering TV screen. However, the problem can be greatly simplified if you are able to put down a printed listing of the program side-by-side with the original.

Next, you will probably move on from published listings to writing your own programs. Here a printer will help you to develop a clear and well-structured programming style, since these are features which will stand out clearly from your listings. By the time you reach this stage, however, you are really hooked, and a terminal case of computeritis is usually diagnosed!

The discussion so far has been restricted to using the resources of the computer itself. However, computers really come into their own when we can set them to work in our everyday lives. One of the best examples in this area is probably word processing, which is arguably the greatest advance since the introduction of the typewriter. With a word processing program running on your computer, you can type letters, correct your mistakes, change your mind as often as you like, and still end up with perfectly presented letters at the end of the day; all assuming of course that you have a printer!

Whatever your reasons for wanting a printer, choosing the right one can be as important as the selection of your computer. The decision to buy a printer can easily involve spending at least as much again as the computer itself (a printer will typically cost between £180 and £450), so it is important to choose one which really is suited to your needs. The choice available is now quite considerable, and the range of facilities offered can be bewildering, so before looking at some of the printers available, we will start by looking at the basic features to be found on today's machines.

A FEW PRINTER BASICS

Inside the computer there are essentially two types of information which concern us when we talk about using a printer to produce a permanent copy; we usually think of these two types as characters and graphics. We will start by looking at characters, and will come back to graphics a little later.

Characters are the numbers, letters, and punctuation marks which make up the so-called character set of the computer. They also appear on the display screen and on the keyboard. Internally these characters are usually represented by a set of one-byte ASCII codes. When we want to print a sequence of characters, therefore, the computer simply has to send the corresponding stream of ASCII codes to the printer. There are two ways to transfer this byte stream from the computer to the printer; serial and parallel. The serial link transfers bytes one bit at a time, and usually conforms to the RS232C standard (or an equivalent). The more popular parallel interface usually conforms to the Centronics standard, and transfers a complete byte at a time. The important thing to bear in mind here is to make sure that the printer port on the computer is compatible with that on the printer!

At the receiving end, the printer decodes each byte as it arrives, and sends the appropriate commands to the printer mechanism to cause the corresponding character to be printed. The actual form of the printed character depends on the 'font' of the printer, and is something which may or may not be variable, depending on the type and model of the printer.

Many printers have a number of built-in fonts which are selectable by the computer, whilst others have a facility to allow the operator to change fonts when required. However, and at any instant, the currently selected font determines the way in which the printer will interpret each ASCII code sent by the computer. In the main these codes correspond to the keyboard and screen symbols, but there are ranges (particularly of the lower-numbered codes) which are usually reserved for commands from the computer to the printer, e.g. new page, change font. These control codes are often referred to as escape sequences because they frequently involve a pre-defined sequence of codes, starting with an 'ESCAPE' code (decimal 27).

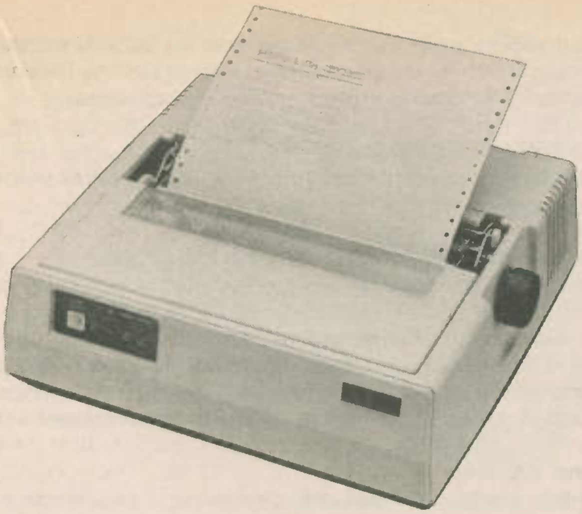
So far we have seen how the computer tells the printer which characters it wants printed, and how it controls various features such as the font. We will now go on to look at how the characters themselves are actually printed.

PRINTER TYPES

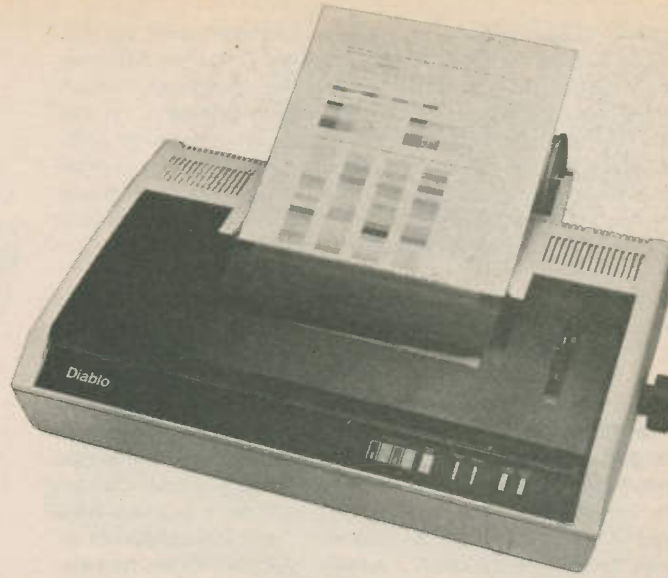
There are quite a number of different types of printing mechanism used today, but the major difference between them is the way in which the individual characters are formed on the paper. The most popular printers for small computers today are undoubtedly the daisywheel and dot matrix types. Printer technology is not static, however, and cheaper, quieter, and more versatile machines are constantly being announced. A particular driving force at present is the quest for low power printers suitable for portable computers. Below we look briefly at the features of today's popular types of printers which fall within our price range.

Daisywheel

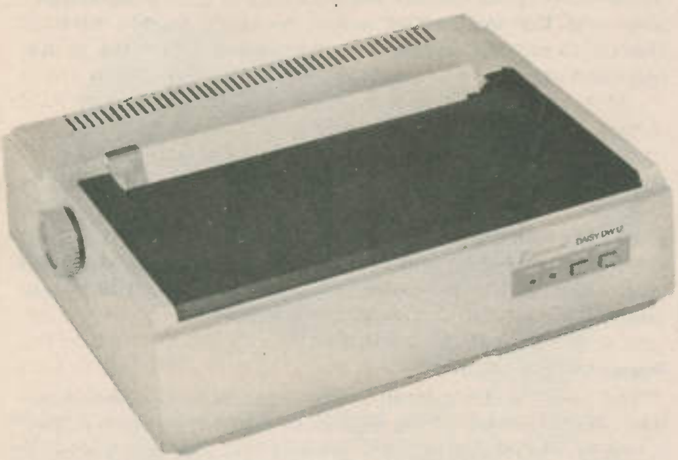
The daisywheel printer works in a similar way to an electric typewriter. The font is on a plastic daisywheel with flat spokes (so called because of its similarity in appearance to the petals of a daisy), and the characters are embossed on



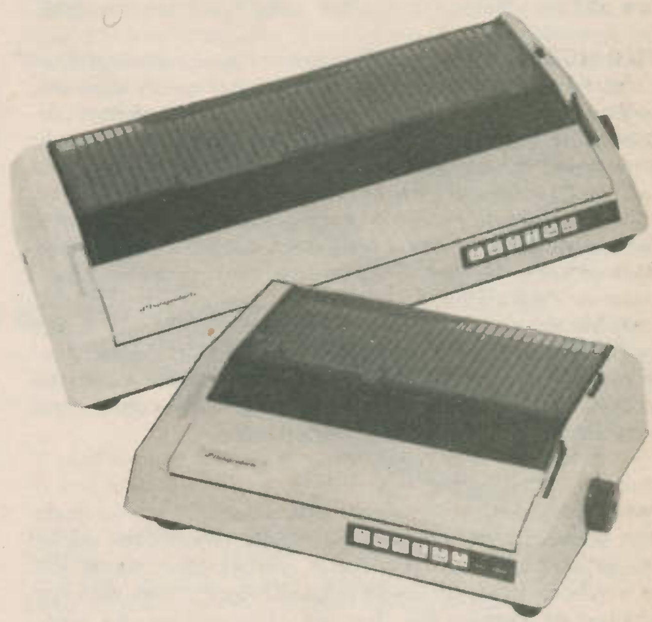
Model: Tandata M82A **Print format**: Dot Matrix **C.P.S.**: Variable **Interface**: Serial/Parallel **Paper**: Sprocket Feed **Notes**: Viewdata graphics **Price**: £299+VAT **Supplier**: Tandata, Albert Rd. North, Malvern, Worcs (06845 68421).



Model: Geveke C150 **Print format**: Dot Matrix **C.P.S.**: 20 **Interface**: Parallel **Paper**: Friction **Notes**: Optional Interface **Price**: £1095+VAT **Supplier**: Geveke Electronics, Unit 201, Landsbury Est., 102 Lower Guildford Rd., Knaphill, Woking, Surrey (04867 88676).



Model: DW12 **Print format**: Daisywheel **C.P.S.**: 12 **Interface**: Centronics **Paper**: 300mm Friction **Notes**: Tractor option **Price**: £275+VAT **Supplier**: X-Data, 750–751 Deal Ave., The Trading Estate, Slough, Berks (0753 72331).



Model: Paper Tiger, 8010, 8020 **Print format**: Dot Matrix **C.P.S.**: 180 **Interface**: RS232/Centronics **Paper**: 200, 305mm Tractor **Notes**: Block graphics **Price**: £469, £645+VAT **Supplier**: Data Products International, Data Products House, 136–138 High St., Evesham, Worcs (0784 31161).

Model: Tandata PPX Compact **Print format**: Thermal **C.P.S.**: Variable **Interface**: Centronics **Paper**: 110mm Thermal **Notes**: Viewdata **Price**: £171.35 inc. VAT **Supplier**: Tandata Marketing, Albert Rd. North, Malvern, Worcs (06845 68421).

the ends of the spokes. The wheel is rotated until the appropriate spoke is aligned with the print hammer. An electromagnetic hammer then strikes the character, which presses it against the ribbon, producing an imprint on the paper. The print head then moves across one character position, ready for the next printing operation. Daisywheel printers are capable of the very highest print quality, but are relatively slow and noisy in operation. Changing fonts is a simple matter of changing daisywheels.

Dot Matrix

A dot matrix printer is one which works by placing a pattern (matrix) of dots on the paper to form the characters. This is done by firing a vertical bank of fine wires (usually there are between seven and nine wires, but it can be just one) at the paper through the ribbon. The wires are fired by individual solenoids as the print-head moves across the paper. In this way each character is built up one column at a time, with the print-head moving across the paper one dot position at a time. The dot pattern for each character is usually held in ROM inside the printer; some models include more than one font, selectable by special codes from the computer. In addition, matrix printers usually allow more than one size of any particular font to be printed (again selected by the computer). This is usually done by changing the horizontal spacing and/or repeating each dot column twice, but the basic dot pattern (which defines the font) remains unchanged.

Typical matrix printers use an array of seven-by-nine dots for their standard character fonts, but larger matrix sizes are also available. In general, the larger the number of dots per line of print, the better the appearance of the characters; a typical figure is 480 dots per line. Many dot matrix printers now include a so-called near letter quality (NLQ) font. This usually makes use of columns of dots at a half-dot pitch (whereas most fonts use a whole-dot pitch), and although slower to print, the NLQ fonts do give a much smoother appearance to the printed characters.

Overall, matrix printers are typically 5 to 10 times faster than daisywheels, usually offer a good range of print styles, but are noisy and do not offer quite the same print quality as daisywheel printers. As we shall see later, many dot matrix printers also offer the possibility of graphics.

Ink Jet

Both daisywheels and dot matrix printers are inherently noisy because they work by physically striking the paper through a ribbon. Ink jet printers, on the other hand, are much quieter because they have no ribbon. Instead, they fire a stream of charged ink droplets at the paper. An electrostatic arrangement then deflects the stream in much the same way as a television tube, and causes the characters to be drawn on the paper.

A recent simplification of the ink jet principle is to do away with the electrostatic deflection, and use a bank of ink nozzles instead. In much the same way as an impact dot matrix print-head, the characters are then made up from a matrix of ink dots. This approach has also been cleverly adapted to allow printing in colour; each jet produces dots of a different colour, with the characters then being built up one row at a time. The result is rather slower than with single-colour printing, and the character fonts tend to be more limited, but colour printers of this type are a very cost-effective way of producing multi-colour hard copy.

Electro-sensitive

The electro-sensitive system uses a special paper which is sandwich of aluminium foil, ink and paper. Printing is performed by wires which are in contact with the foil side of this sandwich. When a wire is momentarily raised to a high voltage, a small hole is melted in the foil, exposing the ink below. The result is a black dot on a silvery background. Electro-sensitive printers are not widely used due to their need for special paper, but they are quite common in lower cost, narrow-paper applications.

Thermal Matrix

This is another type of printer which requires special paper. It is similar to the impact dot matrix printer discussed above, but instead of striking wires through the ribbon, the printhead burns spots directly on heat-sensitive paper. Thermal printers are very quiet and relatively cheap, but the cost and need for special paper can be a distinct disadvantage.

Thermal Transfer

Thermal transfer printers are a relatively new development. A special heat-sensitive ribbon is used with the same sort of print-head as used in the thermal matrix printers. Plain paper is used, however, and spots of dye are transferred from the ribbon to the paper when heated. Thermal printers are quiet in operation, but the ribbons are still rather expensive, and the technology would probably benefit from a chance to mature before they become a real force to be reckoned with.

PRINTER FEATURES EXPLAINED

When choosing a printer there are a number of features which we must consider carefully before making a final selection. Inevitably, any choice will involve some form of trade-off between those features which are desirable, those which are essential, and cost.

Paper Width

The paper width quoted in the manufacturer's specification usually relates to the maximum width that can be used in the printer. Some cheaper printers will only operate on a special size of paper (often supplied only in rolls), but most will now accept paper up to about 240 mm wide. This means that standard cut-sheet or narrow fan-fold paper can be used, depending on the type of paper feed fitted (see below), and usually allows up to 80 standard characters to be printed on a line.

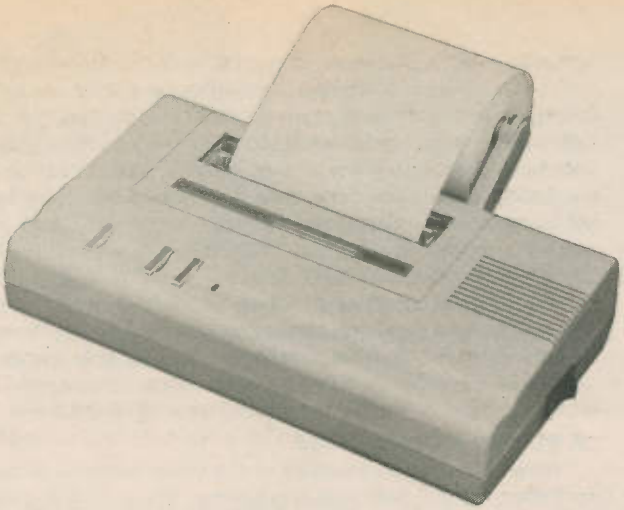
Paper Feed

There are two main types of paper feed in common use, and most printers support one or both types. Friction-feed relies on the same principle as used in typewriters, where the paper is squeezed between two rollers, one of which is driven by a motor. This type of paper feed allows the use of either cut-sheet or roll paper.

Tractor-feed requires the use of paper which has sprocket holes down its edges; the holes are often on perforated strips which can be removed after printing. The sprockets are fed over toothed (tractor) wheels which are driven by the paper feed motor. The separation between the wheels is adjustable, so different widths of paper can be used.

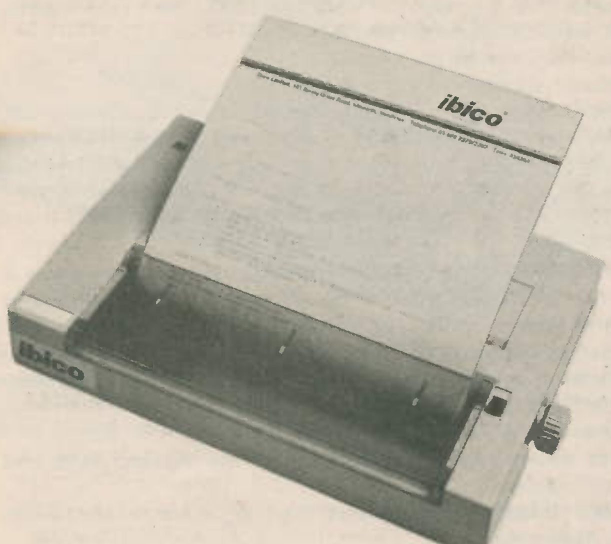
Pin-feed is a variation of tractor-feed, but with either a small or no range of width adjustment. A number of printers with pin-feed also have an optional tractor-feed accessory. If you need to use narrow paper (or sets of labels), it is important to check whether the range of adjusment is adquate for your requirements.

Tractor-feed printers are suitable for many applications, but they do mean that only sprocketed paper can be used.

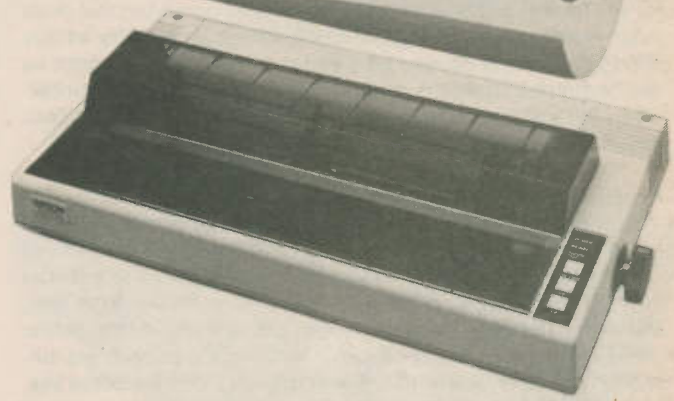


Model: Commodore1520 **Print format**: 4-Colour Broken Line **C.P.S.**: 14 **Interface**: Serial (Commodore) **Paper**: 114mm Continuous Roll **Notes**: Interface available **Price**: £99.99 inc. VAT **Supplier**: Commodore, 1 Hunters Rd., Weldon, Corby, Northampton (0236 5608).

Model: Commodore MPS 801 **Print format**: Dot Matrix **C.P.S.**: 50 **Interface**: Serial (Commodore) **Paper**: 250mm Pin Feed **Notes**: Interface available **Price**: £200 inc. VAT **Supplier**: Commodore, 1 Hunters Rd., Weldon, Corby, Northampton (0236 5608).

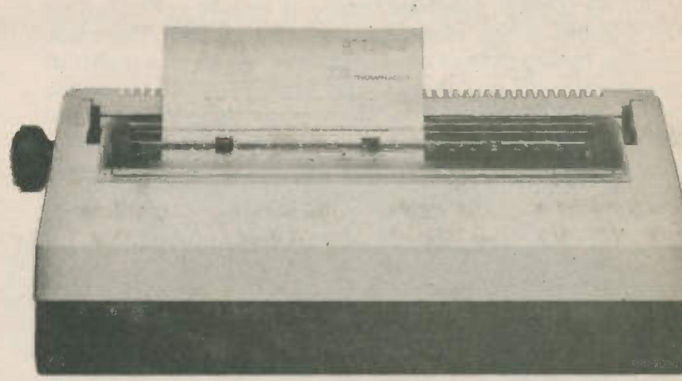


Model: Ibico Mini **Print format**: Daisywheel **C.P.S.**: Not known **Interface**: Centronics **Paper**: Friction **Price**: Not known **Supplier**: Ibico Ltd., 181 Spring Grove Rd., Isleworth, Middlesex (01-568 2379).



Model: Epson FX-100 **Print format**: Dot Matrix **C.P.S.**: 160 **Interface**: Centronics **Paper**: 210mm Friction **Notes**: Serial option **Price**: £569+VAT **Supplier**: Epson, Dorland House, 388 High Rd., Wembley, Middlesex (01-902 8892).

Model: Fastext 80 **Print format**: Daisywheel **C.P.S.**: 80 **Interface**: Centronics **Paper**: Friction **Notes**: Tractor option **Price**: £195+VAT **Supplier**: Smith-Corona, Unit 23, Northfield Ind. Est., Beresford Ave., Wembley, Middlesex (01-900 1222).



Model: TRD 7020 **Print format**: Daisywheel **C.P.S.**: 20 **Interface**: RS232/Centronics **Paper**: 360mm Friction **Notes**: Tractor available **Price**: £375+VAT **Supplier**: Triumph Adler, Jordan House, 47 Brunswick Place, London (01-250 1717).

Print Styles

The range and ease of use of different print styles depends significantly on the type of printer. Changing styles on a daisywheel printer is a simple matter of changing the wheel, but this is not something which can usually be done in the middle of a print run. Mixing print styles with a daisywheel is therefore not usually possible, unless all of the characters are available on the same wheel.

Dot matrix printers normally have a small number of basic fonts (often only one). However, a variety of printing styles for the font(s) provided is usually possible on all but the most basic models. The change of style, in the same way as any change of font, is caused by a series of control codes sent by the computer. There is, unfortunately, little agreement between different manufacturers on the control code sequences used for this purpose.

Proportional Spacing

Proportional spacing is a facility which is available on some printers. Instead of treating each character as if it is of equal width, a proportional spacing facility takes account of the fact that, say, a 'W' is wider than an 'I'. This means that, instead of the gaps between letters being unequal, as usually produced on a computer display, there is a constant gap between adjacent letters. The result is very pleasing to the eye, and is the same as produced by conventional typesetting; the only problem is that few word processors are sophisticated enough to be able to produce both left *and* right margins aligned with such a print style!

Ribbons

Mundane maybe, but daisywheel and impact dot matrix printers all require ribbons in order to be able to operate. These are almost invariably now of the easily changed cartridge variety, and contain either a plastic film or an inked ribbon. The film types are common in daisywheel printers, where the highest quality print is to be expected. Inked ribbon still predominates for dot matrix printers, where they have the advantage of being re-usable (unlike the single-use films), and hence longer lasting.

GRAPHICS

As we mentioned earlier, characters are only one of the two types of potentially printable information which can be manipulated by a computer; the other is graphics. We will now look at some of the facilities which are available for producing graphical output on today's printers.

There are basically two types of graphics printing available, and these tend to complement the low-resolution and high-resolution graphics modes on computers. The first, known as a block graphics facility, is usually controlled by ASCII codes in the range decimal 128 to 192. The block graphics facility defines a set of shapes, based on a matrix of two blocks wide and three blocks high, which fill the space defined for a character. Each block within the matrix is either completely filled or empty. By printing a series of such graphics symbols, it is possible to build up a pictorial output, although it can require a significant amount of programming.

Block graphics is often available on daisywheel printers (although it may require a special wheel), and is offered on a number of other printers. Where a higher resolution facility is available, however, the block graphics facility is frequently omitted and the ASCII codes re-allocated for another purpose, e.g. the italic character set. Such printers also often allow the user to programme his own character set (although it must be said that working out the necessary sequence of control codes for the first time can lead to an acute case of mental indigestion!), and if need be, a block graphics facility can then always be added by the user.

The second type of graphics involves the ability to be able to control the positioning of individual dots from the print-head. With such a capability, the programmer is able to produce any dot pattern he desires. With this type of graphics facility, the number of dots per line and the degree of control are critical to the performance. To achieve true screen images of high resolution displays will typically require a minimum of 640 dots per print line; more if the ability to produce shaded dumps of multi-colour displays is required. For a true high resolution graphics dump, therefore, a minimum of 640 dots, and desirably 960 dots per line are necessary.

A BUYER'S CHECKLIST

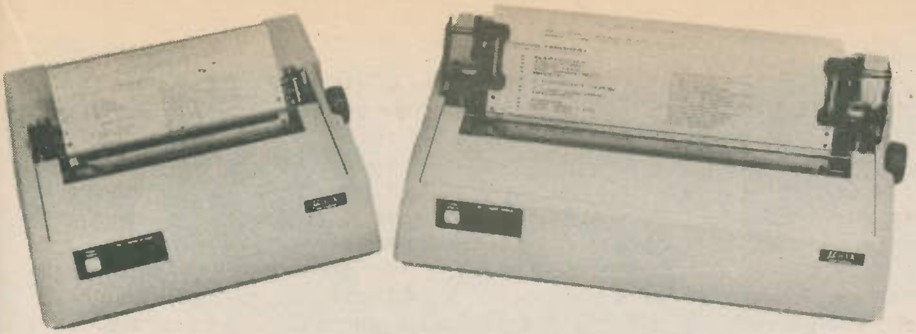
Now that we have looked at the basic features of today's printers, we will conclude this section of our printer guide by suggesting a buyer's checklist. The first step, however, before trying to decide on a printer, is to decide exactly what it is that you want to be able to do with it. Only then are you in a position to start the selection process in earnest. By answering the questions below, you should be able to narrow down your field of choice. Many printers will probably give you more facilities than the minimum that you require, but at least you will have narrowed the field, and cost will then probably also have an effect on your final choice.

Print quality—letter quality, NLQ, or is standard dot matrix quite adequate?
Paper width—wide, standard, or is a non-standard width acceptable?
Paper handling—friction (essential for cut sheet), pin-feed, tractor-feed, or a combination?
Paper—standard or special? If you want to use multi-copy stationery, then either a daisywheel or an impact dot matrix printer is essential.
Graphics—none, block or dot-addressable (matrix only)?
Print styles—more than one font (e.g. italics), number of styles for each font, facility to have user-defined characters, proportional spacing, sub-/super-scripts, underlining?
Interface—serial or parallel?
Speed—the figures quoted in Characters Per Second are always only a guide, but they are useful for comparisons; first ask how important is speed?
Size—will it fit on the bench?
Options/Extras—what is available?
Other—always check that what you expect is provided, e.g. true descenders (tails on g, p, etc.), and bi-directional logic-seeking printing are now usual but are not yet universal features.

EXTRAS

When you have made your choice and set out to buy a printer, it is worth thinking of a few extras which you might add to your shopping list to make life with a printer a little easier, sooner or later.
Interface cable—this is absolutely essential, but not likely to be cheap at around £15.
Paper—easy to forget!
Dust cover—keep the dust out of the moving parts and avoid problems.
Spare ribbons—keep spares; the shop is *always* shut when you need one!
Stand—allows paper to be kept under the printer, saving precious space.
Software—word processors and screen dumps are easy to use, but difficult to write.

PRINTER BUYER'S GUIDE....



Model: X-Data Microline 82A, 83A **Print format**: Dot Matrix **C.P.S.**: 120 **Interface**: Centronics/RS232 **Paper**: 201mm, 308mm Friction **Notes**: Optional Interfaces **Price**: £299+VAT, £489+VAT **Supplier**: X-Data, 750–751 Deal Ave., The Trading Estate, Slough, Berks (0753 72331).

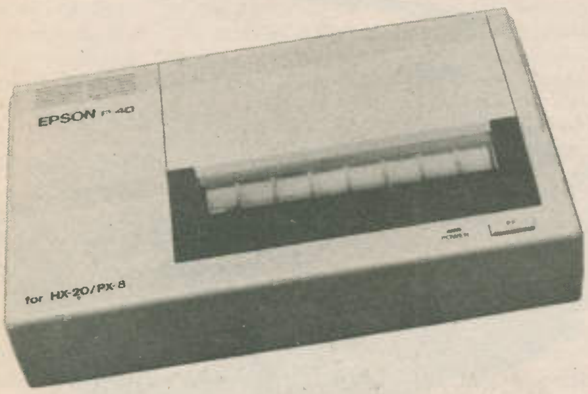
Model: Geveke L32 **Print format**: Dot Matrix **C.P.S.**: 150 **Interface**: Centronics compatible **Paper**: 381mm Friction/Tractor **Notes**: Adjustable tractor **Price**: Not known **Supplier**: Geveke Electronics, Unit 201, Landsbury Est., 102 Lower Guildford Rd., Knaphill, Woking, Surrey (04867 88676).

Model: Silver Reed EXP400 **Print format**: Daisywheel **C.P.S.**: 10 **Interface**: Centronics compatible **Paper**: 300mm Friction **Notes**: Tractor option **Price**: £275+VAT **Supplier**: Silver Reed (UK) Ltd., Silver Seiko House, 19–23 Exchange Rd., Watford, Herts (0923 35616).

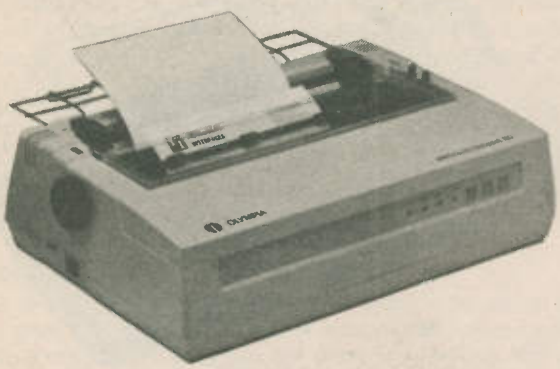
Model: Riteman Plus **Print format**: Dot Matrix **C.P.S.**: 120 **Interface**: Centronics **Paper**: 300mm Friction **Notes**: Tractor option **Price**: £249+VAT **Supplier**: Micro Peripherals, 69 The Street, Basing, Basingstoke, Hants (0256 473232).

Model: Aculab 1200DL **Print format**: Daisywheel **C.P.S.**: 25 **Interface**: Centronics/RS232 **Paper**: 103mm Friction **Notes**: Letter-guide option **Price**: £495+VAT **Supplier**: Aculab, Unit A, Station Approach, Leighton Buzzard, Beds (0525 371 393).

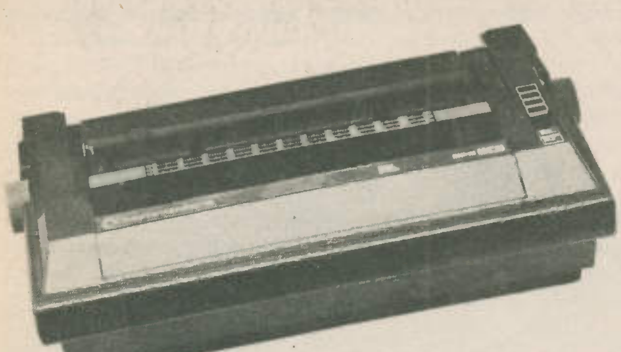
Model: Datafax SCP 800 **Print format**: Colour Pen **C.P.S.**: 6–12 **Interface**: Centronics **Paper**: 220mm Pin feed **Notes**: 4-colour plotter **Price**: £199+VAT **Supplier**: Datafax House, Bounty Rd., Basingstoke (0256 64187).



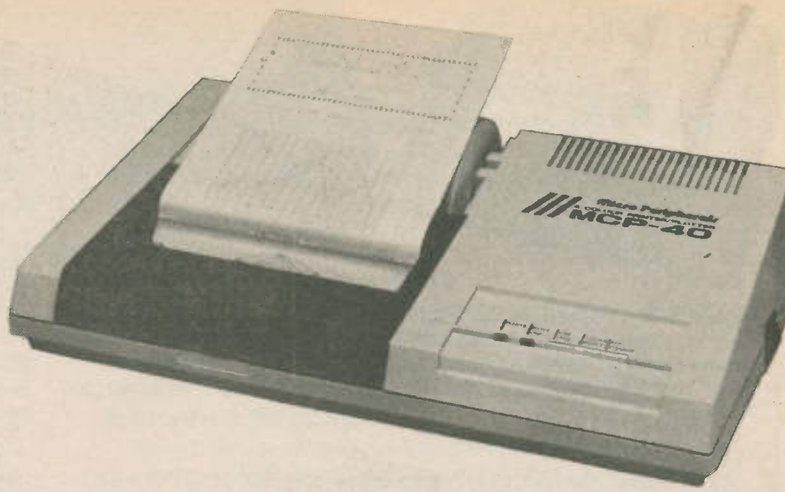
Model: Epson P-40 **Print format**: Thermal **C.P.S.**: 45 **Interface**: Serial/Parallel **Paper**: 250mm Thermal/Friction **Notes**: Bit-image Graphics **Price**: £95+VAT **Supplier**: Epson (UK) Ltd., Dorland House, 388 High Rd., Wembley, Middlesex (01-902 8892)



Model: Electronic Compact RO **Print format**: Daisywheel **C.P.S.**: 14 **Interface**: RS232/Centronics **Paper**: 305mm Friction/Tractor **Notes**: Software available **Price**: £399+VAT **Supplier**: Intelligent Interfaces, 436 Wood St., Stratford-upon-Avon, Warwickshire (0789 296879).

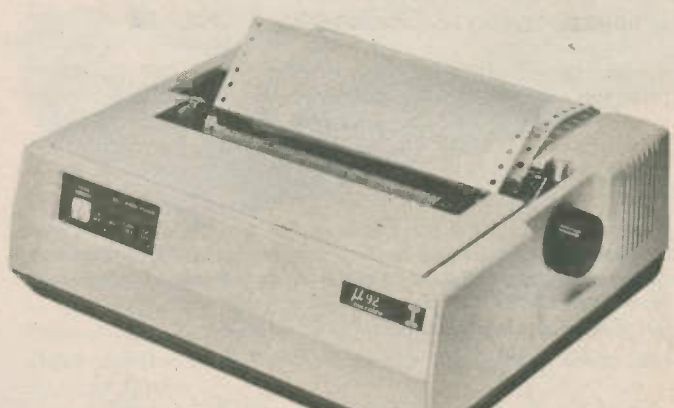


Model: Commodore DPS 1101 **Print format**: Daisywheel **C.P.S.**: 18 **Interface**: Serial (Commodore) **Paper**: 303mm Friction **Notes**: Interface option **Price**: £399 inc. VAT **Supplier**: Commodore, 1 Hunters Rd., Weldon, Corby, Northampton (0536 205252).



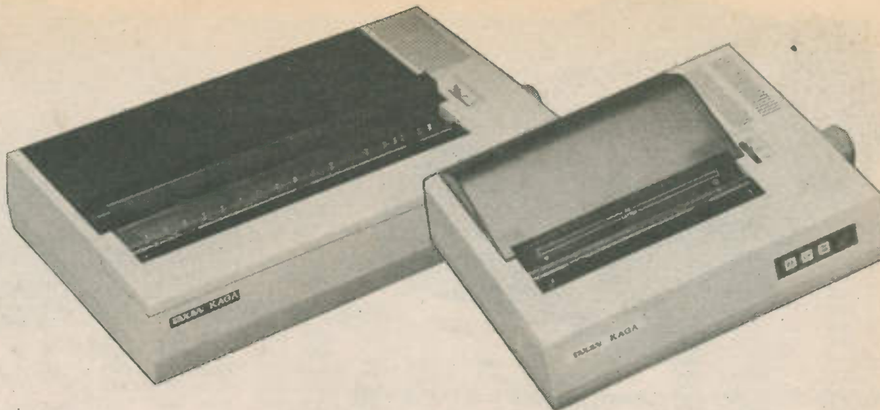
Model: Micro Peripherals CPP 40 **Print format**: Pens **C.P.S.**: 12 **Interface**: Centronics **Paper**: 115mm Friction **Notes**: MCP 40 Illustrated **Price**: £99+VAT **Supplier**: Micro Peripherals, 69 The Street, Basing, Basingstoke, Hants (0256 473232).

Model: Smith-Corona D100 **Print format**: Dot Matrix **C.P.S.**: 120 **Interface**: Centronics **Paper**: 270mm Tractor **Notes**: Friction option **Price**: £249+VAT **Supplier**: Smith-Corona, Unit 23, Northfield Ind Est., Beresford Ave., Wembley, Middlesex (01-900 1222).



Model: X-Data Microline 92 **Print format**: Dot Matrix **C.P..S.**: 160 **Interface**: Centronics **Paper**: 240mm Tractor/Friction **Notes**: Various interfaces and feeds **Price**: £429+VAT **Supplier**: X-Data, 750–751 Deal Ave., The Trading Estate, Slough, Berks (0753 72331).

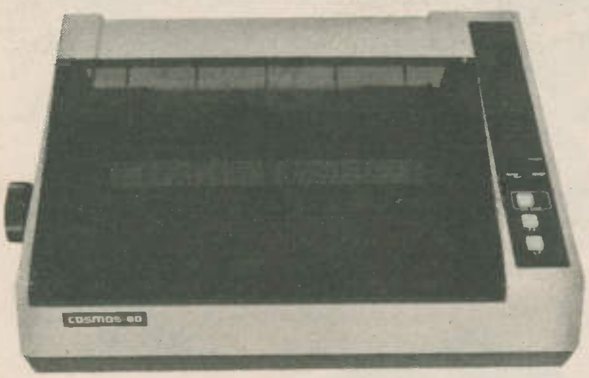
PRINTER BUYER'S GUIDE....



Model: Taxan Kaga KP 810, 910 **Print format**: Daisywheel **C.P.S.**: 140 **Interface**: Centronics **Paper**: 240mm Friction **Notes**: Serial option **Price**: £319, £399+VAT **Supplier**: Data Efficiency, Finway Rd., Hemel Hempstead, Herts (0869 253361).

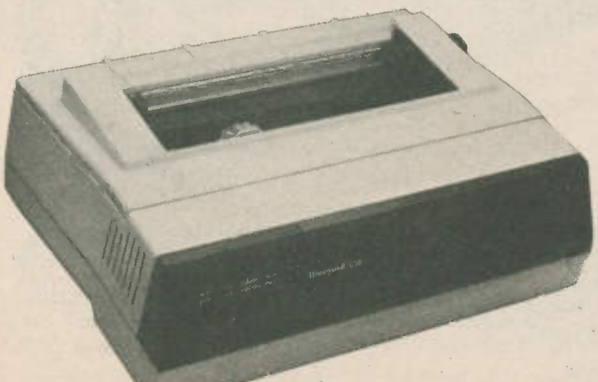
Model: Diablo 620 API **Print format**: Daisywheel **C.P.S.**: 20 **Interface**: RS232/Centronics **Paper**: 309mm Friction **Notes**: Tractor option **Price**: Not known **Supplier**: Geveke Electronics, Landsbury Est., 102 Lower Guildford Rd., Knaphill, Woking, Surrey (04867 88676).

Model: Silver Reed EXP500 **Print format**: Daisywheel **C.P.S.**: 16 **Interface**: Centronics/RS232 **Paper**: 330mm Friction **Notes**: Tractor option **Price**: £329+VAT **Supplier**: Silver Reed (UK) Ltd., Silver Seiko House, 19–23 Exchange Rd., Watford, Herts (0923 35616).

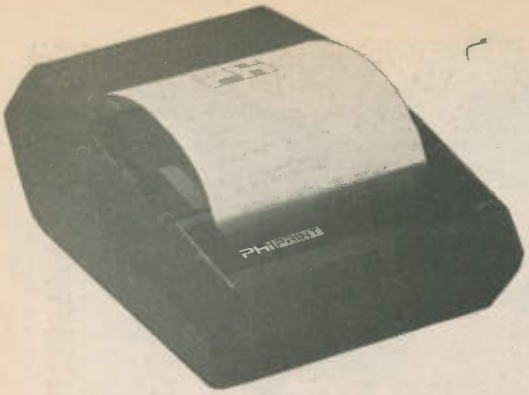


Model: Comos 80 **Print format**: Dot Matrix **C.P.S.**: 80 **Interface**: Centronics **Paper**: Friction/Tractor **Notes**: Serial option **Price**: £199+VAT **Supplier**: Quad Eight/Westrex, Unit 1, Fairway Drive, Greenford, Middlesex (01-578 0957).

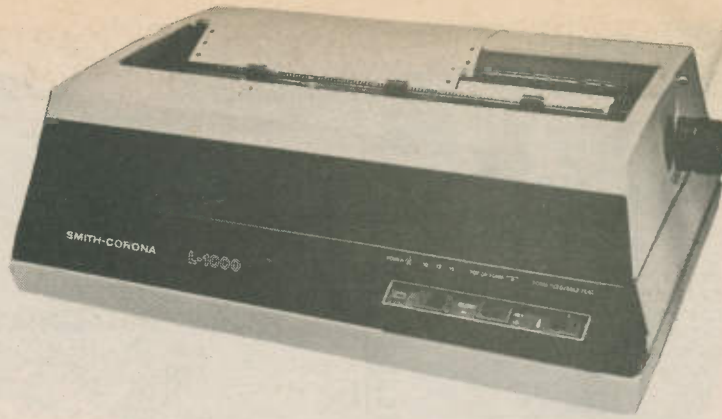
Model: Epson FX80 **Print format**: Dot Matrix **C.P.S.**: 160 **Interface**: Centronics **Paper**: 210mm Friction **Notes**: Serial option **Price**: Not known **Supplier**: Epson (UK) Lt., Dorland House, 388 High Rd., Wembley, Middlesex (01-902 8892).



Model: Honeywell L38 **Print format**: Dot Matrix **C.P.S.**: 400 **Interface**: Centronics Compatible **Paper**: 381mm Tractor **Notes**: Adjustable tractor **Price**: £438+VAT **Supplier**: Geveke Electronics, Landsbury Ind. Est., 102 Lower Guildford Rd., Knaphill, Surrey (04867 88676).

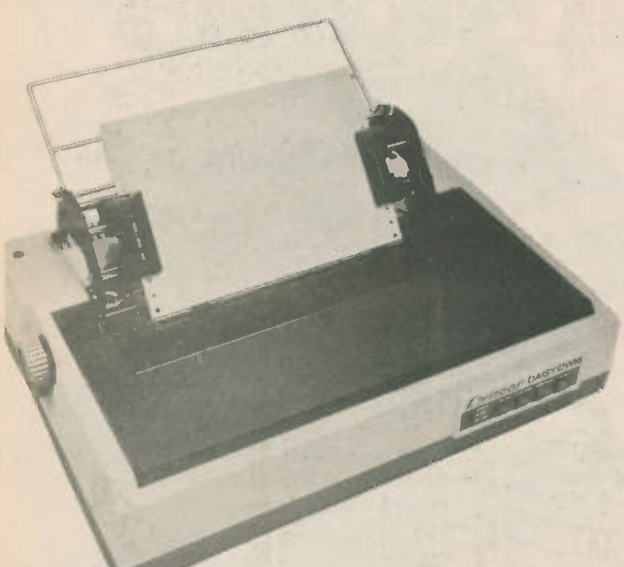


Model: PhiPrint **Print format**: Thermal Dot **C.P.S.**: 20 **Interface**: Centronics **Paper**: 112mm Thermal **Notes**: Bit-image graphics **Price**: Not known **Supplier**: Phi Mag Systems Ltd., Trigoniggie Ind. Est., Falmouth, Cornwall (0326 76060).

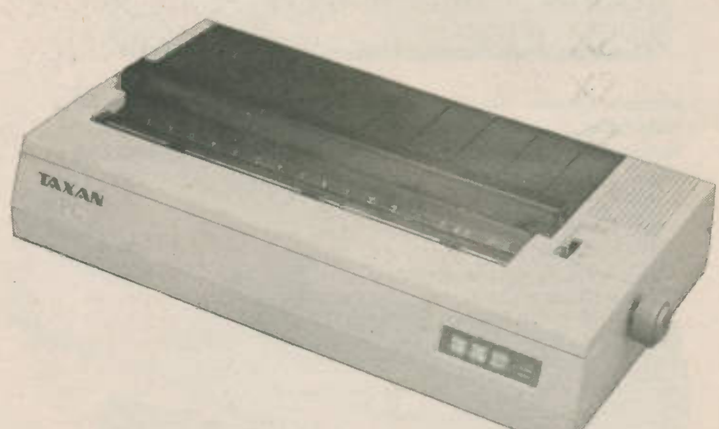


Model: Smith-Corona L1000 **Print format**: Daisywheel **C.P.S.**: 12 **Interface**: Centronics/Serial **Paper**: 330mm Friction **Notes**: Tractor option **Price**: £260+VAT **Supplier**: Smith-Corona, Unit 23, Northfield Ind. Est., Wembley, Middlesex (01-900 1222).

Model: X-Data Microline 84 **Print format**: Dot Matrix **C.P.S.**: 200 **Interface**: Centronics **Paper**: 308mm Friction **Notes**: Serial interface option **Price**: £489+VAT **Supplier**: X-Data, 750–751 Deal Ave., The Trading Estate, Slough, Berks (0753 72331).



Model: X-Data DW16 **Print format**: Daisywheel **C.P.S.**: 16 **Interface**: Parallel/Serial **Paper**: 300mm Friction **Notes**: Tractor option **Price**: £329+VAT **Supplier**: X-Data, 750–751 Deal Ave., The Trading Estate, Slough, Berks (0753 72331).



Model: Taxan KP 910PC **Print format**: Dot Matrix **C.P.S.**: 140 **Interface**: Centronics **Paper**: 390mm Friction/Tractor **Notes**: Various types **Price**: £499+VAT **Supplier**: Data Efficiency, Finway Rd., Hemel Hempstead, Herts (0442 60155).

MARCO TRADING

LINEAR I.C.s

CA3011	1.80
CA3012	1.75
CA3014	2.38
CA3018	1.10
CA3020	2.10
CA3028A	1.30
CA3035	2.55
CA3080E	1.80
CA3085	1.20
CA3086	0.68
CA3090AQ	5.00
CA3130E	1.40
CA3140E	0.60
HA1336W	3.15
LM324N	0.55
LM339	0.65
LM348	0.90
LM380	1.65
LM381N	1.45
LM382N	1.45
LM386	0.99
LM387	1.45
LM389N	1.20
LM3914N	2.55
LM3915N	2.60
ML232B	2.10
555	0.35
C-mos555	0.88
741	0.25
SAS560S	1.85
SAS570S	1.85
SL901B	5.20
SL917B	6.25
TA7205AP	1.50
TA7222P	2.12
TDA1004	2.90
TLO72	0.98
TLO81	0.68
TLO84	1.28

RESISTOR KITS

¼W Pack 10 each value E12 10R-1M
Total: 610 resistors — ONLY 4.80
¼W Pack 5 each value E12 10R-1M
Total: 305 resistors — ONLY 2.75
½W Pack 10 each value E12 2R2-2M2
Total: 730 resistors — ONLY 5.25
½W Pack 5 each value E12 2R2-2M2
Total: 365 resistors — ONLY 3.50

SOLDERING AIDS

Antex 15W iron	5.00
Antex 18W iron	5.00
Antex 25W iron	5.20
Antex Elements	2.00
Antex Bits	0.95
Antex stands	1.90
Desolder Tool	4.50
Spare nozzle	0.45
25W Kit-iron with 13A plug & stand	ONLY 6.20

NI-CAD CHARGER

Universal charger to charge PP3, AA, C, D — PRICE 6.00

NI-CADS

PP3	4-45, 4	16.00
AA	0-95, 10	8.00
HPII	2-30, 4	8.50
C	2-35, 4	8.75

CHART RECORDERS

Brand new 3 channel pen recorders complete with charts spares kit. Full spec. upon request – Once only bargain £40 + £10 p&p plus 15% VAT.

TELECOM EQUIP

BT Plug & 3M lead	1.25
BT MASTER SOCKET	2.85
BT Sec Skt	1.95
BT 4-core cable 1M	0.15
100M	12.00

ROTARY POTS

0.25W Carbon Log & Lin 1K-2M2 each 0.32
10 3.00
Any 100 28.00

VEROBOARD

2½ × 3¼	0.85
2½ × 5	1.00
2½ × 17	3.07
3¼ × 17	1.05
3¼ × 5	1.15
3¾ × 17	4.10
4¾ × 17¾	4.95
Pkt of 100 pins	0.30
Spt face cutter	1.48
Pin insert tool	1.85
Vero Wiring Pen & Spool	4.50
Dip Board	3.85
Vero Strip	1.25

MULTI METER SPECIAL

Requires AA cells (not supplied) and leads, etc.
Russian Type A U4324 — 20,000 D.P.V.
D.C. Voltage: 0.6, 1.2, 3, 12, 30, 60, 120, 600, 1200;
A.C. Voltage: 3.6, 15, 60, 150, 300, 600, 900;
D.C. Intensity M/A: 0.06, 0.6, 6, 60, 600, 3000;
A.C. Intensity M/A: 0.3, 3, 30, 300, 3000;
D.C. Resistance: 0.2, 5, 50, 500, 5000 kOhm;
g.e. level dB: −10 to +12.

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BF195	0.10	2N3055	0.45
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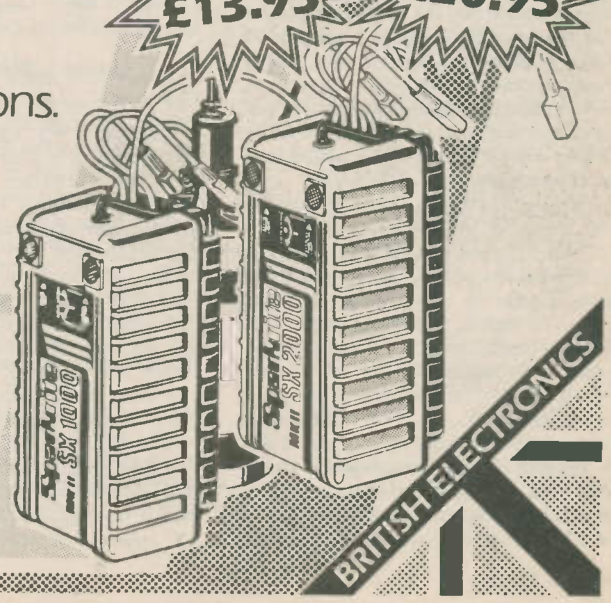

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BBC Micro Forum...

David Whitfield MA MSc CEng MIEE

THIS MONTH, in *BBC Forum,* we are looking at how to build an 8-line driver for the user port. The interface described will allow you to drive a range of external hardware (such as relays and lamps, etc.), and will also serve as a useful buffer between your micro and the outside world. Then, if anything does go wrong, it is an external interface in need of repair, rather than a micro which requires return to a service centre for attention.

As mentioned last month it is our intention in these pages to look at the hardware behind the port, so that the why and the how of the interfacing techniques become a little clearer. We will begin, therefore, with a look at the user port. To do this, however, an introduction to the system as a whole is necessary.

INSIDE THE BBC MICRO

What goes on inside the BBC Micro is often a complete mystery to many owners. Indeed, the fear of an invalidated warranty often prevents even the lid being taken off for inspection. On the other hand an engineer has been described as someone whose first action with a new 'toy' is to dismantle it. Most owners fall somewhere between these two extremes, although your scribe tends towards the latter extreme. If you venture inside the case, however, the view is of a keyboard, power supply, and a large double-sided printed circuit board, and you may be left little the wiser. The problem here is the traditional one of not being able to discern the wood for the trees. The components may be familiar, if only by repute, but what do they all do?

In simple equipment, the usual approach is to try to work out the design by seeing what everything is connected to, but this seems rather inappropriate in this case. Anyone trying this with anything as complex as a micro is assured of hours of entertainment, but may be left little the wiser if the exercise is undertaken without at least a few hints and pointers.

Fig. 1 shows the overall block schematic for the BBC Micro. We shall be referring back to parts of this complete picture many times in the future when we look at the various interface ports, but for the moment the drawing is presented in its entirety to serve as a reference. Rather than attempt to describe the system's configuration in one month, we will confine ourselves to looking at any new area as we meet it, month by month. For readers who wish to look further into the design of the micro, there are now many good books available, and we shall be including brief reviews of a selection of useful books in future columns. For the moment our concern is with the user port, so let us look a little closer at what lies behind the port.

THE USER PORT

The hardware in the BBC Micro is memory mapped, which means that the registers in the hardware devices (i.e. in the interface hardware inside the computer) appear as addresses in the main memory. It also means that the registers may be set-up/read-back using ordinary CPU write/read instructions. There are in fact 3 pages of addresses which have been reserved for memory mapped hardware operations; a page is 256 bytes of memory, starting at an address which is a multiple of 256. The addresses from &FEOO to &FEFF (page &FE) are reserved specially for the system hardware. This page of memory has been given the name 'SHEILA', while two other pages (&FC = 'FRED' and &FD = 'JIM') have been reserved for use with the 1MHz bus. Be assured that these names are not misprints! The 256 addresses within Sheila are allocated as shown in Table 1.

Address (Hex)	Description
FE00–07	Video controller
FE08–0F	Serial controller
FE10–1F	Serial ULA
FE20–2F	Video ULA
FE30–3F	Paged ROM selector
FE40–5F	System VIA
FE60–7F	User VIA
FE80–9F	Floppy disc controller
FEA0–BF	ECONET controller
FEC0–DF	A-to-D converter
FEE0–FF	Tube interface

Table 1. Sheila addresses

Looking at Fig. 1 and Table 1, we see that the user port is connected to the user VIA (Versatile Interface Adaptor), which is allocated addresses FE60–FE7F. This VIA has two sections (A and B) which are used for the printer and user ports, respectively. As shown last month, all of the port B lines (i.e. PB0–PB7 and CB1/2) appear on the user port connector (on even-numbered pins 6–20 and 2/4, respectively). The circuit behind the connector (see p. 503 of the User Guide) shows that there are *direct* connections from the VIA pins to the user port's connector.

The 6522 is a 40-pin pack which contains two 8-bit programmable bidirectional ports (A and B), two 16-bit programmable timer/counters, a serial-parallel shift register and latched I/O registers. It must be said that the VIA is an extremely complex device, *but* its basic features are really quite easy to use for most applications. Let us have a look therefore at some of the VIA's basic features to see how they can be used.

The 8 lines in the B port can be individually programmed as inputs or outputs using the Data Direction Register (DDRB). When the VIA is reset (as when the BREAK key is pressed, for example), all of the lines are programmed as inputs. Table 2 shows that DDRB is VIA register 2, which appears as address &FE62 (i.e. &FE60 + register number). Setting a bit to a 0 in DDRB configures the corresponding I/O line as an input, while a 1 makes it an output. Thus, for example, writing &F0 to DDRB will set PB7–4 as outputs and PB3–0 as inputs. Each time a new byte is written to DDRB, it overwrites the previous settings.

Address (Hex)	Register Number	Designation
FE60	0	ORB/IRB
FE61	1	ORA/IRA
FE62	2	DDRB
FE63	3	DDRA
FE64	4	T1C–L
FE65	5	T1C–H
FE66	6	T1L–L
FE67	7	T1L–H
FE68	8	T2C–L
FE69	9	T2C–H
FE6A	10	SR
FE6B	11	ACR
FE6C	12	PCR
FE6D	13	IFR
FE7E	14	IER
FE7F	15	ORA/IRA

Table 2. User VIA Registers

The data lines which have been configured as outputs may be set high or low by writing 1 or 0, respectively, to the output/input register ORB/IRB at address &FE60. Writing a value to a line configured as an input will have no effect. Sensing the state of a line configured as an input is accomplished by reading from &FE60. So much for how to control the PB0–PB7 data lines, but how can we use them as outputs to drive real loads?

8-LINE DRIVER

The I/O lines on the B port are capable of sourcing up to 1mA at 1·5 volts in output mode, while in the low state they can sink up to one standard TTL load of 1·6mA at 0·4 volts. This is not enough to drive the majority of 'real-life' loads, but it does allow the

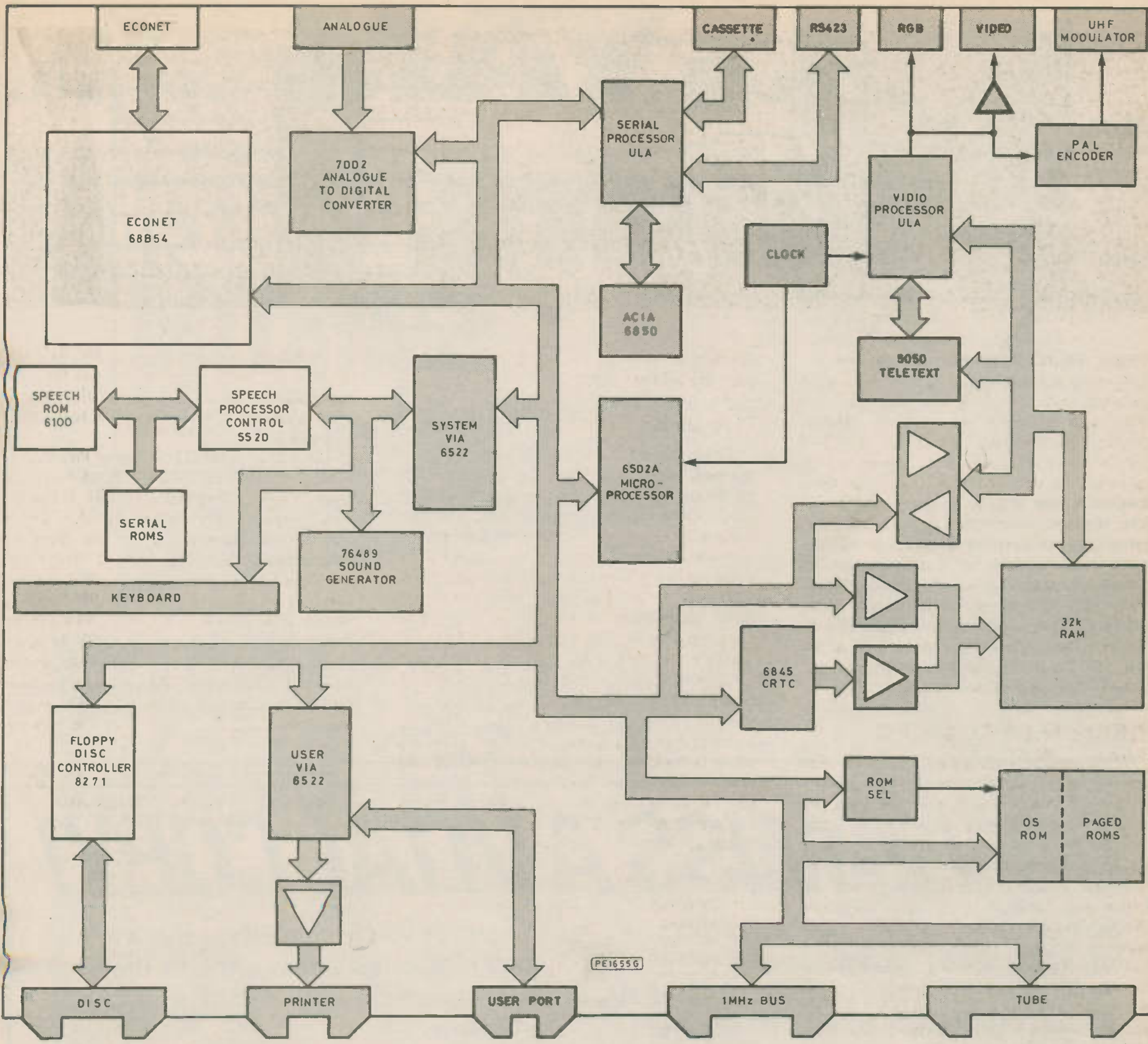

Fig. 1. System block diagram

PB0–PB7 to drive Darlington transistor circuits directly. A Darlington driver then allows loads requiring much heavier currents to be switched on and off, and provides a useful safety barrier between the loads and the VIA.

Fig. 2 shows a high current Darlington output driver arrangement. An octal driver of this type is shown in Fig. 3 connected to eight l.e.d.s, which are acting as loads and indicate the state of the output lines. The driver i.c. comes in an 18-pin package, and is type ULN2803A, available from 'RS Components' as part number 303–422. In this arrangement a logic 1 at the input of a driver will illuminate the corresponding diode. Each of the eight drivers is an open collector stage which has a maximum operating voltage of 50V, and will sink up to 500mA. The stages all incorporate diodes to protect them when switching inductive loads, and more than one stage may be paralleled to increase the output sink current. In a practical application, the l.e.d.s can be replaced by relay coils, lamps, or another type of load. The l.e.d.s are shown connected between the driver output and the +5V supply, but any other supply (up to the maximum) can be used, as shown in Fig. 2.

The prototype 8-line driver unit was built on a small piece of veroboard. A piece of 20-way ribbon cable with a 20-way IDC socket at the computer end (RS 469–881, 467–289, or equivalent) was used for the connection between the computer and the unit. Pin 1 at the computer's connector is indicated by a small triangular symbol on the case. At the board end in the prototype a second IDC socket/plug pair was used, but the wires may just as easily be soldered directly to the vero tracks. The exact constructional details are not critical, and will depend very much on the load arrangement you wish to drive.

The adjacent listing is a simple test program which sets up the user port, and then causes the eight l.e.d.s to count continuously in binary from 0 to 255. Exit from the program by pressing ESCAPE. As we shall see next

```
10  REM User Port Test
20  REM **************
30  REM
40  REM Produces a
50  REM binary count
60  REM on PB0—>PB7.
70  REM
90  REM Initialise to
90  REM all O/Ps and
100 REM reset time.
110 REM
120 ?(&FE62)=&FF
130 TIME=0
140 REPEAT
150 Count=TIME DIV 100
160 ?(&FE60)=Count MOD256
170 UNTIL FALSE
180 END
```

Listing for Test Program

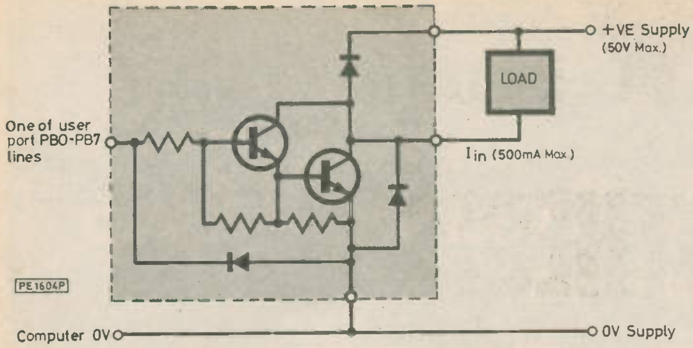

Fig. 2. Darlington driver

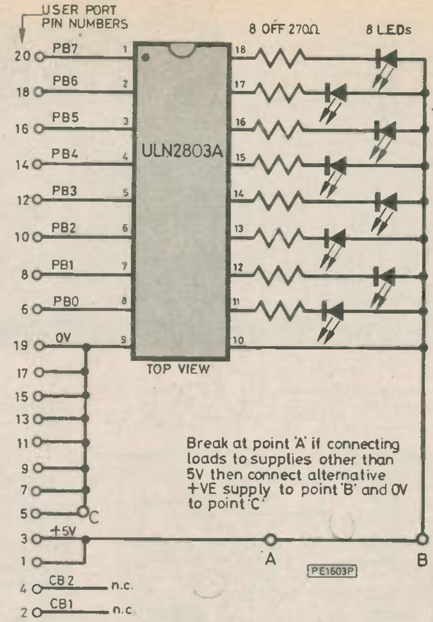

Fig. 3. 8-line output driver

month, this type of direct programming of the hardware is not the only way to control the system's hardware (and is certainly not the recommended method for compatibility with 2nd processors, etc.), but it is a simple and effective demonstration (after all this is not a software column!). A reminder in passing is that, at start-up, PB0–7 are configured as inputs, and the driver behaves as if these are outputs set to logic 1, so beware that the loads will all be on! The driver described next month will overcome this problem.

FINALLY

It is now over to you to develop some practical applications for this unit. Your scribe's test project involved some flashing lights for the festive season, but the range of applications for this simple interface is enormous.

NEXT MONTH

We have looked at how to connect the computer to the outside world. Next month we look at a more sophisticated interface, and then move on to connecting inputs to the micro.

THE LEADING EDGE

BLACK WATCH ON WHEELS?

What surprises me about the Sinclair car, or more accurately pedal-powered side-car with battery on board, is how no-one seems to have done the obvious and simple sums. It brings to mind one of Sir Clive Sinclair's past disasters, the 'Black Watch'. People who bought construction kits found the component parts too large to fit into the housing.

No launch in history can ever have been so widely leaked as the Sinclair vehicle. But even after the launch, at which a very nervous Sir Clive corrected the press, people were still reporting that the drive motor is a modified Hoover washing machine motor.

It is *not*. It is a 12V d.c. brush motor made by Polymotor, an Italian subsidiary of Philips. This motor uses ceramic permanent magnets, a 2-pole commutator and a pair of brushes.

To comply with the Government 1983 regulations for electrically or assisted cycles, which allow untaxed, uninsured, untrained, unbelted, unhelmeted, 14 years olds or disqualified drivers to drive and park with impunity, the onboard motor must have a maximum power consumption of 250 watts.

The Polymotor drive has a maximum free running speed of 4100 rpm; the 250W rating is for continous running at 3300rpm. This is geared down in two stages (epicyclic and belt) by a ratio of 13:1. Obviously this is necessary to increase torque.

The front brake is a bicycle calliper and the rear brake is a drum. There is no attempt at recharging the battery with regenerative braking. So all inertial energy is lost as heat when the brakes are applied.

For no-load 250W running, the motor is drawing just over 20 amps from a 12 volt battery. When the motor starts to work, for instance over grassy ground or up a slight incline, the current drain increases to 80 or 90 amps.

When the motor is labouring, it gets slower and slower with increasing torque until there is maximum torque at stall speed. At this point 140 amps are running through the windings.

Obviously this would very soon burn out the motor and drain the battery, probably buckling the plates. So the Sinclair vehicle has a chip which integrates current and time whenever the battery is connected.

At stand still with 140A drain, this circuit trips a relay after around 4 seconds. At 80 or 90A consumption it trips in two or three minutes. At high running speed, with minimal load, there is no need for tripping. Warning lights tell the driver to "get pedalling" as an early warning before switching the relay.

Because the vehicle body and component parts are moulded from plastics, which will melt and might even burn if there is serious overheating, there are two back up systems for the control chip. The first back up is a temperature sensitive thermistor mounted in a probe inside the motor housing. The second back-up is a primitive bimetallic strip on the housing.

PEDAL POWER

The battery is a 35 ampere hour lead acid unit. This is around the size of a car battery. The press and media have talked about 20 or 24 miles per charge. Sinclair's own publicity material puts the range for a single battery charge at "up to 20 miles" and promises "one thousand miles running for the average price of a gallon of petrol".

Although strictly true these claims are very misleading and are bound to be misreported by the popular media. There is no way in the world that a 35 ampere battery can run the vehicle over average terrain for 20 miles on a single charge, unless the driver is doing most of the work with pedals. Without pedalling, and with starts, stops and slopes without regenerative braking, the driver will be lucky to get more than a few miles.

Sinclair might just as well have claimed 200 or 2000 miles per charge, for all the sense the 20 mile claim makes. With almost 100 per cent pedalling, the battery could stay charged for hundreds of miles.

Is this a joke? someone said to me at the press conference. Someone else had a wonderful idea. Summer holiday camps should buy a fleet of these vehicles, keep them permanently on charge and let campers drive them round the safe private roads and pathways, like dodgem funfair cars.

A nice idea, but by no means what Sir Clive Sinclair has in mind. He says he stands to lose around £7 or £8 million of his own money. Personally I should think that loss is a guaranteed certainty.

VIDEO CHANGE

Watch out for a major change in policy from Philips over LaserVision. The company is now going to stop trying to flog a dead horse and sell its videodisc system as a dumb carrier for feature films.

If videodisc had come on the market before video tape, everyone would have raved about the clear pictures, clean sound and convenience of use. They would have bought a videodisc player first and then bought a video tape recorder when they later became available.

But because videodisc came late on the market there was already a large park of video recorders in people's homes. Libraries by then were renting feature films on prerecorded video tape. Not surprisingly only a very few people were prepared to buy videodisc instead of, or as well as, video tape.

Foolishly RCA and Hitachi tried launching their technically primitive, grooved capacitance disc system, CED. Predictably it failed commercially.

Wisely Thorn EMI decided not to launch JVC's VHD grooveless capacitance disc system on the domestic market. Instead Thorn invested money in producing interactive programmes, so that industry and education could use VHD players under computer control with interactive programmes. But still Philips spent a fortune trying to persuade the public to watch films on optical videodisc.

In 1984 Philips cut player prices to less than half the original 1982 launch price of £500. Because film companies didn't think it was worth issuing and distributing programmes on videodisc for the few people buying players, Philips cooked up a convoluted subsidy system.

The film company pays Philips' disc pressing plant in Blackburn to press discs. Philips then buys the discs from the film company and tries to sell them to the public through trade dealers. In return for making programmes available, the film companies get guaranteed payment and Philips shoulders the burden of selling the unsaleable mountains of discs.

In July 1984 Philips claimed that LaserVision sales were "double" those for the corresponding period for 1983 and that disc purchases had "greatly increased". But the company would not say double what or quantify the great increase!

Now the Philips headquarters in Eindhoven has taken a hand. It has sold a large quantity of players to China, which uses the same PAL TV system as Britain, and has cancelled a domestic launch in France.

Philips subsidiaries in Britain, Germany, Holland, Austria and Switzerland, where LaserVision is already on sale, have been told that they must adopt a completely new strategy. Instead of pushing the system for feature films, they must spend money on developing its potential for interactive video, and at the same time try to sell to specialist markets. This is exactly what Thorn EMI has been doing all along.

Philips in Britain has struck a deal with the BBC, whereby Philips puts up £0·5 million to help the BBC produce a modern version of the Doomesday Book on videodisc. Philips has also mailed out 90,000 direct advertisements to opera and ballet lovers, using the subscription lists from Covent Garden, Glyndebourne and the National Opera, offering them performances on disc at around £20 a time.

Now Philips is looking at other specialist groups, like fishermen, naturalists, sports enthusiasts and car buffs. Although Philips says bravely that some feature films will still be issued, it's clear that this market is being phased out.

The specialist ploy could well work. The only puzzle is why Philips spent so long and so much money flogging what was so obviously the dead horse of feature film release.

BARRY FOX

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"Rugby" Controlled Clock

PART 1 · Stephen Ibbs

THE National Physical Laboratory at Teddington in Middlesex contains one of the master time standards that exist around the world, others being in Germany, Canada, U.S.A., etc. These are maintained and referenced to each other so that all precision timings can be related to a known constant. The actual definition of the SI unit of time, the second, was decided in 1967 at the 13th General Conference of Weights and Measures as: "the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Caesium 133 atom" . . . out goes Big Ben!!

The 1Hz signal derived from the standard is transmitted as a radio signal from Rugby, and is coded by interrupting the carrier wave with 100 or 200ms breaks to indicate a binary 0 or 1, the binary code containing information about the time, date, year, etc. The code is transmitted during each cycle of 1 minute, and becomes correct at the following 60th or 0 second, when the same information is sent again as a fast code on second 0. Originally, only the fast code was sent, with carrier interruptions only marking the start of each second, but the introduction of the slow code has enabled decoders to be designed with relative ease.

The time transmitted is UK CIVIL TIME, i.e. changing automatically for GMT and BST, and each minute contains the following information: minute, hour, day, date,. month, year. In addition, data about GMT/BST indication, parity checks, etc., are sent by continuing some carrier breaks for an extra 100ms and seconds 1–16 transmit data about Universal time as obtained from the Caesium standard, and the time obtained from the earth's rotation.

Because the earth's rotation is not exactly uniform, the time obtained by these two forms of measurement varies, and the difference is transmitted as double carrier breaks, the number of seconds affected being multiples of 0·1 secs. in difference. Double breaks of seconds 1 and following show a positive difference . . . i.e., earth's rotational time is ahead of Universal time, and double breaks from seconds 9 and following show a negative difference. When either exceeds 0·8 secs., a 'leap' second is inserted or deleted at the 16th second during June or December. This happens every few years and readers may remember such an occurrence a short time ago. At the time of writing, the earth's rotational count is 0·1 sec. ahead of Universal time, indicated by one double break at the 1st sec. If the Rugby transmitter requires maintenance, this is scheduled for a few hours on the first Tuesday of the month.

This project will show how you can decode the time pips to produce a digital display of the date, hours, minutes and seconds. Further options will show how you can obtain the day information as well. It has been deliberately kept quite simple; consequently it will not be able to tell valid from invalid data, e.g., caused by radio interference, and it will obviously not display the correct time when 'Rugby' is off the air for maintenance. However, it will always reset itself as soon as it has received correct data. Green and yellow 7-segment displays have been used, and with a 'G' range Vero case, the result is a very smart and accurate clock that will baffle people because it has no setting buttons!

CIRCUIT DESCRIPTION

The circuit (Fig. 1) for this receiver was designed by John Robinson, to whom many thanks are extended for permission to publish it here. It should be stated at the outset that if readers have not had any experience of building an RF project, they might find some of the construction details a little awkward. For this reason the decoder has been designed to accept a receiver kit that can be purchased from 'Cirkit' and built without special test equipment.

This design is not difficult to build and align if an oscilloscope is available. L1, C1 and C3 form a resonant circuit, tuned by C3 to 60kHz, the frequency of the Rugby transmission. Pin 11 and 10 of IC1e are joined together and, being an inverter gate, the only stable state it can maintain is exactly $\frac{1}{2}$ supply voltage. Thus it acts as a very stiff bias source for pin 9 of IC1d, L1 providing the d.c. path. This causes IC1d to perform within its linear region, acting as an

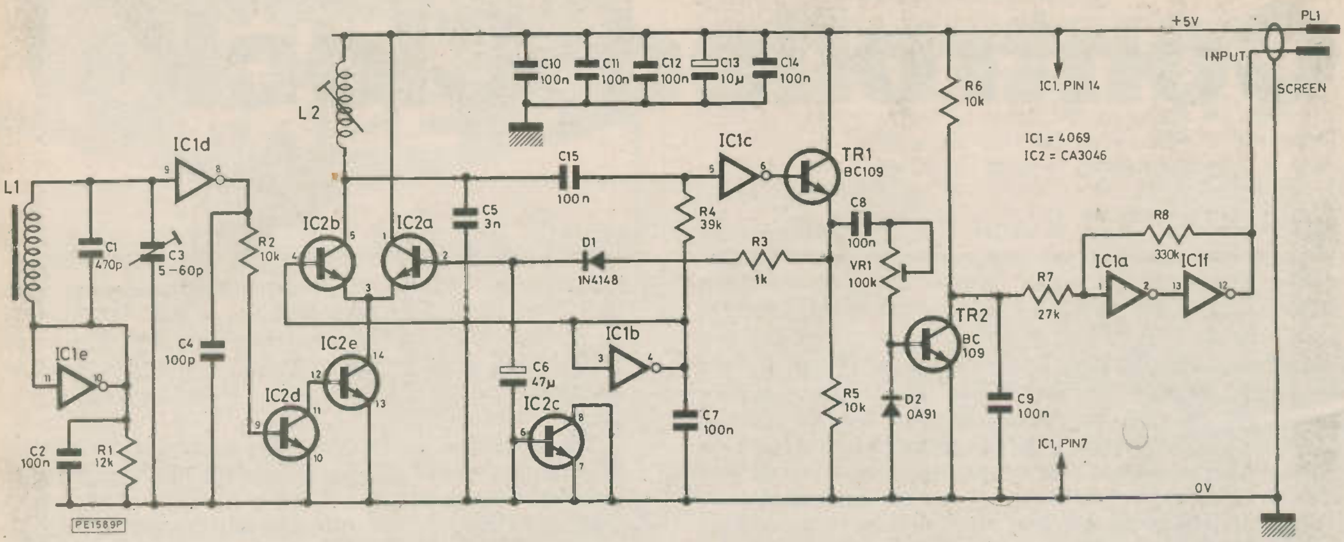


Fig. 1. Circuit diagram of the Receiver

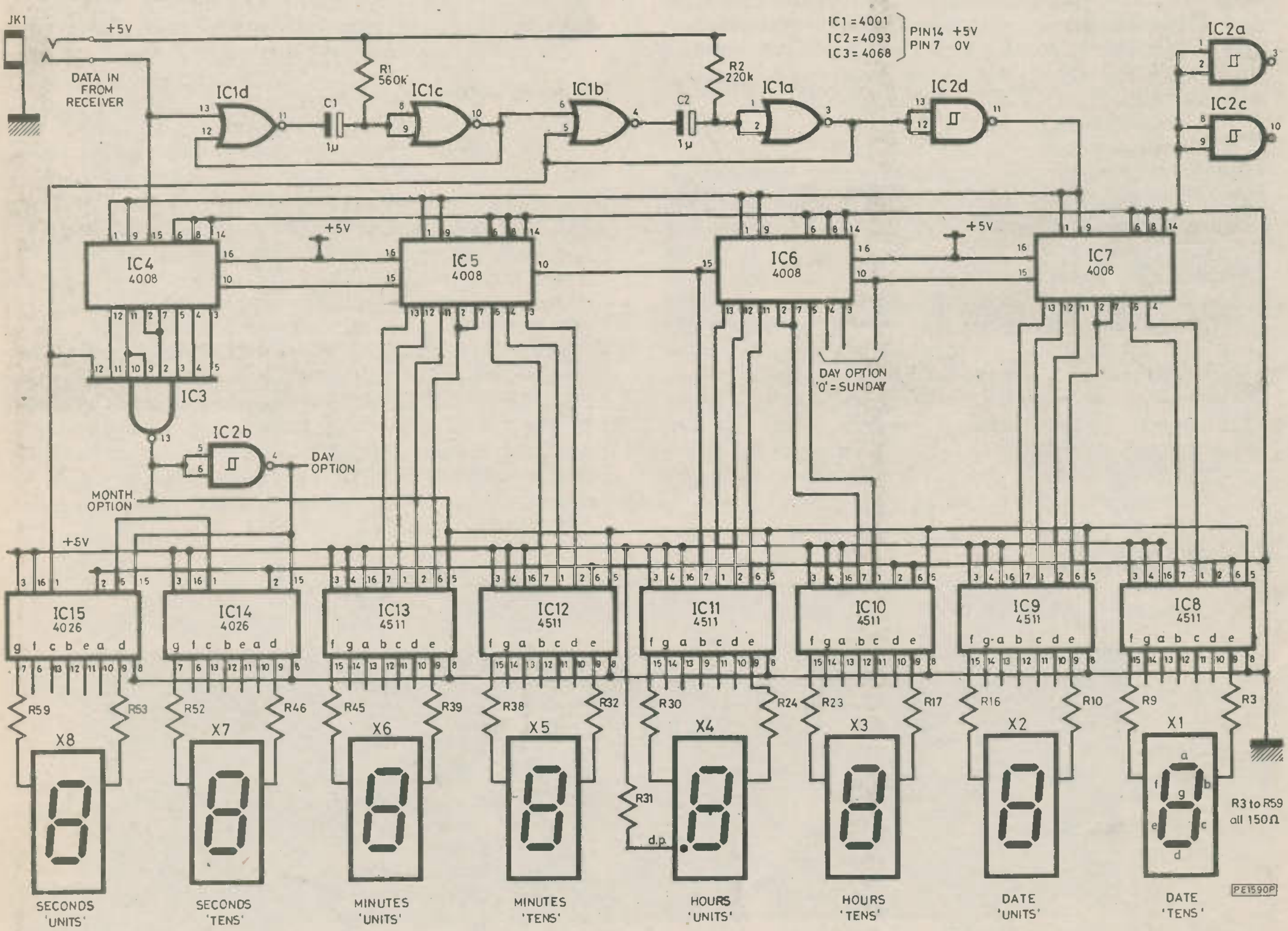


Fig. 2. Circuit diagram of the Decoder

amplifier for the received signal. The signal is further amplified by two transistors contained within the 3046 before being fed to the emitters of the long-tailed pair of transistors, one of which has L2 as its collector load, tuned to 60kHz by a ferrite core.

The signal then goes to IC1c, again biased into its linear region by IC1b, where it is amplified before being fed into the emitter-follower TR1, acting as a buffer. Feedback is provided by R3, D1 and C6 for stability, and the signal goes into TR2. VR1 acts as a gain control, and D2 cuts off the negative peaks. The Rugby pulses consist of breaks in the otherwise very pure carrier wave, and so during these breaks

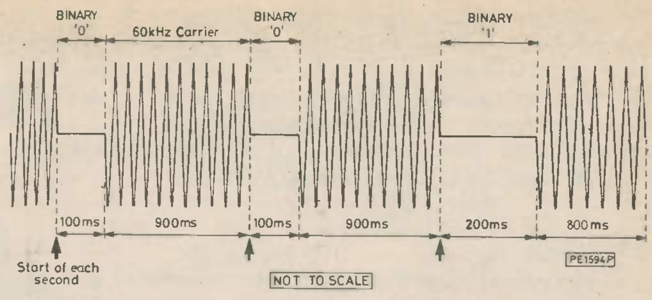


Fig. 3. The 'Rugby' pulse waveforms

COMPONENTS . . .

DECODER BOARD

Resistors

R1	560k
R2	220k
R3–R59	150 (57 off) or 8 off d.i.l. resistor packs (RS 140–322)

Capacitors

C1, C2	1µ tant (2 off)

Semiconductors

IC1	4001
IC2	4093
IC3	4068
IC4–IC7	4008 (4 off)
IC8–IC13	4511 (6 off)
IC14, IC15	4026 (2 off)

Miscellaneous

AEG/Telefunken yellow displays D353 (4 off)
AEG/Telefunken green displays D352 (4 off)
Soldercon pins
P.c.b.s.
Vero case G-range 3G
3·5mm stereo jack plug and socket
20mm fuseholder and fuse (250mA)

POWER SUPPLY

Capacitors

C1	2200µ 16V elect
C2	220n
C3	2µ2 tant

Semiconductors

REC 1	1A bridge rectifier
IC1	7805

Miscellaneous

9V 1A transformer
P.c.b.

DAY OPTION

Resistors

R1	150

Semiconductors

IC1	4029
IC2	4051
7 red l.e.d.s	

RECEIVER

Resistors

R1	12k
R2, R5, R6	10k (3 off)
R3	1k
R4	39k
R7	27k
R8	330k
VR1	100k min. 3mm preset (Cirkit)

Inductors

L1	Ferrite rod (F14, 200mm, 10mm dia. Maplin) 40 s.w.g. wire
L2	CAN1A350EK (Toko)

Semiconductors

D1	1N4148
D2	OA91
TR1, TR2	BC109 (2 off)
IC1	4069
IC2	3046

Capacitors

C1	470p (see text)
C2, C7, C8, C9, C10, C11, C12, C14, C15	100n min. ceramic (9 off)
C3	5–60p trimmer
C4	100p ceramic
C5	3n ceramic
C6	47µ tant
C13	10µ tant

YEAR AND MONTH OPTION

Resistors

R1–R28	150 (28 off) or 4 off d.i.l. resistor packs

Semiconductors

IC1	4015
IC2, IC3, IC4, IC5	4511 (4 off)

Constructor's Note

The Rugby receiver and Toko coil is available from **Cirkit,** Park Lane, Broxbourne, Herts. Receiver stock no. 40–06002.
The displays are available from **AEG/Telefunken,** 217 Bath Road, Slough, Berkshire.

TR2 will have nothing to amplify; consequently its collector will be pulled high by R6, taking with it pin 1 of IC1a. This gate, along with IC1f, is arranged as a Schmitt trigger to ensure a clean, fast rise and fall time to the final pulse train which then goes to the decoder board. When the carrier resumes, after either 100ms or 200ms, TR2 conducts, pulling pins 1 and 12 of IC1 down to 0V (Fig. 3).

DECODER

The circuit diagram of the Decoder is shown in Fig. 2. The reason for so many i.c.s is to avoid multiplexing the data into the display drivers. This can produce so much noise with the digits constantly switching, causing sudden current-dumping, that the 'Rugby' signal would be swamped by the noise.

The pulses coming from the receiver enter pin 13 of the first monostable formed by IC1c and d. This acts as a latch to prevent the circuit being triggered twice (by the double pulses), by lasting for approx. 600–700ms. Its output changes state at the same time as the trigger pulse, and fires another monostable, IC1a and b, which, after approx. 150ms, via IC2d, clocks the shift register formed by IC4 to 7. Note that a Schmitt trigger is specified for IC2d to ensure that the rise time is fast enough.

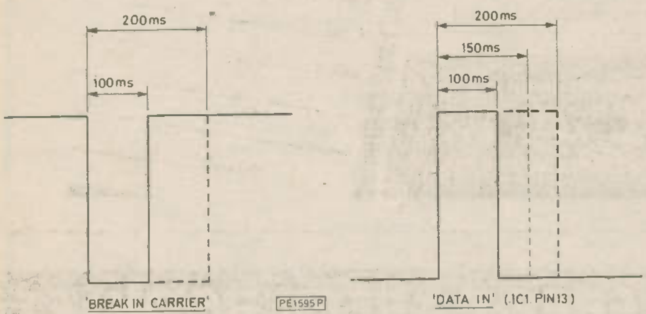


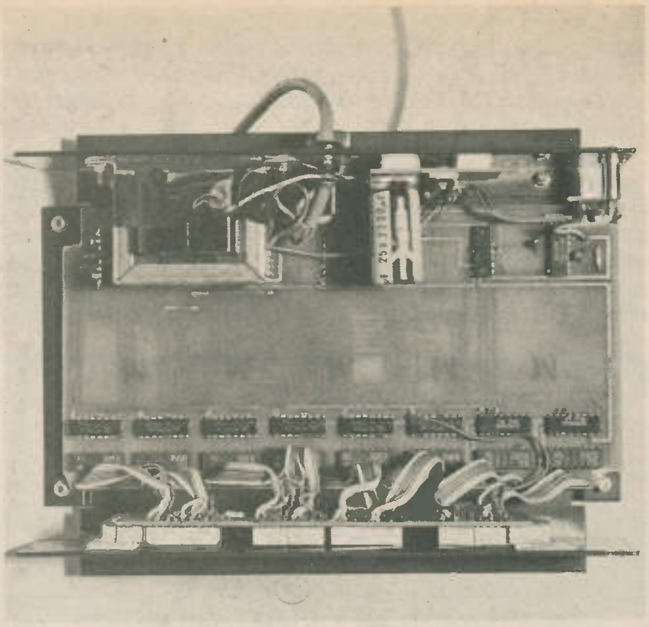
Fig. 4. Data level at pin 13 IC1

It will be seen from Fig. 4 that the data level sampled at pin 13 of IC1 (pin 15, IC4), 150ms after triggering will be the required '0' or '1'. On each subsequent clock-pulse, this serial data stream shifts through the eight outputs of each of the four registers cascaded together. Thus IC4 to 7 act almost as a serial to parallel converter because, on the 59th sec., the 32 output pins will be displaying the state dictated by the last 32 secs. of 'Rugby' pulses.

The six '1's from the framing pattern will form six of the outputs of IC4, and these are connected to seven of the inputs of a 4068 NAND gate. The 8th and final NAND input comes from the rising edge of the 60th sec. data pulse (taken from the 150ms monostable to avoid double-loading of data caused by the double pulses), at which point the output of the 4068 goes low, latching the data from the register outputs into the display drivers, providing the date, hours and minutes display.

SECONDS DISPLAY

The seconds display is produced by using the data pulses from the 150ms monostable to clock two cascaded BCD counters with built-in 7-segment decoders and display drivers. The '60th sec.' pulse from the 4068 is inverted and used to reset the counters so that they constantly re-cycle through 0–59. All the display drivers require current-limiting resistors and readers can either use separate resistors (150 ohms), which is the cheaper alternative, or, as in the



Internal view of the Decoder

prototype, d.i.l. resistor packs which are more expensive but much quicker to install, and give a neater finish. The decimal point of one of the displays is activated to mark the separation of the hours from the minutes.

POWER SUPPLY

The power supply (Fig. 5), being a standard transformer, bridge rectifier and regulator circuit needs little comment, but it is mounted on its own p.c.b. for safety reasons.

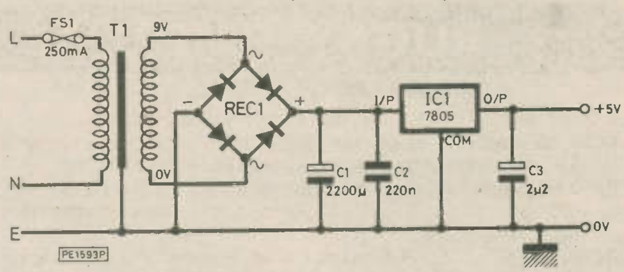


Fig. 5. Circuit diagram of the p.s.u.

NEXT MONTH: Layout and wiring of the p.c.b.s and alignment procedure

INDUSTRY NOTEBOOK

By Nexus

Value for Money

The ever-rising cost of defence equipment is, or should be, a matter of concern for every taxpayer. The Ministry of Defence has, in fact, a newly aggressive stance to ensure value for money for every taxpayer's pound. The Minister himself, a successful businessman needs no lessons from the Chancellor or the Prime Minister in economic discipline.

Thus the move to open competitive tender of which the contract for Type 2050 sonars for the Royal Navy is a fine example. They are destined for Type 22 Batch 3 and Type 23 frigates.

The competition was won by Ferranti's Cheadle Heath Division who submitted four different proposals, that with Marconi as subcontractor being the Ministry selection. For Ferranti the contract is worth £24 million if successfully completed plus the possibility of export orders which could bring the total to £50 million or more.

Heady stuff, indeed! Ferranti has now become the prime contractor for Type 2050, the successor to Type 2016 in which the company was only subcontractor to Plessey. But all is not yet in the bag. When Ferranti has completed the first set to Ministry satisfaction the production of the remaining sets will still be open to competitive tender so that everyone will still need to be alert on performance not only in design and development but also on production.

The principal advances in technology to be incorporated in Type 2050 sonars are a switch from a single large mainframe computer to distributed processing using microcomputers and the use of digital instead of analogue signal processing. The latter will lean heavily on original work of the Admiralty research establishment.

Another welcome development in defence procurement is Thorn EMI's involvement in the development of a terminally guided warhead for the US Multiple Launch Rocket System (MLRS). Thorn EMI is in a consortium of French, West German and US companies on the project with Thorn EMI's share being worth some £15 million.

It is the first major co-development programme under a Memorandum of Understanding between the four nations. The two-way street across the Atlantic which has been virtually one-way for many years could now start to have real substance.

Social Responsibility

Ferranti is actively recruiting engineers for the sonar contract and, in fact, most defence equipment contractors are constantly searching for new talent. But in the background is a debate that has been running for a number of years. Should an engineer use his talent for potentially destructive activities or, on principle, undertake only constructive or humanitarian work?

A number of the early atomic scientists, shocked at the monster bomb they created, pulled out. An extreme case, perhaps, but illustrating the point. It is estimated that 40 per cent of the world's scientists and engineers are engaged in one form or another on designing and building military equipment. So clearly very large numbers are prepared to tolerate if not actually relish such employment.

Social responsibility is very much a matter of personal conscience. The IEE lays down rules of conduct for professional engineers. A member's work should constitute no avoidable danger of death or injury or ill health to any person.

A member must also take all reasonable steps not to waste natural resources, and not to damage the environment. But lawful work in connection with equipment intended for the defence of a nation is not considered an infringement of the guidelines although it obviously, if the equipment is used in anger, kills people, wastes natural resources and damages the environment.

If one works in a munitions factory the choice is clear cut. One helps make shells, bullets and bombs or, if a pacifist in the true sense, one finds more congenial employment elsewhere.

For the scientist and engineer the position is ambiguous. The laser scientist is interested in lasers. They have many beneficial applications in fields as diverse as surveying and eye surgery. But also as military target markers and rangefinders, not to mention potential use in the US Strategic Defence Initiative, popularly described as Star Wars, although in this case they would be purely protective against incoming missiles and thus arguably humanitarian.

The communications engineer is in equal difficulty. His military radios may be used to order a salvo to be fired, aiding destruction. Or to call up an ambulance to save a life. Even civil broadcasting is used by many countries to poison the mind (evil) as well as to educate and entertain (good).

Sonar and radar have both peaceful and aggressive applications and the same may be said of any engineering discipline or any type of product. Even the humble toilet roll gives aid and comfort to those engaged in military operations just as much as to those in the home.

It is worth remembering that the armed services have beneficial use in other than military operations. Hundreds of lives are saved annually by air-sea and mountain rescue military helicopters. Armies throughout the world are employed in natural disasters, building temporary bridges, providing transport and other relief facilities. Naval craft are often first on the scene of a shipwreck.

It is right that social responsibility should be a subject of discussion among engineers, always bearing in mind that even good intentions can have evil consequences. It could be argued from a high moral stand-point that the whole of Britain's defence industry should be closed down and the armed forces disbanded. But the resultant unemployment and economic disturbance would be disastrous for thousands of families immediately and for the whole nation in the event of attempted subjugation by a foreign power.

Cellular War

No moral dilemma was involved in Racal's decision to sponsor Grand Prix yachting as part of the publicity campaign for Vodafone. The 45ft craft with its 12-man crew is to compete under the name of Vodafone Venture '85 and is expected to provide a strong challenge in the classic Admirals Cup as well as other races during the working-up period.

Racal won the race to get Vodafone cellular radio into service a few days before rival Cellnet. No doubt Cellnet will be responding with some publicity ideas of like nature.

With so many new names around it is good to see that cellular radio has brought back a real old timer, Marconiphone. This brand name was popular in the 1930s on domestic radio receivers made in the Hayes factory of EMI alongside the HMV models. Both had the same chassis internally, the difference being in cabinet styling when a radio was a piece of furniture as well as a source of entertainment.

Marconi, the original owners I suspect, must have reacquired the brand name because it now appears as Marconiphone cellular products in a range of telephones for the cellular market.

How commercially successful the new service will be is anyone's guess at the moment. The other much-heralded innovation, the cabling of Britain, is proceeding more slowly than anticipated with no overnight fortunes being made. Cellular radio has the advantage of being directed, initially at least, to the professional person where the cost benefit equation is fairly easy to work out. Also to the well-heeled such as fellow competitors to Vodafone Venture '85. I recall yacht-racing once described as equivalent to standing fully clothed under a cold shower tearing up £5 notes. Cellular radio costs peanuts in comparison.

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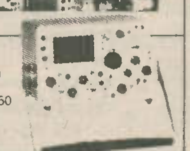

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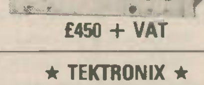

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MY WELL-THUMBED copy of *Collins English Dictionary* which, I may have mentioned before, doubles as a doorstop, defines the word 'materialism' as 'interest in and desire for money and possessions rather than spiritual or ethical values'.

This is why I hesitated at first to label an old friend of mine, Dr. Max Smollett, a materialist. Nevertheless, that's what he is alright. But in quite another and much more complimentary sense of the monniker.

Dr. Smollett heads a tight-knit 45-strong team, of which 25–30 are qualified scientists and engineers, which forms the Central Materials Laboratory of the Philips organisation in the UK. In these modest numbers the Laboratory serves in many vital ways the 20-odd establishments that make up the manufacturing side of the group.

But let Max take up the story which puts into perspective the key role that materials research has played and is still playing in the forward march of electronic technology.

"We're organised into a number of groups," he said. "One of the most important in this safety-conscious age deals with hazardous materials and environmental hygiene. Here we're intimately concerned with the proper protection of the company's employees.

"Our hazardous materials adviser assists local plant managements on all aspects of the measurement and control of potentially dangerous situations arising from the use of various chemical products. He also works closely with the company's medical advisers and sites are visited regularly to inspect and advise on current procedures. Backing this activity we have an environmental hygiene coordinator whose field covers the legal situation, modification of production processes to reduce the quantity of materials discharged, the design of effluent disposal and treatment processes, air filtration, the storage of hazardous materials on site, water treatment, soil pollution and so on.

"Our development group works on what I'd call non-standard projects"

"The analysis and measurement of various materials used in the manufacture of Philips products is another of our responsibilities. We also undertake short-run pilot production of components and devices on an experimental basis. Particularly we concentrate on metals, chemicals, PCBs and ceramic boards.

"Our development group works on what I'd call non-standard projects. In other words, those which do not fall easily into any other category. This group's job is to exploit new technologies in order to provide devices either for selling in the market place or for use in our plants. And all along the line we are adding to our knowledge and experience of new materials as they come into use.

"A wide range of services is provided by the metallurgical section. They include the manufacture of trial quantities of experimental alloys, the production of microsections for examination and interpretation, microhardness testing and advice on the metallurgical suitability of components and materials and quality checks in terms of mechanical properties and dimensions.

"Finally, there is our technical photography section which, among other tasks, produces high-precision artworks which have a role in the manufacture of thick film circuits, thermoelectric coolers, high-precision graticules and the photo-chemical etching of components."

★ ★ ★ ★ ★

New materials, many with exciting potentialities, are always coming on to the scene. At present CML is taking a long hard look at lithium niobate, used in the manufacture of surface wave filters. When suitably processed it can replace inductors, capacitors and resistors. And it can make a solid contribution to the continuing crusade for smaller size and volume of equipments.

With such a wide range of responsibilities and interests, CML needs and has an equally wide range of disciplines in its ranks. "Of course," said Max, "we have physicists. We also have chemists, some specialising in analysis, and other 'general' chemists who are undaunted by any problem, organic or inorganic, whether or not it involves materials to which they are accustomed. They really thrive on investigation. Then there are our metallurgists, plastic technologists and 'natural' engineers who are able to design engineering and mechanical processes."

Talking of the contribution made to electronics by materials research, Max said: "The range of materials in direct use in electronic equipment is far wider than you might suppose and stretches from silicon and germanium to high-grade plastics with electronic properties. But getting some of these materials into active use in equipment is no overnight job. It can take 10–15 years from conception to inception."

What does Max recall in the way of milestones in materials research? "There are several," he said. "One of them is the progress made in the purification of silicon. The present standard was undreamed of 20 years ago. The same goes for cadmium mercury telluride, used in the infrared sector. Here again, we have achieved remarkably high standards of purity. But there are still problems to be licked. And licked they will be."

Anything exciting on the stocks? Currently CML is looking at the new molecular beam epitaxy machines (costing £500,000 a throw) which have the ability to build up a material atomic layer by atomic layer, thus revealing all kinds of properties that lie in the quantum mechanical field.

An example of this is to build up a material in such a way that instead of giving out an invisible ray of light when a voltage is applied, it can be constrained to emit light for different wavelenghts. This means an entirely new dimension in physics. It means that materials can be tamed and controlled to a remarkable degree.

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It seems likely, therefore, that the physicists of today will have to start learning new tricks. This, I suspect, is unlikely to put off Max Smollett. A man in his fifties, with a lifetime's association with electronics, he has seen plenty of changes, accepted them and added to his store of knowledge and experience.

"It seems likely that the physicists of today will have to start learning new tricks"

He took his doctorate at the Imperial College, London, in solid state physics, with a concentration on epitaxial layers, conditions of growth and stability, etc. Then, feeling he might benefit by getting out of his own backyard for a time, he applied for and won a 2-year scholarship in theoretical physics at the Sorbonne in France.

After that he began, at the ripe old age of 26, to think about a job. He hankered after an academic career, but jobs were scarce and the pay was low. So he offered his experience in semiconductor physics to the Mullard (now Philips) Research Laboratories at Redhill, Surrey, and joined them in 1953.

Then as the commercial markets began to open up he moved to the company's purpose-built semiconductor plant at Southampton. There he held a number of posts of great diversity working in the infrared field, in transistors and then, more recently, integrated circuits.

To his latest appointment he has brought an intimate acquaintance with many of the triumphs, setbacks, but always challenging phases in the development and high-speed advance of electronic technology.

Like others who take the reasoned view, Max Smollett believes that the standards of quality, reliability and long life that both manufacturers and consumers are seeking, in a greater degree than ever before, have their roots in the materials that industry sells and the public buys.

Any competent chef can serve you a satisfying dish. But only if he has the right ingredients.

SEMICONDUCTOR CIRCUITS

TOM GASKELL BA(Hons) CEng MIEE

PROGRAMMABLE VOLTAGE DETECTORS (ICL8211CPA & ICL8212CPA)

LAST month we looked at an i.c. which could monitor four voltage levels simultaneously in a very sophisticated way. This month we stay on the theme of voltage monitoring and look at a couple of fairly simple yet extremely useful programmable voltage detectors made by Intersil.

The ICL8211 and ICL8212 (the 'CPA' suffix simply refers to their temperature range and package type) are very low power bipolar i.c.s intended for precise voltage detection or generation. Each device contains an accurate voltage reference, a comparator, and a pair of output buffer/drivers. Fig. 1 shows the pinout for both i.c.s, and Fig. 2 their specifications.

BASIC OPERATION

The internal voltage reference for both i.c.s is nominally 1·15V. The voltage which is fed to the threshold input (pin 3) by the external circuitry is compared with this internal reference voltage. In the case of the 8211, when the threshold input voltage drops *below* the reference, the output turns on. The 8212 operates in the inverse mode; when the threshold input voltage rises *above* the reference, its output turns on.

The output for both i.c.s is an open collector npn transistor, with its emitter connected to 0 volt. Hence, when the output turns on, current will be sunk from the load into pin 4. The output of the 8211 is current limited to typically 7mA, which makes it suitable both for general use and for directly driving an indicator l.e.d. without the need for a series resistor. The output of the 8212 has no current limit, so care must be taken to avoid exceeding the 30mA maximum current shown in the specification. (An upper limit of 25mA is recommended in practice.) In both cases the load should be connected between a positive supply rail (not necessarily the i.c.'s own supply: the load supply should not exceed +30 volts, however) and pin 4.

TYPICAL USE OF THE I.C.s

Fig. 3 shows a typical application of the 8211. (Assume that R3 is omitted for the moment.) A potential divider, R1 and R2, across the supply rails feeds a voltage to the threshold input of the i.c. If this voltage drops below 1·15V the output of the i.c. turns on, sinking typically 7mA from the 'low voltage' warning l.e.d. into pin 4. The values of R1 and R2 are chosen to scale the voltage at pin 3 such that the i.c. output turns on at the required supply voltage. The i.c. itself can work over a range of 2·2 to 30V, allowing considerable flexibility in the range of voltages which can be monitored. The values of R1 and R2 are determined by:

$$\text{Supply voltage to cause i.c. to 'trip'} = \frac{1\cdot15\,(R1 + R2)}{R1}$$

The current which is allowed to flow down the resistor chain could be as high as 50µA. On the other hand, an obvious application of the i.c. is in monitoring battery voltages, where high current consumption is undesirable. Both i.c.s are optimised for low quiescent current consumption in their 'output turned off' state (22µA for the 8211 and 20µA for the 8212) to minimise their effect on battery life. Hence, a very low resistor chain current is to be aimed for when designing within battery powered systems. The practical minimum is 6µA, since currents below this become comparable with the input current at pin 3 of the i.c., and inaccuracies can result. In conjunction with the equation shown above for the 'trip' voltage, we can therefore add the current determining equation:

$$\text{Resistor chain current} = \frac{\text{supply voltage}}{(R1 + R2)}$$

(i.e. 0·000006A up to 0·000050A)

HYSTERESIS

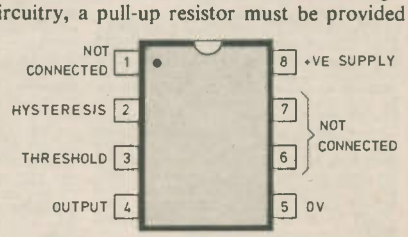
Both i.c.s have a low current switched output, the 'hysteresis' output, connected to pin 2. This is an open collector pnp transistor with its emitter connected to the positive supply rail, and is switched on (causing pin 2 to be pulled up to near the positive supply) for input voltages to pin 3 in excess of the nominal 1·15V. It can be used with simple feedback arrangements (for example, R3 in Fig. 3) to provide some positive feedback, or hysteresis, around the i.c. The hyteresis ensures that once the i.c. output has turned on, the input voltage has to change by a considerable amount before the i.c. will turn off again. This is very useful in stopping oscillation or 'hunting' around the threshold point. In the case of 8212 without hysteresis, for example, the i.c. turns on as soon as the threshold input exceeds 1·15V. This causes the output to be turned on, sinking current from the load, which as a result might cause the supply voltage to drop slightly, turning off the i.c. again . . . etc, etc! Hysteresis establishes a 'dead band', helping to prevent or reduce this oscillatory effect.

There are several ways of introducing hysteresis into the system, the two most common ones being shown in Fig. 4. The circuit of Fig. 4a requires that all of the current flowing in the resistor network should be able to be sourced by the hysteresis output, which is capable of supplying 15µA according to the specifications. For the circuit of Fig. 4b, the current to be sourced by the hysteresis output will be defined by the values of the two trip voltages. For low values of hysteresis, circuit (b) is to be preferred. The equations shown define the low and high trip voltages; the low trip voltage is the voltage at which the i.c. output changes state when the supply voltage is decreasing, and the high trip voltage is the voltage at which the output changes when the supply is increasing. If used for other purposes in the circuitry (other that simply switching the threshold resistor network as shown in Fig. 4), it is recommended that the hysteresis output current should be limited to 10µA.

USING THE I.C.s

Although any voltage between −5V and the positive supply rail may be applied to the threshold input (pin 3), it is advisable to limit it to below +6V, since above that voltage the input current increases dramatically. Prolonged operation above this voltage can cause a decrease in performance of the i.c. When resistive dividers are used to feed the threshold input, the monitored voltage can be higher than the i.c.s own supply voltage, as long as the voltage at pin 3 (and pin 2 if appropriate) is kept below the i.c. positive supply, and preferably below +6V as explained above.

If the output is to be used to feed into logic circuitry, a pull-up resistor must be provided



ICL8211CPA
&
ICL8212CPA

Fig. 1. Pinout

Characteristic	Notes	ICL8211CPA Minimum Value	ICL8211CPA Typically	ICL8211CPA Maximum Value	ICL8212CPA Minimum Value	ICL8212CPA Typically	ICL8212CPA Maximum Value	Units
Supply Voltage	0 to +70°C (Spec's are measured at +5V unless otherwise stated)	2·2		30	2·2		30	V
Quiescent current	Voltage at Pin 3 (V_T) = 1·3V	10	22	40	50	110	250	μA
	Voltage at pin 3 (V_T) = 0·9V	50	140	250	10	20	40	μA
Temperature range	Spec's are measured at +25°C unless otherwise stated	0		+70	0		+70	°C
Output current, max	Sunk into pin 4	4	7	12	15		30	mA
Current into any pin of I.C.	(or out of any pin), absolute maximum			±30			±30	mA
Output voltage	At pin 4	−0·5		+30	−0·5		+30	mA
Threshold input voltage (pin 3)	For supply voltages of 2·2 to 25V	−5		(+ve supply)	−5		(+ve supply)	V
	For supply voltages of 25 to 30V	(+ve supply −30)		(+ve supply)	(+ve supply −30)		(+ve supply)	V
Hysteresis voltage	i.e. voltage at pin 2	(+ve supply −10)		(+ve supply +0·5)	(+ve supply −10)		(+ve supply +0·5)	V
Threshold trip voltage (at pin 3)	Ouput current =4mA Output voltage =2·0V; +ve supply = 2·2V	0·98	1·145	1·19	1·00	1·145	1·19	V
	+ve supply = 5V	0·98	1·15	1·19	1·00	1·15	1·19	V
	+ve supply = 30V	1·00	1·165	1·20	1·05	1·165	1·20	V
Threshold voltage temp. coefficient	Output current = 4mA, output voltage = 2·0V		+200			+200		ppm/°C
Threshold line regulation	Variation in threshold voltage for ±10% supply change		±1·0			±1·0		mV
Threshold input current (into pin 3)	Voltage at pin 3 = 1·15V		100	250		100	250	nA
	Voltage at pin 3 = 1·00V		5			5		nA
Maximum Hysteresis current	*i.e.* Available from pin 2 (voltage at pin 3 = 1·3V)	15	21		15	21		μA
Hysteresis saturation voltage	7μA flowing from pin 2 (voltage at pin 3 = 1·3V)	(+ve supply −0·2)	(+ve supply −0·1)		(+ve supply −0·2)	(+ve supply −0·1)		V
Hysteresis leakage current	+ve supply = +10V, pin 2= 0V, pin 3 = 1·0V			0·1			0·1	μA
Output saturation voltage	Pin 4, output current = 4mA		0·17	0·4		0·17	0·4	V
Output leakage current	+ve supply = +5V			1·0			1·0	μA
	+ve supply = +30V			10			10	μA
Power dissipation	Up to 50°C			300			300	mW

Fig. 2—Specifications

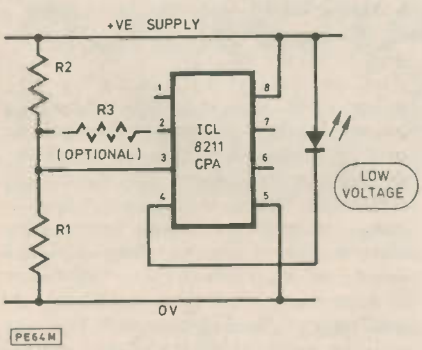
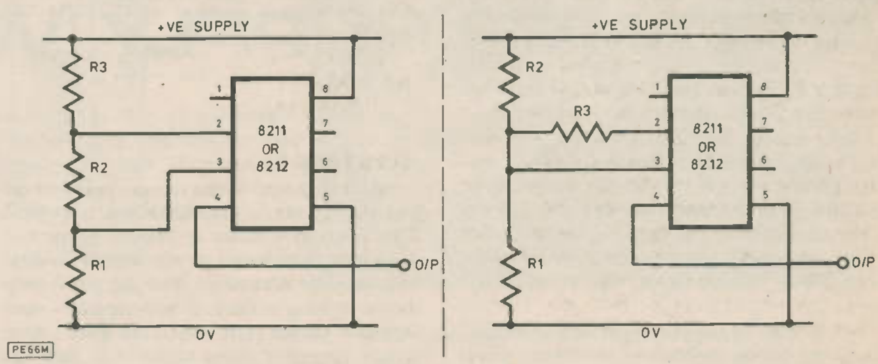


Fig. 3. Low voltage supply indicator



$$\text{Low trip voltage} = \left(\frac{(R1 + R2) \times 1{\cdot}15}{R1}\right) + 0{\cdot}1$$

$$\text{High trip voltage} = \frac{(R1 + R2 + R3)}{R1} \times 1{\cdot}15$$

$$\text{Low trip voltage} = \left(\frac{R2\ R3}{(R2 + R3)} + R1\right) \times \frac{1{\cdot}15}{R1}$$

$$\text{High trip voltage} = \left(\frac{(R1 + R2)}{R1}\right) \times 1{\cdot}15$$

Fig. 4. Two alternative methods of adding hysteresis

between pin 4 and the logic positive supply rail. For TTL use 1k, for LSTTL use 4k7, or in the case of CMOS logic use any suitable value, typically between 10k and 1M. The 8211 is guaranteed to be able to drive 2 conventional TTL or 8 LSTTL inputs, and the 8212 to drive 4 conventional or 16 LSTTL inputs.

APPLICATIONS

There are many applications of the ICL8211CPA and ICL8212CPA which are in the area of voltage monitoring, supply monitoring, transducer level detection, etc. Such is the versatility of these i.c.s, however, that more diverse uses for them are possible. Fig. 5, for example, shows a simple voltage regulator using an external npn power transistor as the series pass element. The output voltage is defined by:

$$V_{out} = \frac{1{\cdot}15\,(R1 + R2)}{R1}$$

The two capacitors are necessary to ensure

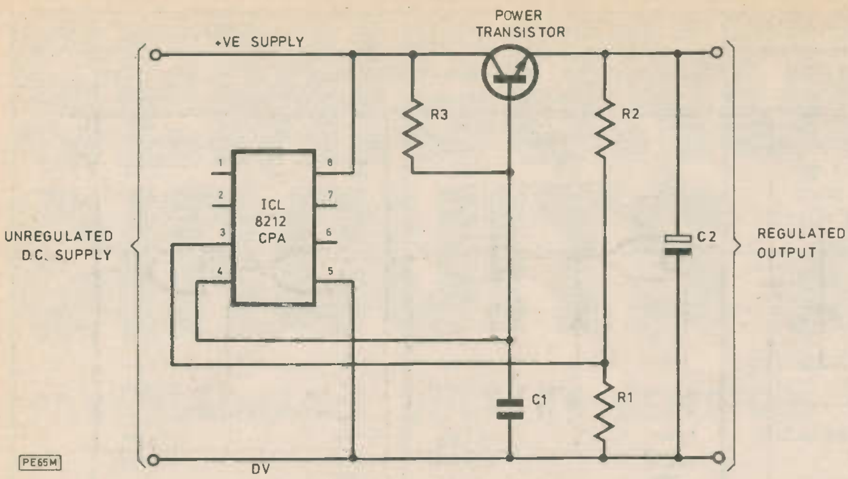


Fig. 5. Simple voltage regulator

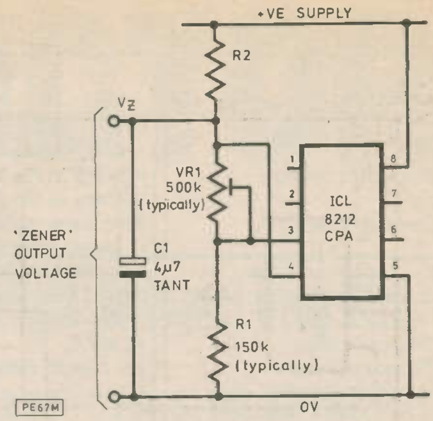


Fig. 6. 'Programmable Zener' (voltage reference)

stability, since the 8212 has no internal frequency compensation. This regulator can be used with lower input voltages than most commercially available regulators, and uses less power than almost any commercially available device. It is ideal, therefore, for use as a supply regulator in battery powered systems.

Fig. 6 shows the 8212 being used as a 'programmable Zener diode'. R2 is the resistor which would normally be provided between the positive supply rail and the Zener's cathode. VR1 and R1 set the 'Zener' output voltage, and C1 stabilises the circuit, again due to the lack of internal compensation in the i.c. The value of the Zener voltage is given by:

$$V_{Zener} = \frac{1\cdot15\,(R1 + \text{the set value of VR1})}{R1}$$

Typical 'Zener' equivalent impedances over the current range 300μA to 25mA will vary from 4 to 7 ohms.

Finally, the i.c.s can be used as a constant current source or sink, as shown in Fig. 7. The 8211 will provide approximately 130μA, and the 8212 approximately 25μA of current. The equivalent parallel resistance is in the tens of megohms, making them fairly accurate current sources and sinks which are suitable for many biasing applications in differential amplifiers, comparators, etc.

Although nominally intended as voltage monitoring devices, especially in low power or battery powered systems, the ICL8211 and 8212 can be seen to have numerous applications in different types of circuitry. The ICL8211CPA is widely available, although the price seems to vary considerably so shop around. It is sometimes referred to as the ICL8211A, or even just the ICL8211—these usually do mean the 8 pin d.i.l. version described here. Both the ICL8211CPA, and the ICL8212CPA, are available from **Hawke Electronics**, Amotex House, 45 Hamworth Road, Sunbury-on-Thames, Middlesex.

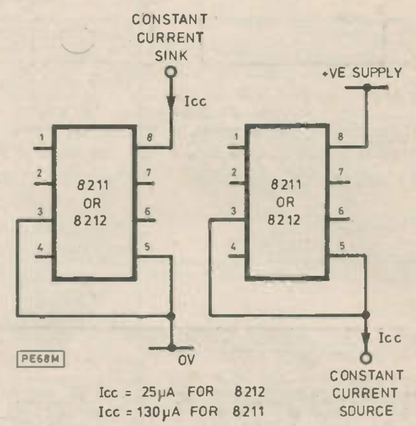


Fig. 7. Using the i.c.s as constant current sources

A POWER SUPPLY 'WATCHDOG'

Last month's applications project provided us with a very comprehensively monitored three rail power supply system. One of the things that it couldn't do, though, was to warn us if the power failed completely. Fig. 8 shows a circuit which is capable of warning us of both over- and under-voltage conditions on a supply, even if that supply has dropped to zero.

IC1 is used to monitor over-voltage conditions, and IC2 to monitor under-voltage conditions. Normally, the outputs of IC1 and IC2 are both turned off, and hence the logic output is at logic 1 (a high level). If an excessively high voltage appears on the supply, the voltage at pin 3 of IC1 rises above 1·15V and the output of IC1 turns on, taking pin 4 down almost to 0V. This forces the threshold input of IC2 (pin 3) almost to 0V, which turns on the output of IC2 providing a logic 0 (low level) on the logic output. Likewise, a very low voltage on the supply will cause IC2 to trip of its own accord since the voltage presented at pin 3 by the network R3, R4 and R5 will drop below 1·15V.

Hysteresis is provided for IC2, as shown in Fig. 4a. The high trip voltage (i.e. the voltage at which the i.c. turns off when the power supply voltage is increasing) is chosen to be higher than the voltage at which IC1 trips. The low trip voltage is chosen to be the voltage at which the power supply is considered to be excessively low. By this means the 'watchdog' circuit is non-volatile—once tripped it cannot reset itself, even if the power supply has gone down to 0V and back up again, since the voltage applied to the IC2 resistor chain would have to exceed the voltage necessary to turn IC1 on if IC2 were to be turned off, and this in turn would force IC2 to turn hard on again! A momentary reset switch is provided to set up the system when power is first applied. It must be pressed to reset the system after every occasion on which the cirucit is tripped.

THE ALARM

IC3 with its associated components forms an audible alarm to warn that the circuit has been tripped. IC3a and IC3b act as a slow running oscillator with a wide mark/space ratio, which in turn gates on and off the audio oscillator formed by IC3c and IC3d. The audio oscillator directly drives a small piezo sounder X1. The slow running oscillator is arranged to turn on the audio oscillator for only a fraction of a second, once every few seconds, providing a slow regular 'blip' sound. R8 determines the 'off' time, and R9 the 'on' time; varyng either of these will vary the respective durations of the silence and the audible tone. This has been arranged to minimise power consumption, since the triggering of the alarm indicates that the power supply might be failing—a situation which might be made even worse by a dramatic increase in power consumption of the circuit.

D1 and D2 allow for a standby battery to be provided for the audible alarm, to allow it to function even with the main power supply turned off. The alarm battery should preferably have a voltage just below that of the main power supply, so that it will only be used if the main supply drops significantly in

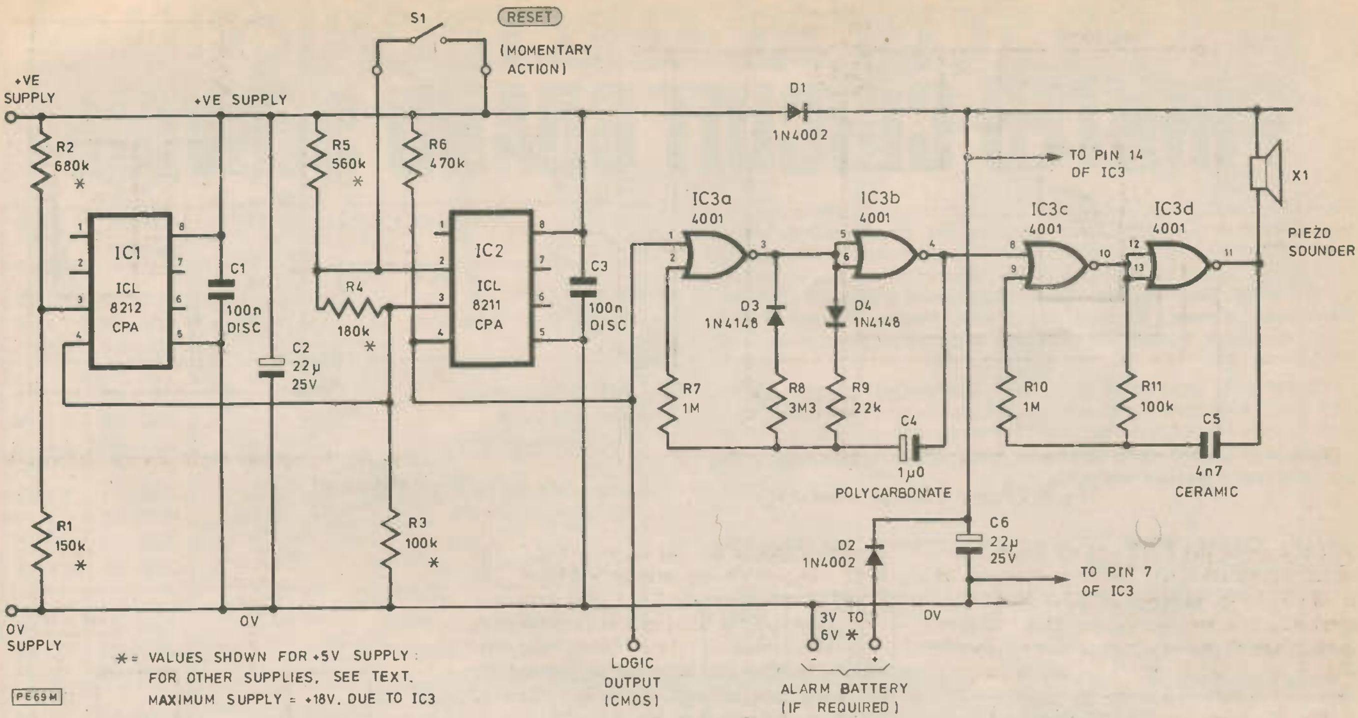


Fig. 8. Power supply 'Watchdog'

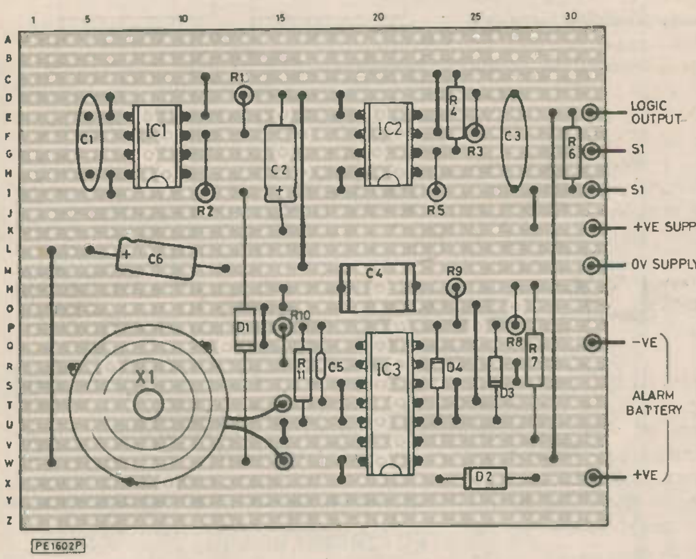
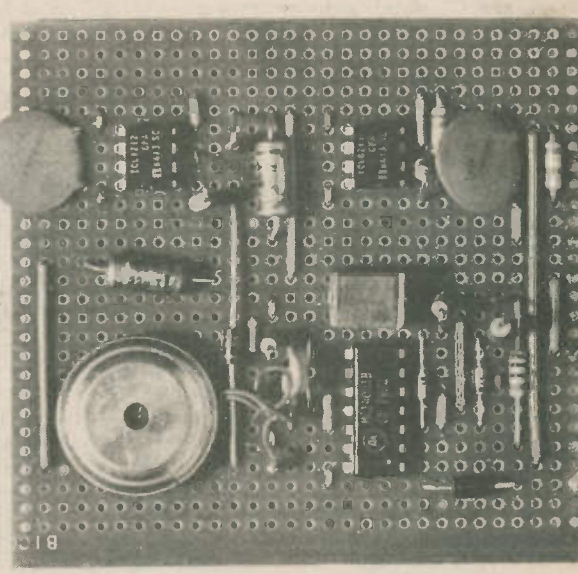


Fig. 9. Veroboard layout



Photograph of Veroboard layout

voltage. Although it may be allowed to exceed the main supply in voltage, it should not do so by more than 25% or so, since there is a danger of a high level at pin 1 of IC3a not being sufficiently high to act as a valid logic 1 level.

APPLICATIONS

This circuit is ideal for long term monitoring of a supply which must be continuously present. For example, this could be a battery backup supply for an otherwise volatile memory system or a comprehensive timing circuit. Any failure of the supply, either high or low, will cause a logic 0 to appear at the logic output and the alarm to sound, even if the supply is quickly reinstated, until the reset button is pressed.

Resistors R1, R2, R3, R4, R5 and the alarm battery, are all shown for a 5 volt supply rail, but they can all be scaled for other voltages using the principles described earlier. With such high values used for the resistors, the trip voltages can be a little in error from those predicted by the equations, so some experimentation may be necessary. Variations in the 1·15V internal reference should be borne in mind, also; these are shown in the specifications, Fig. 2. The logic output should feed into CMOS logic, or into suitable buffering prior to TTL circuitry, since the input of TTL or LSTTL, if connected directly to the logic output, could feed a logic 1 into IC3 pin 1 in the absence of a power supply to IC1 and IC2, preventing correct alarm operation. This circuit is ideal for use in battery systems, largely due to its low current consumption (well under 100µA) in the 'normal' state.

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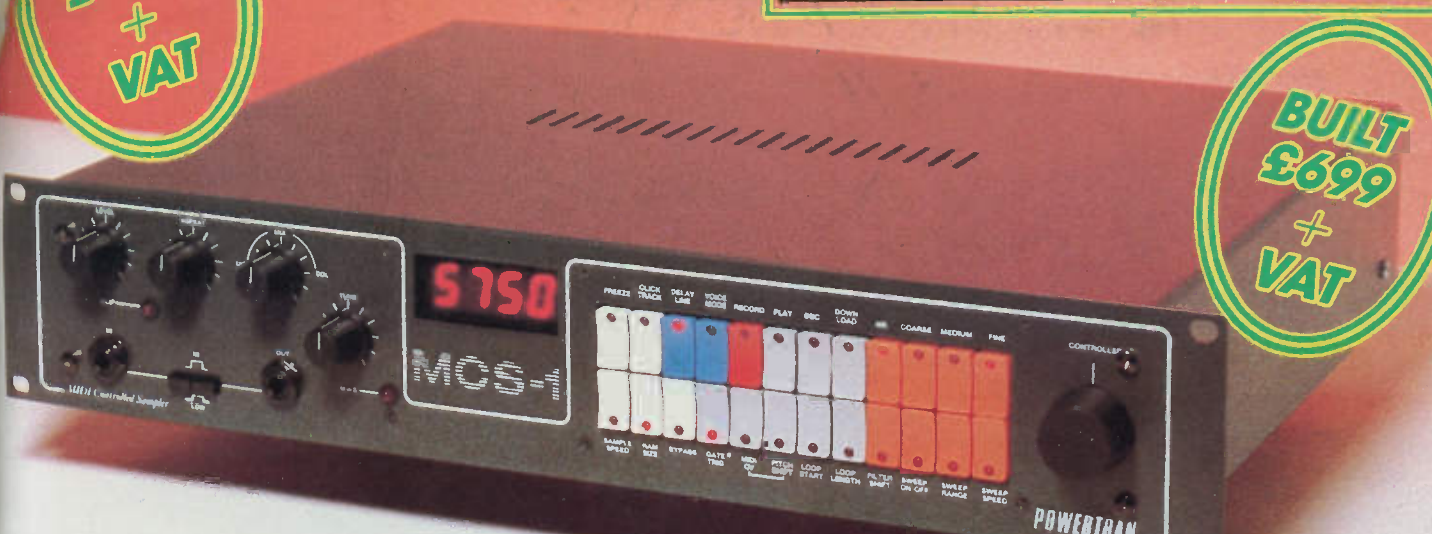

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