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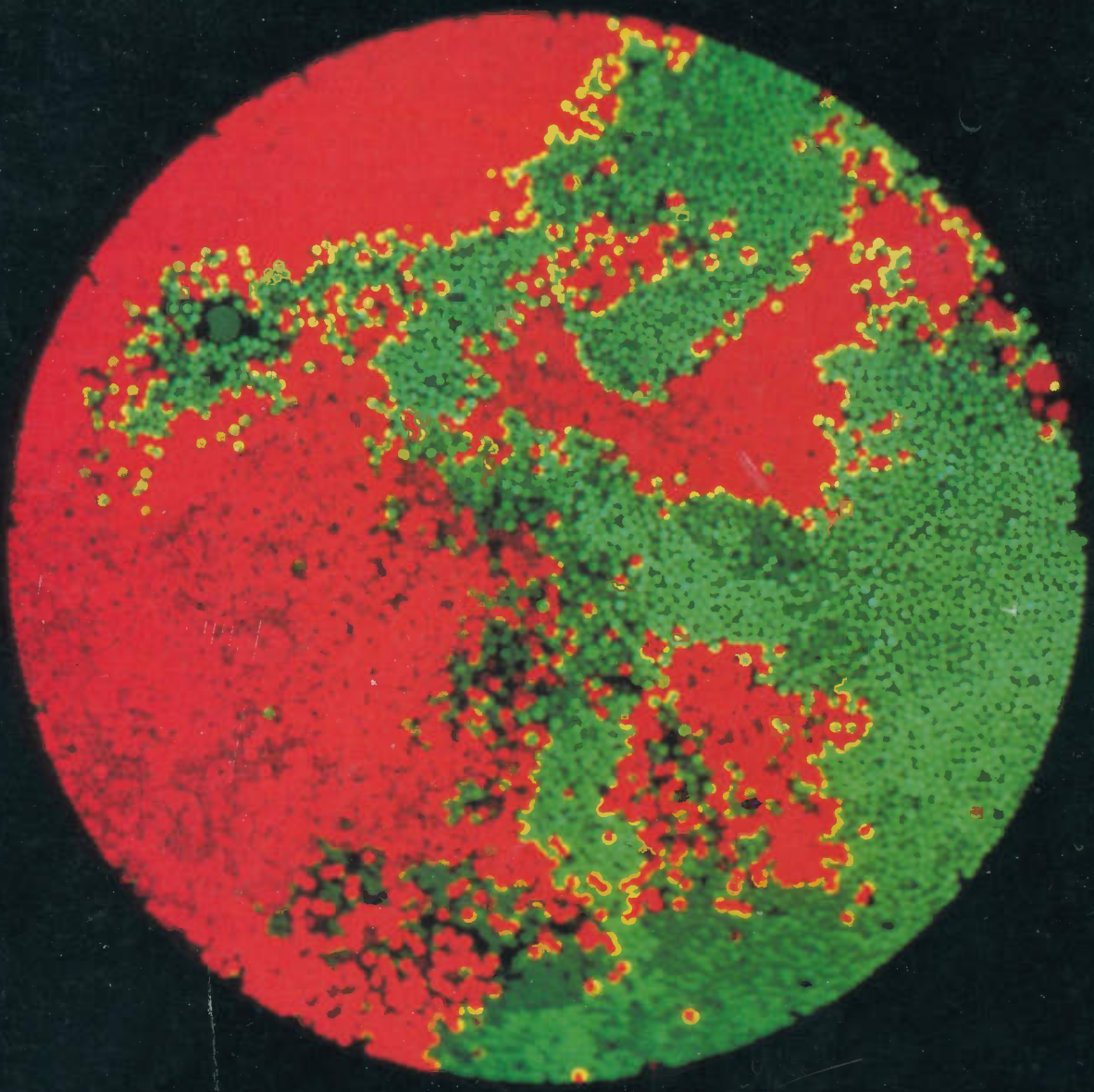
PRACTICAL

MARCH 1986 · £1·25

ELECTRONICS

ROBOTICS · MICROS · ELECTRONICS · INTERFACING



FIBRE OPTIC AUDIO LINK

AMSTRAD I/O · CLOCK TIMER

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ELECTRONIC MAIL

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MAGENTA

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Exceptionally easy to use. A crystal timebase eliminates setting up procedures.
Ideal for schools, labs, and industry as well as electronics enthusiasts from beginners to experts.
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Enjoyable introduction to electronics. Full of very clear full colour pictures and easy to follow text. Ideal for all beginners — children and adults. Only basic tools needed. 64 full colour pages cover all aspects — soldering — fault finding — components (identification and how they work).
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COMPONENTS SUPPLIED ALLOW ALL PROJECTS TO BE BUILT AND KEPT.
Supplied less batteries & cases.
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COMPONENT PACK £16.98
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Book available separately.

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A specifically designed test bed for the practical side of the 8 part educational series 'Introduction to Digital Electronics' Practical Electronics Oct 83 — May 84. Full kit includes screen printed pcb, power supply, connector strips and turned pin sockets (less case).

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An easy to follow book suitable for all ages. Ideal for beginners. No soldering, uses an S-Dec Breadboard. Gives clear instructions with lots of pictures. 16 projects — including three radios, siren, metronome, organ, intercom, timer, etc. Helps you learn about electronic components and how circuits work. Component pack includes an S-Dec breadboard and all the components for the projects.
Adventures with Electronics £3.58. Component pack £20.98 less battery.

HIGH PERFORMANCE STEPPING MOTOR DRIVER

As featured in December issue
Kit including PCB, I.C. & All Parts £20.98
Transformer 30V 18VA £5.98 extra
Case (houses PCB only) £2.95 extra
Lead & Connector for BBC Computer £1.98
Motor – ID35 £14.50
TEA1012 also available separately £6.88. Data £1.00

TOOLS

Antex X5 soldering iron 25W 240V £7.25, 12V £7.45, 24V £7.65, 110/115V £7.35.

Antex Model C soldering iron 240V	£6.98
Heat sink tweezers	45p
Solder handy size 5	£1.39
Solder carton	£2.50
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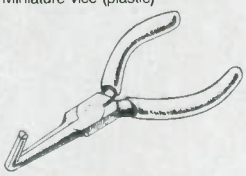
Multimeter Type 2 20,000opv	£17.98
Multimeter Type 3 30,000opv (taut baud)	£27.98
Multimeter Type 4 10M digital	£39.98
Desolder pump	£5.48
Signal injector	£2.98
Circuit tester	78p
Helping Hands jig & magnifier	£7.98
Miniature vice (plastic)	£1.85



BOOKS

A Practical Introduction to Microprocessors. Penfold	£2.10
Basic Electronics. Holder & Stoughton	£8.98
Beginners Guide to Building Electronic Projects. Penfold	£2.25
BBC Micro. Usborne First Guide to	2.26
DIY Robotics & Sensors Billingsley. BBC	£7.95
Commodore 64	£7.99
Elementary Electronics. Sladdin	£5.98
Experiements with Your Computer (Science)	£2.43
Science How to Design & Make Your Own PCBs. BP121	£2.15
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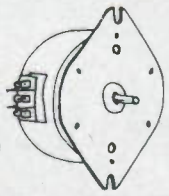
How to Make Computer Model Controllers. Potter	£3.19
Inside the Chip. Usborne	£2.19
Interfacing to Microprocessors & Microcomputers	£6.50
Machine Code for Beginners. Usborne	£2.45
Making Music on the BBC Computer. Waugh	£6.45
Micro Interfacing Circuits Book 1	£2.45
Microprocessors for Hobbyists. Coles	£4.98
Practical Computer Experiments. Parr	£1.95
Practical Things to do With a Microcomputer. Usborne	£2.19
Programming for Education on the BBC Computer. Scriven/Hall	£6.45
Questions & Answers — Electronics. Hickman	£3.45
Understanding the Micro. Usborne	£1.85
Usborne Introduction to Electronics	£2.45

BBC HEART RATE

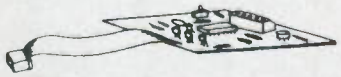
BBC Heart Rate Monitor—
Ready Built £35.99

Practise relaxation or monitor fitness with this plug in heart rate monitor. Connects directly to the BBC computer. Programs give continuous heart rate displays, bar charts, graphs etc. Supplied with sensor, software & instructions—ready to plug in and use.

STEPPER MOTOR



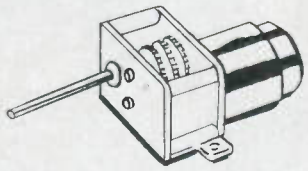
BBC TO ID35 STEPPER MOTOR INTERFACE KIT £13.99
PCB, driver IC, components, connectors and leads included. Demonstration software, listings, circuit diagram, pcb layout and construction details given. Requires unregulated 12Vdc power supply.
INTERFACE KIT (ref PE) £13.99.
OPTIONAL POWER SUPPLY PARTS £4.67.
ID35 STEPPER MOTOR 48 Steps. 12V £14.50.



DC MOTOR SETS

MOTOR — GEARBOX ASSEMBLIES 1.5V-4.5V.
Miniature precision made. Complete with quality electric motors. Variable reduction ratios. Long 3mm dia output shafts.

Small unit — type MGS (3-2200rpm)	£3.49
Large unit — type MGL (2-1150rpm)	£3.98



PULLEY WHEELS — metal 3mm bore	
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FLEXIBLE METAL COUPLING 3mm	£2.98
FISCHERTECHNIK DC MOTOR SETS	
SMALL TYPE 187	£9.85
LARGE TYPE 185	£9.90
DC MOTOR 1.5V-4.5V RPM 4,400-8,700 Shaft dia 2mm L 10mm. Body 29×38mm	
DC MOTOR TYPE — DC28	£1.98
FLEXIBLE STEEL SPRING DRIVING BELT 12" long. Joins to itself or 2 or more can be joined where long lengths are needed.	47p

BBC — DC MOTOR CONTROLLER

FISCHERTECHNIK MOTOR CONTROL SYSTEM FOR THE BBC COMPUTER (BUILT) £46.55 (PE)
A high precision DC motor driver and BBC B computer interface system. Supplied complete with applications software cassette.
Ready to run control system supplied complete with mains lead, ribbon cable and user port connector, and terminal posts and plugs for the motor connection. Also included are the software cassette of 3 programs and instructions. The software is easily transferable to disc.
Recommended motor is the Fischertechnik type 185 as used in the u-t2 motor and gear set.
Motor (185) available separately £9.90.

fischertechnik

We offer a range of the superb Fischertechnik sets. These cover robotics, electronics, electromechanics, motors and gears, and basic construction.
Robotics kit build 11 different working models including a robot arm, graphics board, sorting system etc. Note that not all the models can be built at the same time. Simple to assemble. Easily combined with all other Fischertechnik kits. Top quality. Includes 2 motors, an electromagnet, lamps, potentiometers, switches etc.

ROBOTICS Kit (554) PE	£64.99
Construction/base kit (ut1)	£37.50
Motors and Gears (ut2)	£42.70
Use ut2 to motorise ut1	
Electromechanics (ut3)	£73.20
Electronics (ut4)	£93.90

BBC — ROBOTICS INTERFACE

A READY TO USE INTERFACE for the BBC computer and the Fischertechnik Computing and Robotics Kit (554).
Allows the BBC computer to operate all 11 of the standard models which can be built from the Fischertechnik Robotics kit.
The interface features forward — reverse and on/off control of four DC motors; on/off control output for driving an electromagnet or similar device; and eight switch inputs for reading microswitches or other binary inputs.
Two independent analogue input channels are provided for position sensing.
Supplied complete with connectors and leads the interface requires a power source of 9-12 volts at 1A.
Detailed programming information is supplied with the interface. A software disc with a comprehensive set of programs is also included.
FISCHERTECHNIK ROBOTICS — BBC COMPUTER INTERFACE (BUILT) (PE) £69.95

CATALOGUE

Brief details of each kit, book contents, and illustrations and descriptions of our range of tools and components are all included.
Robotics and Computing section included.
Our advert shows just a selection of our products.
Up to date price list enclosed. Official orders welcome.
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PE ROBOTICS MICROS ELECTRONICS INTERFACING

VOLUME 22 No 3
MARCH 1986

ISSN 0032-6372

FRONT COVER

This month's front cover picture shows a fibre optic cable cluster, capable of carrying 1000's of signals. Photograph by The Science Photo Library.

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Audio transmission system employing fibre optic light guide

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Provides a Spectrum reset facility without loss of memory contents

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OUR APRIL 1986 ISSUE WILL BE ON SALE FRIDAY, MARCH 7th, 1986 *(see page 27)*

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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.**

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

SIEMENS mulitlayer miniature capacitors.
250V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 8n2, 10n, 15n, 22n **7p;** 18n, 27n, 33n, 47n **8p;** 39n, 56n, 68n **9p,** 100nF **11p.**
100V: 100n, 120n, **10p;** 150n **11p;** 220n **13p;** 330n **18p;** 470n **23p;** 680n **30p;** 1MF **34p;** 2M2 **50p.**

CERAMIC Capacitors: 50V
Range 1pF to 6800pF **4p;** 10nF, 15n, 33n, 47nF **5p;** 100nF/20V **7p** 220nF/6V **8p.**

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

RESISTORS S.I.L. Package: 7 Commoned, 100Ω, 470Ω, 680Ω, 1K, 2K2, 4K7, 10K, 47K, 100K **18p.**
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K, 100K **20p.**

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**
¾" Cermet Multiturn 100 to 500K **89p**

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
5W	0.22Ω - 1M		20p	10p
1% Metal Film	51Ω-1ME24		8p	6p

TRANSISTORS

AC126/7	30	BC237/8	10	BFR41/79	25	TIP29A	32
AC127/8	35	BC307B	15	BFR80/81	25	TIP29C	38
AC141/2	35	BC308B	12	BFR98	105	TIP30A	35
AC176	25	BC327/8	12	BFX29/84	28	TIP30C	37
AC187/8	25	BC337/8	12	BFX84	35	TIP31A	38
AC188	25	BC441	34	BFX85/86	35	TIP31C	45
AD142	120	BC461	34	BFX87/88	28	TIP32A	43
AD149	79	BC477/8	22	BFY50/51	30	TIP32C	45
AD161/2	42	BC516/7	30	BFY52	30	TIP33A	70
AF118	95	BC547/8	12	BFY53	35	TIP33C	75
AF124/6	60	BC549C	12	BFY55	35	TIP34A	85
AF139	40	BC556/7	15	BFY56	35	TIP34C	105
AF239	55	BC558/9	15	BFY64	40	TIP35A	120
BC107/8	12	BCY41/42	30	BFY90	80	TIP35C	130
BC107B	14	BCY70	18	BRY39	50	TIP36A	130
BC108B	14	BCY71	20	BSX20	28	TIP36C	140
BC108C	14	BCY72	18	BSX29	32	TIP41A	50
BC109	12	BCY78	30	BSY25	35	TIP41B	52
BC109B	14	BD131/2	55	BSY95	35	TIP42A	55
BC109C	14	BD132	50	BU105	180	TIP42B	58
BC114/5	25	BD135	45	BU205	160	TIP120	70
BC117/8	25	BD136/7	35	BU206	200	TIP121	73
BC119	35	BD138/9	35	BU208	170	TIP141	120
BC140	29	BD140	40	MJ520	50	TIP142	120
BC142/3	28	BD158	68	MJ521	90	TIP147	120
BC147/8	12	BD245	65	MJ2955	90	TIP2955	70
BC147B	15	BD434	70	MJE340	54	TIP3055	70
BC148C	10	BD695A	150	MJE371	100	TIS43	50
BC149	12	BD696A	150	MJE2955	99	TIS44	45
BC149C	15	BF115	45	MJE3055	70	TIS88A	50
BC153/4	30	BF154/8	30	MPF102	40	TIS90	30
BC157/8	14	BF167	35	MPF103/4	30	TIS91/93	32
BC159	11	BF173	35	MPF105	30	VK1010	99
BC167A	14	BF177	35	MPSA05	23	VN10KM	65
BC168C	12	BF178	35	MPSA06	25	VN46AF	90
BC169C	12	BF179	40	MPSA08	30	VN66AF	110
BC171/2	12	BF184	35	MPSA12	29	VN88AF	220
BC173	15	BF194/5	12	MPSA55	30	VN89AF	120
BC177/8	16	BF198/9	18	MPSA56	30	ZTX107/8	12
BC179/81	20	BF200	35	MPSA70	40	ZTX109	12
BC181	30	BF224	40	MPSU02	58	ZTX212	28
BC182/3	10	BF244A	28	MPSU05	50	ZTX300	13
BC184	10	BF244B	29	MPSU06	55	ZTX301/2	16
BC182L	10	BF245	38	MPSU55	60	ZTX303	25
BC183L	10	BF256B	45	MPSU56	65	ZTX304	17
BC184L	10	BF257/8	32	OC23	170	ZTX320/26	30
BC186/7	28	BF259	30	OC28/36	220	ZTX500/1	14
BC212/3	12	BF394	40	OC41/42	75	ZTX502/3	18
BC212L	10	BF451	40	OC70	40	ZTX504	25
BC213L	12	BF494/5	40	OC72	50	ZTX531	25
BC214	10	BF594/5	30	OC75/76	55	ZTX550	25
BC214L	12	BF839/40	25	OC76	50	2N696	30
				OC81/82	50	2N697	23
				OC83/84	70	2N698	48
						2N699	48

2N706A	25	2N5457	30				
2N708	25	2N5458/9	30				
2N914/5	32	2N5485	36				
2N918	40	2N5777	45				
2N930	20	2N6027	32				
2N1131/2	40	2N6109	60				
2N1303/4/5		2N6290	70				
2N1307	70	2SA636	250				
2N1613	30	2SA671	250				
2N1671B	160	2SA715	75				
2N2160	325	2SC495/6	85				
2N2219A/20A/		2SC1061	250				
21A/22A	25	2SC1096	85				
2N2369A	18	2SC1162	45				
2N2646	45	2SC1172/3	125				
2N2846	80	2SC1306	100				
2N2904A/05A/		2SC1307	150				
06A/07A	26	2SC1449	95				
2N2926G	10	2SC1679	190				
2N3053	25	2SC1678	140				
2N3054	55	2SC1923	65				
2N3055	50	2SC1945	225				
2N3442	140	2SC1953	90				
2N3615	199	2SC1957	90				
2N3663	20	2SC1969	165				
2N3702/3	10	2SC2028	85				
2N3704/5	10	2SC2029	200				
2N3706/7	10	2SC2078	170				
2N3708/9	10	2SC2091	85				
2N3710	10	2SC2166	165				
2N3771	179	2SC2314	85				
2N3772	195	2SC2335	200				
2N3773	210	2SC2465	125				
2N3819	35	2SC2547	40				
2N3820	60	2SC2612	200				
2N3822/3	60	2SD234	75				
2N3866	90	2SK45	90				
2N3903/4	15	2SK288	225				
2N3906/5	15	2SJ83	225				
2N4037	60	2SJ85	225				
2N4058	15	3N128	115				
2N4061/2	15	3N140	115				
2N4264	30	40251	150				
2N4286	25	40311	60				
2N4289	25	40313	130				
2N4400	25	40361/62	70				
2N4427	80	40408	76				
2N4859	78	40412	90				
2N5135	30	40467	130				
2N5138	25	40468	85				
2N5172	25	40594	105				
2N5180	45	40595	110				
2N5191	75	40603	110				
2N5194	80	40673	70				
2N5305	24	40871/2	90				

LINEAR IC's

555 CMOS	80	LM349	125	SP0256AL	425	8250	£11
702	50	LM358	50	SP8629	350	8251	350
709C 8 pin	35	LM377	210	TA7120	120	8253	380
710	50	LM379	495	TA7130	125	8255	400
741	16	LM380	80	TA7204	150	8256A	£15
747C 14 pin	60	LM381N	150	TA7205	90	8257A	400
748C 8 pin	35	LM382	130	TA7222	150	8259	400
753 8 pin	185	LM384	140	TA7310	120	8271	£45
810	160	LM386	90	TAA900	395	8272	£15
9400CJ	375	LM387	120	TAA700	275	8279	750
ADC0808	£10	LM389	160	TAD100	159	8282	450
AY-1-1320	225	LM393	60	TBA120S	70	8283	450
AY-1-5050	99	LM394CH	380	TBA540	275	8284	550
AY-1-6720	210	LM558	170	TBA550Q	330	8288	£11
AY-3-1270	720	LM725CN	300	TBA641	290	8748	£33
AY-3-8910	390	LM733	65	TBA800	80	8T26A	99
AY-3-8912	430	LM1871	300	TBA810S	95	8T27	150
AY-5-1317A	630	LM1889	400	TBA820	80	8T31	350
AY-5-3500	650	LM2907	395	TBA920Q	200	8T95N	90
AY-5-8100	650	LM3900	45	TBA990	350	8T97N	90
CA3011	130	LM3909	85	TCA270	350	9364AP	550
CA3012	175	LM3911	175	TCA280A	220	9602	220
CA3014	275	LM3914	265	TCA940	175	4027	95
CA3018	86	LM3915	265	TCA950	200	4116-200n	125
CA3019	90	LM3916	300	TCA965	180	4164-150	200
CA3020	210	LM13600	110	TDA1008	310	4416-2	299
CA3023	210	LS7220	295	TDA1010	220	4532-3	250
CA3028A	110	M51513L	230	TDA1022	400	4816-100ns	100
CA3035	255	M51515L	320	TDA1024	110	4864-15	200
CA3036	270	M51516L	430	TDA1034	350	6116-150	150
CA3043	275	MB3712	200	TDA1054	110	6116L-120ns	220
CA3045	365	MB3756	440	TDA1490	350	6117-100n	575
CA3046	65	MC1204	250	TDA2002	325	6167-6	795
CA3059	325	MC1301	110	TDA2003	190	6264L-15	400
CA3075	215	MC1310P	135	TDA2004	230	63A03	£10
CA3080E	65	MC1458	35	TDA2006	320	65C02	850
CA3081	190	MC1469	300	TDA2020	320	6502 CPU	325
CA3085	160	MC1488	70	TDA2030	190	6502A	545
CA3086	60	MC1489	70	TDB0791	420	6503	650
CA3090AQ	250	MC1494	695	TL061CP	40	6520	175
CA3123	165	MC1495	300	TL062CP	60	6522A	545
CA3130	85	MC1496L	70	TL071CP	40	6522 VIA	340
CA3140	40	MC1596	225	TL072CP	60	6530 RRIOT	£11
CA3160	95	MC3302	75	TL074CN	110	6532 RIOT	650
CA3161E	180	MC3401	50	TL081CP	30	6545 CRTC	899
CA3162	540	MC3403	60	TL082CP	50	6551 ACIA	650
CA3189	260	MC3404	85	TL083CP	75	6800	220
CA3240E	100	MC3405	150	TL084CP	100	6802	275
HA1366	175	MC3423P	80	TL091CP	60	6803	850
HA1388	235	MC4016	295	TL170	50	6805	670
ICL7106	675	MF10	300	TL497A	185	6809E	680
ICL7107	975	MFC6040	75	TL507	110	6810	150
ICL7611	95	ML924	275	TL509	110	68A02	345
ICL7660	250	NE515	275	UA2240	120	6820	150
ICL8038CC	300	NE529	225	UA78S40	225	68B21	220
ICL8211	225	NE531	120	UAA170	180	6821	150
ICM7217A	£11	NE543	225	UAA180	180	6840	375
ICM7224	785	NE544	170	ULN2003	75	6843	800
ICM7240	300	NE555	25	ULN2004	75	6845	650
ICM7555	80	NE556DB	45	ULN2283	150	6845SP	750
ICM7556	140	NE565	170	ULN2803	190	6846	625
LA3350	250	NE566	295	UPC1025H	375	6847	650
LA4031P	340	NE568	170	UPC1156H	295	6850	120
LA4032	295	NE570	350	UPC1181	395	6852	250
LA4400	350	NE571	420	UPC1182	425	6854	625
LA4422	320	NE592	420	UPC1366	195	68B54	750
LC7120	300	NE565A	115	XR2206	365	68000	£20
LC7130	300	NE566	140	XR2207	400	8017	275
LC7137	350	NE567	130	XR2211	575	8035	350
LF347	120	NE570	370	XR2216	675	8080A	425
LF351	40	NE571	370	XR2266	360	8085A	950
LF353	75	NE5532	150	ZN409C	180	8088	995
LF355	90	NE5534	105	ZN414	80	81LS95	75
LF356	90	OM335	650	ZN423E	130	81LS96	175
LF357	100	RC4136D	55	ZN424E	130	81LS97/98	175
LF398	495	RC4558	40	ZN425E-8	350	8123	160
LM10	325	SAB3209	425	ZN426E-8	300	8131	475
LM301A	30	SAB3271	485	ZN427E-8	600	8150	800
LM307	45	SAB4209	295	ZN428E	450	8154	750
LM308	75	SG3402	295	ZN429E-8	240	8155	400
LM311	45	SG3402	300	ZN459	245	8156	400
LM318	135	SL924	395	ZN1034E	200	8202	£25
LM319	180	SL6270	150	ZN1040E	665	8212	220
LM324	45	SN76003	350	ZNA234E	925	8214	495
LM334Z	125	SN76013	150			8216	150
LM335Z	130	SN76127	135			8224	£3
LM337	250	SN76477	95			8226	£3
LM339	40	SN76488	380			8228	310
LM348	60	SN76489	525			8243	290

JUST PHONE YOUR ORDER, WE DO THE REST

COMPUTER IC's

2102L	160	UPD7002	440	74S287	200	7454	25
2114	250	UPD7007	725	74S288	180	7460	25
2147-3	£3	WD1691	£14	74S289	200	7470	48
2516	300	WD1770	£14	74S299	540	7472	35
2532-4	300	WD2143	850	74S301	350	7473	40
25L32	450	280CPU 2·5	295	74S365	250	7474	36
2564	£6	Z80ACPU4M	280	74S373	375	7475	48
27L08	450	Z80ACTC	310	74S374	375	7476	40
2716-5V	300	Z80B	£8	74S412	380	7480	50
2732	350	Z80DART	650	74S470	325	7481	175
2732A	585	Z80ADART	800	74S471	600	7482	90
27256-2	600	Z80ADMA	900	74S472	400	7483	85
2764-250	200	Z80DMA	795	74S473	00	7484	100
27C64	495	Z80P10	250	74S474	400	7485	100
26501	75	Z80AP10	315	74S475	425	7486	35
27128/250n	300	Z80S10-1	850	74S571	300	7489	170
256K DRAM	495	Z80AS10	900	74S573	450	7490	55
3242	675	Z80AS10-2	£9			7491	65
4027	95					7492	55
4116-200n	125	**74S**		**75**		7493	50
4164-150	200	74S00	40	75107/8/9	90	7494	90
4416-2	299	74S02	40	75110	90	7495	65
4532-3	250	74S03	40	75119	140	7496	72
4816-100ns	100	74S04	40	75121	130	7497	170
4864-15	200	74S05	40	75150	115	74100	195
6116-150	150	74S08	40	75151	180	74104	68
6116L-120ns	220	74S09	40	75154	125	74105	68
6117-100n	575	74S10	40	75158	150	74107	40
CD4724	150	74S11	50	75159	140	74109	60
COM8017	275	74S15	60	75160	350	74110	55
DM8131	275	74S20	40	75161	350	74111	55
DP8303	450	74S22	60	75162	450	74112	170
DP8304BN	350	74S30	50	75182/3	90	74116	160
DS3647	600	74S32	50	75183	105	74118	100
DS3691N	350	74S37	50	75188/9	100	74119	150
DS8820	110	74S38	70	75322	140	74120	90
DS8830	140	74S40	40	75325	165	74121	45
DS8831	125	74S51	40	75353	140	74122	50
DS8832	150	74S64	40	75361	150	74123	73
DS88LS120	300	74S65	40	75365	185	74125	50
E9364	800	74S74	70	75376	95	74126	50
E9365	£28	74S85	295	75376	210	74128	55
FD1691	£15	74S86	140	75450	80	74130	60
FD1771	£15	74S112	150	75451/2	50	74136	63
FD1791	£22	74S113	120	75454	70	74141	80
FD1793	£23	74S114	120	75491/2	65	74142	230
FD1795	£28	74S124	300			74143	250
FD1797	£28	74S132	90	**TTL 74**		74144	225
HD26501	750	74S133	50	7400	22	74145	85
HD4315	250	74S134	60	7401	22	74147	130
HD6301	225	74S135	110	7402	22	74148	105
HM6845	755	74S138	170	7403	25	74150	130
IM6402	380	74S139	170	7404	25	74151	60
INS8060N	1250	74S140	75	7405	25	74153	70
MC1488	70	74S151	140	7406	38	74154	135
MC1489	70	74S153	140	7407	38	74155	75
MC14411	675	74S157	200	7408	25	74156	90
MC14412	725	74S158	190	7409	25	74157	75
MC3242	590	74S162	300	7410	25	74159	175
MC3446	250	74S163	300	7411	25	74160	90
MC3447P	315	74S168	300	7412	25	74161	90
MC3486	225	74S169	300	7413	35	74162	90
MC3487	225	74S174	250	7414	50	74163	90
MM5837	£7	74S175	300	7416	35	74164	110
MM5280D	695	74S181	138	7417	35	74165	90
MM5303	635	74S182	250	7420	25	74166	130
MM5307	1275	74S188	180	7422	30	74167	200
MM5387A	865	74S189	225	7423	32	74170	160
MM58174	875	74S194	280	7425	32	74172	390
RO-3-2513L	700	74S195	350	7426	36	74173	100
RO-3-2513U	650	74S196	300	7427	30	74174	100
SAA5050	875	74S197	250	7428	30	74175	80
SFF96364E	800	74S201	500	7430	22	74176	80
SP0256AL2	475	74S225	500	7432	29	74177	80
TCM3101J	£13	74S226	375	7433	35	74178	120
TMS2716-3	725	74S240	375	7437	29	74180	85
TMS4047	100	74S241	375	7438	39	74181	230
TMS4164-15	200	74S244	475	7440	25	74182	85
TMS4416-2	335	74S251	225	7441	85	74184	160
TMS4500A	£12	74S257	225	7442	65	74185	160
TMS4532-3	350	74S258	225	7443	95	74186	75
TMS6011	500	74S260	70	7444	100	74188	75
TMS9914	895	74S262	£10	7445	100	74190	117
TMS9927	£14	74S274	00	7446	100	74191	140
TMS9928	£10	74S275	00	7447	95	74192	191
TMS9929	£10	74S280	00	7448	98	74193	110
ULN2003	75	74S281	00	7450	25	74194	90
		74S283	00	7451	30	74196	63
				7453	25	74197	120
							85

74198	190	LS27	22	LS248	100	4014	50
74199	200	LS28	24	LS249	100	4015	40
74221	95	LS30	22	LS251	55	4016	25
74246	125	LS32	22	LS253	70	4017	45
74247	120	LS33	23	LS256	90	4018	55
74248	145	LS37	25	LS257	55	4019	35
74249	172	LS38	25	LS259	90	4020	50
74251	90	LS40	22	LS260	70	4021	55
74259	140	LS42	50	LS261	100	4022	60
74265	60	LS47	75	LS266	25	4023	20
74273	150	LS48	75	LS273	80	4024	35
74276	150	LS49	95	LS275	350	4025	20
74278	150	LS51	22	LS279	55	4026	90
74279	75	LS52	25	LS280	180	4027	30
74283	110	LS54	22	LS283	70	4028	40
74284	300	LS55	22	LS290	80	4029	45
74285	310	LS63	52	LS292	850	4030	20
74286	90	LS73	28	LS293	75	4031	125
74290	85	LS74	28	LS294	999	4032	65
74293	85	LS75	38	LS295	130	4033	130
74297	165	LS76	28	LS297	850	4034	145
74298	156	LS78	34	LS298	100	4035	70
74351	175	LS83	65	LS299	220	4036	250
74365	68	LS85	70	LS320	210	4037	115
74366	68	LS86	35	LS322	360	4038	75
74367	68	LS90	40	LS323	300	4039	270
74368	65	LS91	86	LS324	140	4040	45
74376	117	LS92	50	LS325	150	4041	55
74390	100	LS93	45	LS326	290	4042	45
74393	103	LS95	58	LS327	290	4043	45
74425	60	LS96	90	LS347	120	4044	50
74426	65	LS107	40	LS348	140	4045	110
74490	89	LS109	45	LS352	115	4046	60
		LS112	40	LS353	85	4047	50
74C		LS113	38	LS355	220	4048	50
C244	195	LS114	36	LS356	200	4049	25
C245	195	LS122	55	LS363	140	4050	25
C373	220	LS123	60	LS364	150	4051	50
C374	220	LS124	120	LS365	42	4052	50
C922	400	LS125	37	LS366	42	4053	60
C923	525	LS126	37	LS367	42	4054	70
C925	595	LS132	52	LS368	42	4055	70
		LS133	44	LS373	80	4056	85
74 HC		LS135	28	LS374	80	4057	£10
74HC00	30	LS136	35	LS375	55	4059	400
74HC02	30	LS138	48	LS377	100	4060	70
74HC04	55	LS139	48	LS378	85	4061	£5
74HC08	30	LS145	90	LS379	127	4062	995
74HC10	30	LS147	130	LS384	457	4063	80
74HC20	30	LS148	115	LS385	310	4066	25
74HC32	40	LS151	55	LS386	50	4067	230
74HC24	55	LS153	65	LS390	60	4068	20
74HC42	65	LS154	120	LS393	48	4069	20
74HC51	30	LS155	55	LS395	100

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

DIODES

AA119	8
AA129	10
AAY30	8
BA100	10
BY100	15
BY126	12
BY127	10
CRO33	198
OA9	10
OA47	10
OA70	9
OA79	10
OA81	10
OA85	10
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	12
1N5404	14
1N5406	15
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

BRIDGE RECTIFIERS
(plastic case)

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	30
2A/50V	26
2A/200V	40
2A/400V	42
2A/600V	50
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	56

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

VARICAPS

BB105B	40
BB106	40

TRIACS

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

SCR's Thyristors

0·8A-100V	32
5A/300V	38
5A/400V	40
5A/600V	48
8A/300V	60
8A/600V	95
12A/100V	78
12A/400V	95
12A/800V	138
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5064	38
2N4444	130

DIAC

ST2	25

SOLDERCON PINS

100	45p
500	200p

VERO TOOLS

Spot face cutters	150p
Pin insertion tool	185p

OPTO ELECTRONICS

LED

0·125"	
TIL209 Red	10p
TIL211 Green	14p
TIL212 Yellow	14p
TIL213 Amber	14p
0·2"	
TIL220 Red	12p
TIL222 Green	14p
TIL226 Yellow	14p
Flashing Red	55p
Bi colour R/G	100p
Bi colour G/Y	100p
Tri colour R/G/Y	85p
Hi-Bright Red	95p
Hi-Bright Green	100p
Hi-Bright Yellow	95p
Rectangl. R,G & Y	35p
Rectang. Stackable Red Green Yellow	18p
Triangular R & G	18p
Infra Red	
LD271 (emit)	46p
TIL32 (emit)	52p
SFH205 (detector)	100p
TIL78 (detector)	55p
TIL38 (emit)	50p
TIL100 (detector)	90p
7 Segment Display	
DL704 ·3" C.An	120p
DL707 ·3" c.Cth	120p
FND357 or 500	100p
TIL321 ·5" C.An	140p
TIL322 ·5" C.Cth	140p
·3" Green C.An	140p
·3+1" Red or Green	150p
Bargraph 10 Seg.	250p
Bargraph NSM3914	400p

ILCT6	135p
ILI74	80p
ILD74	130p
ILQ74	220p
TIL111	70p
TIL112	70p
TIL113	70p
TIL114	70p
TIL116	70p
BPX25	150p
BPX65	320p
BPW21	280p
TIL81	82p
OCP71	120p
ORP12	78p
2N5777	50p
4N33	135p
Pin Diode	720p
Smith Rec.	700p

0·5" LCD DISPLAYS

3½ digit	495
6 digit	625

OPTO SWITCH
Reflective TIL139 **225**
Slotted similar to RS **186**

FERRIC CHLORIDE
Crystals 1lb **150p + 50p p&p**

DALO ETCH RESIST
Pen plus spare tip **100p**

COPPER CLAD BOARDS

Fibre Glass	single sided	double sided
6"×6"	100p	125p
6"×12"	175p	225p

ALUM.BOXES

4×2½×2"	100
4×2¾×2½"103	
4×4×2½"	120
5×4×2"	105
5×2¾×1½"	90
5×2¾×2½"130	
5×4×1½"	99
5×4×2½"	120
6×4×2"	120
6×4×3"	150
7×5×3"	180
8×6×3"	210
10×4¼×3"	240
10×7×3"	275
12×5×3"	260
12×8×3"	295

VERO BOARDS 0·1"

2½ × 1	30p
2½ × 3¼	95p
2½ × 5	110p
3¾ × 3¾	110p
3¾ × 5	125p
3¾ × 17	420p
4¾ × 17	590p
VQ Board	195p

VERO WIRING

PEN + Spool	380p
Spare Spool	75p
Combs	8p
Pen + Spool + Combs	599p

DIP Board	395p
Vero Strip	95p

PROTO DECs

Veroblock	480p
S-Dec	350p
Eurobreadboard	590p
Bimboard	575p
Superstrip	
SS2	1350p

VERO PINS per 100

Single Ended	55p
Double Ended	60p
Wire Wrape S/E	155p
Wire Wrape D/E	255p

VOLTAGE REGULATORS

1A T0220 Plastic Casing

	+ve		−ve	
5V	7805	45p	7905	50p
12V	7812	45p	7908	55p
15V	7815	45p	7912	55p
18V	7818	45p	7915	55p
24V	7824	45p	7918	50p

100mA T092 Plastic Casing

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

ICL7660	248	LM317K	250
78H05 5V/5A	550	LM317	99
78H12 12V/5A	640	LM323K	500
78HG+5 to +24V 5A	695	LM337T	175
		LM723	30
79HG −2.25V to −24V 5A	785	TBA625B	75
LM309K	120	RC4194	375
TL497	185	RC4195	160
		78S40	225

SWITCHES

SLIDE 250V

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

TOGGLE 2A 250V

SPST	35
DPDT	48
4 pole on off	54

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

SUB-MIN TOGGLE 2 amp

SP changeover	64
SPST on off	58
SPDT c/off	85
SPDT Biased	105
DPDT 6 tags	80
DPDT C/OFF	88
DPDT on/on/on	185
DPDT Biased	145
4-pole 2 way	220

MINIATURE
Non Locking
Push to make **15p**
Push break **25p**
ROTARY: (Adjustable Stop Type)
1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way **48p**

ROTARY: Mains 250V AC, 4 Amp **68p**

DIP SWITCHES: (SPST) 4 way **65p**; 6 way **80p**; 8 way **85p**; 10 way **100p**; (SPDT) 4 way **190p**.

AMPHENOL CONNECTORS

	IDC	Solder
24 way IEEE plug	465p	460p
24 way IEEE socket	485p	480p
36 way Centronics plug	395p	390p
36 way Centronics socket	480p	450p

ASTEC UHF MODULATORS

6MHz Standard	375p
8MHz Wideband	450p

ANTEX Soldering Irons

C15W	600p	C517W	620p
G18W	620p	XS25W	650p

DIL SOCKETS

	Low profile	Wire wrap	Turned Pin Low profile
8 pin	8p	20p	18p
14 pin	10p	28p	23p
16 pin	10p	40p	28p
18 pin	16p	40p	33p
20 pin	20p	58p	37p
22 pin	22p	60p	39p
24 pin	25p	68p	42p
28 pin	28p	78p	52p
40 pin	30p	89p	72p

ZIF SOCKET (TEXTOOL)

24 way	550p
28 way	650p
40 way	800p

DIL PLUGS (Headers)

Pins	Solder	IDC
14	40p	95p
16	45p	100p
24	85p	135p
28	150p	195p
40	200p	225p

RIBBON CABLE (price per foot)

Ways	Grey	Colour
10	15p	25p
16	20p	30p
20	25p	40p
26	40p	65p
34	50p	80p
40	60p	90p
64	90p	125p

'D' CONNECTORS:

Pins	9 way	15 way	25 way	37 way
MALE				
Solder	55p	80p	120p	150p
Angle	110p	175p	225p	300p
Strait	100p	100p	160p	250p
FEMALE				
Solder	90p	125p	180p	275p
Angle	150p	200p	260p	390p
Strait	100p	125p	195p	355p
COVERS	75p	70p	70p	85p

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

SIL Sockets 0.1"

	.1"	.156"
2× 6 way	—	75p
2×12 way	—	160p
2×15 way	—	165p
2×18 way	175p	160p
2×22 way	200p	170p
2×23 way	150p	—
2×25 way	250p	245p
2×28 way	180p	—
2×30 way	280p	—
2×36 way	300p	—
2×40 way	320p	—
2×43 way	400p	—
2×75 way	600p	—

20 way **65p**
32 way **95p**

EDGE CONNECTORS

SPECTRUM 32K UPGRADE

Upgrade your 16K Spectrum to full 48K with our RAM Upgrade Kit. Very simple to fit. Fitting instructions supplied. **ONLY £18**

IDC CONNECTORS (Speed block type)

2 rows	PCB Male with latch Strt. Pins	Angle Pins	Female Header Socket	Female Card-Edge Connector
10 way	65p	65p	65p	110p
16 way	75p	75p	80p	185p
20 way	90p	90p	95p	185p
26 way	105p	110p	115p	230p
34 way	115p	130p	135p	320p
40 way	140p	145p	150p	335p
50 way	165p	170p	175p	350p
60 way	195p	210p	225p	495p

SPECIAL OFFER

	1+	10+
2764 – 250ns	194p	185p
27128 – 250ns	295p	285p
6116LP – 300ns	165p	145p
6264LP – 150ns	395p	385p

TRANSFORMERS

3-0-3V; 6-0-6V; 9-0-9V; 12-0-12V; 15-0-15V @100MA **130p**
PCB mounting; miniature; Split bobbin.
3VA: 2×6V /0·25A; 2×9V /0·15A; 2×12V /0·12A; 2×15V /0·2A **235p**
6VA: 2×6V /0·5A; 2×9V /0·3A; 2×12V 0·25A; 2×15V /0·2A **280p**
Standerd split Bobbin type.
6VA: 2×6V /0·5A; 2×9V /0·4A; 2×12V /0·3A; 2×15V /0·25A **250p**
12VA: 2×4V5 /1A3; 2×9V /0A6; 2×12V /0A5; 2×15V /0A4; 2×20V /0A3 ..... **345p** (35p p&p)
24VA: 2×6V /1A5; 2×9V /1A2; 2×12V /1A; 2×20V /0A5 ..... **385p** (60p p&p)
50VA: 2×6V /4A; 2×9V /2A5; 2×12V /2A; 2×15V /1A5; 2×20V /1A2; 2×25V /1A; 2×30V /0A8 ..... **520p** (65p p&p)
50VA multirail: +5V/5A, +12V, +25V, −5V, −12V @ 1A **620p** (65p p&p)
100VA: 2×12V /4A; 2×15V /3A; 2×20V /2A5; 2×25V /2A; 2×30V /1A5; 2×50V 1A ..... **955p** (75p p&p)
(PS p&p charge to be added over & above our normal postal charge)

JUMPER LEADS
IDC FEMALE RECEPTACLE Jumper Leads 36"

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

COMPUTER CORNER

- **CENTRONICS** (NLQ) Printer **£99**
- **EPSON LX80** Printer NLQ **£220**
- **EPSON FX80** Printer **£265**
- **EPSON FX100** Printer **£429**
- **KAGA/TAXAN KP810** Printer **£199**
- **KAGA/TAXAN KP910** Printer **£335**
- **BROTHER HR15** Daisywheel Printer **£315**
- **Centronics PRINTER CABLE** for all the above printers to interface with the BBC Micro **£7**
- **KAGA KX1201G Hi-RES,** Green Monitor. **£90**
- **ZENITH 12" Hi-RES,** Green Monitor 40/80 column select switch, value for money. **£70**
- **MICROVITEC 14"** colour monitor. RGB input. Lead incl. **£179**
- **MICROVITEC 1451** Hi-res 14" Monitor incl. Lead **£229**
- **KAGA II 12" Hi-RES,** RGB Colour Monitor **£255**
- **KAGA III 12" ULTRA Hi-RES,** RGB Colour Monitor **£310**
- **TEX EPROM ERASER.** Erases up to 32 ICs in 15-30 min. **£30**
- **Spare** 'UV lamp bulbs **£8**
- **9½"** Fan fold paper (1000 sheets) **£7**

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

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

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LJU 1/4A Mini Line Master	430p
LJU 1/6A Mini Line Extension	295p
LJU 2/4A Line Master	370p
LJU 2/6A Line Extension	250p
LJU 3/4A Flush Master	370p
LJU 3/6A Flush Extension	240p
LJU 10/3A Dual Splitter	550p
4 WAY BT plug	65p

DISC ALBUMS

Attractively finished in beige leather-vinyl, these conveniently store up to 20 discs. Each disc can easily be seen through the clear view pockets.

ONLY £4.25

5¼" Disc Drive
HEAD CLEANING KIT
£7.50

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A complete word processing package (which can be heavily modified to your requirements, maintaining large discount). We supply everything you need to get a BBC Micro running as a word-processor. Please call in for a demonstration.

Example Package:
BBC Micro, with DFS Interface, Wordwise, Twin 400K EPSON Disc Drives, 12" High-res green monitor, Brother HR15 Daisywheel printer, Beebcalc & Database software on Disc, 10 3M Discs, 500 sheets of paper, 4 way mains trailing socket, manuals and all cables.
Only: £999

CRYSTALS

32·768KHz	100
100KHz	400
200KHz	370
455KHz	370
1MHz	270
1·008M	275
1·28MHz	450
1·5MHz	420
1·6MHz	595
1·8MHz	545
1·8432M	200
2·0MHz	225
2·4576M	200
2·5MHz	225
2·56250M	220
3·2768M	150
3·57954M	95
3·6864M	300
4·0MHz	140
4·032MHz	290
4·194304M	150
4·433619M	100
4·608MHz	200
4·80MHz	200
5·0MHz	150
5·185MHz	300
5·24288M	390
6·0MHz	140
6·144MHz	140
6·5536MHz	200
7·0MHz	150
7·168MHz	175
7·68MHz	200
8·0MHz	140
8·08333M	395
8·867237M	175
9·00MHz	200
9·375MHz	350
10·0MHz	170
10·5MHz	250
10·7MHz	150
10·24MHz	200
12·0MHz	175
12·528MHz	300
14·31818M	155
14·7456M	175
14·765MHz	250
15·0MHz	200
16·0MHz	200
18·0MHz	150
18·432M	150
19·968MHz	150
20·0MHz	150
24·0MHz	150
24·930MHz	325
29·695MHz	150
26·670MHz	325
27·125MHz	295
27·145M	190
27·648MHz	300
38·66667M	240
48·0MHz	175
55·5MHz	400
100MHz	270
116·0MHz	300
145·8MHz	225

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SPECIAL OFFER THIS MONTH ..... **ONLY £365**
We stock the full range of BBC Micro peripherals, Hardware & Software like, Disc Drives (Top quality Cumana & Mitsubishi), Diskettes, Printers, Printer Paper, Interface Cable, Dust Covers, Cassette Recorder & Cassettes, Monitors, Connectors (Ready made Cables, Plugs & Sockets), Plotter (Graphic Tablet) EPROM Programmer, Lightpen Kit, Joysticks, Sideways ROM Board, EPROM Eraser, Machinecode ROM, The highly sophisticated Watford's 16K BEEB DFS, WORDWISE, BEEBCALC, Software (Educational Application & Games), BOOKS, etc. etc. Please send SAE for our descriptive leaflet.

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- **CS100 – TEC** Single sided 40 track 100K 5¼" Single Disc Drive **£89**
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- **CD400 – EPSON** Double sided 40 track 400K 5¼" TWIN Disc Drives **£140**
- **CD800S – MITSUBISHI** Dual 800K, Double sided 40/80 track switchable **£179**
- **DFS** Manual (comprehensive) ..... **£7** (NO VAT)
- **DISC INTERFACE KIT** for BBC **£56**
- **TWIN** Disc Drive CASE with Power Supply to house your own Drives **£38**

N.B. All single drives with power supply with be supplied in a twin Case for later inclusion of a second Drive.

(Carriage on disc drives £7 Securicor)

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SUPER HY-LIGHT STROBE KIT

Designed for Disco, theatrical uses, etc.

Approx. 16 joules. Adjustable speed. Price £45 + £2 p&p (Total inc. VAT £54.05; Case and reflector price £17 + £2 p&p (total inc. VAT £21.95); Foolscap SAE for further details including Hy-Light and Industrial Strobe Kits.

ULTRA VIOLET BLACK LIGHT FLUORESCENT TUBES

4ft 40 watt £10.44 (£12.00 inc. VAT)
2ft 20 watt £7.44 + £1.25 p&p (£9.99 inc. VAT)
18in. 15 watt £5.00 + 75p p&p (£6.61 inc. VAT)
13in. 10 watt £4.00 + 75p p&p (£5.46 inc. VAT)
12in. 8 watt £3.60 + 50p p&p (£4.71 inc. VAT)
9in. 6 watt £3.00 + 50p p&p (£4.02 inc. VAT)
6in. 4 watt £3.00 + 50p p&p (£4.02 inc. VAT)

230V AC Ballast Kit for either 6in, 9in or 12in tubes £5.50 p&p 55p (£6.96 inc. VAT).

175 WATT SELF-BALLASTED BLACK LIGHT MERCURY BULBS. Available for either B.C. or E.S. fitting, price £11.80 + p&p £1.25 (total inc. VAT £15).

400W UV LAMP & BALLAST complete — £53.80 + p&p £3.50 (£69.50 incl. VAT).

400W UV LAMP only, £25.00 + p&p £2.50 (£31.63 incl. VAT).

ROBOT ENTHUSIASTS
1. ESCAP precision Swiss-made ironless rotor, 6V DC geared Motor with 70-1 gearbox. 6V DC – 16 r.p.m. 3V – 8 r.p.m. amazing power; no load current; only 10 ma. approx. Size: 4 × 2½ cm. Ex-equipment, tested and guaranteed. ONLY £4.50 + 50p p&p (total inc. VAT £5.75).

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Sigle make will switch up to 250V A.C. 10 amps. Recommended operating voltage 8-28V D.C. but will work at less than 5V D.C. silent, contactless, opto isolated. Suitable for use with T.T.L. Logic for switching mains voltage. Mfr. by Teledyne. Offered at fraction of mfrs. price: £3.00 + 45p p&p (total inc. VAT £3.97).

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Type 1. Heavy duty 10A c/o contacts. Type 2. V3 c/o contacts. Type 3. Sub-miniature c/o contacts. All button type. Price £6.90 inc. VAT for 10, any type. Post paid. N.M.S.

VORTEX BLOWER & SUCTION UNIT

Powerful multi-stage dynamically balanced totally enclosed rotors, 1½in. inlet and outlet. 110V AC. £22.00. Switchable transformer for 240V AC £8.00 p&p £3.00 – total £37.95 inc. VAT.

VBL4 CENTRIFUGAL BLOWER

240V AC powerful 1/50 h.p. .23A motor. £18.00 + £2.00 p&p (Total inc. VAT £23.00). N.M.S.

CENTRIFUGAL BLOWER

Smith Type TFB 1706. 240V A.C. Aperture 45-40mm £6.50 p&p £1 (inc. VAT £8.62).

12/24V DC CENTRIFUGAL BLOWER

0.4A producing 30 cu.ft. £7.50 + £1.00 p&p – total inc. VAT £9.78. N.M.S.
METER 90mm dia. 0/300V A.C. M/C rect. £5.00 p&p £1 inc. VAT £6.90.

COOLING or EXTRACTOR FAN

Quiet smooth running. Size 4¾x4¾x1½. Supplied for 240V a.c. operation. Price £5.75 + £1 p&p (Total inc. VAT £7.75) N.M.S.

VARIABLE VOLTAGE TRANSFORMERS

INPUT 230, 240V a.c. 50/60 OUTPUT 0-260V.

200W, 1A Max.	£19.50
0.5KVA 2½A Max.	£22.00
1KVA 5A Max.	£31.00
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15KVA 75A Max.	£285.00

All V.V.Ts plus carriage and VAT

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Dual input 200-240V or 380-415V. Star connected
3KVA, 6KVA, 10KVA, available. Phone for details.
Comprehensive range of TRANSFORMERS L.T. ISOLATION & AUTO (110-240V). Either cased with American socket and mains lead or open frame type available for immediate delivery. Leaflet on request.

SPECIAL OFFER: Brand new Safety Isolation Transformers. Primary 0-104-110-120V. 0-104-110-120V. Secondary 0-104-110-120V. 0-104-110-120V. 3KVA @ £60.00. 4kVA with 0-110V, Secondary only @ £80.00 + Carriage and VAT. 'Phone for further details.

12V D.C. BILGE PUMPS

400 G.P.H. 15ft. head, 3amp, £8.00 + £1.00 p&p (£10.35 inc. VAT).
700 G.P.H. 10ft. head, 3.5amp, £11.50 + £1.50 p&p (£14.95 inc. VAT).
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Why waste money? Build your own EPROM ERASURE for a fraction of the price of a made-up unit. Complete kit of parts less case to include 12, 8 watt 2537 Angst. Tube. Ballast unit, pair of bi-pin leads, Neon indicator, safety microswitch, on/off switch and circuit.
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Warning: Tube used in this circuit is highly dangerous to the eyes. Unit must be fitted in suitable case.

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16 UF 900V. A.C. 50/60 Hz. Ideal power factor correction etc. 9¼x6x4¾ ins. Wt. 7½ Kg. Price £12.00 + £3.00 p&p (Total inc. VAT £17.25). N.M.S.

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Superior Quality Precision Made NEW POWER RHEOSTATS

Heavy duty brush assembly continuously rated.
25 WATT 5/10/25/100/300/1kΩ 1.5Ω £4.25 + 30p p&p (£5.23 inc. VAT).
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Black Silver Skirted Knob calibrated in Nos 1-9, 1½in. dia. brass bush. Ideal for above Rheostats 30p ea. + VAT.

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5 rpm 240V AC Mf. by Carter, £6.05 £1 p&p (£8.11 inc. VAT). N.M.S.
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Suitable TRANSFORMER for 230-240V AC operation. Price: £5.20 + p&p £1.40 (Total inc. VAT £7.59). N.M.S.
38.3 rpm GEARED MOTOR. Torque 35lb.in. reversible 115V AC inc. start capacity. Price: £11.55 + £2.00 p&p (Total inc. VAT £15.58). N.M.S.
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100.7 rpm 65lb in reversible 115 volt AC price £30.00 p&p £4.50 (Total inc. VAT £39.68).
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57 rpm 240V 1/22 h.p. continuously rated REVERSIBLE 50lb.in. manuf. by Wynstruments. New. Ideal for garage doors, curtains etc. ONLY £14.00 + £2.00 p&p (incl. VAT £18.40), inclusive capacitor.

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Suitable TRANSFORMER for 230-240V AC operation. Price: £5.20 + p&p £1.40 (Total inc. VAT £7.59). N.M.S.
24V DC 200 rpm 10lb/in. Mf. by either Parvalux or Cater. Ex-equip. tested. £8.00 + £1.50 p&p (Total inc. VAT £10.93).
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DIODES

POTS
PRE-SETS
MOTORS

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Soldering Station complete with 30W or 40W iron (state which) £7.95
XS25 W Iron kit/ complete with steel & plug attached 10.00

CS 18W, as above	9.90
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Antex 18W iron	5.50
Antex 25W iron	5.75
Antex elements	2.75
Antex bits	0.90
Antex stands	2.10
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Spare nozzles for Soldersucker	0.65

RESISTORS – CARBON FILM 5%

¼W 1RO to 10M (E12 Range)	2p each. 15p/10. 75p/100
½W 2R2 to 10M (E24 Range)	2p each. 15p/10. 75p/100
1W 10R to 2M2 (E12 Range)	7p each. 65p/10. 6.00/100
2W 10R to 2M2 (E6 Range)	8p each. 70p/10. 6.00/100

RESISTOR KITS – each value individually packed

¼W pack 10 each value E12 – 10R to 1M 610 pieces	5.75
¼W pack 5 each value E12 – 10R to 1M 305 pieces	3.35
½W pack 10 each value E12 – 2R2 to 2M2 730 pieces	7.95
½W pack 5 each value E12 – 2R2 to 2M2 365 pieces	4.75
1W pack 5 each value E12 – 2R2 to 1M 353 pieces	15.00
2W pack 5 each value E6 – 10R to 2M2 317 pieces	18.50

NI-CAD CHARGER

Universal Ni-Cad charger, charges PP3, AA, C,D.
Price £5.99
Rechargeable Batteries
AA (HP7) 85p 10/75p each
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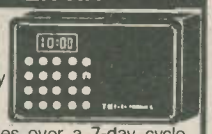

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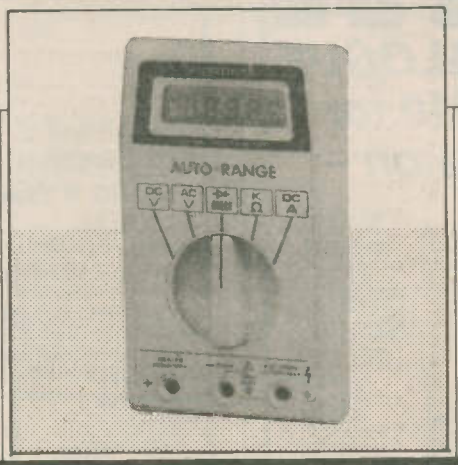

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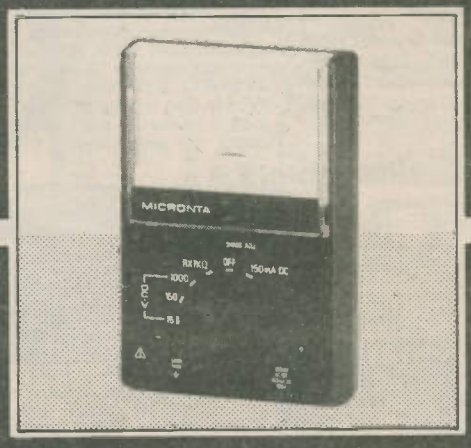

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***Editorial* 01-727 7010**

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

IN NOVEMBER, *Practical Electronics* celebrated its twenty-first birthday. In those twenty one years the magazine has grown into one of the most widely respected popular electronics titles. Each issue is read avidly by tens of thousands all over the world. For all these years *Practical Electronics* has been under the ownership and guidance of *IPC Magazines Ltd.* Now the magazine has changed ownership and will from the next issue be under the guidance of ***Practical Electronics Magazines Ltd.*** The new owners will continue the tradition of quality and advancement in the exciting field of electronic technology.

The editorship of *Practical Electronics* is being taken over by myself, Nick Hampshire. I have written many books on computing and electronics, and have edited and published several computer magazines. Richard Barron the current assistant editor is staying with the magazine and will help to ensure that the magazine continues to provide our existing and loyal readers with the kind of articles and projects which has made Practical Electronics the success that it is today. I shall also be acting as publisher in association with Angelo Zgorelec who is well known to many as the founder of *Personal Computer World Magazine,* the first European personal computer magazine.

I wish to assure all our readers, subscribers and advertisers, that Practical Electronics under its new ownership will continue to provide the kind of editorial which you both expect and demand. Expanding the size of the magazine will give me space to include new editorial material, thereby allowing more extensive coverage of subjects relating to leading edge LSI and micro technologies. To help decide what you as readers want from the magazine I am including in this issue a special reader survey. I hope that as many readers as possible will complete and return the survey form (see page 25). This is important since it is on the basis of this research that I will decide on the editorial contents, and what type of projects to include in future issues.

WELCOME CRITICISM

I would welcome any ideas or criticism from our readers and advertisers. I would also like to encourage any readers who have developed a project which they think others would like to hear about to write to me with a short description as I will constantly be looking for new authors with good, original and innovative ideas.

I wish to take the opportunity of thanking my predecessors as editors, Mike Kenward, and founding editor Fred Bennett, for the great job they have done over the last twenty one years. I am looking forward to continuing this tradition of high standards over the next twenty one years of Practical Electronics, and I hope all our loyal readers will agree.

. . . Nick Hampshire

BACK NUMBERS and BINDERS . . .

Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), Practical Electronics Magazines Ltd., 16 Garway Road, London W2, at £1.40 each including Inland/Overseas p&p. Please state month and year of issue required.

Binders for PE are available from the same address as back numbers at £5.50 each to UK or overseas addresses, including postage, packing and VAT.

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

...NEWS &

WHEN TO START?

At what age should one start to learn about electronics? The answer—as early as possible! At least, that is the idea in Wirral, where the Borough's Education Authority asked Bromborough's INTECH (Information Technology Centre) to develop an idea of Simon Jones, a teacher at Sandbrook Primary School, Wallasey, for teaching basic electronics to primary and early secondary school children.

The result is the successful Wirral Electronics Pack, now being offered to schools and education authorities throughout Britain.

The pack is permanently housed in a carton with a fitted cellular plastic interior liner—the individual cells containing separately all the materials necessary for simply constructing 10 experiments which will introduce 3rd and 4th year juniors or 1st year secondary school pupils to the fundamental concepts of electronics.

Worksheets are included which instruct users—both teachers and pupils—how to set up each experiment correctly to achieve an end result. Each experiment demonstrates the nature of electricity and how it flows in a circuit.

Power is supplied cheaply and safely by 4 ordinary 1·5 volt HP2 or equivalent dry batteries (not included). Spacers gripped between the batteries provide tapping points for 1·5, 3, 4·5 or 6 volts as required.

Project No. 12 gives instruction in building a multifunction alarm system (intruder and fire), but children and teachers can develop their own projects from there —the Electronics Pack is a springboard rather than a closed learning system.

This is further borne out by the fact that Stage II, which will link more advanced experiments to school computers, is already being developed. Stage II will then make a bridge to the Micro-Electronics for All course. (See *Practical Electronics* January and February.)

For further information on the Wirral Electronics Pack Stage I (£22.25 inc VAT and p&p) contact Bromborough INTECH Centre Ltd. (051-334 2771).

OPTICAL FIBRE RECORD

A new world record for optical fibre transmission set by British Telecom promises to help contain the cost of expanding the network. A team of engineers have succeeded in transmitting data over 32 km of singlemode fibre at a rate of 2·4 Gbit/s, the fastest rate yet achieved over an installed cable.

Unlike previous laboratory demonstrations this feat was achieved over an existing cable. It illustrates the feasibility of upgrading existing optical systems without the need to replace cables. Considerable sums could be saved in the future by providing only new terminal electronics to expand the capacity of cables rather than replacing complete systems.

The data rate achieved, 2,400 million bits of information per second, represent a 16-fold capacity increase over the existing 140 Mbit/s systems. It is equivalent to passing 30,720 separate speech channels, or 32 full-bandwidth colour television pictures, down the same single optical fibre.

The key factor in the trial was the use of a ridge-waveguide distributed feedback (DFB) laser, developed at British Telecom's Martlesham research laboratories. It gives an absolutely pure single wavelength output at 1·52 microns, which is necessary to avoid the distortion which would occur with less pure, multi-wavelength signal sources in this application. The wavelength, longer than that used by current fibre systems (1·3 microns), was chosen because of the significantly lower losses (and hence further transmission) at this frequency.

The record was set on a cable linking Birmingham with Tamworth.

SATELLITE TRACKER

Two Satellites, UOSAT 1, launched in 1981 and known as OSCAR 9, and UOSAT 2 or OSCAR 11, launched in March 1984, are helping to generate more enthusiasm from pupils for geometry, maths, science, geography and computer systems. But until recently communicating with OSCAR 9 and OSCAR 11 has not been easy, involving electronics, computing and satellite tracking knowledge.

Now, after 15 months of work, the problems have been eliminated by Steve Webb whose track record in the electronics industry includes ten years work with Ferranti and Marconi on space and defence satellite systems.

Steve developed a basic receiver for his children after they got bored playing space invader games on their home computers —and they were thrilled to be able to receive data, news bulletins, and messages from space. He says his children provided the inspiration for ASTRID (Automatic Satellite Telemetry Receiver and Information Decoder) which is now about to be launched world-wide.

The fully automatic system will operate with any computer that has a suitable serial interface. Its system was originally developed with the BBC Micro because of the good quality educational software readily available with this computer. However, ASTRID has now been adapted for the Sinclair Spectrum and others.

The antenna can be attached to a TV mast, even a garden fence, providing it can see as much sky as possible. Some who have tested the product say it will even work with the aerial indoors.

ASTRID costs £149 (inc. VAT and p&p), it is supplied with receiver/decoder, antenna, power supply and leads plus test tape with display software. For further details contact, M. M. Microwave Ltd., Kirby-moorside, York YO6 6DW. (0751 31620).

MARKET PLACE

IDEA '86

IDEA '86 (Internepcon Development in Electronics Award) is a new award scheme initiated by Cahners Exhibitions Ltd.—the organisers of Internepcon, the UK's longest running national electronics show. The impetus behind IDEA '86 is to not only encourage the tradition of British innovation, but also provide the professional support necessary to manufacture and successfully promote and market the design. IDEA was officially launched in January this year.

The entrants will be taken from three main areas—individuals with an idea who are prepared to go into full time business, students in the final year of an elelctronics degree or other suitable technical qualification and small independent companies employing less than 10 staff.

IDEA '86 has, therefore, been conceived to encourage and help develop those ideas on new products which might otherwise be lost to industry.

The awards will be a bi-annual event—providing an ongoing impetus for new enterprise in the UK electronics industry, and continuously supporting those innovations through to the marketplace.

Entry deatails and further information can be obtained from Lucinda Hopkins/Chris Corfield, Infopress Limited on 01-353 2320.

OOPS! SORRY

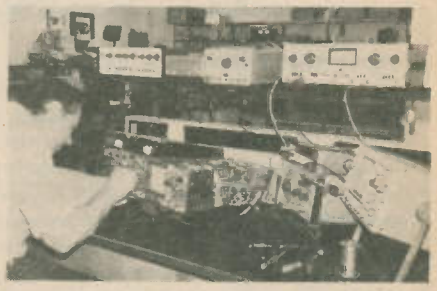
In the January news item 'CD With a Difference' we wrongly stated that the CARIN navigation system was presently available, we also published an approximate cost price.

Unfortunately we have since been informed that our source of information was inaccurate. Philips have demonstrated a prototype installation in Eindhoven and fully expect to be manufacturing a product sometime in the future. However, the time scale on this will be measured in years rather than months and therefore no information can be given on launch dates or prices.—Apologies to all concerned.

Calibration Service

Advance House of Instruments has recently appointed the Bedfordshire-based Beds. Industrial Calibration Centre on an exclusive basis to provide a back-up service for in and out of warranty repairs on the Advance House of Instruments' ranges of electronic test and measuring instruments.

Beds. Industrial Calibration Centre undertakes repair, servicing, and calibration of a wide range of instruments and also provides an emergency repair facility and a 7-day turnround as standard for calibration. Precision measurements are performed in a modern, clean, temperature-controlled room and are traceable to the National Physical Laboratory via the British Calibration Service. Repaired and calibrated equipment is soak tested and given a final test prior to being wrapped and delivered. All equipment repairs and calibration is supported by full documentation in the form of fault reports. Calibration certificates are available at a nominal cost. Information from Advance House of Instruments, Raynham Road, Bishop's Stortford, Herts CM23 5PF. (0799 26699).



IT'S A SMALL WORLD

Very often in our field we need to take a close look at our work, it is not always easy to illuminate the area at the same time. The Spirig Pocket Inspection Microscopes will, however, solve both these problems at the same time. Arguably these aids are being marketed as pocket size, they are certainly portable and would be a handy addition to the hobbyist toolkit.

Two types are available—the Spirig 30 (30× magnification) and the Spirig 100 (100× magnification). Their prices are £22.42 and £32.77 respectively (inc. VAT and p&p). From Cobonic Ltd., 32 Ludlow Road, Guildford, Surrey GU2 5NW. (0483 505260).

POINTS ARISING...

BURGLAR ALARM
Feb '86

The 12V bulb used to indicate an alarm condition should be connected to terminals 13 and 14 and not terminals 3 and 4 as stated in paragraph 1, page 31 of the Burglar Alarm project. Terminal 3 is connected directly to the mains as shown in Fig. 5.

Briefly...

It looks likely that Amstrad will launch a combined TV/Video-recorder later this year. According to reports, the machine could be the first of its kind, having the capability of receiving TV broadcasts in full. So far similar combinations have only incorporated monitors, they are used for business presentations etc.

Whilst on the subject of Amstrad machines, it has been brought to our attention that 'Locoscript' discs for the 8256 have an inherent bug (page number insertion fails to operate). Replacements available free of charge.

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 Brian Butler.

Sound Eighty Six Feb. 18–20. Novotel, Hammersmith. **F**
Electrex '86 Feb. 24–28. NEC, Birmingham. **G**
Scottish Electronics Technology Show Feb. 25–27. Exbn. Centre, Glasgow. **B**
Business Telecom '86 Mar. 4–6. Barbican Centre. **I**
Instrumentation '86 Mar. 5/6. Cresh Hotel, Bristol. **J**
Atari Computer Show Mar. 7–9. Novotel, Hammersmith. **O**
Electro-Optics/Laser International Mar. 18–20. Metropole, Brighton. **B**
Robotics and Automated Systems Mar. 25/26. Imperial College. **P**
CAD '86 Apr. 8–10. Metropole, Brighton. **L**
Internepcon Production Show Apr. 8–10. NEC, Birmingham. **B**
British Electronics Week Apr. 29–May 1. Olympia. **N**

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Fibre Optic Audio Link

R.A.Penfold

Guided light audio transmission system —experimenting with fibre optics

ALTHOUGH there has been a great deal written about fibre-optics in the technical press over the years, and this technology is now beginning to have a real impact in the communications industry, fibre-optic constructional projects seem to have been all but nonexistent so far. While it has to be admitted that the capabilities of fibre-optic cable are far in excess of anything most amateur users are likely to require (when did you last want to send twenty-five TV signals over a single cable), simple data links can also be provided, and can be surprisingly inexpensive. The cable itself has fallen in price over the years, and is now just a little more expensive than ordinary electric cable.

This article describes a simple fibre-optic audio link which does not require any special or difficult to obtain electronic components. A frequency modulation system is used to give good linearity and a signal to noise ratio of better than 60dB. A high brightness l.e.d. is used as the modulated-light source and an ordinary phototransistor acts as the light receiver. The prototype has only been tried over a range of 20m, and this should be adequate for most purposes. This range is achieved with ease though, and the system should be capable of operating over a substantially greater range without the need for any modifications. Whether or not the system has any real advantages over an ordinary electric-cable link is debatable, but at the very least it represents an interesting project for schools and experimenters.

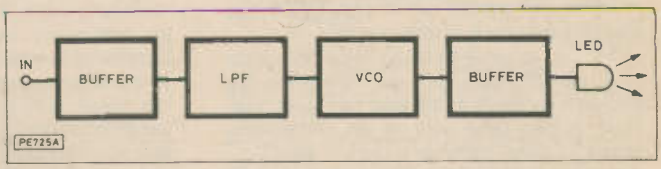


Fig. 1. Transmitter block diagram

essary to have clear air between the emitter and the detector. Whether the cable is laid out in a straight line or bent into a complex shape, the degree of attenuation it provides remains much the same.

There are two basic types of modulation that can be applied to this application, AM (amplitude modulation) and FM (frequency modulation). With amplitude modulation the transmitting l.e.d. is at about half brightness under quiescent conditions, and its brightness is varied in sympathy with the audio input voltage. Positive input voltages give a proportional increase in brightness, while negative voltages give a proportional decrease in brightness. The photodetector is connected in a potential divider circuit which is in turn connected across a voltage source. The varying light level is thus converted to varying resistance through the detector element, and to a varying voltage by the potential divider circuit.

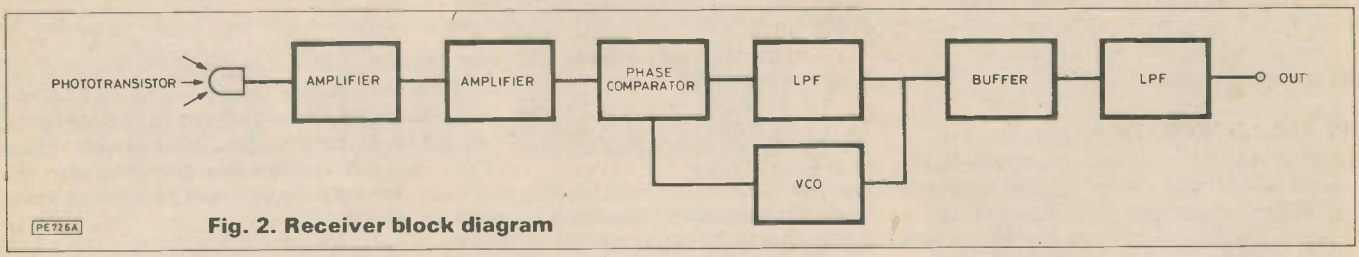


Fig. 2. Receiver block diagram

SYSTEM OPERATION

The type of cable needed for a link of this type is a single polymer filament of about 1mm in diameter and covered with plastic sleeving to protect the core. The latter gives the cable an appearance which is very much the same as ordinary single core insulated electric cable, but the fibre-optic cable is generally a little less flexible though. Light fed in at one end of the cable tends to travel down the filament, reflecting from one wall to the other, eventually emerging at the other end. The difficulty when producing fibre-optic cable is to keep the losses down to a low level, and a typical (inexpensive) modern cable has an attenuation of about 1dB per metre. In other words, the light level reduces by a factor of ten for every 20m of cable.

This may not seem to be very good in comparison to an ordinary coaxial cable, and only represents about one tenth of the range for a given level of attenuation, but it is adequate for many purposes. If used to link an l.e.d. to a photodetector, the range obtained via the cable is vastly more than can be obtained by simply directing the light direct from the l.e.d. to the detector. Of course, the other advantage of using a fibre-optic cable is that it is not necessary to have clear air between the emitter and the detector. Whether the cable is laid out in a straight line or bent into a complex shape, the degree of attenuation it provides remains much the same.

Although an AM system has the advantage of being extremely simple, it has a major drawback in that any non-linearity anywhere in the system produces distortion on the audio output signal. In practice quite significant levels of distortion would almost certainly result, and it is better to use an FM system where non-linearity in the l.e.d., l.e.d. driver, and photodetector do not affect the audio output quality. This equipment uses a simple FM set-up, and the block diagrams for the transmitter and receiver are shown in Fig. 1 and Fig. 2 respectively.

The transmitter is slightly the more simple of the two devices, and really consists of little more than a VCO (voltage controlled oscillator). The output frequency of the VCO is dependent on the control voltage, and this voltage is modulated by the audio input signal. The receiver must convert the variations in frequency back into an audio signal using some form of frequency to voltage converter. The l.e.d. is simply being switched on and off, and it is the switching frequency rather than the l.e.d. brightness that is proportional to the amplitude of the audio input signal. Therefore the l.e.d. and photodetector cannot introduce distortion into the system. An FM system is not distortionless though, and the VCO

must have good linearity, as must the frequency to voltage converter at the receiver, if a good quality audio output is to be obtained. In practice good VCO and detector linearity are easily achieved.

TRANSMITTER AND RECEIVER

Returning to Fig. 1, the transmitter is more than just a VCO, and one of the additional stages is a buffer stage at the output which provides a reasonably high drive current to the l.e.d. A buffer stage at the input gives the circuit a fairly high input impedance and provides a low output impedance to drive a lowpass filter circuit. This stage ensures that the excessive modualtion frequencies are not allowed to reach the VCO. A bias voltage for the control input of the VCO is supplied by the buffer stage via the lowpass filter.

A phototransistor is used as the light detector, and this provides good sensitivity at the fairly high carrier frequency of around 100kHz. Another point in favour of phototransistors is that they are readily available with a built-in lens that gives a fairly narrow viewing angle. This is important in this application as it helps to ensure that the light from the end of the cable is efficiently coupled to the semiconductor detector element. The output from the detector circuit is quite low at typically only a few mV RMS or less. A two stage high gain amplifier is used to boost and clip the signal to give virtually squarewave output to drive the frequency to voltage converter circuit.

PHASE LOCKED LOOP

A phase locked loop provides the frequency to voltage conversion. The phase comparator, lowpass filter, and VCO make up the phase locked loop. The relative phase and frequency of the input signal and the VCO are checked by the phase comparator, which provides a series of output pulses. These pulses are integrated by the lowpass filter to produce a reasonably smooth control voltage for the VCO. If the VCO is at a lower frequency than the input signal or even if it is just slightly lagging the input signal in phase, the output from the lowpass filter goes to a high voltage and boosts the operating frequency of the VCO. Similarly, if the VCO is at a higher frequency than the input frequency, or leading it in phase, the output of the lowpass filter goes to a low voltage. This reduces the VCO's operating frequency.

There is a negative feedback action here which results in the VCO locking on to the same frequency as the input signal, and also keeping in phase with it. This assumes that the input frequency is within the locking range of the circuit. For proper demodulation the carrier frequency of the transmitter must be roughly matched to the centre frequency of the VCO in the PLL, and the deviation at the transmitter must not take the carrier outside the locking range of the PLL. Severe distortion usually results if lock is lost on signal peaks.

Of coures, in this application it is not the output of the VCO that is of value, but the control voltage from the lowpass filter. This rises and falls in sympathy with fluctuations in the input frequency, and provided the VCO has good linearity, it provides the required linear frequency to voltage conversion. A phase locked loop may seem to be an unnecessarily complex way of doing things, but using a suitable PLL integrated circuit this type of detector can actually be very simple and inexpensive. PLL detectors give excellent results, and an acceptable signal to noise ratio from weak and noise infested input signals.

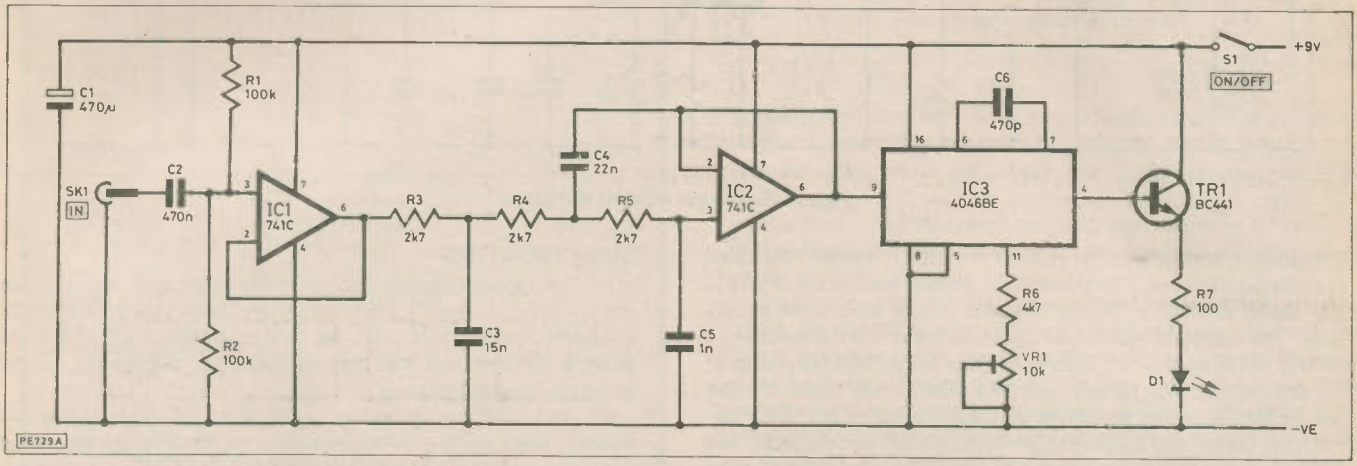


Fig. 3. Transmitter circuit diagram

The demodulated audio output is fed via a buffer stage to a second lowpass filter. This filter ensures that there is no significant carrier breakthrough at the output, and as it is an active type it also provides the unit with a low output impedance.

TRANSMITTER CIRCUIT

Fig. 3 shows the circuit diagram for the transmitter. The circuit is designed around IC3 which is a CMOS 4046BE phase locked loop, but in this circuit only the VCO section of the device is utilized. C6, R6, and VR1 are the timing components, and VR1 is adjusted to match the centre frequency of the transmitter VCO to that of the PLL decoder in the receiver circuit. The carrier frequency of the prototype is just over 100kHz, and the peak deviation can be quite high at up to about 30kHz or so.

TR1 operates as an emitter follower buffer stage at the output of the VCO, and this drives the l.e.d., D1 at a current of approximately 40mA. The output waveform of IC1 is a squarewave signal, and D1 is therefore switched off for about 50% of the time. This gives an average l.e.d. current of about 20mA. Originally a higher l.e.d. current was used, together with an ordinary 5mm red l.e.d., but this gave poor results with a mediocre signal to noise ratio. In fact it was difficult to align the optics accurately enough to get the system to operate at all. Filing down the lens on the l.e.d. gave a much improved signal to noise ratio, but optical alignment remained critical. In the final unit a high brightness red l.e.d. is used, and the specified device (a CQV51J) was found to give excellent results. Even using an average l.e.d. current of only around 20mA a good signal to noise ratio is provided, and optical alignment is far from critical. An infra-red l.e.d. might give improved results since most phototransistors have a response which peaks in the infra-red part of the spectrum. However, not all fibre-optic cables will transmit efficiently in the infra-red part of the spectrum, and the cable used in the prototype proved to be very inefficient with an infra-red source. A high brightness red l.e.d. probalby represents the safest option.

IC1 is the input buffer stage and it gives the unit an input impedance of nominally 50k. The lowpass filter is based on IC2 which also operates as a unity voltage gain buffer stage. The filter is a conventional third order (18dB per octave) type which gives the system a bandwidth of about 15kHz. This is marginally less than the full audio range, but is sufficient to provide a very respectable audio quality (comparable to FM radio).

RECEIVER CIRCUIT

The circuit diagram of the receiver appears in Fig. 4. TR2 is the phototransistor, and although a BPX25 is specified for this

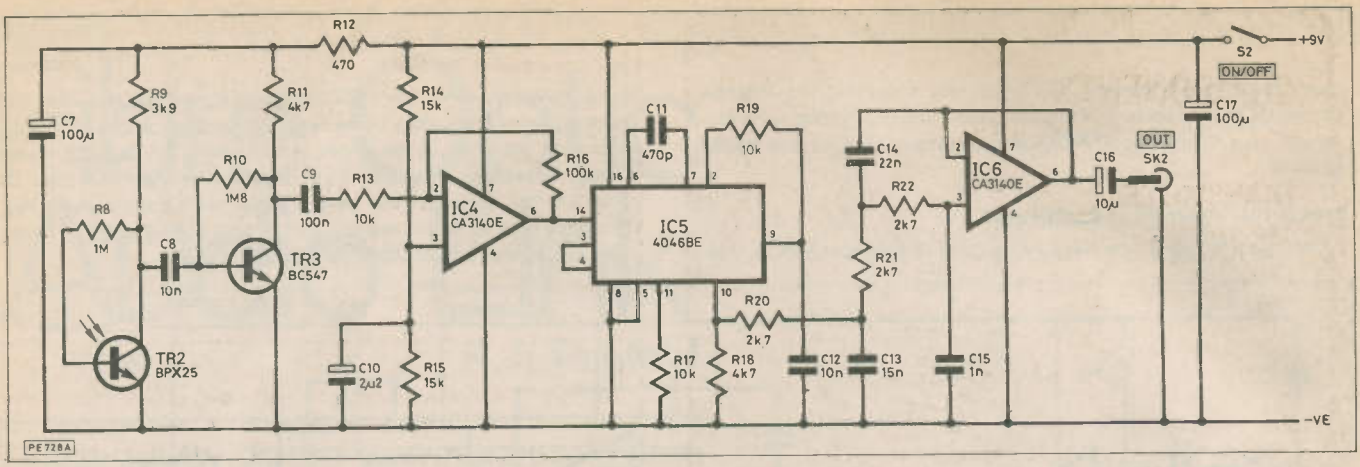


Fig. 4. Receiver circuit diagram

component, similar devices such as the TIL81, and BPY62 seem to work equally well. The collector to emitter resistance of TR2 is connected with R9 to form a potential divider across the supply lines. The pulses of light cause the collector to emitter resistance of TR2 to fall slightly, and this generates small negative pulses at the collector of TR2. R8 provides TR2 with a small quiescent bias current which aids its sensitivity and high frequency performance.

TR3 is connected as a high gain common emitter amplifier, and it provides the first stage of amplification. IC4 is connected as an inverting amplifier with a voltge gain of 20dB, and this provides the second stage of amplification. The clipped signal at the output of IC4 is compatible with the input of IC5, which is another 4046BE CMOS phase locked loop. In this case it is used as the phase locked loop detector. The link across pins 3 and 4 connects the output of the VCO to the input of the phase detectors (only one of which is used here). R19 and C12 form the lowpass filter between the phase comparator's output and the control input of the VCO, while C11 and R17 are the VCO's timing components. R18 is the load resistor for the built-in source follower buffer stage of IC5, and it is from here that the demodulated audio signal is taken.

IC6 is used as the basis of the lowpass filter at the output of the unit, and this is essentially the same as the filter at the input of the transmitter. The circuit will handle signal voltages of up to about 1V RMS or so with distortion of under 1%. Although one might expect there to be exactly unity voltage gain through the system, there is in fact a loss of a few dB. This is due to the buffer stage in IC5 having a voltage gain of somewhat less than unity.

CONSTRUCTION

Printed circuit designs for the transmitter and receiver are shown in Fig. 5 and Fig. 6 respectively. Both boards are pretty straightforward to construct, but bear in mind that IC3 to IC6 are all MOS devices, and that they consequently require the normal antistatic handling precautions.

D1 and TR1 are mounted horizontally on their respective boards. The boards are then mounted on the base panels of the cases with D1 and TR1 positioned behind holes drilled in the front panels. Cases of about 150mm by 100mm by 50mm are suitable incidentally. There is no fibre-optic equivalent of a 3·5mm jack plug and socket available, and so something has to improvised. Fig. 7 shows the arrangement used in the prototype equipment. The front panel holes are fitted with small grommets having an inside diameter of about 5mm. Some sleeving is then used to link each grommet to its opto device, so that when the end of the cable is pushed into the grommet it is guided to the opto device. Heat-shrink sleeving is ideal, as the opto devices have a wider diameter than the cable, and by shrinking the sleeving the cable will be made a tighter and more reliable fit. The sleeving must be fitted and shrunk prior to mounting each opto device. It can be shrunk by holding it over the flame from a match, and rotating the sleeving so as to heat it evenly over its entire surface. Be very careful not to overheat the sleeving or the component, or your fingers for that matter. This system seems to work very well in practice, making the fibre-optic cable as easy to use as an ordinary audio cable fitted with jacks. If you prefer not to use heat-shrink sleeving, results seem to be perfectly acceptable using

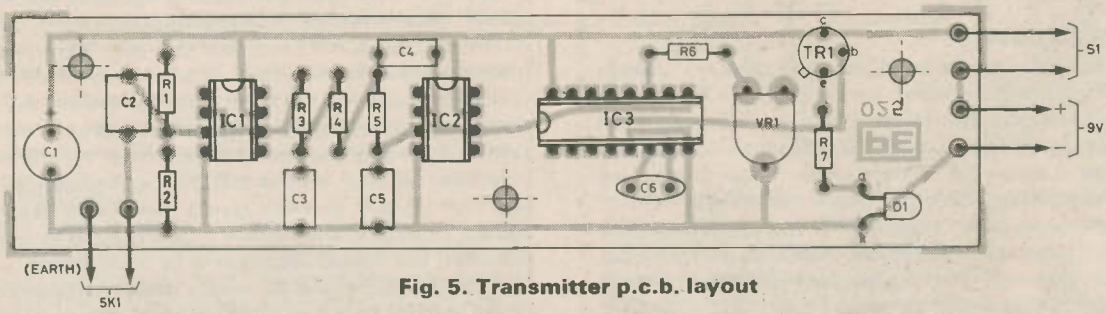


Fig. 5. Transmitter p.c.b. layout

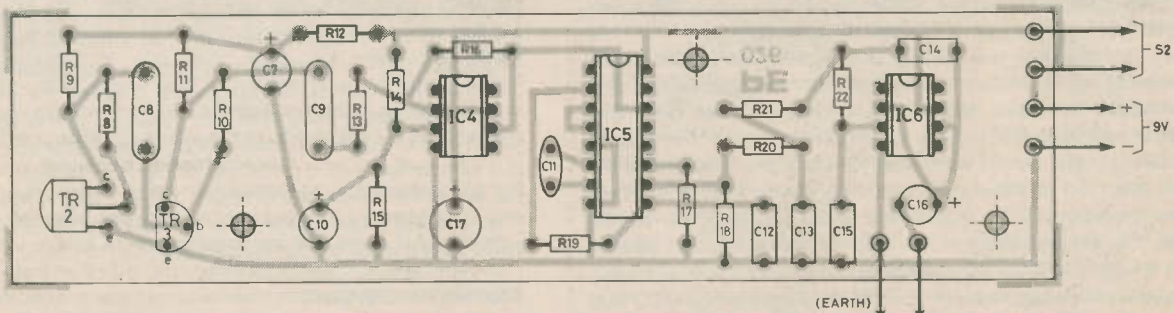


Fig. 6. Receiver p.c.b. layout

COMPONENTS . . .

TRANSMITTER

Resistors

R1,R2	100k (2 off)
R3–R5	2k7 (3 off)
R6	4k7
R7	100
All ¼W carbon	
VR1	10k sub-min hor preset

Capacitors

C1	470µ 10V radial elect
C2	470n carbonate
C3	15n carbonate
C4	22n carbonate
C5	1n carbonate
C6	470p ceramic plate

Semiconductors

IC1, IC2	741C (2 off)
IC3	4046BE
TR1	BC441
D1	CQV51J 5mm High brightness red l.e.d.

Miscellaneous

S1	Rotary on/off switch
SK1	3·5mm jack socket

Case 152 x 102 x 51mm; printed circuit board PE 025; 16 pin d.i.l. i.c. holder; 8 pin d.i.l. i.c. holder (2 off); battery and connector; control knob; heatshrink sleeving; grommet; fixings, etc.

RECEIVER

Resistors

R8	1M
R9	3k9
R10	1M8
R11,R18	4k7 (2 off)
R12	470
R13,R17,R19	10k (3 off)
R14,R15	15k (2 off)
R16	100k
R20–R22	2k7 (3 off)
All ¼W carbon	

Capacitors

C7,C17	100µ 10V radial elect (2 off)
C8	10n polyester
C9	100n polyester
C10	2µ2 63V radial elect
C11	470p ceramic plate
C12	10n carbonate
C13	15n carbonate
C14	22n carbonate
C15	1n carbonate
C16	10µ 25V radial elect

Semiconductors

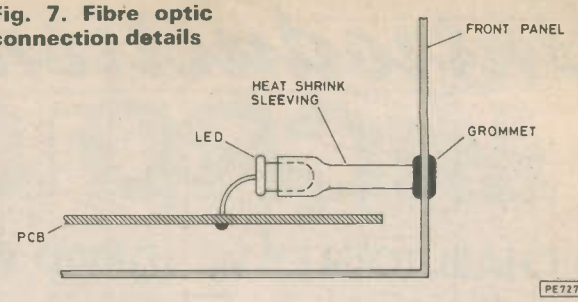
IC4,IC6	CA3140E (2 off)
IC5	4046BE
TR2	BPX25 or similar
TR3	BC547

Miscellaneous

S2	Rotary on/off switch
SK2	3·5mm jack socket

Single core fibre optic cable; case about 152 x 102 x 51mm; printed circuit board PE 026; 16 pin d.i.l. i.c. holder; 8 pin d.i.l. i.c. holder (2 off); battery and connector; heatshrink sleeving; grommet; control knob, fixings, etc.

Fig. 7. Fibre optic connection details

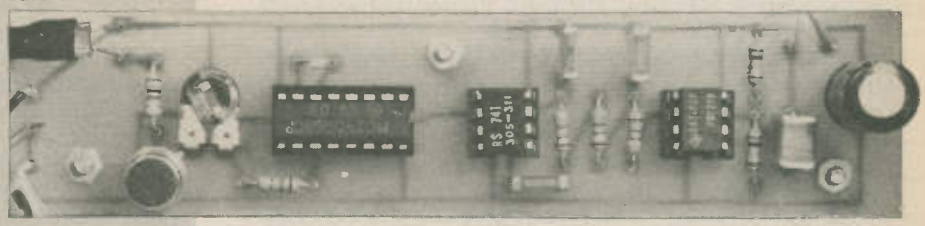


ordinary PVC sleeving having an inside diameter of about 5mm.

The current consumption figures for the transmitter and receiver units are about 28mA and 10mA respectively. This permits economic battery operation, but in both cases it is advisable to use a fairly high capacity type, such as a PP9 or six HP7 size cells in a plastic battery holder. Connection to the latter is via an ordinary PP3 style battery clip.

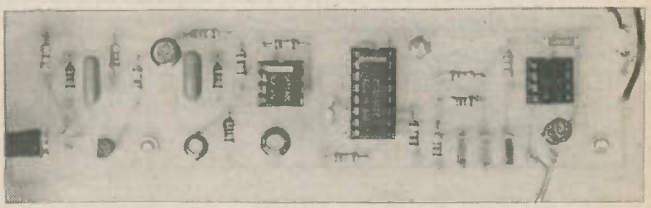
Fibre-optic cable is often supplied with rather rough cut ends which do not aid good light transmission. Much more efficient light transmission can usually be obtained by cutting off a small piece from each end of the cable using a sharp modelling knife, making the cuts as cleanly as possible and at a right angle to the cable. Provided a good clean cut is made there should be no need to polish the ends of the cable in order to obtain good results. A very important point to note is the the fibre-optic cable will fracture and cease to provide good light transmission if it is bent into tight curves. The minimum recommended radius for most single filament cables is about 20mm.

Photos below illustrating both p.c.b.s



ADJUSTMENT AND USE

For good results the system must be used with a fairly high input level of around 250mV to 1V RMS. For use with a low level source such as a microphone a suitable preamplifier must be added ahead of the transmitter. Only one adjustment has to be made to the completed system, and this is to set VR1 for optimum large signal handling ability. If an oscilloscope and audio signal generator are available these can be used to aid the correct adjustment of VR1, using the standard procedure. If suitable test gear is not available it does not really matter, and VR1 can be given any setting that gives good results with no obvious distortion on the output signal. The PLL detector has a wide lock range and the setting of VR1 is not particularly critical.



If stereo operation is required, the most simple way of achieving this (and the only way with the present design) is to use a separate transmitter and receiver circuit for each channel, with a twin fibre-optic cable providing the link. Similarly, a twin cable plus two sets of circuits could be used to provide a two-way link. The signal to noise ratio should be quite good unless a very long connecting cable is used. If necessary though, a higher transmitter output power can be used to give an even lower noise level, and this merely entails reducing the value of R7 to about 47Ω. Of course, this gives the transmitter a higher current consumption. ★

Introduction to MICRO SYSTEMS

MICHAEL TOOLEY BA DAVID WHITFIELD MA MSc CEng MIEE

PART 6

THIS MONTH sees the final part of this introduction to micro systems series. In it we will be taking a look at some of the peripheral chips available to suppport the 6502 CPU which was introduced last month. We will then move on to conclude the series by briefly reviewing the capabilities of the Z80 family.

6502 PERIPHERALS

The 6502 CPU has its own family of peripheral support chips, and Table 6.1 lists a selection of the more popular of these devices. In addition, however, 6502-based systems are also able to make immediate use of the peripheral chips provided for the 6800 family. This is due to the common bus structures used in these two micros. As a practical example of this capacity for "mix-and-match", we find that although the BBC Micro is designed around a 6502A CPU, and uses two 6522 VIAs from the 6502 support family, it supplements these with a 6845 CRTC and a 6850 ACIA from the 6800 family.

Many of the 6502's peripheral chips are very similar to the 6800 family devices, e.g. the 6545 CRTC is pin-compatible with the 6845. Others are more accurately best considered as broad equivalents to 6800 family devices, but usually with additional facilities. For example, the 6522 VIA is generally equivalent to the 6821 PIA, but it has the added features of two programmable interval timers and a shift register.

Before we move on to discuss the Z80 family, we will take a brief look at the 6502's VIA. This device is of particular interest because it introduces the type of programmable timing facilities which are frequently required in designing a micro system. In other micro families, these facilities are frequently provided separately in a programmable timer chip, e.g. the 8255 Programmable Interval Timer (PIT) in the 8080 family. With the 6522 we see the combination of parallel I/O and programmable timers. As system designers know, this can save a considerable amount of extra wiring if the number of 40-pin packages can be reduced by even one.

Table 6.1. 6502 peripheral devices

6520	Parallel I/O
6522	Versatile Interface Adaptor: Parallel I/O + Timers (VIA)
6530	ROM + RAM + Timer + I/O
6532	RAM + Timer + Parallel I/O
6541	Keyboard/Display Controller
6545	CRT Controller
6551	Asynchronous Communications Adaptor (ACIA)

6522 VIA

As we have already mentioned, the 6522 versatile interface adaptor (VIA) is in many respects best described as a super-6821. It features two 8-bit bidirectionial I/O ports, two 16-bit programmable timer/counters, a series-to-parallel and parallel-to-series shift register, as well as providing input data latching on the peripheral ports.

The pin connections for the VIA are shown in Fig. 6.1, with the corresponding internal block diagram shown in Fig. 6.2. As can be seen from these two diagrams, the 6522 has many more internal registers than the 6821. The 6522's sixteen registers (compared to the six to be found in the 6821) are individually-addressable via the

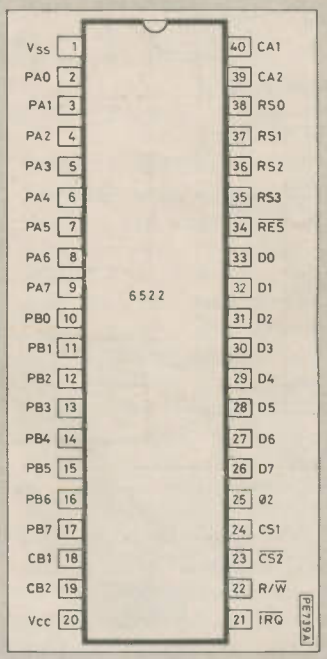


Fig. 6.1. 6522 pin connections

four register select lines, RS0 to RS3, in accordance with the scheme shown in Table 6.2. Many of the additional register addresses are provided in support of the additional functions provided by the VIA when compared with a PIA. One immediate and simplifying consequence of the increased number of register addresses used, however, is that the data direction and data I/O registers are not required to share the same register address, as was the case with the 6821. This makes simple I/O programming much easier, since it is possible to identify the effect of I/O instructions without referring back to any previous setting of bits in other registers.

Space unfortunately does not allow us to examine the operation of all of the 6522's registers in any detail. We will confine ourselves, therefore, to looking briefly at some of the additional features not previously encountered in peripheral devices. For further information, it is necessary (as indeed it usually is) to refer to the manufacturer's data sheet.

VIA TIMERS & SHIFTER

Interval Timers: There are two interval timers provided in the 6522 VIA, and these are referred to as T1 and T2. Since there are some significant differences in their capabilities and modes of operation, we will look at each of the timers in turn.

Timer 1 (T1): Interval timer T1 consits of two 8-bit latches (T1L-L and T1L-H), and a 16-bit counter (T1C-L + T1C-H). The latches are used to store the data which is to be loaded into the counter. When loading values into the counter, the CPU cannot write directly into the least significant byte of the counter. Instead, it must load the low order latch (T1L-L), and the contents of this latch are then automatically transferred into the low order half of the counter (T1C-L) when the CPU writes to the high order half of the counter (T1C-H). This allows both halves of the counter to be loaded simultaneously using only a single instruction, thereby avoiding possible timing errors caused by skew effects. After loading has occurred, the counter is decremented at the $\emptyset_2$ clock rate. When the 16-bit count reaches zero, the T1 interrupt flag (bit 6

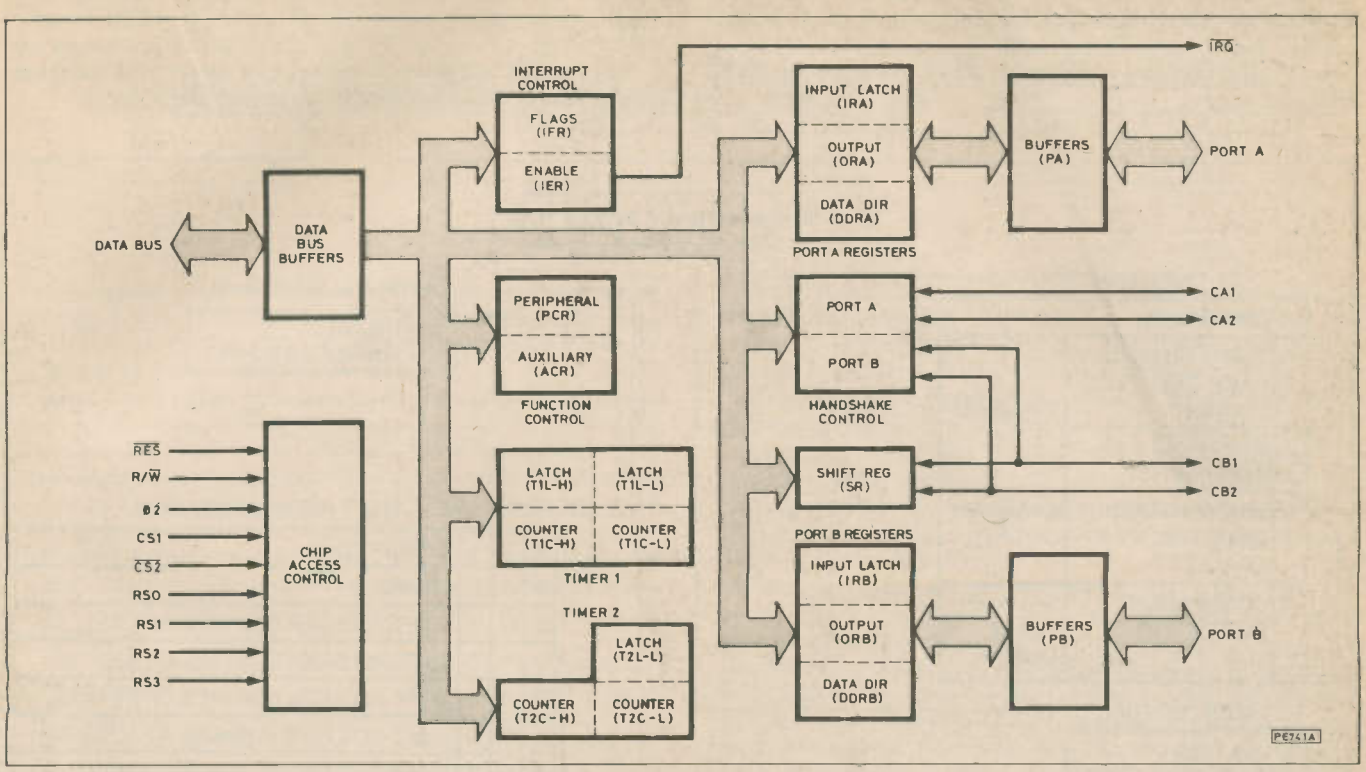


Fig. 6.2. 6522 block diagram

in register 13) is set. If T1 timer interrupts are enabled (see later), the $\overline{IRQ}$ user CPU interrupt line is also asserted low.

The subsequent operation once the counter has reached zero depends on the setting of bits 6 and 7 in the auxiliary control register (ACR—register 11). The significance of these bits is shown in Fig. 6.3. If bit 6 is set to a 0, no further interrupts will occur until the counter has been reloaded. The counter will, however, continue to decrement to allow the CPU to determine the time since the interrupt occurred. This is known as the "one-shot" timer operating mode. If bit 6 is set to a 1, the contents of the two latches (T1L-L and T1L-H) will be re-loaded automatically into the counter when the count reaches zero, and the whole process will then repeat. The timer is here operating in "free-run" mode.

In addition to generating interrupts, the timer can also be configured to drive the PB7 peripheral line. This behaviour is enabled when bit 7 in the ACR is set to a 1, and disabled when bit 7 is set to a 0. In one-shot mode, PB7 goes low when the counter is loaded, and returns high when the count reaches zero. Thus, the timer can be used to generate a programmable pulse width; operation in this mode is illustrated in Fig. 6.4. In free-run mode, the state of PB7 is inverted every time the timer expires. In the simple case, this allows the production of a square wave output whose pulse width is not affected by the time taken to service the interrupt. In sophisticated applications, the latch settings may be altered after each interrupt (which will not affect the count currently running, but will determine the *next* setting), allowing complex waveforms to be synthesised using this mode of timer operation.

Timer 2 (T2): The second timer operates either as an interval timer (in the one-shot mode only), or as a counter for counting

Table 6.2. 6522 peripheral registers

Register Number	RS Coding				Register Desig.	Description	
	RS3	RS2	RS1	RS0		Write	Read
0	0	0	0	0	ORB/IRB	Output Register "B"	Input Register "B"
1	0	0	0	1	ORA/IRA	Output Register "A"	Input Register "A"
2	0	0	1	0	DDRB	Data Direction Register "B"	
3	0	0	1	1	DDRA	Data Direction Register "A"	
4	0	1	0	0	T1C-L	T1 Low-Order Latches	T1 Low-Order Counter
5	0	1	0	1	T1C-H	T1 High-Order Counter	
6	0	1	1	0	T1L-L	T1 Low-Order Latches	
7	0	1	1	1	T1L-H	T1 High-Order Latches	
8	1	0	0	0	T2C-L	T2 Low-Order Latches	T2 Low-Order Counter
9	1	0	0	1	T2C-H	T2 High-Order Counter	
10	1	0	1	0	SR	Shift Register	
11	1	0	1	1	ACR	Auxiliary Control Register	
12	1	1	0	0	PCR	Peripheral Control Register	
13	1	1	0	1	IFR	Interrupt Flag Register	
14	1	1	1	0	IER	Interrupt Enable Register	
15	1	1	1	1	ORA/IRA	Same as Reg 1 Except No "Handshake"	

negative pulses on peripheral pin PB6. Selection of the mode of operation of T2 is controlled by bit 5 of the ACR, as shown in Fig. 6.3. The timer comprises a write-only low-order latch (T2L-L), a read-only low-order counter (T2C-L), both sharing the same register address, and a read/write high-order counter (T2C-H). The two counter registers act as a 16-bit counter which counts down at the $\emptyset_2$ clock rate.

Each interrupt flag also has associated with it an interrupt enable bit in the interupt enable register (register 14). This allows the CPU to decide in advance, for each possible source of interrupt in the VIA, whether this should be allowed to give rise to a user interrupt or not. This can save the CPU a lot of time in its own interrupt handling routines, and generally increases the flexibility of the system by devolving work from the CPU to the peripheral device.

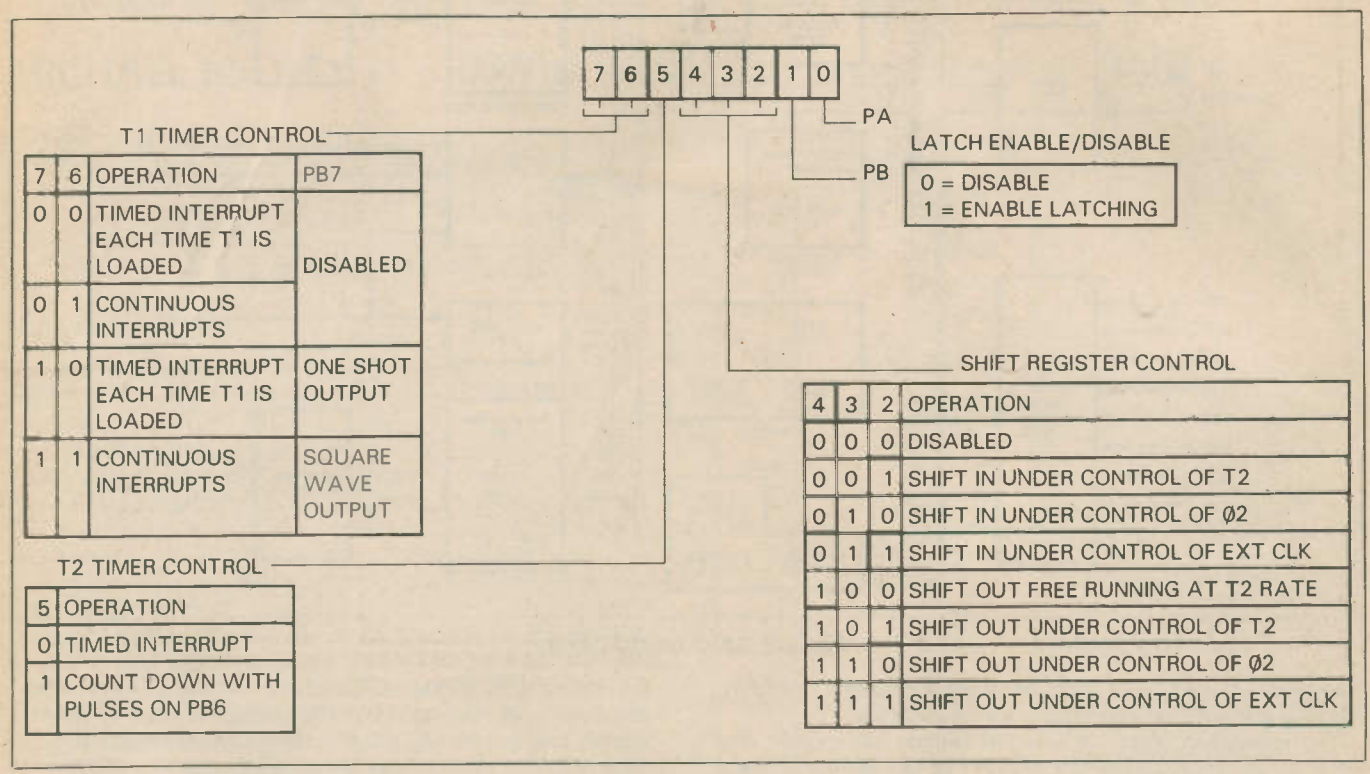


Fig. 6.3. Auxiliary control register

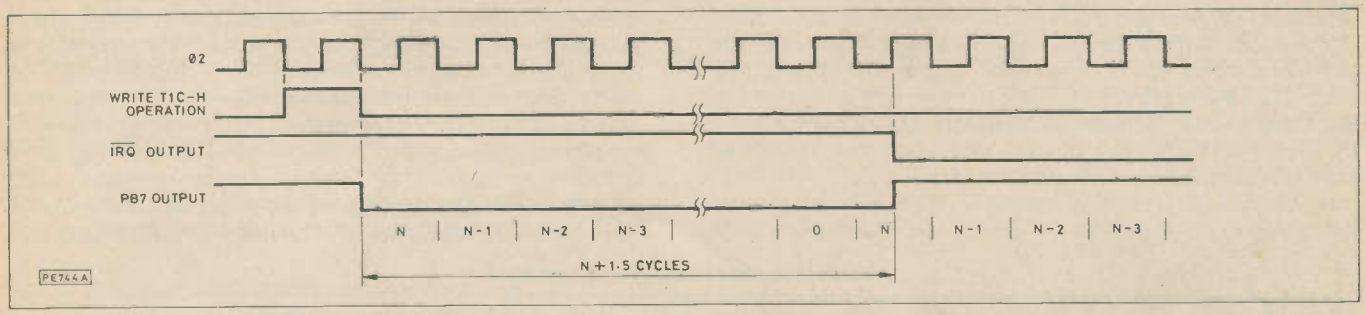


Fig. 6.4. One-shot timer operation

In the one-shot mode, T2 starts to count down when the CPU loads the high-order part of the counter, i.e. in the same manner as the operation of T1 in this mode. When a zero count is reached, the VIA generates an interrupt and sets the flag in the interrupt flag register (in this case it is bit 5 in register 13).

In the pulse counting mode, however, T2 serves primarily to count a predetermined number of the negative-going pulses on PB6 input and then generate an interrupt. This is accomplished by first loading a number into T2. Writing to T2C-H will clear the interrupt flag of any previous interrupt. The write operation will also cause the counter to decrement each time a pulse is applied to PB6. In order to be recognised, however, the pulse must be low on the leading edge of the $\emptyset_2$ clock. When the count reaches zero, an interrupt will be generated, but the counter will continue to count. The pulse counting sequence is summarised in Fig. 6.5.

Timer Interrupts: In both T1 and T2, the corresponding interrupt flags in register 13 are usually reset in one of two ways. The flag is cleared either by reading from the low-order half of the counter, or by writing to the high-order half of the counter. In each case, further timer interrupts will not be generated until the corresponding flag has been cleared. The interrupt flags may also be cleared directly by writing a 1 to the appropriate bit in register 13.

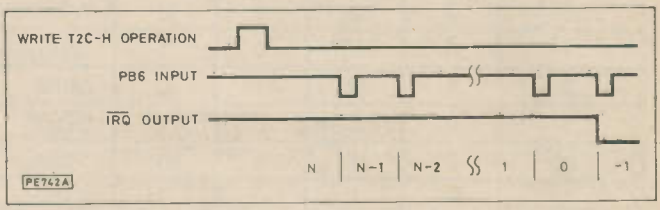


Fig. 6.5. Pulse counting mode

To assist the CPU in determining the source of an interrupt in a micro system, the 6522 provides an easily tested flag (bit 7) in register 13 which indicates whether an interrupt exists within the VIA. If not, then the CPU can rapidly pass on to another device, without having to look in detail at the individual flags.

Shift Register: The shift register (SR) allows serial data transfers to be performed into and out of CB2, i.e. serial-to-parallel and parallel-to-serial conversion between CB1 and the SR, respectively. The shifter has eight different modes of operation (including a 'disabled' mode), and the current mode of operation is selected by the setting of bits 2 to 4 in the auxiliary control register

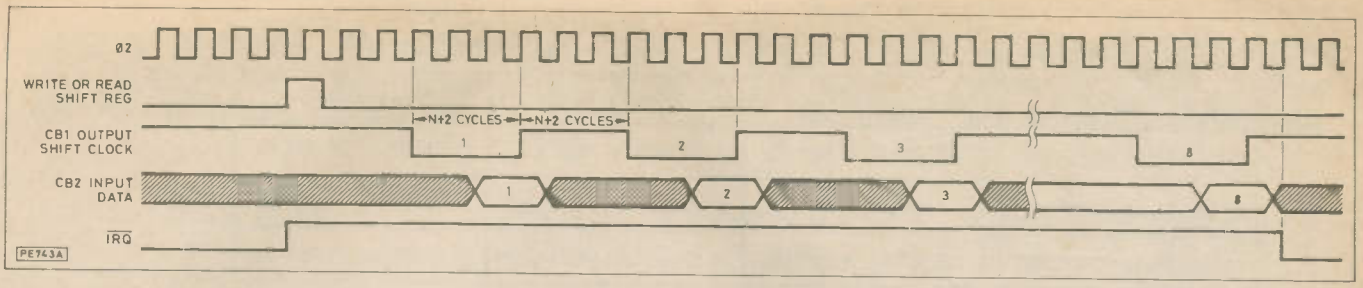


Fig. 6.6. Shift in under control of T2

(ACR—register 11). The values set in these bits allow selection of the shift direction (in/out), and control of the clock source (T2, $\emptyset_2$, or an external clock at CB1). All data shift operations are under control of an internal modulo-8 counter.

Space does not allow us to examine all of the shift register modes in any detail, so we will limit ourselves to looking at just one of the seven possible active modes; mode 000 is the eighth mode which disables shifter operation. Mode 001 (i.e. bits 4 and 3 of ACR set to 0, and bit 2 to 1), shifts data into the shift register under control of T2. Fig. 6.6 summarises the sequence to be described. During the operation, shift pulses are generated on the CB1 pin for use in the external circuitry. The time between these CB1 pulses is determined by the system's $\emptyset_2$ clock period, and by the user-defined contents of the low order T2 latch (T2L-L).

If the SR interrupt flag in register 13 is already set, the shifting operation starts on the next read or write of the shift register (SR—register 10). Otherwise, the first shift will occur the next time that T2 expires after the SR read or write (hence explaining the dependence of performance on the value of the system's $\emptyset_2$ clock period). The first data bit is then shifted into the low-order bit of the SR. The first bit is subsequently shifted into the next higher bit of the SR every time there is a negative-going clock edge (from T2). The external circuitry should be arranged so that the shifter's input data changes before the positive-going edge of the CB1 clock. The data is then shifted into the SR during the $\emptyset_2$ clock cycle following the positive-going edge of the CB1 clock. After eight CB1 pulses, the SR interrupt flag will be set, an interrupt will occur (if enabled), and shifting will cease. Thus the overall effect is to convert the serial data at CB2 into a parallel byte in SR.

All this can but give a flavour of the power of the 6522. The VIA must be a candidate for 'the' peripheral device in a small micro system where there is only room for one such device. Now we turn our attention to the Z80.

Z80

The Z80 was designed by a group of one-time Intel employees who left and founded Zilog. The first product of this enterprise was and is one of the undisputed successes of its time. In addition to its definite technical advantages over the other micros of the time, it also gave the necessary impetus to one of the original 'standards' for small business computers by becoming the target CPU for CP/M. In truth CP/M was originally developed for the 8080A, but with the advent of the Z80 (a super-8080A, which does everything and more that an 8080A will do, including run 8080A code), subsequent CP/M developments tended to be directed more and more towards this powerful machine. It is interesting to consider in passing how many other of the processors which were introduced in 1977 are still being used in new machines in 1986. A brief look at the design of the ever-expanding Amstrad range soon shows that there is still plenty of mileage left in this device.

So far so good, but what is it that made the Z80 such a popular micro with system builders? One of the answers must undoubtedly be the amount of software support which is available for the Z80. In many ways this is an answer to the original criticism that the Z80 designers paid too high a price for retaining compatibility with the then very popular 8080A . With the benefit of 20-20 hindsight, the strong following which the Z80 gained from providing this 8080A compatibility, also gave it the vital headstart it needed in the second-generation 8-bit architecture race.

The Z80 runs from a single +5V supply, and uses only a single chip to provide all of the functions necessary for the CPU. The pin functions and assignments for the Z80-CPU are shown in Fig. 6.7.

The Z80 features minicomputer-style I/O and vectored interrupts. It has a large instruction set of 158 instructions, including the 78 instructions of the 8080A as a subset. These instructions provide extensive facilities for string, bit, byte and word operations. Block searches and block transfers, together with indexed and relative addressing result in very powerful data handling capabilities.

Duplicate sets of both general-purpose and flag registers are provided, easing the design and operation of control software thorugh rapid context switching. The programming model of the Z80 is shown in Fig. 6.8. There are essentially three groups of registers in the Z80. The first consist of duplicate sets of 8-bit registers; a principal set and an alternative set (indicated by the ' suffix). Both sets of registers have an accumulator, a flags register and six general-purpose registers. Transfer of data between these duplicate sets of registers is accomplished by means of "Exchange" instructions. The result is faster response to interrupts and easy, efficient implementation of such versatile techniques as background/foreground processing. The second set of registers have assigned functions: Interrupt Register (I), Refresh Register (R), Index Registers (IX and IY), Stack Pointer (SP), and the Program Counter (PC). The third group consists of two interrupt status flip-flops and two flip-flops to identify the current interrupt status mode. It is perhaps worth a brief look at some of the registers which may not be familiar from looking at other micros.

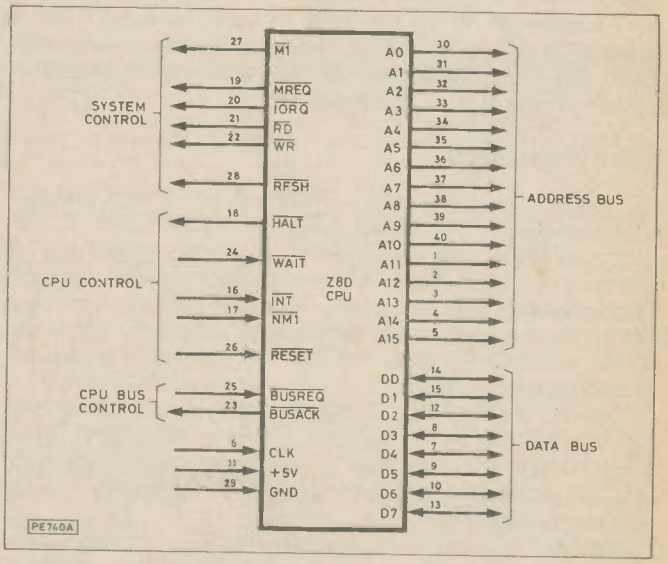


Fig. 6.7. Z80 pin functions and assignments

Memory Refresh: This register provides a user-transparent dynamic memory refresh capability. The lower 7 bits are automatically incremented, and all 8 are placed on the address bus during each instruction fetch cycle refresh time (i.e. when the $\overline{\text{RFSH}}$ signal output is low). This can be used as a refresh address to the system's dynamic memories, thereby simplifying system design.

Interrupt Register: This register holds the upper 8 bits of the memory address to be used in forming the 16-bit address to point to the table of addresses for the interrupt service routines. This register is used in servicing interrupts in mode 2, where the lower 8 bits of the address are provided by the interrupting peripheral device.

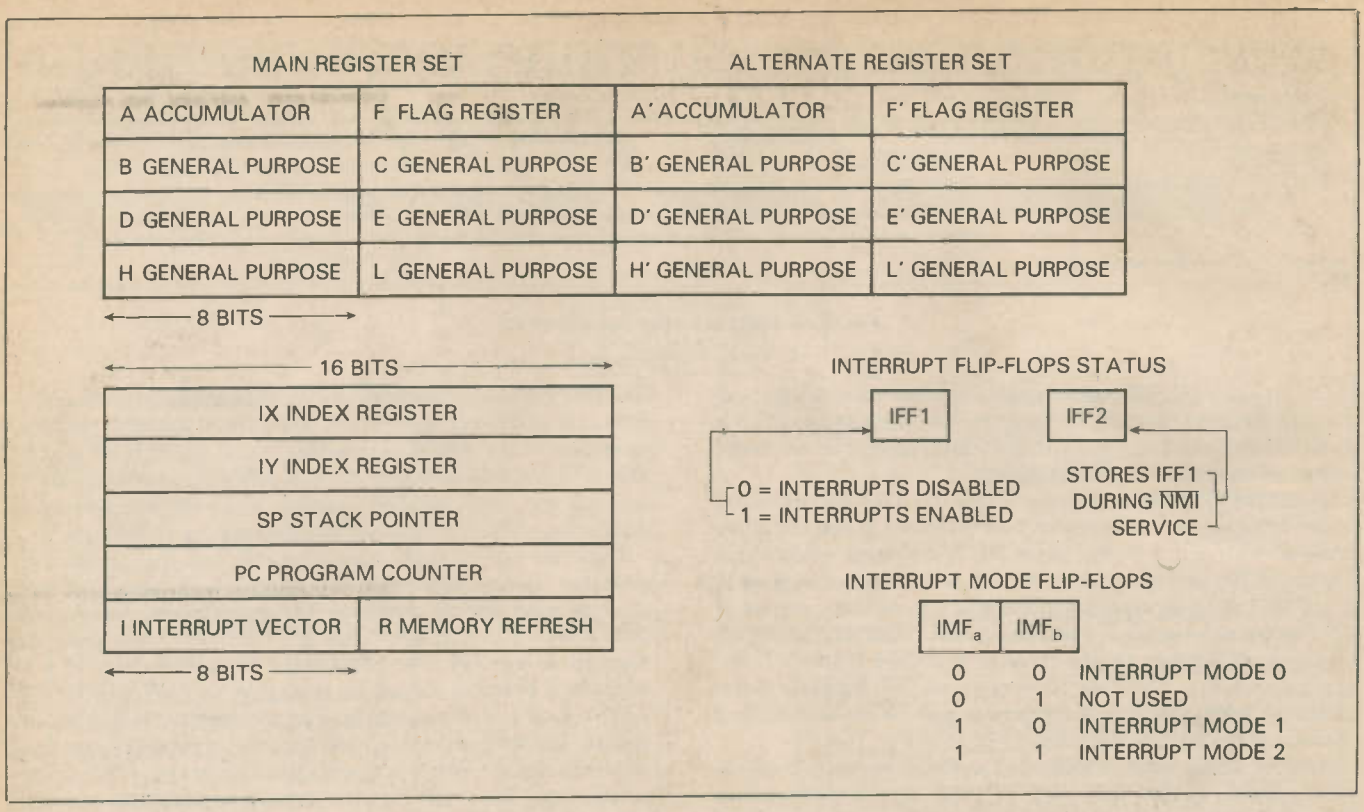


Fig. 6.8. Z80 programming model

Interrupt Mode: These flip-flops reflect the current interrupt mode, which may be 0, 1, or 2. Mode 0 is the 8080 mode, whereby the interrupting peripheral places an instruction on the bus. This is normally a restart instruction which will initiate a call to the selected one of eight restart locations in page zero of memory. Mode 1 is very similiar to the NMI mode, but it jumps to the code contained at location 0038 for its service routine (whereas an NMI uses location 0066). This mode is intended for non-Z80/8080 systems. Mode 2 is the flexible vectored mode described above, particularly intended to use the Z80 family and compatible peripheral devices most effectively.

Z80 PERIPHERALS

There are five major support peripherals which were designed specifically for the Z80. Instead of numbering these separately, it is common practise with the Z80 family to describe each device in terms of the family name, followed by the functional acronym (CPU, PIO, etc). Each device does, in fact, also have a conventional (different) part number, e.g. the standard Zilog Z80 CPU is the Z8400, or the Z8300 if from the low power family. The popular peripheral chips in the Z80 family are described briefly below.

Z80-PIO: The PIO (Parallel Input/Output) operates in both byte I/O transfer mode (with handshaking), and in bit mode (without handshaking). The PIO may be configured to interface with standard peripheral devices such as printers and keyboards. Typical part number: Z8420.

Z80-CTC: The CTC (Counter/Timer Circuit) features four programmable 8-bit counter/timers, each of which has an 8-bit prescaler. Each of the four channels may be configured to operate in either counter or timer mode. Typical part number: Z8430.

Z80-DMA: The DMA (Direct Memory Access) controller provides dual-port data transfer operations, and also has the ability to terminate data transfer as a result of pattern match in the transferred data. Typical part number: Z8410.

Z80-SIO: The SIO (Serial Input/Output) controller provides two channels. It is capable of operating in a variety of modes for both synchronous and asynchronus communications. Typical part number: Z8440.

Z80-DART: The DART (Dual Asynchronous Receiver/Transmitter) provides low cost asynchronous serial communication. It has two channels and a full modem control interface. Typical part number: Z8470.

CONCLUSION

This brings us to the end of our short series on the basics of micro systems. We hope that it has given enough of an insight into the workings of these fascinating machines to allow some sense to be made of the huge volumes of application data now available on the subject. As mentioned originally, a series such as this can hope to do little more than provide a general introduction to the subject. From here on the best course will depend very much how you wish to make use of of the basic technology.

The cost of providing a particular level of capability, counter to the natural law in most other spheres of endeavour, is likely to continue to fall for quite some time to come. The applications for micro system technology are generally limited only by the ingenuity of you, the designers, whilst the capabilities of the basic components are constantly being improved. The future for this technology therefore seems assured.

Photo illustrating the BBC Micro which employs a 6502 CPU as the main processor, but may use a Z80 as a second processor

TO COME: Next month in *PE* we will be outlining details of some constructional projects which will employ both the 6502 and Z80 microprocessors.

THE LEADING EDGE

RELIGION IN SPACE

Writing for a monthly magazine is always a gamble. There is a good chance that anything written will be out of date before it appears in print. Predictions are particularly dangerous. They can be proved right or wrong while the writer's words are still at the printers.

By the time this appears in print, British Telecom *should* have staged what it claims will be the world's biggest satellite hook-up. It's not for a pop concert; it's not for a boxing match. It's for a round-the-world religious event which was scheduled to be held at the end of 1985.

In November British Telecom announced that it was charging religious organisation Campus Crusade for Christ "just under £1 million" for what CCC called the "world's first inter-continental satellite congress". What the world needs most, said a CCC spokesman, is an explosion of love.

So the event, scheduled for 93 public sites through 52 countries at the end of December, was christened *Explo 85*. The idea came to 53 year old American Bailey Marks while shaving in Germany. He says God told him to use satellites. No kidding. That's what CCC's press release says.

London firm Satellite Express was booked to handle the ground stations. BT International booked seven satellites to ring the globe. The plan was for high profile religious notables, like Billy Graham, to preach in front of TV cameras which beam sound and vision signals back to London via the Telecom Tower in Maple Street.

These would then be edited at Limehouse studios in London's docklands and the highlights bounced back for display around the world. The signals pass through BT's earth stations at Goonhilly and Madley.

BT had its fingers firmly crossed that nothing would go wrong with the satellite links. Although the land lines and microwave links between the earth stations and tower have back-ups, there is often no reserve channel if a satellite link goes down. Communication satellites are now so fully booked that some signals are carried by spare channels, leaving no spare spares for back up.

CABLE NEWS

You may be wondering how American TV station *Cable News Network* is reaching Britain. Normally the US and Europe don't share cable programmes from a single satellite, because the beams aren't wide enough.

In this case it is all done with one satellite, but in a special way.

The signal for Ted Turner's all-news station CNN is beamed up from Atlanta, Georgia, in the 6 Gigahertz C-band to the spare channel on the Atlantic Ocean *Intelsat VA-F11* communications satellite. This sits at 27·5 degrees West over the Equator. On board the satellite the signal is changed in frequency to Ku-band, at 11 Gigahertz. It is then "cross strapped" to another transponder on the same satellite. This beams it down to earth in the direction of Europe.

Cross-strapping is an expensive exercise, because, in satellite jargon, it "sterilises" two half channels. Normally signals go up in the C-band and are sent back down in the C-band; or they go up in the Ku-band and come back down in the Ku-band. Cross-strapping means that only the C-band up link is used with only the Ku-band down link. The C-band down link and Ku-band up link are wasted.

There is a great deal of talk in Britain about satellite reception now that the Government has agreed to license home dishes and promised to make planning permission easier. What people in the business gloss over, is that some signals are beamed down from *Intelsat V* and others from the *Eutelsat I-F1* satellite. This sits at 13 degrees East and carries British pop programme Music Box, the general entertainment programme Sky Channel and French, Italian, German and Dutch film and entertainment channels. *Intelsat V* at 27·5°W carries CNN as well as Premiere, the Thorn-EMI film channel, the general entertainment channel Mirrorvision, Screen Sport and the Children's Channel.

All these programmes are, of course, intended primarily to serve cable stations, so the signals are low powered. The satellite transponders are running at 20W or less instead of the 200 or more watts needed for DBS, at 12 Gigahertz.

What this means in practice is that the dishes must be large, usually 1·6 metres in diameter. It also means that a viewer must either choose between programmes from *Intelsat* or *Eutelsat;* or they must have two equally large dishes, each pointed on one satellite; or they need a motor drive which moves the dish from the direction of one satellite to the other. A system to receive from both satellites will cost the best part of £2,000.

Note well, incidentally, the government's talk about relaxing the rules for planning permission on satellite dishes is confused. One government department, the Department of the Environment, hasn't been talking to the others, the Home Office and Department of Trade and Industry. The DoE is allowing dishes of 90cm diameter, or less. The DTI and Home Office are allowing people to receive cable station satellite signals.

They are doing this because Britain's plans for DBS have gone phut. But 90cm dishes are what you need for DBS. The low power communications satellites which distribute the cable programmes need larger dishes that the DoE allows.

WRONG BLEND

It isn't only the government which is in a muddle over satellites. I fear Robert Maxwell of the Mirror Group could come seriously unstuck with his plans to broadcast a new TV channel direct into British homes from a French satellite. His office admits he has not yet even considered the technical problems. They didn't understand my questions, let alone offer any answers.

France and West Germany plan to go ahead this summer (1986) with the launch of two 200W DBS satellites, *TV-SAT* for West Germany and *TDF-1* for France. Like the DBS satellites planned for Britain, but now, sadly shelved, these will transmit enough power for reception by 90cm dishes.

Maxwell isn't buying a satellite. He is renting a channel from the French government for £6 million a year. The plan, says his spokesman at the Mirror Group, is to broadcast English language programmes to an audience of 280 million people across the whole of Europe.

First problem for Maxwell is that he is relying on the ability of satellite receivers to produce clear pictures from inadequate signals. The French satellite has a footprint which covers France. Other countries will only receive mainly overspill signals, at lower power.

Maxwell's office says he intends people to buy their own dishes. Alternatively they can use dishes which they have already bought to receive cable signals from the communications satellites *Eutelsat* and *Intelsat*.

But Maxwell's office also says he will broadcast in English language only and leave it to foreign countries to dub on their own languages. This is, of course, impossible. How can people with their aerials dub on different language sound.

Then there is the question of dish alignment. Dishes lined up to receive from *Eutelsat* (in orbit at 13 degrees East) or *Intelsat* (at 27·5 degrees West) will need realignment to receive from the French DBS satellite *TDF-1* which (with the German craft) will be at 19 degrees West. And this is a quite different orbital slot from the one at 31 degrees West allocated to Britain and Ireland.

Maxwell also hasn't thought about what TV standard to use for transmission. France uses 625 line SECAM and the rest of Western Europe uses 625 line PAL. The French and German Governments have said they will adopt the new MAC standards for their DBS services. So will Maxwell send PAL out of a French satellite, and so make his programmes unobtainable in the country which transmits them? Or will he use SECAM and make the programmes useless for the UK?

Or will he try and use MAC? If he uses MAC then he faces exactly the same problem which turned the BBC off the idea of satellites. Initially there will be no equipment available to receive what he transmits. And that is no way to make money.

Only one thing seems certain. Maxwell needs a down-to-earth technical adviser for his high-in-the-sky plans.

BARRY FOX

Amstrad I/O

Richard Sargent

24 I/O lines located at any user port address

THE BASIC used by the CPC464 has a wealth of commands which would make this computer very easy to use with a user port and control-device peripherals. There is of course one snag—the Amstrad computer has no user port, other than its dedicated Centronics Printer Port.

The project described in this article provides 24 I/O lines which can be used, often directly, to control relays, l.e.d.s and other paraphernalia of the outside world. Special consideration has been given to the decoding circuitry so that it can respond to any of the CPC464 user-port addresses. The circuit is best built up on a piece of veroboard, and a PIA (Peripheral Interface Adaptor) of your choice can be included on the board if you wish. The preferred chip, and the one used in the prototype, is the 8255 which will supply the full complement of 24 user lines, which can be programmed as inputs and/or outputs.

In the present climate of chip shortages it's a good idea to be flexible. The 8255, which incidentally is used inside the CPC464 for keyboard and sound-chip duties, is not particularly cheap at the moment and you might wish to use instead a Z80 P10 or even a 6522 or 6521 PIA.

DECODING

The addresses which have been put aside for user peripherals are those with a high byte of F8, F9, FA or FB and a low byte in the range EO to FF. By a careful selection of TTL chips it is possible to tie in to any of those legal addresses. The starting point is to examine the BIT PATTERN of the range of addresses to see which bits remain constant and which bits are allowed to change. (see Fig. 1).

The circuit design starts by assuming address A9 and A8 to be low and therefore decodes the most significant byte as 11111000 F8. However, if port address F8xx clashes with another user add-on then one or both of bits A9 and A8 may be decided in the high condition which will give port addresses F9xx, FAxx or FBxx. Hence the w w bits are *wired* to shift the I/O board to alternate blocks of address space.

The least significant byte can change through 32 consecutive port addresses, as determined by the state of bits A0–A4. The PIA chips like to have A0 and A1 to themselves, and they will decode these lines internally so we can forget about z z for the moment.

Address lines A2, A3 and A4 are taken to a 3-line to 8-line decoder and the eight outputs are CHIP SELECT signals, one of which drives the onboard PIA. The remaining seven are available as select lines for other I/O boards, and their addresses are given in Fig. 2.

CIRCUIT DESCRIPTION

The port decoder uses IC1, an 8-input NAND gate to decode all the address lines which are high (see Fig. 3). When that is the case an intermediate enable signal E1 is produced. IC2 decodes the permanent lows A10 and IORQ. On the prototype IC2 is a 74LS54 acting as a straightforward NOR gate and as such it will only produce an output when all inputs are low. When this is the case the second intermediate enable signal E2 occurs. E2 is ANDed with M1 to produce E3 (see Fig. 8). All I/O peripherals should be enabled only when M1 is in its high state, otherwise you will run into problems when the Z80 CPU uses certain of its interrupt modes. IC3B normally has its two inputs tied high and so produces a low signal which is inverted by IC3C to form the remaining intermediate enable signal, E4. E4, E3 and E1 enable IC4, the 3-line to 8-line decoder, which then happily responds to the A2, A3 and A4 address lines to give a low chip-select pulse on one of its Q output lines. The stripboard layout is shown in Figs. 9 and 10.

Block selection is made by changing one or both of the links LK1 and LK2. If A9 is "high" for the required address, LK1 should be strapped to pin B, and similarly, A8 should be linked through to pin D if it also is "high" for the required address.

A RESET pulse is provided at switch-on time by the components C1 and R1.

CONSTRUCTION

The CPC464 has a 25 x 25 way edge-connector at standard 0·1" spacing and a slot for a polarising key between track 21 and 23. The odd-numbered tracks indicate the top or component side of the computer's p.c.b. As Fig. 4 shows, this is a standard Z80 CPU expansion bus, although it is labelled "Floppy Disc" by Amstrad in preparation for their disc system peripherals.

A 30-way ribbon cable joins the 25 x 25 way connector to the I/O board. 34-way cable is the nearest standard size, although you may prefer to use 10-way for the DATA lines, +5V and GND (since they are together at one end of the Veroboard) and 20-way for the remaining signals. The CPC464 signals are brought into the lefthand side of the board, where LK1 and LK2 in conjunction with ICs1–4 develop the eight chip-select signals Q0–Q7. On this board it is the Q0 signal which is used to enable the 8255, but for different addresses the other Q signals should be used as shown in Fig. 2. Plenty of room has been left on the righthand edge of the board so that if you wish the I/O lines can be taken to other components rather than being brought to the edge of the board. The 100n decoupling capacitors are not shown on the component overlay—they should be mounted across the supply pins of ICs 1–4 and since they are flat disc ceramic types, they can be mounted on the copper side of the board. The whole assembly should be housed in a plastic box, and if you don't require too many extra components beside the PIA then a Verobox type 201 with dimensions of 205 x 140 x 40 will fit the bill nicely. The I/O lines can be brought out to cheap screw-terminals mounted on the side of the box.

THE 8255

This is an NMOS IC which is easy to program to various input and output configurations, and simple to interface to other TTL and CMOS chips (see Fig. 5). Being of NMOS construction it only has a limited current drive on output, and currents over 16mA will overheat the IC. However, it is designed to drive 1 standard TTL load, and constructors are advised to place a cheap TTL buffer between their expensive PIA and the relays, etc. that are being driven. The 8255 can be damaged by static electricity and long wires trailing across work surfaces to some remote sensor are to be avoided: buffering using a 74LS04 is again the solution. Fig. 6 shows some typical interface circuits for inputs, while Fig. 7 shows how the 8255 should be buffered when its lines are used as outputs.

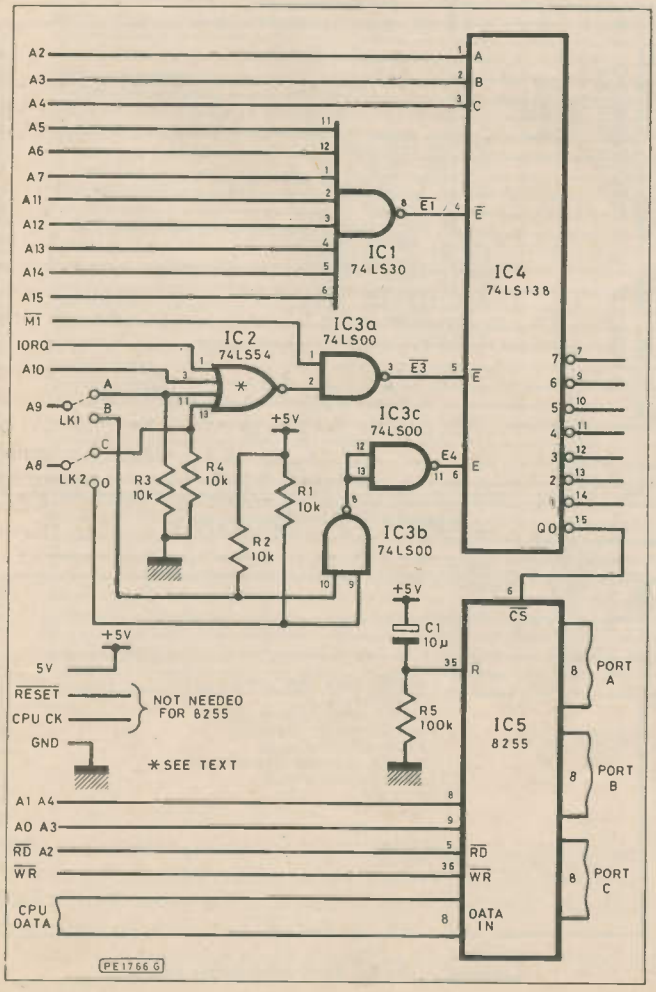
Fig. 1. Bit patterns

```
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
1  1  1  1  1  1  0 w w 1 1 1 y y y z z
when w w = 0 then y y y can be used as
a binary counter, decoded to give one of
eight possible port BLOCKS:
F8E0-F8E3, F8E4-F8E7, F8E8-F8EB, F8EC-F8EF
F8F0-F8F3, F8F4-F8F7, F8F8-F8FB, F8FC-F8FF
Further decoding can be accomplished if the
main port board uses a chip which can accept
the z z signals.
Any change in the decoding is made by
changing links LK1 & LK2 on the board.
```

	A9=0 A8=0	A9=0 A8=1	A9=1 A8=0	A9=1 A8=1
Q0	F8E0-F8E3	F9E0-F9E3	FAE0-FAE3	FBE0-FBE3
Q1	F8E4-F8E7	F9E4-F9E7	FAE4-FAE7	FBE4-FBE7
Q2	F8E8-F8EB	F9E8-F9EB	FAE8-FAEB	FBE8-FBEB
Q3	F8EC-F8EF	F9EC-F9EF	FAEC-FAEF	FBEC-FBEF
Q4	F8F0-F8F3	F9F0-F9F3	FAF0-FAF3	FBF0-FBF3
Q5	F8F4-F8F7	F9F4-F9F7	FAF4-FAF7	FBF4-FBF7
Q6	F8F8-F8FB	F9F8-F9FB	FAF8-FAFB	FBF8-FBFB
Q7	F8FC-F8FF	F9FC-F9FF	FAFC-FAFF	FBFC-FBFF

Fig. 2. Select line addresses

Fig. 3. Full circuit diagram



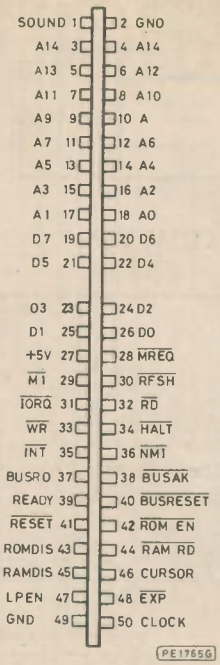
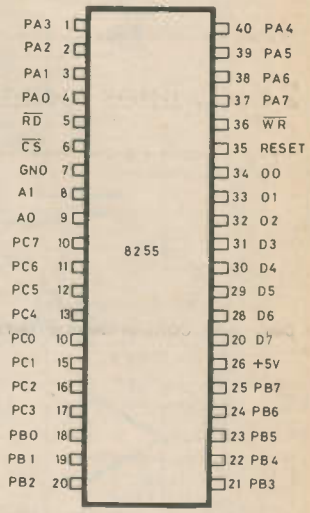


Fig. 4. Standard Z80 expansion bus

Fig. 5. The 8255 PIA



In its simplest configuration, the 8255 PIA has three 8-bit ports A, B and C, mapped at F8E0, F8E1 and F8E2. The CONTROL port is at F8E3. At power-on all the PIA lines are in a high impedance state and the ports must be set up by sending a control word to the chip. The 8255 can work in one of three modes, called 0, 1 and 2. Mode 0, the basic input/output mode, tends to be the one most often used. If you think you might like to use the more specialised modes 1 and 2, strobed I/O and bi-directional I/O, then the 8255 data sheet is worth purchasing.

Providing you remember that PORT C is divided into two halves, upper and lower, and that these halves may be configured independently of each other, then MODE 0 operations are very straightforward. The Mode 0 control word is worked out by building a bit pattern made up as follows:

D0 *Port C (lower) PC0-3*	1 or 0
D1 *Port B*	1 or 0
D2 Mode 0	0
D3 *Port C (upper) PC4-7*	1 or 0
D4 *Port A*	1 or 0
D5 Mode 0	0
D6 Mode 0	0
D7 Select mode required	0

Load 1 for an INPUT, 0 for an OUTPUT

Eg: OUT &F8E3,&X10001001 causes PORTS A & B to become outputs, PORT C to be input.

It is probably safest to test the 8255 by setting all the ports to input. With no signals attached, the high impedance lines should read 1 and change to 0 when you ground a particular input. Amstrad BASIC is particularly good at examining individual lines of input ports. Listing 1 shows the test routine.

Having now got a working I/O board there are two other "goodies" in the Amstrad BASIC which you will want to use. The first is the logical operator AND which can be applied to bit patterns to form the highly useful masking function on an input value. Listing 2 reads a port and prints the result before, and after, masking.

Logical OR, XOR and NOT can also be used to perform this *bitwise* manipulation of data.

The command WAIT <P>, <M>, (<I>) suspends a program flow until a given I/O port returns a particular value in the range 0–255. The Amstrad manuals don't really explain how this command works. P is the number of the port being monitored and M and I are integer expressions. If I is omitted, it is assumed to be zero. The port status is exclusive ORed with I and the result is

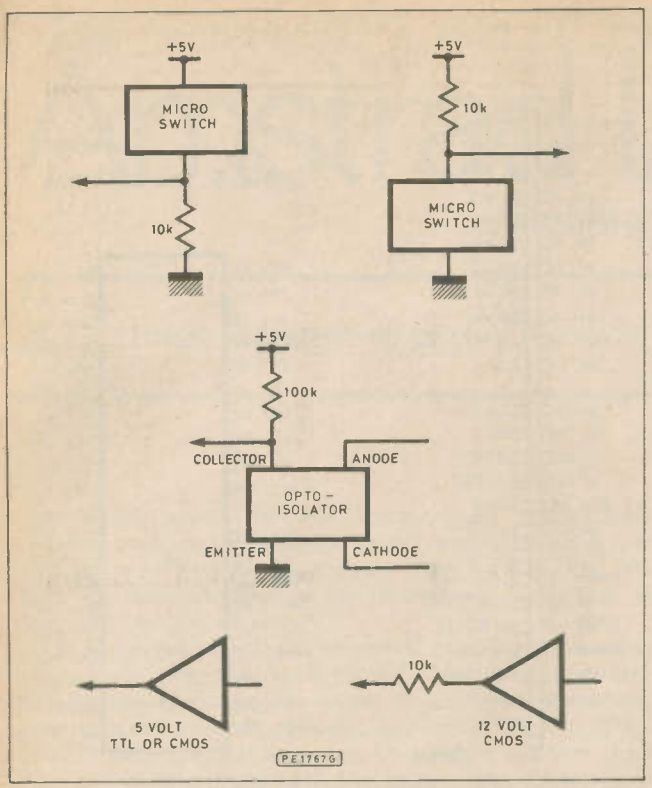


Fig. 6. Typical inputs to the 8255

COMPONENTS . . .

Resistors

R1,2,3,4	10k (4 off)
R5	100k

All 0·25W carbon ±5%

Capacitors

C1,2	10µF	12V electrolytic (2 off)
C3,4,5,6	100n	disc ceramic (4 off)

Semiconductors

IC1	74LS30
IC2	74LS54
IC3	74LS00
IC4	74LS138
IC5	8255

Miscellaneous

Plastic box
Ribbon cable
Veroboard
25 x 25 way edge-connector
14 pin i.c. sockets (3 off)
16 pin i.c. socket (1 off)
40 pin i.c. socket (1 off)
Screw-terminals (3-amp strip type)

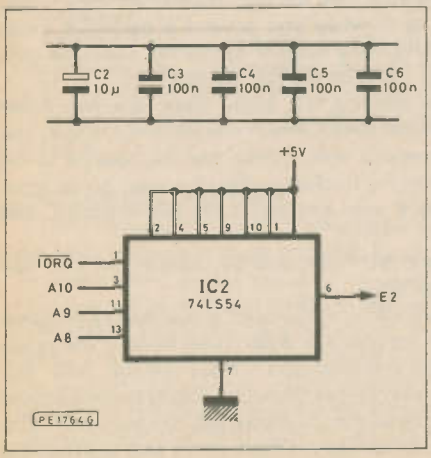
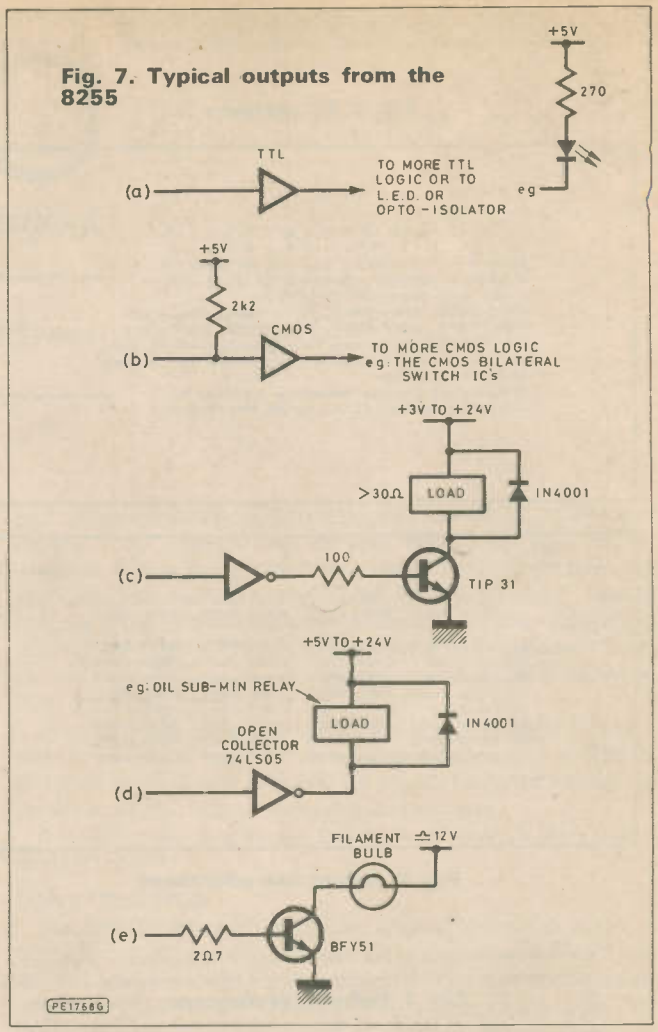


Fig. 8. Decoupling capacitors, and the generation of E3 from E2 and M1 using a 4-wide AND-OR-INVERT gate




```
100 REM **TEST**
110 MODE 1:CLS
120 PRINT "Apply ground to any input"
130 OUT &F8E3,&X10011011
140 PRINT "A         B         C"
150 PRINT "76543210 76543210 76543210"
160 LET A=INP (&F8E0)
170 LET B=INP (&F8E1)
180 LET C=INP (&F8E2)
190 PRINT BIN$(A,8);" "
200 PRINT BIN$(B,8);" "
210 PRINT BIN$(C,8)
220 LOCATE 1,4:GOTO 160

Sample RUN
Apply ground to any input
A        B        C
76543210 76543210 76543210
11111111 11111111 11111110
```

Listing 1. Testing routine

```
100 REM mask out bits 6,1
110 MODE 1:CLS
120 OUT &F8E3,&X10011011
130 LET A=INP (&F8E0)
140 PRINT BIN$(A,8)
150 LET V=A AND &X10111101
160 PRINT BIN$(V,8)
170 STOP

Sample RUN
11111111
10111101
Break in 170
```

Listing 2. Read port and print routine

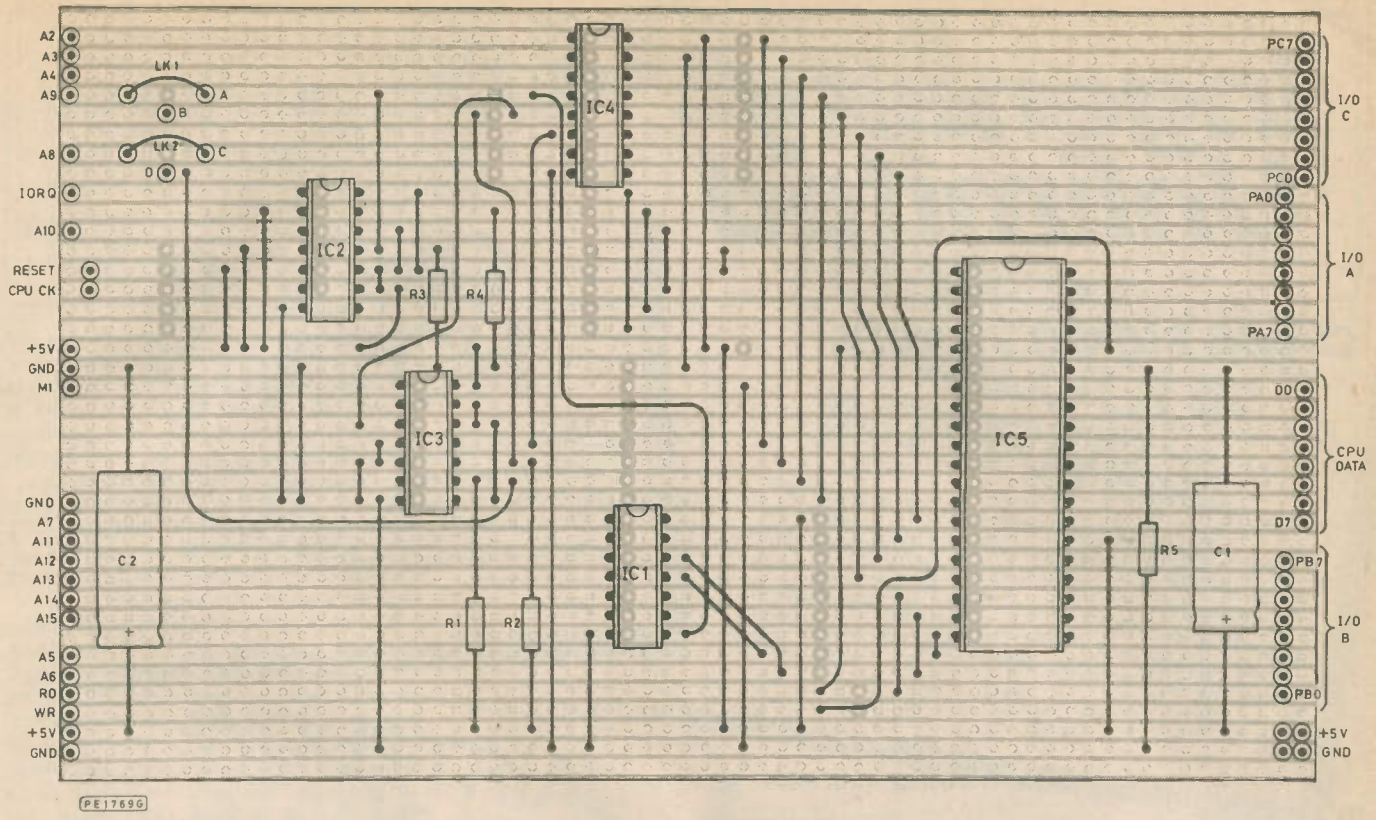


Fig. 9. Component layout of stripboard (actual size)

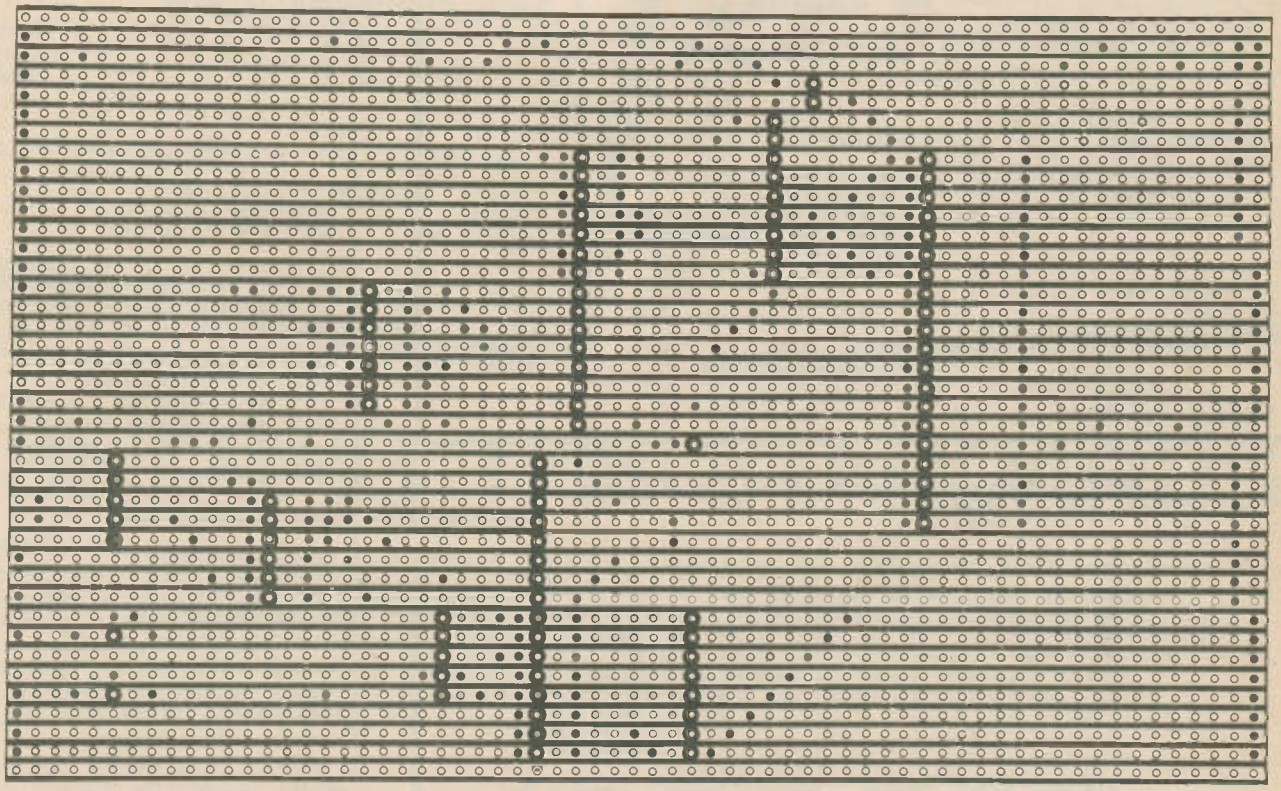


Fig. 10. Stripboard cuttings

ANDed with M. Execution of the BASIC program is suspended until a non-zero value results. M is a mask which picks the bits of port P to be tested and execution is suspended until those bits differ from the corresponding bits of I. For example:

WAIT P,6: Execution stops until either bit 1 OR bit 2 of port P are equal to 1.

WAIT P,255,7: Execution stops until any of the most significant 5 bits of port 10 are 1 OR any of the least significant 3 bits are zero.

This command should be used with care, since BASIC will stick in this WAIT loop if the required condition does not occur, and only a system RESET will effect an escape. ★

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

CLOCK SIGNAL TRACER

SIGNAL	INPUTS					OUTPUTS LOW				DISPLAYS LIT
S_1	A	0	1	0	1	Y_0	Y_3	Y_0	Y_3	GREEN-GREEN
	B	0	1	0	1					
S_2	A	1	0	1	0	Y_1	Y_2	Y_1	Y_2	YELLOW-RED
	B	0	1	0	1					
S_3	A	1	1	1	1	Y_1	Y_3	Y_1	Y_3	YELLOW-GREEN
	B	0	1	0	1					
S_4	A	0	0	0	0	Y_0	Y_2	Y_0	Y_2	GREEN-RED
	B	0	1	0	1					
S_5	A	0	1	1	0	Y_0	Y_3	Y_1	Y_2	ALL FOUR
	B	0	1	0	1					

Table 1. Display truth table

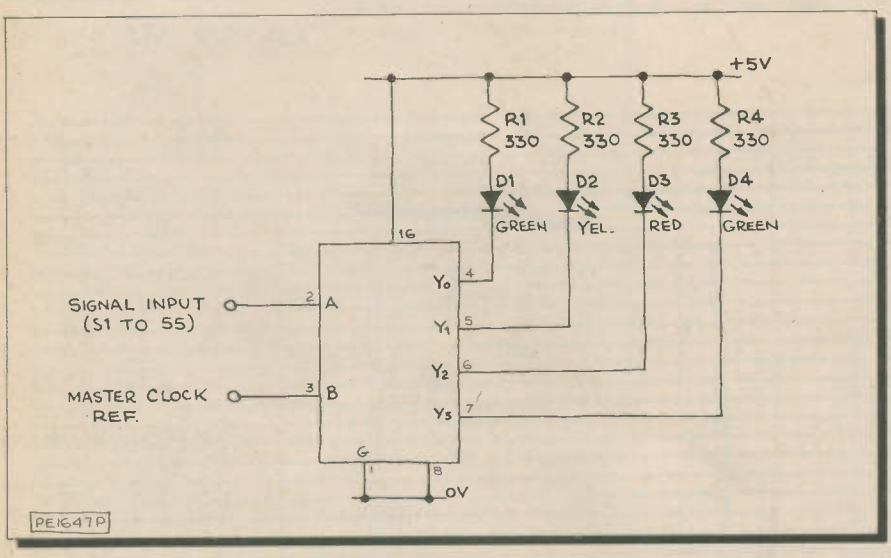

Fig. 1. Circuit diagram of the Clock Signal Tracer

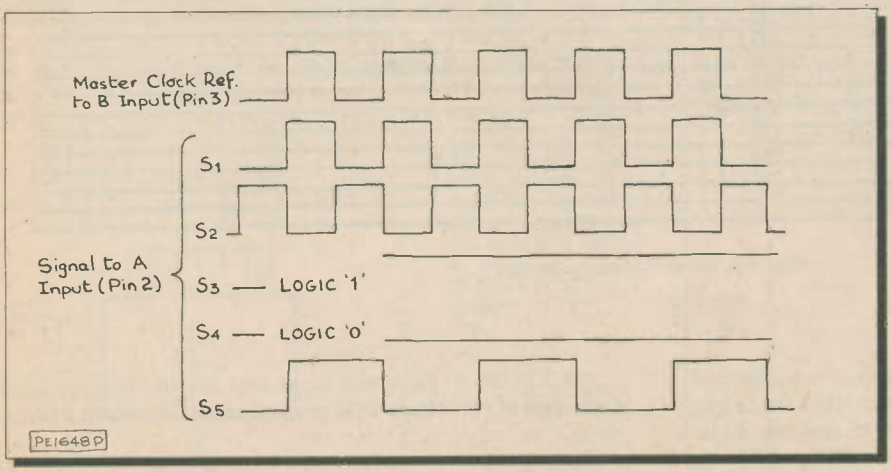

Fig. 2. Waveform diagram of the Clock Signal Tracer

WHILE conventional logic probes are convenient for checking static logic states, they are less useful when it comes to tracing clock signals. As no indication of frequency or phase is given, an oscilloscope normally has to be used to check that the signal being monitored is the correct one.

The circuit, shown in Fig. 1, is for a test probe designed specifically for tracing TTL clock signals. A 74S139 two to four line decoder is used to drive four l.e.d.s which indicate a variety of signal states.

The clock to be traced is fed as a reference to the B input of the chip, Pin 3, while input A, Pin 2, is connected to the probe tip. Fig. 2 shows a range of input signal conditions, and the table (Table 1) details the resultant switching states of the i.c. When both the inputs are the same frequency and phase, i.e. the signal is correct, both green l.e.d.s glow. For an inverted clock signal, the yellow and red l.e.d.s are on. A logic 1 at the probe tip turns on yellow and green l.e.d.s, while a logic 0 brings on green and red. Note that for all frequencies below the reference all four l.e.d.s are lit.

P. Thompson,
Lennoxtown,
Glasgow.

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PRACTICAL

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APRIL 1986 ISSUE ON SALE, FRIDAY, MARCH 7

Spectrum HARDWARE RESTART

R.Macfarlane

THIS board is designed to plug into the Spectrum edge connector and will allow the user to escape from any running program without losing the memory contents. The action is similar to the BREAK key on the keyboard which jumps to a routine within the Spectrum ROM, prints BREAK and eventually returns to the (K) cursor. However, if the BREAK key has been disabled then the only recourse is to remove the power plug and reset the system which, of course, clears the memory contents. It can also be extremely annoying if during the development of a machine code program the computer enters a loop from which there is no escape. With this circuit the Z80 processor can be forced to jump to any address within the Spectrum ROM or RAM.

When running BASIC programs the address of the Auto List routine in ROM was chosen as the restart address. Executing a hardware restart therefore produces an automatic listing of the first few lines of the program and then returns to the (K) cursor. Further Basic commands can now be entered and run, eg, LIST, SAVE, PRINT, etc.

When running machine code the address E000H was chosen. This is the start address of the ZEUS Assembler program which is used to develop machine code programs. Again, executing a hardware restart produces the ZEUS copyright symbol and by using O for OLD, the original source file can be recovered intact.

However, any restart address may be chosen to meet the needs of the individual user.

SYSTEM OUTLINE

When the Spectrum is first switched on the reset line to the Z80 processor chip is held low for a few milliseconds by the action of Ra and Ca (Fig. 1). This ensures that the supply rails are given time to reach their operating voltage and that the CPU is properly initialized.

The initialisation includes:

1) Forcing the program counter to zero.
2) Disabling the interrupts.
3) Setting the interrupt register to 00H.
4) Setting the refresh register to 00H.
5) Setting interrupt MODE 0.

During reset time the address bus and the data bus go to a high impedance state and all control output signals go to the inactive state. No refresh of the dynamic memory occurs so that all memory contents are lost.

When the reset line eventually goes high the CPU executes the instruction found at address 0000H which is the start of the initialisation procedure for the Sinclair Basic in ROM.

In order to restart the system at a different address two conditions must be met. The reset line must be held low for as short a period as possible so that the memory refresh cycles are maintained and memory contents are not lost. When the CPU addresses location 0000H it must find a different set of instructions to the ones held in the Sinclair BASIC ROM. To achieve these conditions, therefore, the external circuit operates in the following manner.

A short 50μS pulse is applied to the reset line of the Z80 CPU. This is of sufficient duration to properly initialize the CPU but have no effect on the memory contents. Coincident with this pulse the Spectrum BASIC ROM is deselected using the $\overline{\text{ROMCS}}$ line on the edge connector and an external ROM selected in its place.

The CPU will then run the program within this new ROM which in fact holds a jump instruction to another address. When the jump is completed the external ROM must be deselected and replaced by the Spectrum BASIC ROM.

To understand how the ROMs are selected and deselected an explanation of the Z80 $\overline{\text{MI}}$ output is required.

The $\overline{\text{MI}}$ (Machine Cycle One) is an active low output which indicates that the CPU is currently executing an operating code fetch cycle. The OP Codes can be any one of the 158 different instructions that the Z80 can execute, eg, LOAD, ROTATE, CALL, JUMP, HALT, etc.

Examination of the Jump instruction is shown in Table 1.

This is a three byte instruction, the first byte containing the OP Code for JUMP, the following two bytes holding the address to be jumped to. However, only when fetching the OP Code from memory will the CPU issue an $\overline{\text{MI}}$ cycle output signal. The CPU knows that the following two bytes must form an address and the $\overline{\text{MI}}$ output stays high.

OP CODE	C3
Low Order Address	A2
High Order Address	12

Table 1. JUMP Instruction

After a reset pulse the CPU program counter is initialized to zero. The address bus is, therefore, 0000H and the CPU is looking for its first instruction. The $\overline{\text{MI}}$ output goes low as the CPU executes an OP Code fetch cycle. The falling edge of the $\overline{\text{MI}}$ output is used to switch from internal to external ROM and control can be handed back to the internal ROM at the next occurrence of an $\overline{\text{MI}}$ cycle.

SPECTRUM KEYBOARD

As stated earlier, when the CPU is reset the interrupts are disabled and the MODE is set to 0. Without wishing to delve deeply into the interrupt structure of the Z80 CPU it is sufficient to say that the Spectrum Keyboard operating system requires the CPU to be in MODE I and that the interrupts are enabled. Before jumping to the new address, therefore, two extra commands must be executed. These are IM I and EI.

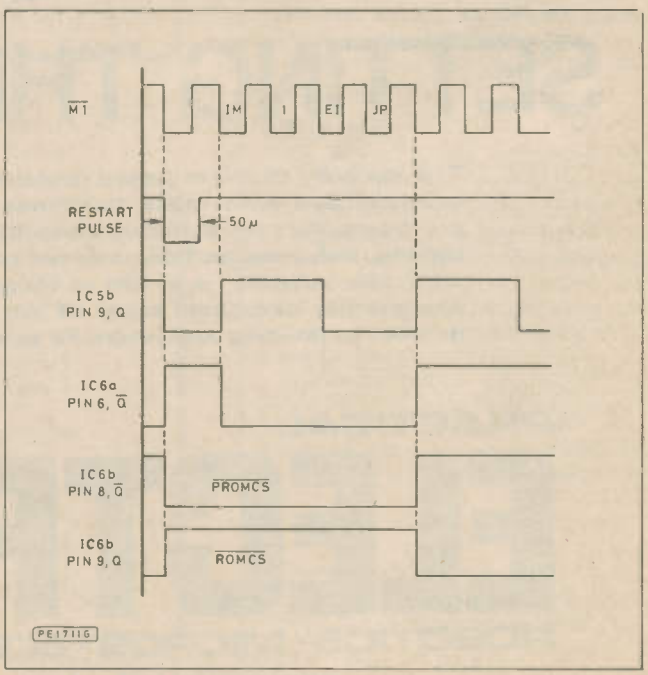


Fig. 1. Timing diagram showing the MI cycles

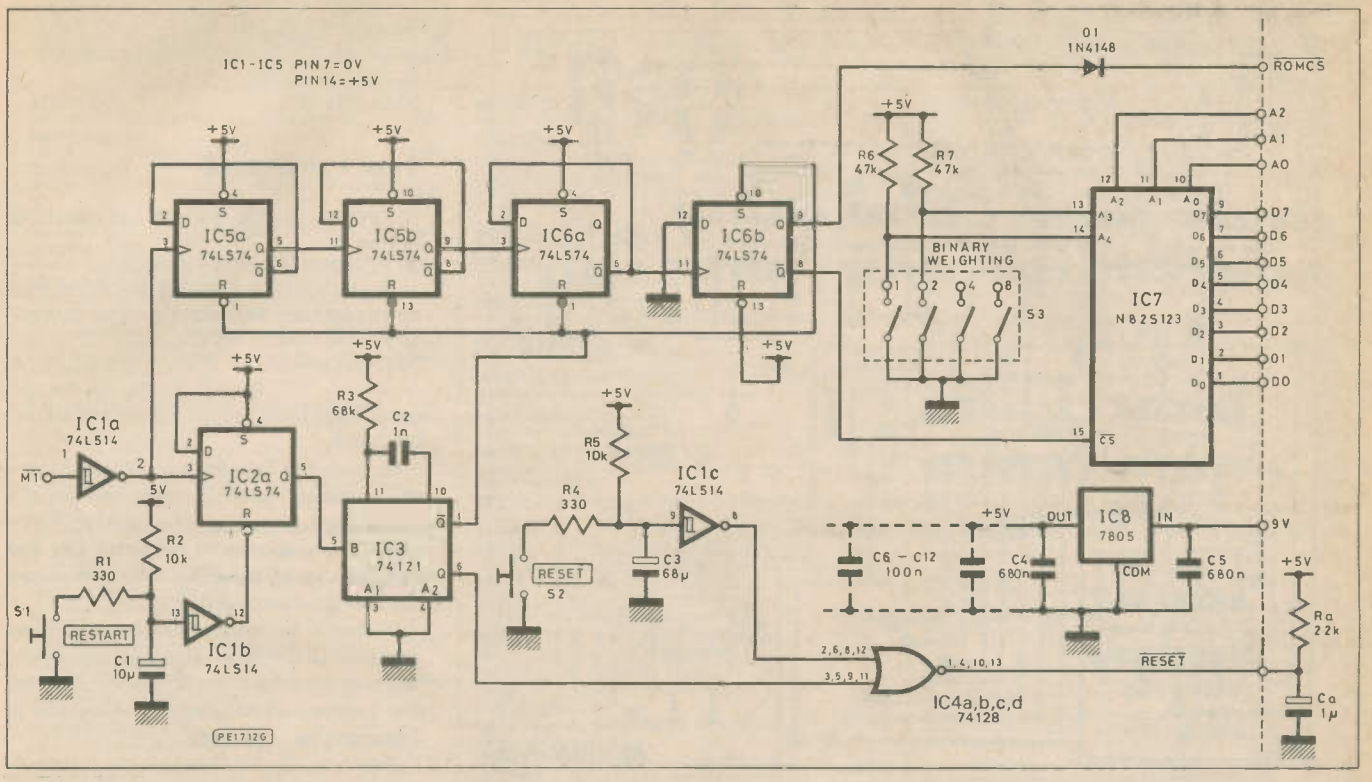


Fig. 2. Complete circuit diagram of the Hardware Restart

IM I is a two byte OP Code and EI a single byte OP Code. This brings the required number of OP Code fetch cycles to be executed in external ROM to four, ie, IM I, EI, JP.

Four MI cycles must, therefore, be counted before returning control to the Sinclair BASIC ROM. The timing diagram of Fig. 1 shows the relevant switching points.

CIRCUIT DESCRIPTION

IC1a buffers and inverts the $\overline{MI}$ signal from the edge connector and the output is fed to the clock inputs of IC2a and IC5a. The reset input to IC2a is held low by the output of IC1b the input of which is held high by R1, R2, C1. C1 serves to debounce the restart switch and R2 limits the discharge current of CI.

When the restart switch is pressed the reset on Pin 1 of IC2a is removed and the next negative going edge on an MI cycle will clock IC2a causing the Q output to go high. Further incoming edges will cause no change since the D input is tied to the 5V rail and only when the restart switch is released will the Q output fall to zero.

The positive going edge at the Q output of IC2a triggers the one shot IC3 to produce a 50µS positive going pulse at the Q output Pin 6, which is in turn inverted by the parallel connected NOR gates of IC4. This parallel connection is required due to the internal combination of Ra and Ca enabling the power up reset for the Spectrum. Using IC4a, b, c, d in this way increases the sourcing and sinking currents and the above timing requirements can be met.

The second NOR input to IC4 is taken from the output of IC1c whose input is identical to IC1b. This provides a means of resetting the Spectrum without removing the power plug and also provides, due to the action of R5, C3, an external power up reset.

The output of IC1a is also fed to the input of IC5a Pin 3, which is connected as a divide by 4 counter. The Q output of IC5b Pin 9 is connected to the clock input of a further divide by 2 stage IC6a. The reset inputs to the three stage counter are taken low during the 50µS Restart pulse by $\overline{Q}$ on IC3 pin 1 and the first negative going edge of $\overline{MI}$ to appear after the restart pulse will cause the $\overline{Q}$ output of IC6a Pin 6 to go low.

After four MI cycles this $\overline{Q}$ output will go high again and is used as a clock input to IC6b.

During the 50µS restart pulse the set input of IC6b Pin 10 goes low causing the Q output at Pin 9 to go high. This deselects the Spectrum ROM and simultaneously the $\overline{Q}$ output at Pin 8 selects the external ROM. When the clock input of IC6b Pin 11 goes high this state is reversed. Further clock inputs to IC6b are ignored due to the D input being tied to the 0V rail and can only change state after the set input is once again taken low by another restart pulse.

IC6b, therefore, selects the external ROM on the negative edge of the restart pulse and selects the internal ROM four $\overline{MI}$ cycles later. Diode, D1 is included in the $\overline{ROMCS}$ line and this input is connected in a wired OR configuration within the Spectrum.

IC7 is a 32*8 tri-state fusible PROM. When the CS Pin 15 is high the data outputs are in a high impedance state and do not affect the operation of the internal data bus on the Spectrum.

Switch SW3 selects one of four 8-byte blocks giving a possible four selectable restart addresses. A0, A1, A2 are connected to the Spectrum address bus and select the program data held in one of these four blocks.

The contents of the PROM are shown in Table 2.

Addr									BLOCK	SW3
00H	ED	56	FB	C3	00	E0	*	*	1	3
08H	ED	56	FB	C3	A2	12	*	*	2	2
10H	*	*	*	*	*	*	*	*	3	1
18H	*	*	*	*	*	*	*	*	4	0

Table 2. Contents of the 32*8 tri-state fusible PROM

POWER SUPPLY

The internal 5V supply from the Spectrum cannot supply the necessary current so an onboard 5V regulator is used. An unregulated 9V from the Spectrum power pack is available on the edge connector and this is used to drive the external restart circuit.

CONSTRUCTION

The printed circuit board is double sided and requires a number of through hole connections to be made using linking pins (Fig. 3).

The resistors and capacitors should be soldered in place first, remembering to solder on both sides of the board where required as some leads form necessary through connections.

The i.c. sockets, regulator and switches can then be added along with the edge connector, being careful to mount this on the

correct side of the board. The i.c.s can now be inserted and with switch SW3 in position 2, the board can be connected to the rear edge connector on the Spectrum.

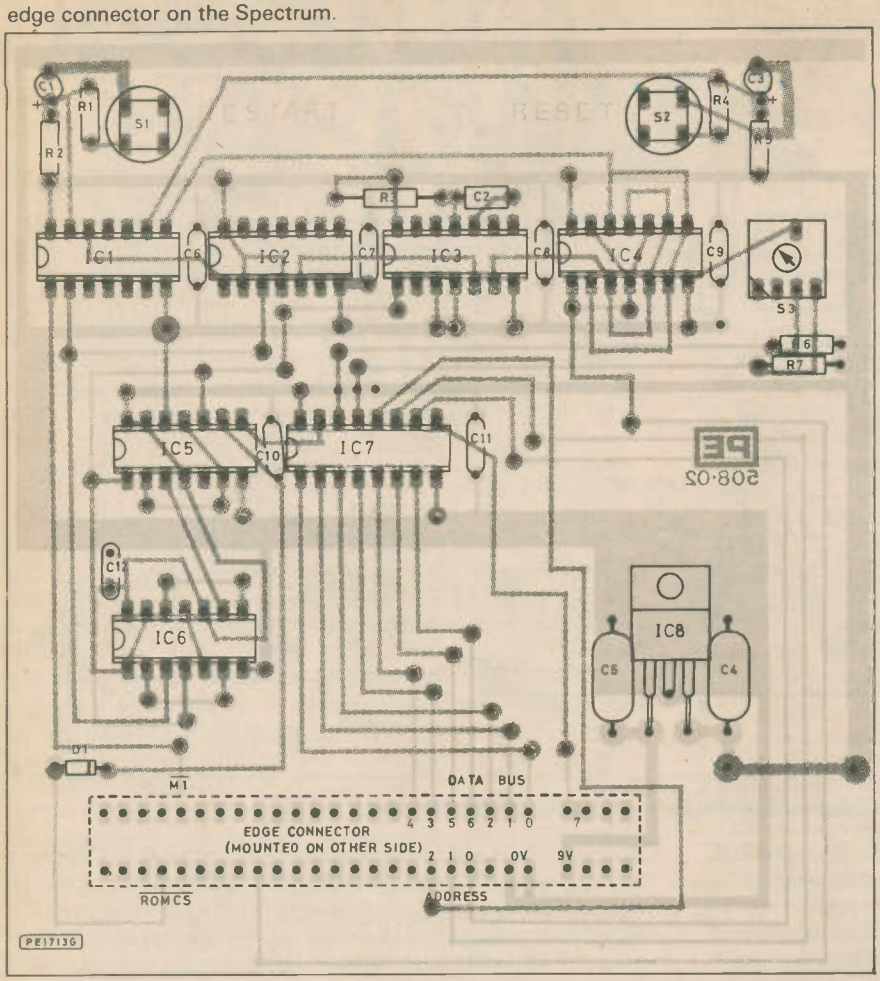
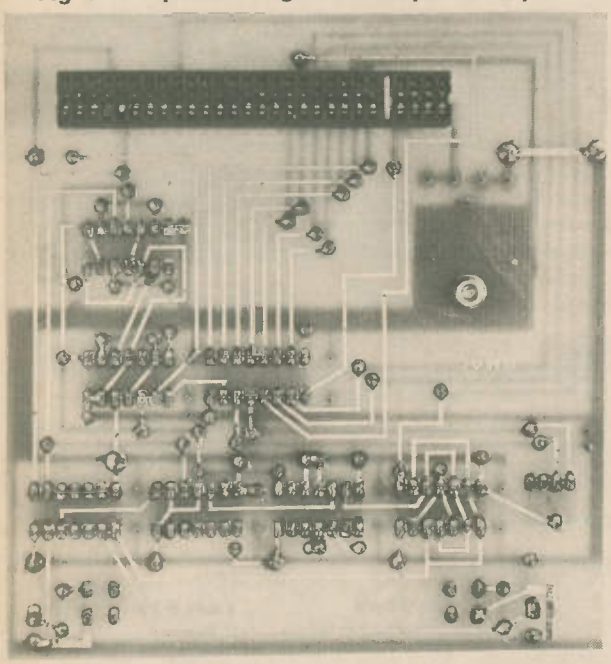


Fig. 3. The p.c.b. design and component layout



TESTING

With the unit connected, power can now be applied. The Spectrum should come up with the familiar white screen and BASIC ROM message. Pressing the RESET button should bring about a similar result.

If the small BASIC program (Test Program 1) is entered and run, execution can be immediately stopped by pressing the RESTART button and an automatic listing of the program will appear. The program can at this point be re-run, listed or saved as desired.

The significance of the restart will become apparent only when the break key is disabled, as the above program could just as easily have been stopped using the break key itself.

Running the Test Program 2 will disable the keyboard interrupt and then print a continuous stream of RESTARTs. There will be no response to the break key and only by use of the RESTART button can the listing be retrieved.

It should be noted that breaking into commercial software is now quite possible but that the board should not be used for the purpose of copying tapes as this is forbidden by copyright.

If running the ZEUS assembler program, then pressing the RESTART button, with SW3 in position 3, will immediately return the user to this program start either from BASIC, without requiring the usual PRINT USR 57344 start up command, or from the currently executing machine code program.

TEST PROGRAMS

Test Program 1

```
40 PRINT "RESTART";
50 GOTO 40
```

Test Program 2

```
10 POKE 23296,243: REM Disable Interrupts
20 POKE 23297,201: REM Return
30 RANDOMIZE USR 23296: REM Run m/c and return to Basic
40 PRINT "RESTART";
50 GOTO 40
```

COMPONENTS . . .

Resistors

R1, R4	330 (2 off)
R2, R5	10K (2 off)
R3	68K
R6, R7	47K (2 off)
All resistors 5% 0·25W carbon	

Capacitors

C1	10µ 16V Tant
C2	1n Ceramic
C3	68µ 6·3V Tant
C4, C5	680n Polyester (2 off)
C6–C12	100n Ceramic (7 off)

Semiconductors

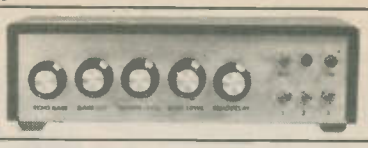
D1	IN4148
IC1	74LS14
IC2, IC5, IC6	74LS74 (3 off)
IC3	74121
IC4	74128
IC7	N82S123 PROM
IC8	7805

Miscellaneous

SW1, SW2	Min. p.c.b. keyboard (R.S. 334–892)
SW3	Horiz. decimal switch (R.S. 334–965)
14-pin d.i.l. skt (6 off)	
16-pin d.i.l. skt (1 off)	
28-way Double sided edge connector (Wire wrap tags)	
P.c.b. Double sided (PE p.c.b. 508–02)	
Linking Pins	

The PROM will normally be supplied with the address of the Auto List routine in SW3 position 2, and the start address of ZEUS in SW3 position 3. The two remaining blocks can be programmed to any user's requirements. ★

EFFECTS, DISPLAY AND TEST KITS



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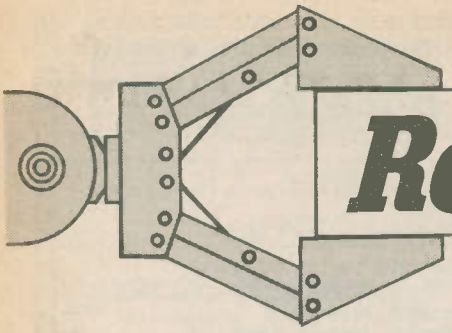


Robotics Review

Nigel Clark

TROLL, the double armed robot from **L. W. Staines** of Essex, the people who brought you the Ogre family, has been completed. Based on the Ogre technology, Troll is similarly robust and strong but inexpensive and can execute some quite complex operations such as picking up a nut with one gripper, a bolt in the other and screwing the two together.

It has a total of nine axes and two grippers. The two arms are joined at the shoulder, as with human beings, and fixed to a single base. The base can revolve through a full 360 degrees and the shoulder moves up and down 80 degrees from the horizontal.

The left upper arm can move through 180 degrees both up and down and extends by 12 inches. The lower arm can move right and left and has a 4 inches extension, on the end of which is a parallel action gripper, controlled by an optical encoder and microswitches.

The right upper arm can move the same distance as the left but it is a more conventional arm, with an elbow which has movement through a total of 180 degrees and a wrist which can move right and left and has continuous rotation, allowing a screwing operation to be carried out.

. . . ogre features . . .

All the parts have the same robust construction which is a feature of the Ogres. It is powered by servos and worm drives with optical encoders providing the feedback. Tests have to be completed but it is thought it should be able to lift 1kg.

Standard interfaces and software are provided for the BBC B and C64 with further sets being considered for the Spectrum and QL. It is possible to teach it routines through the keyboard either with the exact route or moving the arms to a series of points and the device working out the best route to follow.

The ability to write routines on screen before passing them to Troll, as can now be done with the Ogres, is also being considered. Because of its complexity it is not possible for all the motors to move at the same time but move in groups of three or four.

A price has yet to be fixed but it is expected to be in the region of £2,000 and is aimed at higher education and light industrial use.

Staines has also developed a cheaper arm for £70 to be sold by **Commotion**. Known as Baby Kate, it has three axes and a gripper is driven by geared servos under microswitch control. The software is being commissioned by Commotion.

Colne Robotics has decided to postpone the launch of the 6-axis Armdroid II, which was unveiled, as a prototype, at the Automan exhibition earlier this year. Instead it has introduced an upgraded version of Armdroid I, still to be known as Armdroid II, but not as complex as the original Armdroid II, which is now nameless.

. . . new armdroid ii . . .

The new Armdroid II, still with five axes, will be more robust and accurate than Armdroid I with stronger stepper motors, toothed belt drive and optical encoders for feedback. Colne says that it should be possible to use it continuously without supervision. The accuracy is claimed to be ±1mm which is a great improvement on the ±4mm of the earlier version, but the lifting capacity is still in the same region of 300gms to 400gms. At a price of about £700 it is still aimed at the enthusiast and education market.

As before it has its own processor onboard and can be linked to micros via the RS232 port. There are no major changes in the software which is another important difference between the present upgrade and the larger version which is intended to have networking capabilities of up to 15 arms. Development work is continuing on the 6-axis arm and it is expected to be available sometime later in the year.

Meanwhile Colne is linking its Colvis vision system to the Armdroid II and for a little under £2,000 it is possible to get a complete package including the vision system, an arm and the necessary software.

It is controlled by a software system called the Coordinator 32 which has 24K of control software on EPROM and 24K RAM allowing the storage of up to 2,255 steps. It can control two arms in synchronisation.

For existing owners of the Colvis system the rest of the package is available at about £1,000 and owners of the Armdroid I can have the calibration altered so that it will work with the system.

. . . eric withdrawn . . .

Flight Electronics of Southampton has withdrawn its Eric, originally called Max 1, arm. The 3-axis, servo and worm gear driven arm, reported in the December issue of *Practical Electronics* and featured in Flight's latest brochure, will no longer be available.

. . . alfred development . . .

Instead Flight will be selling Alfred 1 which at the moment will only have software for Spectrum, BBC B and RML machines, and not Flight's own microprocessor series. However, software for these machines is being developed.

There is some confusion about the reasons behind the move. Flight said that the company building the machines did not provide them at the right quality and as Flight has a reputation to preserve in the education market it was decided to cancel them.

However, L. W. Staines, makers of the three-axis, servo-worm gear driven Ogres said the machine was a copy and action was threatened.

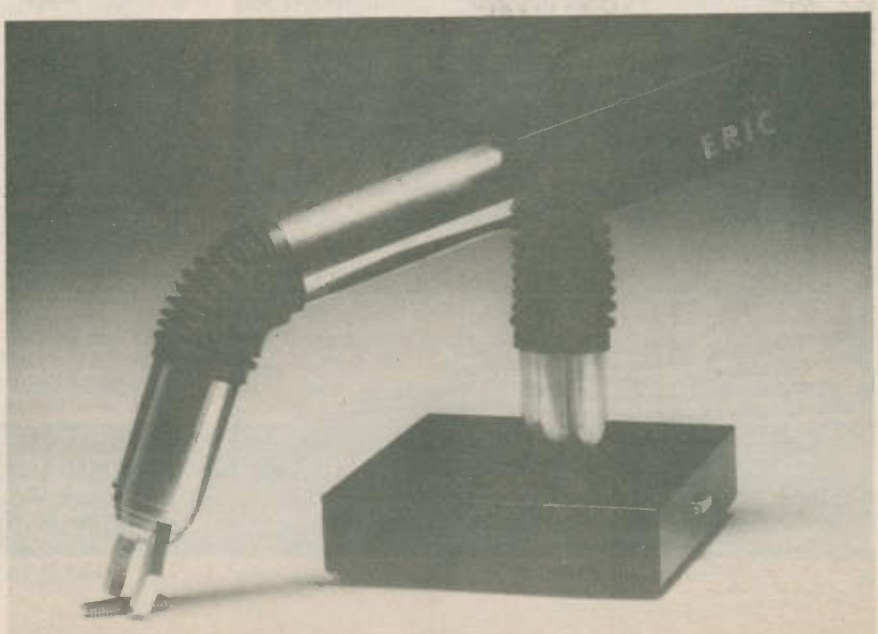
. . . tomy's latest assault . . .

Tomy has introduced its latest assault on the toy robot market, Omnibot Jnr. A price of about £100 puts it between the Verbot, which with a bit of persuasion reacts to voice commands and the top of the range Omnibot with its array of tape decks, internal clock and voice transmitter.

Junior is radio-controlled with a small number of pre-programmed reactions and a 'personality'. When it is switched on it says: "Hello" and when it hits something it says: "Oops excuse me", then reverses and turns to the left, among other things.

It was unveiled at the toy shows and should be in the shops now.

Next Month: More from the fascinating world of robotics.



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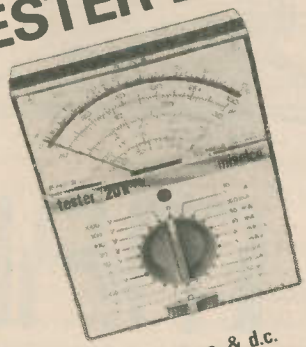

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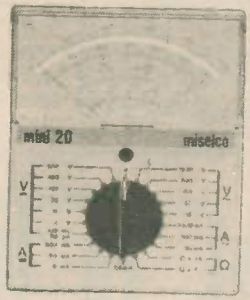

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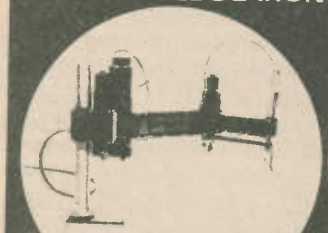

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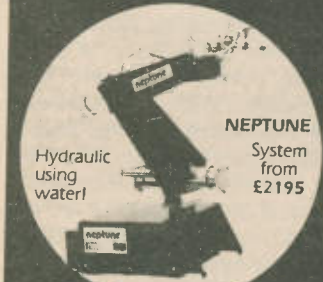

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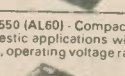

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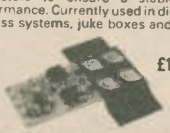

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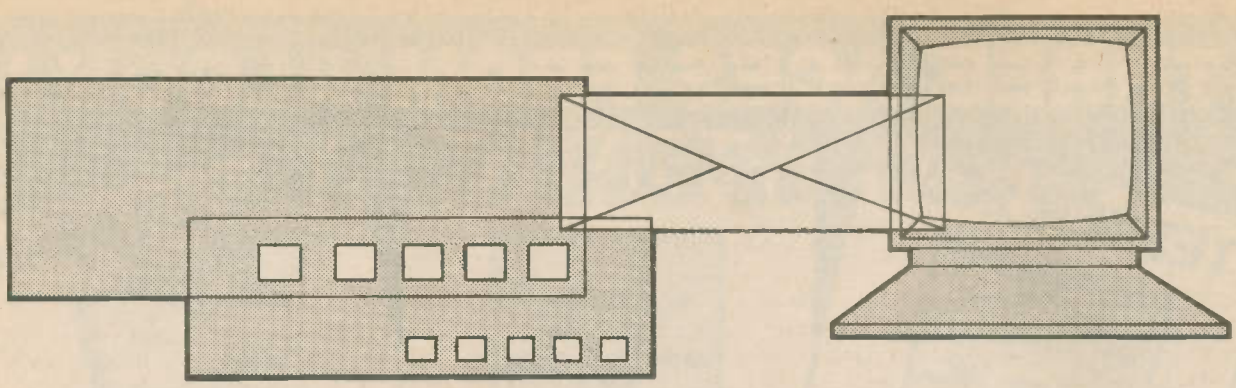


ELECTRONIC MAIL

BARRY FOX

THE popular press enthuses over e-mail as the new "Penny Black". Others see it is as the death of telex. Specialist magazines publish circuits for modems and computer monthlies review the software which enables a home micro to link up with a telephone line. But what exactly is electronic mail; how does it work, what does it offer and where are the snags? Hopefully what follows will answer these and other questions.

E-mail is a development from the technology which lets two computers exchange data along an interconnecting wire. The wire can be a private cable or public telephone line. The computers can be micros or mainframes. The data can be computer programs or text for messages. Normally both the communicating computers must be connected or "on-line" at the same time. Sometimes one computer plays the role of "host" to many others. Its memory may become an open access bulletin board on which remote computers can leave messages for anyone to read. The host may be a powerful computer with a database of information through which remotes can search, from across an office or across the world. This is how **Prestel Viewdata** works.

In an electronic mail system one host computer is used as a box into which a large number of smaller computers can drop messages for later collection by other computers. A system of passwords ensures that only those computers which are entitled to read a message can access it from the host. In this way any two computers can communicate with each other without being on-line at the same time. In theory the computers can be anywhere in the world, making e-mail equivalent to—and more versatile than—telex. In practice a confusion of technical standards and incompatible rival systems means that some e-mail messages get through only by interfacing with the telex network.

TELECOM GOLD

Telecom Gold is one of four e-mail systems available for public use in Britain. The technology is licensed from US company **Dialcom,** now owned by **ITT.** The same system is used in twelve countries, by over 100,000 subscribers, all of whom can communicate with each other. With this power base, and the strength of **British Telecom** behind it, Telecom Gold has been the most successful operator in Britain. But the situation could change, expecially if TG's rivals adopt interface or "gateway" technology which allows different system subscribers to send each other messages. At the moment, all four public systems in use in the UK have adopted different and incompatible standards.

As e-mail technology becomes more mature, and its practical use less of an obstacle course, the system will become as routine a business tool as the telephone. It will then become an electronic penny black. Only Britain's traditional resistance to change can prevent a domino switch from telex, costing several thousand pounds a year in dedicated hardware and lines, to electronic mail handled by cheap microcomputers and conventional telephone lines. But so far the practical difficulties encountered by people who want to use electronic mail as a business tool, rather than tame computers as a hobby, has slowed the progress of e-mail.

Many of the practical difficulties follow from the technical problem of sending digital pulses down wires designed to carry analogue wave signals, such as speech. Telex characters are carried by 5-bit Baudot code words. Until recently telex machines have relied on electromechanical switches triggered by 80 volt plus and minus d.c. pulses sent down dedicated lines. Modern telex equipment relies on much the same technology for e-mail, although to retain compatibility the modern electronic hardware emulates the old electromechanical system.

Confusion is compounded by the by the fact that much of the vital information on computer connection is handed down by word of mouth from poor unfortunates who have learned by trial and error. Even Telecom Gold has not published a clear explanation of the technology on which its system depends, the computer hardware and software needed to make it work or the parameter settings for hardware and software which is available.

Most computer firms make no mention of e-mail in the manuals which accompany their machines and the software which enables them to communicate. To give just one specific example, few manuals bother to explain that when text is prepared "off line" and stored on disc for later transmission by e-mail link it must be stripped of control codes. Wordprocessing programs use hidden control codes to define text layout. If an attempt is made to transmit text that has been prepared by a wordprocessor, it will very probably throw the e-mail system into confusion and emerge with errors at the other end. The trick is to save the message from the wordprocessor as plain text. Most, if not all, programs will allow this—although they all have different names for the procedure.

Computers process and store text as a coded stream of pulses, arranged in groups each signifying a letter or number. Most computers use ASCII (American Standard Code for Information Interchange), with each character represented by seven ones or zeros in an eight-bit word. The eighth bit is spare for other uses, usually error detection by parity check (an extra one or zero is added so that the total number of ones is always either odd or even). Incidentally the way to save text from a wordprocessor for transmission is as plain ASCII text. Saving this way strips out the control codes.

FREQUENCY SHIFT KEYING

Whereas digital data runs as a stream of square pulses, a speech telephone line is designed to carry a limited range of analogue wave frequencies, within a band of around 3kHz. The technique used to send data down a ordinary speech telephone line, is called Frequency Shift Keying, or FSK. A zero is represented by one audible tone frequency and a one is represented by another tone frequency.

A speech telephone line carries both halves of a conversation at the same time. The human ear-brain mechanism is clever enough to

untangle the mixture of incoming and outgoing speech. But computers are not so clever. When two computers are communicating on a two-way line they must use different tones for their zero and one pulses. So each end of the line uses a different pair of frequencies, making a total for four tones per link. These are usually between 1kHz and 2kHz, which is why the signals which flow down the line when computers are communicating are a high pitched chirp or warble. Filters in the modem prevent the outgoing tones feeding back into the input.

When two computer users first try to put their machines on line to send private messages, they must decide who is to use which set of tones. For convenience these are identified as the "Originate" or "Answer" frequencies. For electronic mail, where a large number of personal computers or terminals are all communicating with the same main central computer, it is established practice for the host to choose the Answer frequencies and the subscribers at home or in their offices to choose Originate.

There are two quite separate standards, one for the USA and the other for Europe. In the USA the FSK frequencies were set by Bell and in Europe the standard was agreed by the **CCITT** (International Consultative Committee on Telephone and Telegraph). This means that the hardware needed to interface a computer with a telephone line in North America is not the same as that needed for the UK. So any attempt at direct communication between a home computer in Europe and another in the US will fail unless one of the parties is equipped to handle the foreign set of FSK tones.

If communication is in "full duplex" mode, the computer screens display text which has reached the other end of the line and been bounced back by the computer there. This shows up any errors that have been introduced along the route. In "half duplex" mode each computer shows only the text which it is transmitting, so errors are not revealed. Obviously full duplex operation is desirable but there is a penalty. Because data is travelling in two directions at the same time the system is effectively handling data at twice the real rate.

MODEMS

The hardware needed for converting a stream of ASCII (or telex) text into FSK warbles is a modem, or MODulator-DEModulator. This both generates tones when fed with digital pulses, and recreates digital pulses when it receives incoming tones. Some modems now on sale can be switched between Bell and CCITT format, to enable direct communication across the Atlantic. Fortunately this consideration does not arise if messages are sent via an electronic mail system with host computer. The mail system is transparent. Messages injected with a modem operating on one standard will emerge in a foreign country on the local operating standard. But travellers hit problems if they carry hardware with them. A modem, or computer with built-in modem which is bought in the US, will not work in Europe; a European modem will not work in the US or Canada.

Even when the hardware is bought in the country of intended use, setting up a terminal, with computer and modem connected to the telephone wire, is fraught with difficulties.

Some computers have a slot inside, into which a modem on a printed circuit board can be plugged. It is often cheaper, however, to use an outboard modem. This can be hard-wired into the telephone network, like an extension telephone. Or it can be an acoustic coupler which works like a telephone in reverse, with a microphone to pick up sound from a conventional telephone ear piece and a loudspeaker to inject sound into the telephone mouthpiece. Acoustic modems are useful where the operator is on the move, needing to couple with a different phone every day. It is seldom possible to unplug a hotel telephone, for the simple reason that unpluggable phones are too easy for guests to steal.

Usually an outboard modem connects with the RS232 socket. The pulses run in a serial stream, in on one wire and out on another. Other wires carry additional signals which allow the two computers to work in harmony. Around half a dozen wires are needed for full transmission control. Unfortunately there is no agreed standard on which wires should go to which pins of the 25 way plugs used for RS232 connections! The only safe way to make a connection is to buy all necessary leads at the time of purchasing a modem.

DATA RATES

Even with the correct wire connections, the stream of data coming from the modem is useless to the computer unless it has been loaded with a software program which converts the incoming pulses into text for display on the screen. There are several different data rate standards, of which three are in regular use for electronic mail. Different data rates use different tones. This lets automatic equipment set its own data rate.

At a slow data rate the pulses produce relative long waves, so are less likely to be lost or distorted by noise on the telephone line. But messages take longer to send. This is an important consideration because on some e-mail systems the subscriber must pay both to transmit and receive or read.

Data rates are measured in bits per second, often wrongly equated with bauds or number of modulation changes per second. By clever tone coding, bit rate can be made much higher than baud rate. But at low speeds, of a few hundred signal transitions a second, baud and bit rate are similar or identical.

As a yardstick, telex messages are carried at 50 baud which in practice means around 400 characters a minute. The speeds for computer are laid down by a set of CCITT standards, the *V series*. The usual speed for electronic mail is 300 bits per second in each direction, known as 300/300. This is the **CCITT V21** standard. Higher speeds present problems, especially in duplex mode.

Dedicated data circuits, for instance special phone lines, have four wires. So data can travel in both directions, separately. But electronic mail travels on the public telephone network, which is a two wire system. A data rate of 1200 bits per second is the practical limit. If data is to be sent in two directions at once, for duplex operation, simple FSK coding is not adequate. A combination of phase and frequency shifts is needed. Cheap modems cannot handle the 1200 bits/s duplex standard **(V22)** because the readily available chips on which they rely offer FSK only.

The 1200/75 **(V23)** standard is a useful compromise; data travels at 1200 bits/s in one direction and 75 bits/s in the other. At this speed full duplex FSK is feasible. A link at 1200 bits/s in both directions can work with a cheap modem, but only in one direction at a time. This 1200 bits/s half duplex standard also comes under the V23 heading, but e-mail host computers will usually refuse to work in this mode. The 1200/75 "asymmetrical" approach is useful where one half of the link, such as a database, is sending out much more information than the other. This is the technique used for Prestel. For e-mail, where as much data is usually being sent as received, the 300/300 rate is best. Apart from anything else, there is inevitably more risk of noise on the line introducing errors at 1200 bits/s than at 300 bits/s.

Usually the different speeds and tone frequencies offered by the host are handled by different modems, each on its own phone number. So the host must be accessed on a phone number chosen to suit the data rate eg 583 3000 for the Telecom Gold 300 baud service in London. The calling modem is manually, or automatically, set to match the host data rate.

The speed at which the data leaves the terminal computer, and is accepted by it, must be controlled by software. This will have a menu of options which the operator must select to match the chosen data rate. Unfortunately data rate is only one of a long string of parameters which must be set when the software is tailored to suit the system being used as a terminal. There are a large number of different programs on sale which enable micros to communicate, either with each other or with an electronic mail host. Needless to say they are all different and the instruction manuals which accompany them are often understandable only to the dedicated computer buff. It is a token of the potential value of e-mail as a business tool that so many non-buffs have persevered with the absurd obstacle course and now use the system.

SMART TYPES

Recently I was loaned a modem of the so-called "smart" type. Made by British firm **Tandata** it plays the very clever trick of listening to the tones on the line and then automatically setting its parameters to match those of the computer at the other end. Connection was simple. By far the most difficult part of using it was understanding the appallingly confused instruction books which came with it.

The communications software must add extra data bits to each ASCII word for control functions. An additional "start" bit at the beginning of each word tells the other computer that a character is coming. An additional "stop" bit at the end signals that the

character has finished. This is asynchronous operation. For faster data rates than e-mail the computers are locked in step over much longer periods of time. This is synchronous operation.

Each data word will usually also contain a "parity" bit. This is added to help the other computer sense when an error has been introduced, for instance by noise on the line. Absurdly, the computer world cannot agree even on such basic matters as odd or even parity; i.e. whether the extra bit should bring the total to an odd or even number, or whether parity should be ignored altogether. Instruction codes are usually injected by the software, so that neither computer floods the other with more information than it can handle.

Some software packages pose questions which few people understand, let along are able to answer. The object of this extraordinary obstacle course is to let anyone in the world, with any computer, set its parameters to communicate with any other computer. For electronic mail, far less flexibility is needed. But the electronic mail system providers have to offer a **Help Line** service to assist bewildered subscribers in setting up their computers.

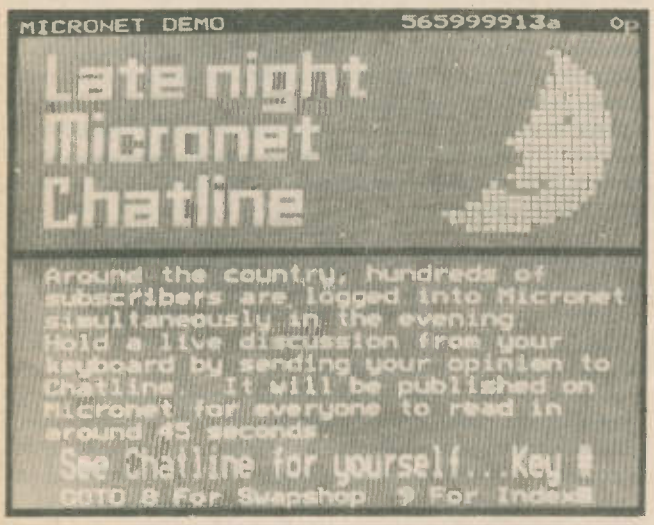
GETTING STARTED

For the benefit of anyone currently struggling to set up a system, the best starting point is as follows:

Data rate of 300 baud, full duplex operation, a word length of 7 data bits, parity even, 1 start bit (generally software assumes this), 1 stop bit and line status set at Enable for Xon and Xoff to let the software freeze the screen if the user wants to stop text scrolling past too fast.

All the UK e-mail systems now allow the subscriber to inject a message into the telex network and receive telex messages on an e-mail terminal.

The wider spread of e-mail will depend on making the technology



A Micronet screen demo

more accessible, for instance by the development of dedicated systems which require no computer expertise to set up. It will also depend on the service providers' ability and willingness to remove irritants from the system. For example, with a portable micro and modem, an e-mail subscriber can in theory communicate easily with the office backwork from the bedside telephone of any hotel in the world. But to do this the subscriber needs the right modem to match the local standard. He or she also has to hope that the hotel switchboard will not mistake the modem tones for a fault and disconnect the line halfway through a message. I know from bitter experience that frequently this happens.

PACKET SWITCHING

In most countries it is possible to route calls back to London, by one of the International Packet Switching Systems. A local telephone company modem accepts calls from a terminal modem, breaks the data into packets and slots it into the 48 kilobit/s stream which now travels by satellite and submarine cables between most countries of the world. But to use IPSS the itinerant e-mailer must know not only the long strings of code numbers and passwords, but be able to find the local PSS phone number from a foreign language operator out of office hours. Making an e-mail hook up from a far-off land can be far more trouble than it is worth.

For users, the biggest potential nuisance is junk e-mail, like rambling advertising literature. An advertiser can send the same message simultaneously to any number of different destinations. At 300 bits/s it can take several minutes to receive and read a tedious message that would take only seconds to scan and discard if it came through the post on paper. On some e-mail services, notably Telecom Gold, the subscriber is charged (at up to 10·5p a minute) for all time on line, whether receiving or sending messages. This is in addition to the cost of the telephone call to the e-mail host computer. Fortunately the e-mail service operators are aware of the problem and will disconnect persistent offenders.

The Dialcom system used by Telecom Gold, the most vigorous e-mail service provider in Britain, relies on Prime 740 and 850 computers as hosts. Each costs around £0·2 million. Incoming calls are automatically connected to the computer by a gang of switch PADs (Packet Assembler and Disassembler). As the number of incoming calls increases, the response time of both switches and host computers slows down. This means that subscribers spend longer on the line connected to TG. Although this in turn means TG earns more money, because the charge rate remains the same even when response time is slow, it makes TG's customers increasingly angry. The situation gets worse if a PAD or computer develops a fault. One of the major disadvantages of electronic mail is that if the hardware or software at either end of the link fails, mail cannot be read; it might just as well be locked in an uncrackable safe.

TG now has around 30,000 subscribers and around 30 Primes. In practice each computer can handle between 50 and 60 connections at the same time. Because only a fraction of its subscribers will be trying to connect at the same time, each Prime computer can serve around 5,000 boxes. As demand grows, TG has no option but to install new computers. Currently TG is buying one a month. These are each given a code number, which is part of the subscriber's box number address. Predictably there is a howl of protest when a subscriber's number has to be changed because a new computer has been installed; all the subscriber's printed stationery suddenly goes out of date.

STAND-BY

TG holds one complete Prime configuration idle as a stand-by system is case there is catastrophic hardware failure. The service does not have its own emergency generator. If the mains power goes down, so does the system. The prospect of every subscriber's data being lost in a crash is too awful to contemplate. A crash should not lose data. But to be on the safe side all user data is archived to magnetic tape each night. The daily archives are retained for one week, weekly archives are retained for four weeks, monthly archives are retained for one year and yearly archives are retained indefinitely.

There has only been one incident in three years, when TG lost some data which had been created between the last nightly archive and the time of failure. But clearly the system is vulnerable and users with valuable data should keep their own copies for 24 hours. But if a customer accidentally deletes valuable data from a mailbox, TG can retrieve it from the back-up tape.

HACKING

Security is always a vexed issue. How easy is it to "hack" into someone else's box and read their mail? No system can be 100 per cent secure. There is no secret over a subscriber's box number. It is just like a house address to which letter mail is sent. The householder uses a lock and key to stop unwelcome guests getting past the front door. For e-mail this is done by a system of passwords; the electronic mail equivalent of a front door key. Without the password no-one can get access to whatever messages are inside a box.

The biggest risk to security is that people who use mailboxes often make it easy for someone to steal their password. They write it on a paper note, load it into a computer program or key the word onto a screen while others are watching.

British Telecom leases lines to four public and three private electronic mail services in the UK. The four public networks are its own **Telecom Gold; Easylink,** which is run by Britain's **Cable and Wireless** in conjunction with **Western Union** in the US; **Comet** run

by **Istel** a subsidiary of **British Leyland**; and **One-to-One** now owned by US telecoms consortium **Telesis**.

All offer a straightforward e-mail message service and all offer a link with the telex network. This can be used either to send and receive conventional telexes (with the cost of the telex added to the e-mail bill) or to bridge the gap between the incompatible e-mail systems, i.e. to send a message from Telecom Gold to Easylink or from One-to-One to Comet. In this respect the new e-mail technology is helping the old telex technology survive.

There is vague talk of interchange or "gateway" software which will let different system mailboxes communicate with each other. Paradoxically, not everyone wants it. Gateway interfacing would help the smaller operators sell their services by offering cut price access to the larger and more expensive networks.

On all services, phone calls are extra because BT refuses to package its charges with those of arms length companies like Telecom Gold or Prestel Viewdata.

In more detail the services on offer compare as follows . . .

SERVICES

Easylink has a few thousand subscribers in Britain (it won't say exactly how many) and a total of 150,000 here and in the US where it has been offering a low cost alternative to dedicated telex for five years. The company has done little to publicise itself in the UK, where it has been operating for a year. But changes are planned.

EL's prices are an initial registration fee of £40 and then a minimum of £12.95 a month. Subscribers only pay extra (at 10p a minute plus the cost of telex transmission) to send messages. It costs 15p per address to which a message is sent, but the first 50 per month are free. Reading messages is free, except of course for the unavoidable cost on all systems of making the phone call to the host computer.

One-to-One began as a private company in March 1984 but in January 1985 was bought by **Telesis**, the Californian and Nevada Bell telephone company spin-off. The user base is small, a few thousand like Easylink, and profile is low. Again like Easylink, Telesis plans aggressive marketing and a change of image.

Registration is £50 and cost on line is 10p per minute. There is no off peak cheap rate but the first half minute of each call is free. That is enough to let a user check whether there is any mail to read.

Comet is run by Istel. It began as an in-house mailbox service for BL but is now on offer to anyone. Istel claims 90,000 mailboxes, mainly distributed through the offices of large companies like Shell, Citibank and, of course, BL. There is no registration fee. Basic cost is £30 a month, with an extra £10 for telex facilities. There is no charge for time on line.

Telecom Gold was created as an arm's length company by British Telecom in April 1982, initially to offer internal mailbox communication for BT. It is now on offer to anyone. The cheapest subscription scale is a one-off registration fee of £40 and on line time charged at 10·5p a minute peak rate, or 3·5p off peak, with a monthly minimum of £10.

Prestel is probably the best known system because it has been available for longer than any of the e-mail services. Prestel is essentially a data base, but it began offering a mailbox service in September 1981. Initially this was available only in selected areas of the country, but in October 1984 Prestel Mail Box became a national service. Any one of the 50,000 Prestel subscribers can now send a short message to any other subscriber.

By way of return competition, Telecom Gold hopes soon to offer its subscribers the opportunity to access data base bases, both in Europe and the US, by e-mail. This already happens on Dialcom in the US.

Ingenuity Unlimited

A selection of readers' original circuit ideas.

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

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

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

SINGLE POT DUAL OVERLAP CONTROL VOLTAGE CIRCUIT

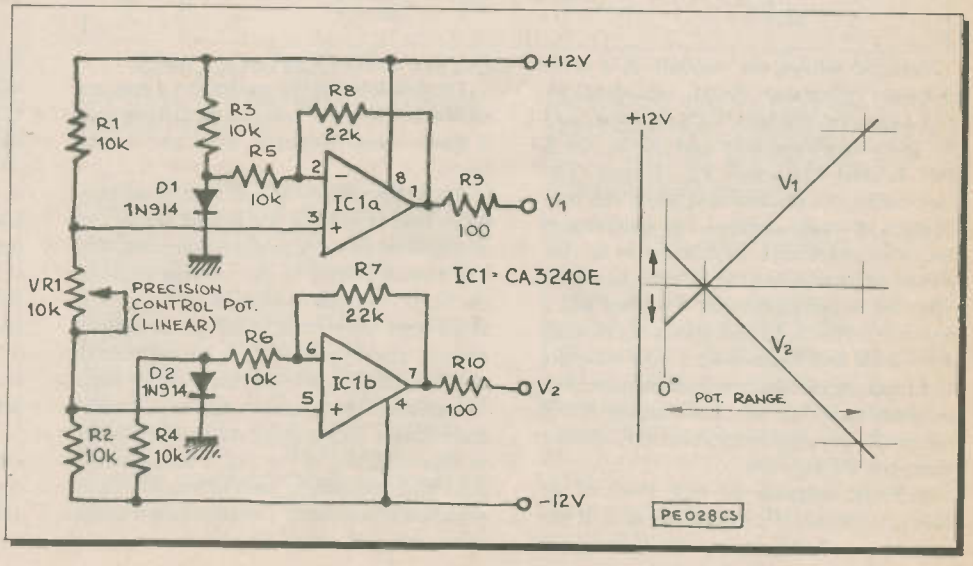
RECENTLY the writer needed a single pot control of two voltages which had to vary from ±12V and cross over to 2Vbe at one end of the pot rotation. Also, the law of the rotation about centre had to be different for the two control voltages. The circuit devised works very well.

This is a linear circuit, but if R7 and R8 are shunted by different diode and bias networks then a non-linear, non-symmetrical system can be developed.

OVERLAP

By shifting D1 and D2 to other voltages, the point of overlap can be set where required.

A. B. Bradshaw,
Sandy,
Beds.



BBC Micro Forum...

Ray Stuart

THIS month's *BBC Micro Forum* looks at the addition of a secondary display, in the form of a small l.c.d. module. This is a feature found on other computers such as the Apricot and could be used to display, for example, function key information or time. The l.c.d. module is easily fitted to the BBC being simply plugged into the computer's User Port.

LIQUID CRYSTAL DISPLAY MODULE

L.c.d. modules consist of a dot matrix l.c.d. with an internal CMOS microprocessor, memory and l.c.d. drivers thereby producing an intelligent alphanumeric display. They are available in a range of sizes from 1 row of 16 characters to 2 rows of 40 characters. Although this article is based on the 2 × 40 character module, the setting-up information, pin connections and programming techniques are applicable to most types.

be seen that it consists of one control chip, four driver chips and the l.c.d., all of which are mounted on a 180 × 35mm printed circuit board. The control chip contains the microprocessor, RAM and Character generator ROM and the input/output circuitry that allows it to communicate with other equipment. It should be noted that this communication is bi-directional thereby allowing the contents of the display to be read by the BBC microcomputer. Having received display information from the BBC microcomputer the control chip undertakes all the refresh and update controls without further intervention by the BBC microcomputer.

L.c.d. modules are available from a range of suppliers, however, the majority use a Hitachi chip set (HD 44780 controller, HD44100 drivers) and the same pinout configuration although the physical appearance may be different. The module described here is the *RS* 588-538 device.

Table 1. Pin functions of l.c.d. module

Pin No.	Function	Level
1	V_{SS}	0V
2	V_{DD}	+5V
3	V_O	< 0·7V
4	RS	0 = inst: 1 = char
5	R/W	0 = write: 1 = read
6	E	⊓↓ latch on fall
7	BD0	
8	DB1	
9	BD2	
10	DB3	Positive
11	DB4	Logic
12	DB5	
13	DB6	
14	DB7	

range for Vo is between 0·2V and 0·7V, outside this range the viewing angle may be so high that the characters become unreadable. Vo is usually adjusted to produce

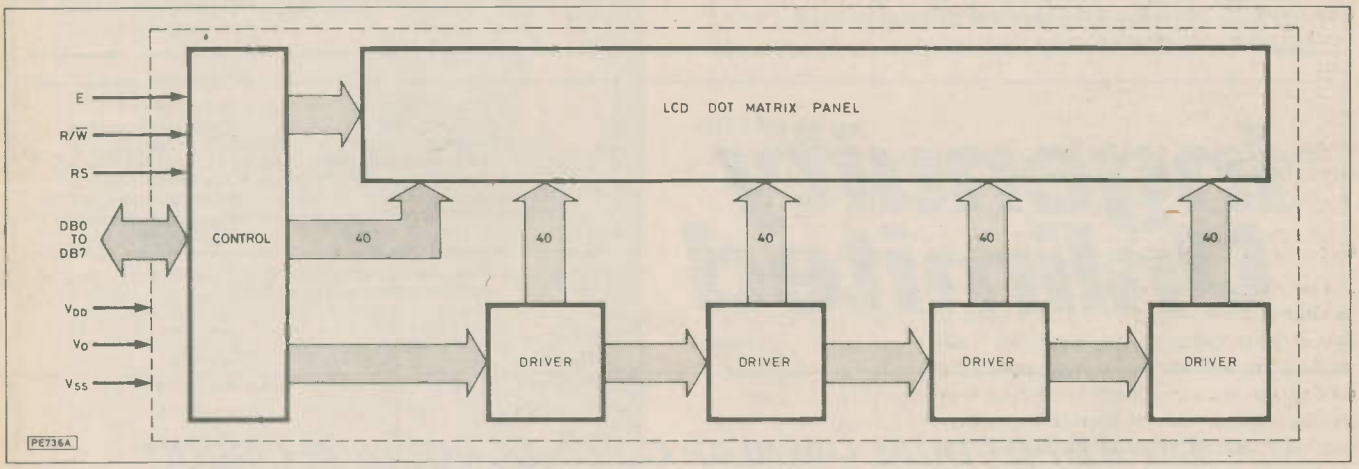


Fig. 1. Display module block diagram

Included within the module is a 192-character generator ROM including 92 Alphanumeric symbols, 62 Kata kana, and 32 Euro/Greek/symbols and RAM for 8 user defined characters, e.g. '£' sign. The user defined characters also allow the production of multi-channel bar graphs and animated characters. Characters to be displayed are written to the module in ASCII form via either an 8-bit or 4-bit bus and a few control lines. All this makes the module easy to use and imposes very little software overhead on the BBC microcomputer. The modules require a 5V, 2mA supply which can easily be supplied by the BBC microcomputer's User Port.

A block diagram of a 2 rows of 40 characters module is shown in Fig. 1. It can

DATA AND CONTROL LINES

The functions of the module's 14 pins are shown in Table 1. These can be divided into 3 power lines, 3 control lines and 8 data lines.

It was previously stated that these modules only require a 5V power supply, so why is there an extra power connection, Vo? The reason relates to the viewing angle of the l.c.d. This type of module is best viewed at an angle other than at 90° to the display making them ideal for use on keyboards, etc. It is possible to adjust the viewing angle to optimise performance for a particular application. This is achieved by altering the voltage supplied to Vo. Fig. 2 shows how a potentiometer can be used to provide viewing angle adjustment. The optimum voltage maximum contrast as opposed to maximum dot darkness.

The eight data lines are used to transfer data to and from the module under control of the three control lines. Data is normally in the form of ASCII characters except when initialising the module or programming the user defined characters.

Now consider the three control lines. The R/$\overline{W}$ line is used to inform the module of the desired data flow direction. When set to '0' data is sent from the computer to the module (write), and from the module to the computer when it is a '1' (read).

The module has only two registers that can be accessed by the BBC microcomputer, these are the Instruction Register (IR) and the Data register (DR). The regis-

ter to be accessed is selected by means of the RS line. '1' selects the Data Register, '0' selects the Instruction Register. The use of these registers will be discussed later.

The remaining control line is designated 'E', and it is this signal that is used to initiate the actual transfer of data, present on the data bus, into the module. The operation of the module is such that the data is latched into either the Data or Instruction Register on a falling edge of the 'E' line. Thus the 'E' line can be considered as a pseudo module-select signal, but note that the module does not have tri-state input/output lines. This means that modules cannot be paralleled as can, for example, memory chips.

CONNECTION TO THE BBC

The module is connected to the BBC by means of a ribbon cable plugged into the User Port as shown in Table 2. However, the user port can only provide a maximum of ten outputs if the CB lines are included, so how can the system work? The answer is to configure the module to run in 4-bit mode. By doing this, one only needs seven lines, 4 data and 3 control. In this mode the module still requires 8-bit data words, but it accepts them as two 4-bit nibbles; the most significant nibble followed by the least significant nibble. By using this mode of operation only seven bits are required instead of the previous eleven and can therefore be linked to the User Port.

When in 4-bit mode the module uses DB4–DB7 as the 4-bit bus and ignores anything that may be present on the other four bits. The User Port bits PB0–PB3 are used as a 4-bit bus with bits PB4 as R/W, PB5 as RS and PB6 as the E signal. It will be described later, when discussing the software, how the unit is set into this 4-bit mode.

INSTRUCTION SET

The full instruction set for the l.c.d. module is shown in Table 3. It can be seen that it is possible to configure the l.c.d. module in a wide variety of operating modes. For example, there is the option of having a cursor displayed as a bar underneath a character position and this can be made to flash on/off if required. The cursor can be made to move to the next character position upon receipt of a character or to remain in a fixed position. The latter can be used to produce a sideways scrolling effect.

These are only a few of the options available and it is obvious that the l.c.d. module is a versatile device. Should you wish to use these facilities to the full, a copy of the relevant device's data sheet should be obtained for further details.

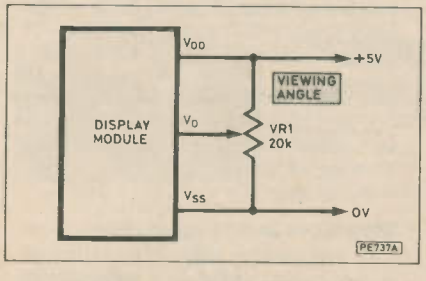


Fig. 2. VR1 is adjusted to give optimum viewing angle

Table 2. BBC to l.c.d. display connections

BBC User Port		LCD Module	
Pin No.	Function	Pin No.	Function
19	0V	1	V_{SS}
1	+5V	2	V_{DD}
6	PB0	11	DB4
8	PB1	12	DB5
10	PB2	13	DB6
12	PB3	14	DB7
14	PB4	5	R/W
16	PB5	4	RS
18	PB6	6	E

Table 3. L.c.d. module instruction set

Instruction	Code RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Comments
Clear display	0	0	0	0	0	0	0	0	0	1	Clears display and homes cursor
Home cursor	0	0	0	0	0	0	0	0	1	X	Returns cursor to home position
Entry set	0	0	0	0	0	0	0	1	I/D	S	Selects cursor direction and shift modes
Display control	0	0	0	0	0	0	1	D	C	B	Selects display, cursor and flash modes
Cursor or Display shift	0	0	0	0	0	1	S/G	R/L	X	X	Moves cursor and shifts display
Function set	0	0	0	0	1	DL	N	F	X	X	Sets interface mode, number of lines and character font
CG RAM address	0	0	0	1	ACG						Selects CG RAM address. Following data is stored in CG RAM
DD RAM address	0	0	1	ADD							Selects DD RAM address. Following data stored in DD RAM
Read busy flag and address	0	1	BF	AC							Reads busy flag. Indicates if module ready
Write data to CG or DD RAM	1	0	Write data								Writes data into CG or DD RAM
Read data from CG or DD RAM	1	1	Read data								Reads data from CG or DD RAM

BIT	1	0
I/D	Increment	Decrement
S	Enable	Disable
S/G	Display shift	Cursor move
R/L	Shift to right	Shift to left
D/L	8-bit mode	4-bit mode
N	2 lines	1 line
BF	Busy	Ready
F	Not used	5 × 7 dots

CHARACTER GENERATOR RAM PROGRAMMING

The character generator RAM (CG RAM) allows one to programme eight 5 × 8 characters of one's choice. An example of this is included in the software listing under PROC_define_£_sign. Once programmed, these newly created characters can be used in exactly the same way as can those contained within the character generator ROM, i.e. they are called by the appropriate data word. To programme a character into the CG RAM one first has to define the required character as 8 rows of 5 dots. A dot is represented by a '1' and no dot by '0' with the leftmost dot the most significant. Thus the hex representation of each line of the character's eight lines can be calculated. The RAM locations between &40 and &7F form the CG RAM. The first 8 bytes (&40–&47) contain data for the first defined character, addresses &48–&4F the second character and so on.

SOFTWARE CONSIDERATIONS

Having generally described the l.c.d. module, let us now examime the software required to drive it. The listing shown in Table 4 is for a basic display in which the required string is displayed on the l.c.d. module starting at the top left position. Should the string be longer than 40 characters it will continue on the lower line. The software has been written as a number of procedures which one can include in one's own programmes.

The first thing to do is to initialise the BBC microcomputer's User Port (PROC_initialise_port). This port can be considered as two memory locations, the Data Direction Register (DDR) address &FE62 and the Data Register Buffer (DRB) at address &FE60. In this case we configure the port as all outputs, and as an output is represented by its corresponding bit in the DDR being '1', we write into the DDR &FF. To provide some known starting value one now drives all the outputs to '0' by writing &00 into DRB.

Having initialised the port one can initialise the l.c.d. module. When power is applied to the l.c.d. module it puts itself into the following mode: 8-bit data bus, 1-line display, display off, cursor off, flash off. For this application the operating mode needs to be changed to 4-bit data bus, display on and 2-line operation. This is achieved by PROC_initialise_l.c.d. Examination of the instruction set command 'Function set' shows that if D/L is '0' the module will be put into 4-bit mode. By setting our 4-bit bus to '&2' the module's 8-bit bus reads this as &2X (X = don't care) and sets itself into 4-bit mode. From now on data is sent as two 4-bit nibbles representing the control bytes &28, &0C, &06, &01. Note that all these are written into the Instruction Register. The l.c.d. module is now ready for use.

To send alphanumeric ASCII characters to the l.c.d. module one creates a message string called string$. Characters are extracted one at a time from the string, split and sent to the l.c.d. display as two nibbles. This is the purpose of PROC_display which writes data into the module's Data Register. First of all it clears the display of any previous messages that may be displayed. It then splits the first character in string$ into two parts called high% and low% and adds 32 to each of these to set the RS bit to '1' thereby selecting the Data Register, and setting the R/W bit to '0' signify that it is a write command.

As previously stated, data is latched into the l.c.d. module by generating a negative edge on the 'E' line. This is achieved by sending the nibble with 'E' set to '0', then sending it with 64 added to its value thereby setting PB6, and hence 'E' to '1', followed by the original value. This produces the required negative edge. This process is then repeated for all the other characters in the string. Should the string contain the ASCII value used by the BBC microcomputer for the '£' sign (96), this is detected and changed to 0. This is because the user defined character for the '£' sign has been allocated character number 0 by PROC_define_£_sign.

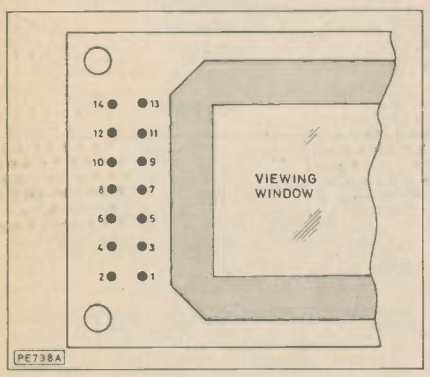


Fig. 3. Pin connections of module viewed from l.c.d. window side

Table 4. Basic display program

```
 10 REM ******************************************************
 20 REM *                                                    *
 30 REM *              BBC - LCD matrix interface            *
 40 REM *                                                    *
 50 REM *            Ray Stuart      December 1985           *
 60 REM *                                                    *
 70 REM ******************************************************
 80
 90 PROC_initialise_port:PROC_initialise_lcd:PROC_define_£_sign
100 REPEAT
110   CLS:INPUTTAB(5,5)"STRING  =  "STRING$:PROC_display
120   UNTIL FALSE
130
140 DEF PROC_initialise_port
150 DDR=&FE62:DRB=&FE60:?DDR=&FF:?DRB=&00
160 ENDPROC
170
180 DEF PROC_initialise_lcd
190 RESTORE 370
200 FOR I=1 TO 9:READ A%:?DRB=A%:?DRB=A%+64:?DRB=A%:NEXT I
210 ENDPROC
220
230 DEF PROC_display
240 ?DRB=0:?DRB=64:?DRB=0:?DRB=1:?DRB=65:?DRB=1
250 FOR I=1 TO LEN(STRING$):CHAR$=MID$(STRING$,I,1)
260   C%=ASC(CHAR$):IF C%=96 THEN C%=0
270   LOW%=(C% AND 15)+32:HIGH%=((C% AND 240)DIV16)+32
280   ?DRB=HIGH%:?DRB=HIGH%+64:?DRB=HIGH%:?DRB=LOW%:?DRB=LOW%+64:?DRB=LOW%
290   NEXT
300 ENDPROC
310
320 DEF PROC_define_£_sign
330 RESTORE 390
340 FOR I=1 TO 18:READ A%:?DRB=A%:?DRB=A%+64:?DRB=A%:NEXT I
350 ENDPROC
360
370 DATA 2,2,8,0,12,0,6,0,1
380
390 DATA 4,0,32,38,32,41,32,40,32,40,33,44,32,41,32,47,32,32
```

Table 5. L.c.d. module abbreviations

DD RAM	: Display Data RAM
CG RAM	: Character Generator RAM
ACG	: CG RAM address
ADD	: DD RAM address (cursor position)
AC	: Address counter, both DD and CG RAM addresses

INSTALLATION

Apart from the l.c.d. module itself the only other component required is a length of 20-way ribbon cable fitted with a suitable 20-way IDC connector and wired to the module as indicated in Table 2. It should be possible to mount the display under the clear plastic legend strip if a suitable size cut-out is made in the case. Once a message has been displayed it will be retained until such time as another is sent or the machine is switched off. Thus it is possible to give information relating to say function keys and then let the programme return to driving the main VDU. Indeed, for some applications an l.c.d. display could be the only display required!

APPLICATIONS

There are numerous applications for an additional display of this type. It could, for example, be used to indicate the function key operations for user programmes, to indicate real time from a battery backed clock, to indicate analogue values by configuring it, with the aid of the programmable character generator, display a multi-channel bar graph, or used for simple animated graphics again with the aid of programmable characters. The scope is, as they say, only limited by the imagination.

Book Corner

The Advanced User Guide, *Bray, Dickens and Holmes,* Cambridge Microcomputer Centre, ISBN 0 946827 00 1. A very complete guide in Chapter 15, but heavy going. Reading one of the other two books first will avoid mental indigestion.

The BBC Micro ROM Book, by *Bruce Smith, Collins,* ISBN 0-00-383075. A very readable step-by-step guide to the working of ROMs, and writing software for them.

BBC Micro ROM Paging System, *Watford Electronics.* A good introduction which is also useful as a summary in conjunction with either of the other two books.

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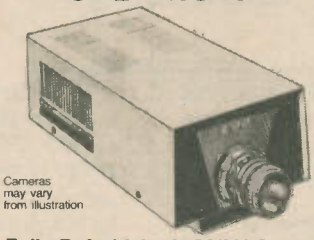

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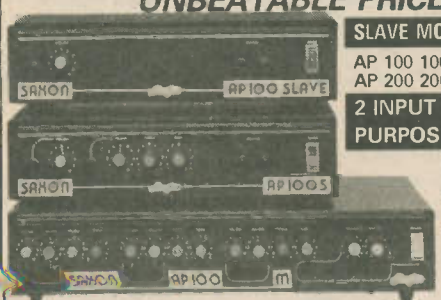

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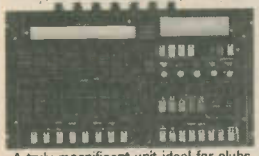

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THE problem following the demise of my old mechanical timer was *exactly* what was to replace it. There are many gadgets around all purporting to be for the purpose. In the end simplicity was allowed to win, and the features built in are shown in the specification box.

1) **Mains powered** (Batteries for someone who spends long night hours in the darkroom can be dreadfully inconvenient.)
2 **9V supply**
   a, To give the safety of batteries. Darkrooms are notoriously damp and electrically inhospitable places.
   b, At 9V or less CMOS 4017s will drive l.e.d.s directly without current limiting resistors.
3) **Autodimming** (A lot of colour processing is done in total darkness, and many photographers work "eyes shut". Afterwards is too late to discover that you forgot to dim the clock.)
4) **Easily read** (In any light from room daylight to total darkness, whilst remaining reasonably safe photographically.)
5) **Count up** (Any form of presetting which does not use multiple timers is not welcome in most darkrooms. When a tank has to be emptied and refilled to a time, and a timer has to be reset at the same time to a time different to the one just used . . .)
6) **Instant reset** (In the above situation any available hand, bottle, tank, elbow will do.)
7) **Indicated time** (Must be capable of exceeding any time the operator would wish to use. The timer will read to 100 minutes then auto reset.)
8) **The display** (In my darkroom things happen on, or as near as one can make it to, a particular second. Any timer then, needs to have an analogue seconds presentation so that some sort of actions can be started *in anticipation* of actual elapsed time.
   Having one l.e.d. for each second puts up the price of the timer but is perfect for ease of reading, quickly, and without ambiguity.)
9) **Minutes** (Since reading the minutes display is usually a far more leisurely affair than reading seconds, and since this time we want to know how long has elapsed rather than how long to go, two seven-segment l.e.d.s provide the information. In order that only elapsed time is displayed all 0s are blanked *unless* there is a number other than 0 in the M.S.D. So at 00 minutes, that is, seconds only elapsed, both seven-segment displays remain blank. At 01 minutes through to 09 minutes elapsed the display shows 1–9. At ten minutes elapsed the display shows 10.)
10) **Parts** (Parts were chosen to be 'standard' and thus available as long as the timer is likely to remain in service. The old timer determined the size of the presentation since the prototype fits the old case.)

HOW IT WORKS

For the purpose for which this timer was designed, input needs to be 9–16V a.c., with sufficient current available to ensure 150–180mA after rectification. One of the small battery eliminators with its rectifier diodes removed is ideal. The intention being to eliminate any possibility of having mains anywhere near the timer. The circuit diagram is shown in Fig. 1.

The incoming a.c. is fed through a 1A bridge or four small diodes arranged as a bridge and the unregulated d.c. stabilised by a 7805 IC1. However, for *timing* purposes a.c. is tapped from ahead of the rectifier, current limited by R1, clipped to supply voltage D1 and D2, and compared for level to the stable d.c. level by IC3, a 4093 Schmitt Nand gate.

The resulting clean 50Hz square wave is divided by five in IC2, a 4018 divide by 'n', cleaned again by IC3, passed to IC4, a 4017 decade counter, to be divided by ten. This output being the 1Hz working signal.

THE SECONDS DISPLAY

The seconds display is a matrix of 60 l.e.d.s, six rows, each row 10 l.e.d.s long. Each row has its cathode route to 0V switched in sequence by a BC108, TRs 1–6.

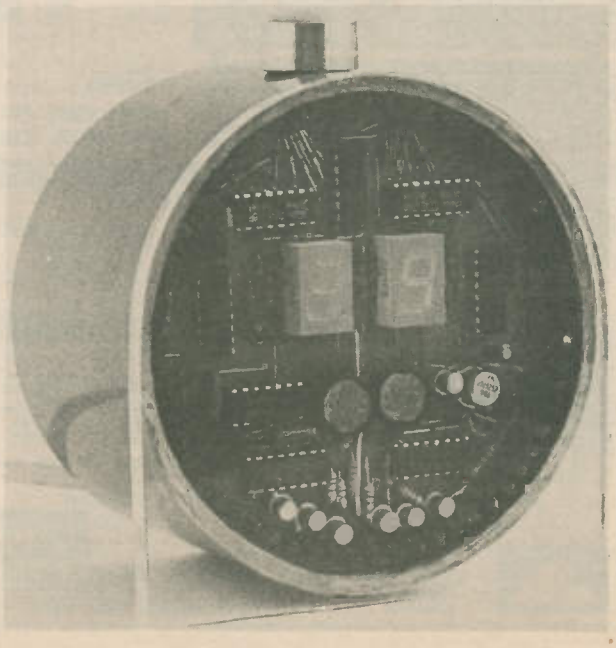
The 1Hz output from IC4 is applied directly to the input of IC5, a 4017. The outputs of IC5 go high in sequence continually, resetting at ten second intervals. Each of the first l.e.d.s in each of the six rows is connected to the first output, i.e. pin 3 of IC5. All of the second l.e.d.s are connected to the second output, pin 2 etc. Only the l.e.d.s which have access to 0V are able to shine, but by switching the rows sequentially all 60 l.e.d.s can be made to shine consecutively.

The carry out pulse from IC5 is the input to IC6, and the outputs from IC6 which change state at 10 second intervals connect the matrix rows to 0V in turn by providing base current to TRs 1–6 through resistors R3–R8.

IC6 is also configured to divide by 6, so the leading edge of the seventh output triggers its own reset and the matrix count starts again at zero. D3 prevents the reset pulse straying to ICs 4, 5 and 7. Since the IC7 reset pulse occurs 60 seconds after counting starts it is also used to drive.

THE MINUTES DISPLAY

When the timing sequence starts, i.e. the reset button is pressed, D4 prevents the reset signal getting to the count input,



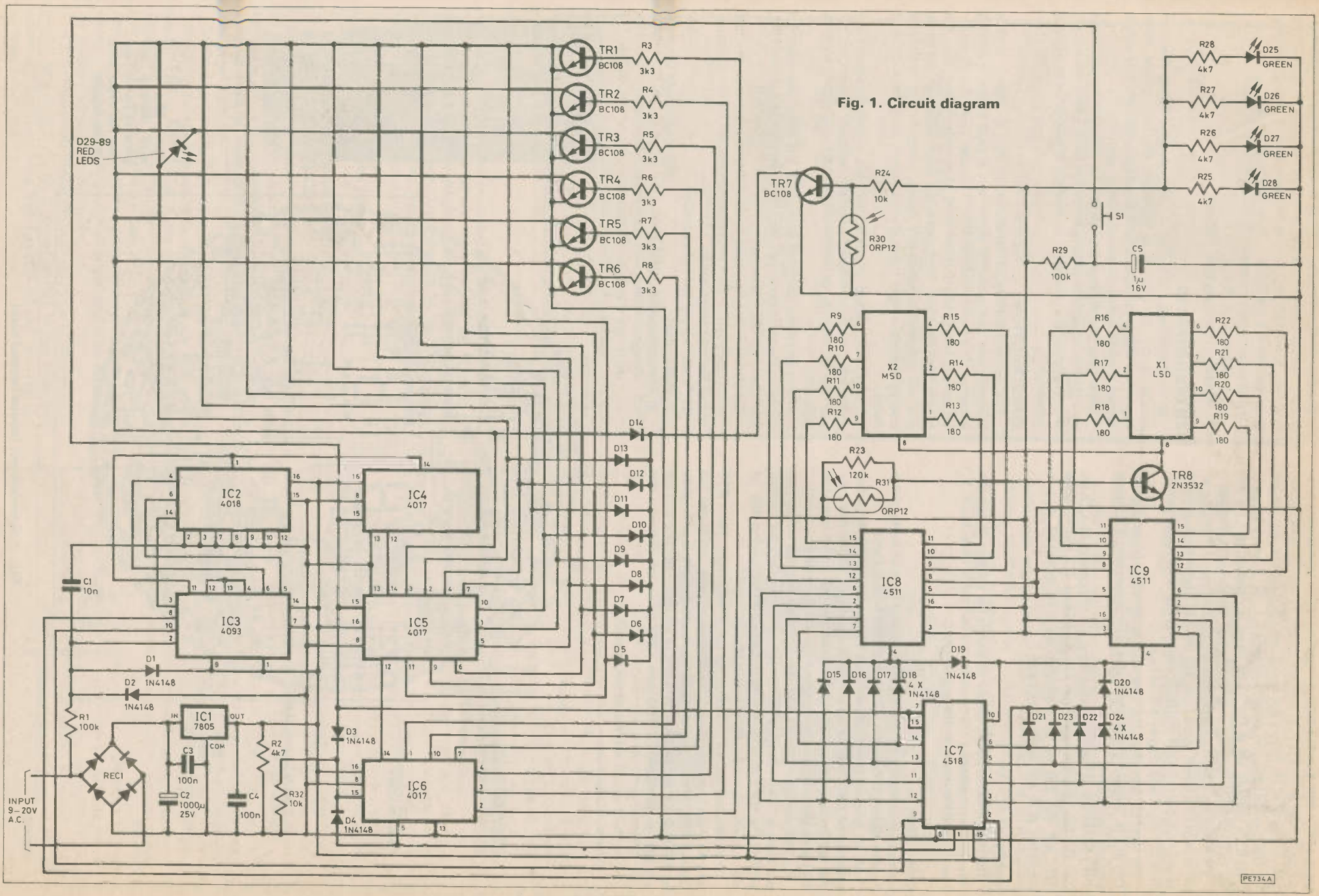


Fig. 1. Circuit diagram

pin 1 of IC7. IC7 is a dual BCD up counter. IC7a counts the l.s.d. via pin 1, resets via pin 7, is enabled by pin 2, and outputs at pins 3, 4, 5 and 6. IC7b counts the m.s.d. via pin 9, is enabled via pin 10, reset on pin 15, and outputs at pins 11, 12, 13 and 14.

All IC7a outputs are at 0V. IC7b count is disabled due 0V pin 10, IC7b pin 9 is high but is ignored since the count is disabled.

ICs 8 and 9 are both disabled due 0V on their respective pins 4. On receipt of a count pulse from IC6 pin 3 IC7 goes high, putting pin 4 of IC9 high via D24 and D20, enabling IC9 to decode the high from IC7 pin 3 and display a 1 as l.s.d.

Pin 10 of IC7 goes high but now pin 9 is low so no count occurs. The m.s.d. display is still blank due D19 preventing IC8 being enabled via its pin 4.

On the arrival of the 10th pulse from IC6 all outputs of IC7a go low, but this time the high from IC4 is counted, IC7 pin 12 goes high, IC8 and IC9 are both enabled via D15 and D19. A 1 is displayed as m.s.d. and a 0 as l.s.d.

RESET

During operation C5 is charged to supply rail voltage. When the reset button is pressed, C5 provides the current to reset ICs 4, 5, 6 and 7 and the count starts again from 0.

DIMMING

Due to the differing power requirements of the two parts of the display slightly different methods are used to dim them.

All 10 outputs from IC5 are also routed via D5–D14 to the collector of TR7. In light conditions the base of TR7 is held low due to R30 conducting. TR7 is turned off and the whole output of TR6 is available to the l.e.d.s which go as bright as they can.

As ambient light reduces R30 stops conducting, the voltage on the base of TR7 rises and TR7 turns on, reducing the current available to the matrix l.e.d.s. R24 prevents TR7 turning fully on and so sets the minimum brightness level.

The minutes readout has the opposite arrangement. Here, R23 and R31 are in parallel, and in high ambient light conditions the base of TR8 is held high, allowing the readout to shine as brightly as R9–R22 will allow. As light falls R31 stops conducting and the voltage on the base of TR8 falls. TR8 turns off reducing the brightness of the display. R23 sets the minimum brightness. Since in the seconds matrix only one l.e.d. is lit at a time, a BC108 is sufficient for TR7, but for the higher current carrying capacity required TR8 is a 2N3252.

Total power requirements:

Total darkness, 30mA.

Ambient room daylight, 130mA.

TOTAL DARKNESS

In total darkness with only 1 l.e.d. lit, i.e., during the first minute. It can be difficult to orientate the face of the timer accurately when reading quickly. L.e.d.s D25–D28 are only visible in near total darkness, to provide the orientation.

Depending on the usage anticipated, for the same reason, it can be a distinct advantage to have every 5th l.e.d. a different colour, this improves the accuracy of reading in almost any lighting condition.

CONSTRUCTION

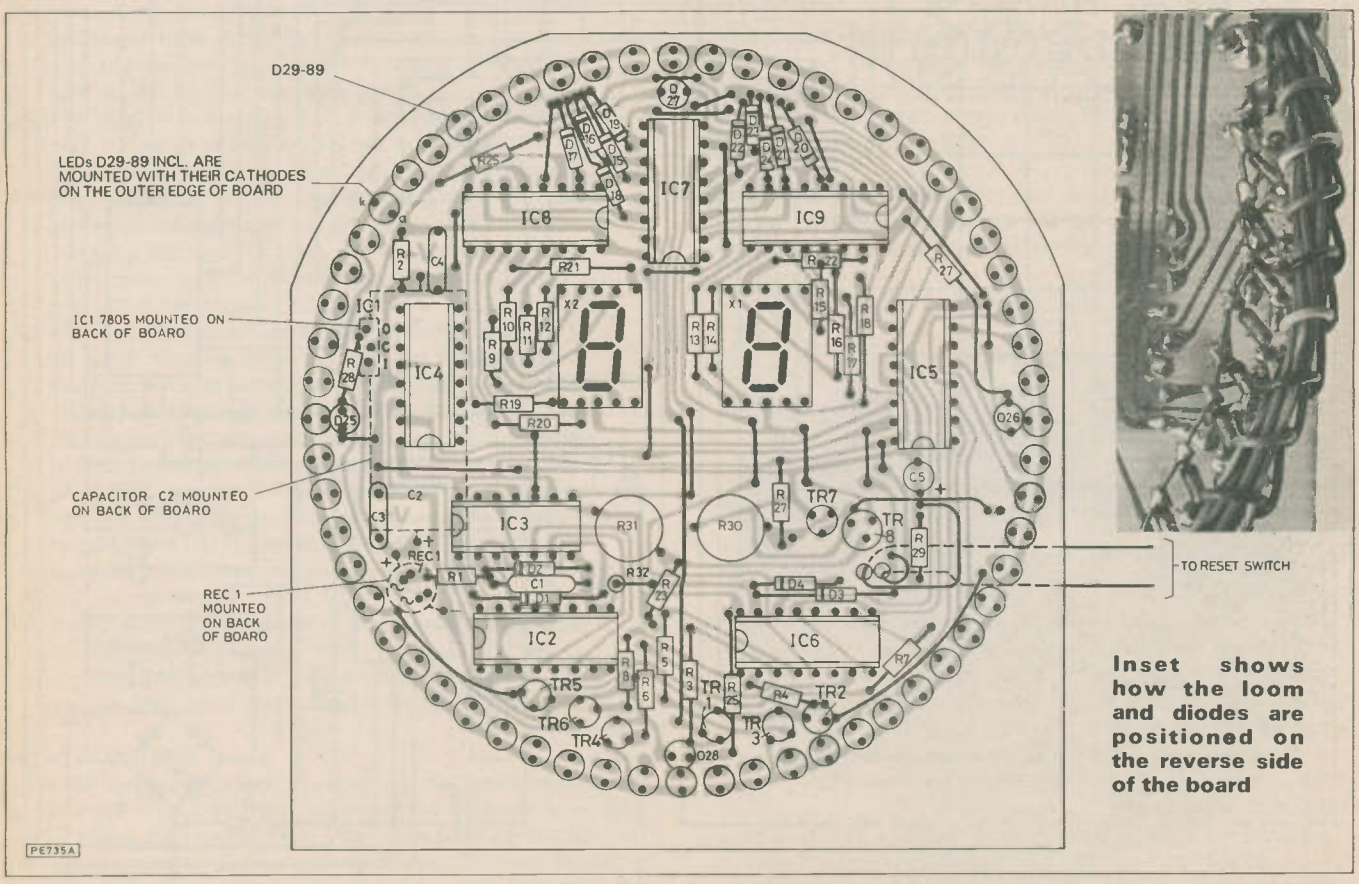
The component layout is shown in Fig. 2. Apart from a soldering iron and meter of some sort a logic probe is almost essential. The probe described in *PE October 1984* is sufficiently versatile to handle any problem likely to be encountered, even if it is only breadboarded. That probe has been tested on the clock and will indicate all necessary levels, being t.t.l. it might not always indicate a high, but it always moves away from 0, i.e. it floats.

Component spacing can be a little tight, especially around IC2 and IC3 and around the seven-segment readouts. Depending, for example, on the type of rectifier chosen, R1 may well lie partially beneath it.

Where possible, and that is most of the time, use standard construction techniques, i.e., links first, resistors and diodes next, then the larger components.

Construction is sequenced in the following order so that the correct operation of each stage may be verified before construction of the next stage starts.

1) Power supply and rail extension.
2) Pulse origin.
3) Pulse division and count.



Inset shows how the loom and diodes are positioned on the reverse side of the board

Fig. 2. Component layout (actual size)

COMPONENTS . . .

Resistors

R1, R29	100k (2 off)
R2, R25–R28	4k7 (5 off)
R3–R8	3k3 (6 off)
R9–R22	180 (14 off)
R23	120k
R24	10k
R30, R31	ORP12 l.d.r.

All resistors 5% ¼W

Capacitors

C1	10n poly
C2	1000µ/25V elect.
C3–C4	100n poly
C5	1µ/16V elect.

Semiconductors

IC1	7805 regulator
IC2	4018
IC3	4093 Schmitt
IC4–IC6	4017 (3 off)
IC7	4518 BCD counter
IC8–IC9	4511 7-seg decoder
REC1	1 Amp bridge
D1–D4, D15–D24	1N4148 (14 off)
D5–D14	1N4148 (10 off)
D25–D28	·125" green l.e.d. (4 off)
D29–D89	·125" red l.e.d. (50 off)
X1, X2	0·6" 7-seg display red
TR1–TR7	BC108 (7 off)
TR8	2N3532

Miscellaneous

S1 push button switch, p.c.b., suitable case. Battery eliminator, Plastic drainpipe (for body). The p.c.b. is available through the p.c.b. service—order code: PE-027

4) Minutes display.
5) Seconds display.

Start by putting the power supply together, REC1 and IC1 and the components around IC2 and IC3, C1–4, D1, D2, R1, R2.

NOTE: IC1 and C2 are mounted on the back of the board. The arrangement is a little untidy, but it keeps the front component height low which may be important at the presentation stage. Caution with the orientation of IC1.

Switch on and test for:

1) a.c. at the site of pin 2 IC3.
2) 5V d.c. pin 3 IC1.
pin 14 IC3, pin 16 IC2.
3) 0V pin 7 IC3, pin 8 IC2.

Extend the power supply rails using links and R25–R28 so that l.e.d.s 1–4 can be fitted and tested. NOTE l.e.d.s 1–4 are extremely dim being only intended to be used in total darkness.

Fit IC2 and IC3. Check for 10Hz pulse train at pin 1 IC2, and at site for pin 14 IC4.

Fit IC4 and check for 1Hz at pin 12, and at site for pin 14 IC5.

Fit IC5 and check the sequence of pulses at the ends of the tracks radiating from the i.c. If you can be certain of the pulse sequence at the track extremities, problems which may occur later will be much easier to deal with. It is most strongly recommended that unless the sequence at the ends of the direct tracks is operating correctly, *no* further installation be done until the problem is located and solved.

Fit IC6 and carefully check the outputs. For a 1/10Hz input to pin 14, pins 4, 3, 2, 7, 10, 1 should go high in that order and remain high for 10 seconds. If all is well R3–R8 and TR1–TR6 can be fitted and tested.

Fit D15–D24 then IC7, not forgetting the links back to IC3.

Test again. It should now be possible to detect the entire sequence of operation at some point on the circuit. If necessary R29 and C5 can be inserted and S1 jury rigged with wire for test.

Fit IC8 and IC9, *caution* with orientation, they are upside down when looking at the markings on the back of the chips, with respect to the other devices on the board. Check that the inputs of IC8 and IC9 result in the desired outputs.

Fit displays 1 and 2 and associated resistors, TR8, R23 and R31.

Run the timer. If all is well, after switching on and pressing the reset, nothing will happen for one minute, then a one should appear in the l.s.d. From then on the number displayed should increase by one every minute until 100 minutes has passed, when the display should go blank and start again. The dimming function can be checked by placing a finger firmly on R31 and observing a noticeable change in the display intensity. The total darkness display brightness cannot be determined by this method, the amount of light passing through your finger will prevent minimum brightness being reached.

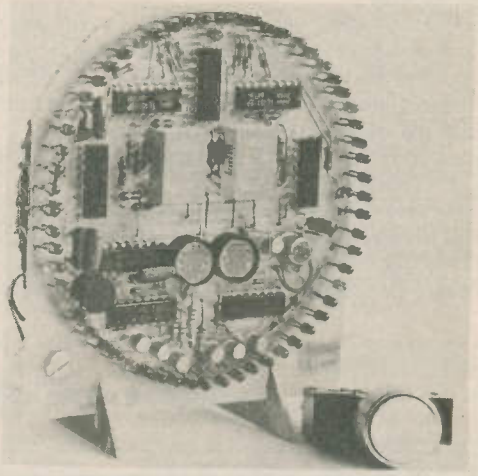
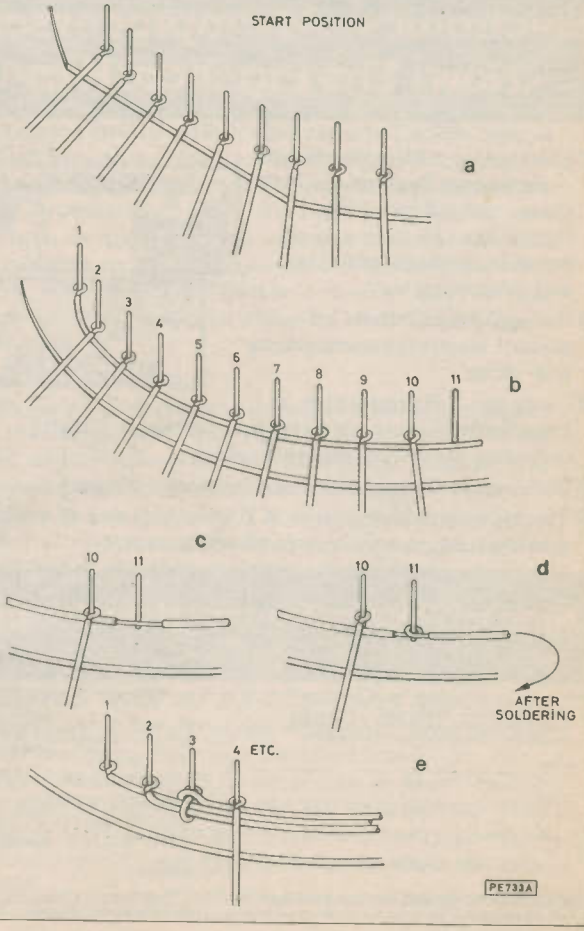


Fig. 3. Wiring hints



Constructing the 60 l.e.d. matrix requries patience if optimum results are to be achieved. Start by deciding whether the l.e.d.s are to lie flush on the board or at some pre-determined height, as required by the container you are going to use. Some l.e.d.s have irregularities built into their legs to assist in this kind of positioning. Having decided a height, make a small jig that will hold the l.e.d., given, say, finger pressure on the l.e.d. side, whilst you solder single-handed on the other side of the board. A short rehearsal with spare l.e.d.s and a spare piece of p.c.b. *at matrix spacing* will pay dividends in neatness later. All face l.e.d.s can now be mounted.

LACING

It is now necessary to join all equally numbered l.e.d.s together. You will require ten lengths of connecting wire, preferably with different coloured covers, each 15 to 20 inches long.

Remove the waste cathode leg from those l.e.d.s already installed. Solder each length of wire to an anode leg. Lay out the wire away from the timer. Using the test battery and resistor, test all l.e.d.s, change any that have stopped working.

SECOND STAGE

Lay the first wire along the legs of the l.e.d.s until you can mark where the insulation is to be split before soldering to the anode of l.e.d. Do not pull the wire tight, to be in position is sufficient. See Fig. 3a. Prevent the strain on the wire from pulling at the leg of l.e.d. 1, split the insulation on wire 1 just short of l.e.d. 11 and pull it 1cm or so sideways. See Fig. 3b. Loop the bare wire round the leg of l.e.d. 11. See Fig. 3c.

Check that wire 1 is not touching wires 9 or 10, otherwise it is possible for the insulation to melt in a position where it cannot be seen. See Fig. 3d. Solder wire 1 to l.e.d. 11. Return wire 1 to the start position, i.e. leading away from the centre. Repeat with wire 2.

Before laying wire 3 to position 13, lay it over wires 1 and 2 still in the start position. See Fig. 3e. Push it back under wires 1 and 2 on the l.e.d. 1 side of l.e.d. 3, firm it up, *do not pull tight,* lay out and solder as for wires 1 and 2. All subsequent wires are to be tied in place before being laid out except those soldered to the 59th and 60th l.e.d.s.

When wire 10 is in place check function of the first 10 l.e.d.s by running the timer.

If the timer is run following every soldering operation on wire 1, more and more l.e.d.s will be brought into the display until all run.

DIMMING

At some time during matrix construction, prepare and install diodes D5—D14. They can run in either direction. They should be soldered to any 10 consecutive face l.e.d.s, but the cathode of D14 should be around the position occupied by l.e.d. 20.

Prepare the diodes by bending small loops at each end of the diodes, use a very small screwdriver or thickish wire offcut. The loops should be at 90° to one another so that the loop at the anode end can drop over the l.e.d. leg, which lies vertically, whilst allowing the loop at the cathode end to accept a *horizontal* collecting wire.

Complete the matrix, testing fully at least every 10th position.

Add the various dimmer components not already fitted.

The timer is now ready for use. There are no adjustments that can be made to the timing function. The only adjustments that might be necessary are to the light output from the l.e.d.s when the timer is operating in total darkness in your darkroom. The prototype timer has been working with a variety of colour sensitive materials in my own darkroom for several months with no apparent problems of any sort.

TIMING PULSES

Timing pulses appear at the following places and rates:

IC3 pin 1 10Hz
pin 14 50Hz
IC4 pin 2 50Hz
IC5 pin 14 10Hz
pin 12 1Hz

★

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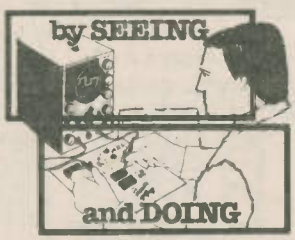

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Nobody can fail to be impressed with the beauty of Sirius, or Alpha Canis Majoris, which is now at its best. From Britain it is never very high up, but it cannot be mistaken, because it is far brighter than any other star; its nearest rival, Canopus, is never visible from Europe, and Sirius is a magnitude and a half brighter than Arcturus, the most brilliant star in the northern hemisphere of the sky.

It owes its pre-eminence more to its closeness than to its power. It is 26 times as luminous as the Sun, but it is a mere 8·6 light-years away, and of the first-magnitude stars only the southern Alpha Centauri is closer than that. It is pure white, and has an A-type spectrum, though it seems to flash various colours because it is shining through a relatively dense layer of the Earth's atmosphere.

Stars twinkle most when they are low down, and Sirius is the sky's supreme "twinkler". Even when seen at the zenith (as it can be, of course, from countries such as Australia) the twinkling is still quite marked.

Sirius is not alone. It has a companion only 1/10,000 as bright, known to be a white dwarf—a star which has used up its reserves of nuclear energy, and may be described as "bankrupt". Because Sirius is known as the Dog-Star, the companion is often nicknamed the Pup but it is a very busy pup. Its mass is about the same as that of the Sun, and its density is some 60,000 times that of water.

Many white dwarfs are known, but the Pup is the most famous of them. It is not easy to see, except with large telescopes, because it is so overpowered by the brilliant light of its primary.

MYSTERIOUS SIRIUS

There is a mystery associated with Sirius. Ancient astronomers, including Ptolemy of Alexandria (who flourished around A.D. 150) described it as red, and this seems remarkable, because Sirius is certainly not red now. Neither is it the sort of star likely to change colour; it is a normal member of the Main Sequence. So what is the explanation?

Various ideas have been put forward. One of these involves the Pup. Before collapsing to the white dwarf stage, a star passes through a period of high luminosity and cool surface temperature. Red giants are common enough—Betelgeux in Orion is one—and is it possible that the Pup used to be a red giant in the days of Ptolemy?

This is intriguing, but there are any number of objections to it. First, the time-scale is all wrong. Though the collapse to the white dwarf condition is rapid by cosmical standards, it is very gradual on the terrestrial time-scale, and would most definitely occupy more than a mere couple of thousand years.

Moreover, a star made up of the present Sirius together with an even more luminous red giant would be startling by any standards; it would surpass Venus, and would easily be visible in broad daylight. Neither Ptolemy nor any of the other astronomers of Classical times gives the slightest indication of this. So it seems that the whole theory must be rejected out of hand.

Then can it be that the twinkling of Sirius really did give the impression that it is basically red? Some years ago, in a television *Sky at Night* programme, I carried out a test, and asked viewers to look at Sirius and send me postcards reporting its colour. I had over 5000 replies and not one of them said that Sirius was red, though because of the strong twinkling red flashes were seen now and then. But Ptolemy lived in Alexandria, where Sirius rises much higher in the sky and the twinkling is less, so that I feel we must reject this also.

All in all, we seem to be forced to the conclusion that there have been mistakes either in observation or (more probably) interpretation or translation. But it is strange all the same, and no explanation seems to be completely satisfactory.

I simply cannot believe that there has been any real change in Sirius during historical times. But I do suggest that you look at it, when the sky is clear, and see what you think. If you can bring yourself to call it a red star, I will be very surprised indeed.

ARIANE

When I went to French Guiana, in July last year, to watch the launching of the *Giotto* probe to Halley's Comet it would be wrong to pretend that I was over-confident. Though *Ariane's* performance has improved tremendously of late, it is not yet totally reliable. Everyone felt a sense of relief when it was put into the right orbit.

Things were not so good for the next *Ariane* launch, from Kourou. There was a

THE SKY THIS MONTH

This is not a very good month from the viewpoint of planetary observers. Venus is almost out of view, though it starts to emerge into the evening twilight just before the end of February. Mars and Saturn are both morning objects, and near the middle of the month they fairly close together, near the boundary between Scorpius and Libra; Saturn is the brighter of the two (magnitude 0·7, as against 1·1 for Mars). Jupiter passes through conjunction on the 18th, and so it also is practically unobservable.

This leaves us with Mercury, which of course is never at all prominent as seen with the naked eye—not because it is faint (its magnitude can exceed those of almost all the stars) but because it cannot be seen against a dark background. It will, however, be an easy evening object in the latter part of this month, reaching greatest eastern elongation on the 28th; it should be seen without any difficulty—given clear skies and a dark horizon free from artificial illuminations.

Of course the evening sky is still dominated by Orion ch is now high in the south after dark; this is also the best time to enjoy the beauty of Sirius. Leo, the Lion, is rising in the east, with the Square of Pegasus sinking in the west and the Great Bear almost at its lowest—with its "tail" pointing almost to the horizon. The W of Cassiopeia is very high and Capella, in Auriga, almost at the zenith.

Note the little triangle of stars close by Capella, known collectively as the Haedi or Kids. Epsilon Aurigae, at the apex of the triangle, is the remarkable eclipsing binary with its period of 27 years. It is usually believed to shine steadily, at magnitude 2·9, between eclipses—the next of which is not due for a quarter of a century: but there have been recent suggestions that it may be less constant than has been thought, so it is well worth watching.

HALLEY'S COMET

Halley's Comet is now out of view. It passes perihelion on the 9th and will then be almost on the far side of the Sun, so that nobody on Earth will see it. However, we may after all be able to study it! The Pioneer *probe now orbiting the planet Venus is to be turned toward it in an effort to record its behaviour as it makes its closest approach to the Sun, and there is no reason why this should not be successful.*

Venus, of course, is on the same side of the Sun as the comet, and if there were any astronomers there they would have a fine view, provided that they placed themselves above the top of the dense all-obscuring atmosphere. From the actual surface of Venus nothing could ever be seen through the cloud-layers.

The comet will again be observable in March and on the night of March 13/14 the Giotto *probe will pass through it, so that with luck it will send back pictures of the ice nucleus. I will have more to say about this next month.*

dual payload, the GTE Spacenet's *F-3* satellite and the ESA/Eutelsat *ECS-3*, both of which were destroyed when the decision had to be taken to abort the mission when *Ariane's* third stage failed.

Since then things have returned to "normal", but the accident did underline the danger of having only one craft for a mission which cannot be repeated for a long time. There was only one *Giotto*, and Halley's Comet will not be back for another 76 years.

Meanwhile the US preliminary attempt to assemble the first stages of a space-station, operating from the Shuttle *Atlantis*, have been completely successful, and this augurs well for the future. We will surely be unlucky if a fully-fledged space-station is not in orbit well before the end of the century.

KECK OBSERVATORY

There is great activity on the summit of Mauna Kea, in Hawaii, the extinct (we hope) volcano which is already the site of several major telescopes, including the United Kingdom Infra-red Telescope (UKIRT). As a site, Mauna Kea, at almost 14,000 feet, is ideal for astronomical observation, apart from the inconvenience of the very thin atmosphere—and even this is not too damaging, because telescopes can now be operated entirely by remote control, and the observer need not be in the dome or even on the same continent.

MAIN SCOPE

The main telescope at the new W. M. Keck Observatory will be a reflector with a 10-metre segmented mirror, made and operated by CARA (the Californian Association for Research in Astronomy). If all goes well, it will see "first light" in 1990, and it should be in full operation in 1991. It will be far more powerful than any existing telescope, and indeed to make a single mirror of this aperture would be a wellnigh impossible task. It will be very interesting to see how it compares with the Hubble Space Telescope, which has a mirror "only" 94 inches in diameter but will have the tremendous advantage of operating from above the Earth's atmosphere.

HISTORY

In view of all these technical developments, it is rather interesting to look back in history to what was once the world's largest telescope—the 72-inch at Birr Castle—built virtually single-handed by the third Earl of Rosse and completed in 1845. It has not been used now for almost eighty years, and was dismantled long ago, but plans are well in hand for bringing it back into action. Naturally it will be of historical value only, but many people will welcome the opportunity to look through the "Leviathan" which was the first telescope powerful enough to show the spiral forms of the objects we now know to be external galaxies.

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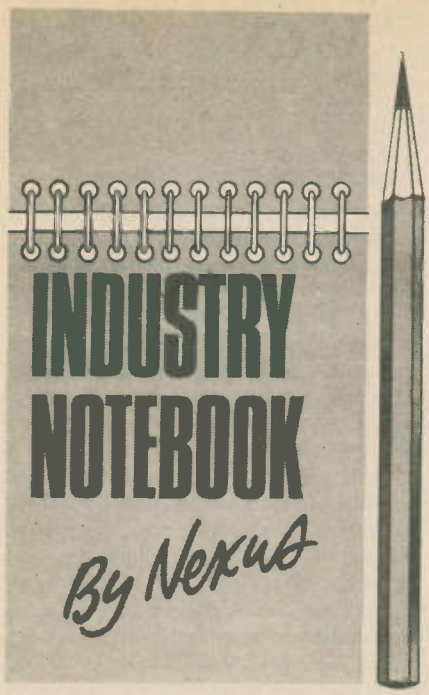

In the first half of this century the telecommunications industry was cosy and conservative—one might almost say dozey. The technology largely consisted of telephones and teleprinters, electromechanical exchanges, manual switchboards and lots of wires carried from place to place on wooden poles. In the UK the Post Office was the major customer for a ring of five or six manufacturers who were always being accused of price fixing and always blandly denying it.

GEC and Plessey

All this changed dramatically under the twin impact of electronics technology and the privatization of British Telecom. In came digital transmission, electronic exchanges, microwave links, optical fibres, satellites, data communications, information retrieval and a variety of new services. Telecomms and computers came together to form what we now call information technology (IT).

Then the newly privatized British Telecom started buying some of its equipment on the world market from foreign countries which were also engaged in this technological revolution and sometimes advancing much faster than the UK. Telecomms equipment, instead of being something you just bought locally when you needed it, became a massive, world-wide business. China, for example, in its 1986–90 Five Year Plan, is allocating some £20 billion for telecomms development. The country aims to increase its number of telephones from the present 5 million to 33 million.

This is the historical background which provides the rationale for GEC's wanting to combine with Plessey. Both companies have big sections making telecomms equipment and have been deeply involved with System X switching technology. At the time of writing the original tentative approach from GEC has developed into a classical take-over battle. GEC are offering £1.18 billion for Plessey, or 160p per share.

Plessey have rejected this offer but say they would be prepared to combine with GEC on the manufacture and marketing of System X alone. They also want to continue their existing collaborative arrangements on future switching systems with the European firms Alcatel of France, Italtel of Italy and Siemens of West Germany.

GEC's reason for wanting such a merger or take-over is to make themselves bigger in telecomms manufacturing in order to compete better in world markets. At present GEC is only about 11th in the international league table of telecomms manufacturers. Plessey is even lower down at about 14th. By becoming larger they could achieve economies of scale, at the same time avoiding the duplication of costs in the two companies, and thereby achieve a reduction of unit costs that would result in better competitiveness in world markets.

This, of course, is the logic behind most mergers/take-overs and is why the Government is encouraging it as a general policy for all UK industry. However, combining with another company, whether by agreed merger or forced takeover, is not the only way of becoming larger. You can also do it by internal expansion, though this might take a long time.

An economist friend of mine tells me there's not much evidence either way on whether combination or expansion is the better expedient for achieving the ultimate aim of lower unit costs. There is obviously a danger in merging or taking-over that you merely replace two small inefficient firms with one large inefficient firm.

Whatever has happened in the take-over battle by the time you read this, there is no question that GEC's intentions are right in the UK as well as right for GEC. Britain's share of the world telecomms market has shrunk from a respectable 20 per cent to practically nothing. It's high time that this downward slide be stopped and reversed.

Chips and Jobs

I see that the Policy Studies Institute has a fairly optimistic message about the effect of microelectronics technology on employment. In a recent report, *Chips and jobs: the acceptance of new technology at work,* the Institute admits there have been some cases of big job losses but says there has been little resistance to the introduction of this technology at the work-place.

Trade unions have generally taken a positive attitude, and the impact of microelectronics technology on working life has so far been marginal. But, warns the Institute, the effect of these changes has yet to be felt in many industries.

There's no doubt at all that certain types of jobs have disappeared almost completely—for example, in making mechanical cash registers and electromechanical telephone exchanges. I happen to know of a case of negotiated redundancies in a mechanical engineering factory due, not to the recession, but to the introduction of CNC (computer numerically controlled) machine-tools. But, of course, new jobs have been created in the manufacture and use of the new electronic systems responsible for the changes.

We can expect much controversy over the social and economic consequences of all this, and we won't get a true overall picture for some time. What is important economically is not a simple totting up of jobs lost and jobs gained—which is not much help to the individuals concerned anyway—but the improvement achieved in productivity per worker.

In the past, for example, American workers have generally been more productive than British workers in comparable manufacturing jobs not because they worked harder but because they have had more kilowatts of powered tools and machinery per capita raising their output. Now, in both countries, this powered assistance is being supplemented by the "intelligence" of automated systems in production, distribution and related office work. Economic prosperity can obviously be good for the quality of life, though not necessarily so. Whether the total effect of these industrial changes will be beneficial is another matter.

Early Warning Five Years Late

It's sad to see a nation which made such a brilliant success of early warning military radar in the 1939-45 world war now sinking to such a low level of efficiency in this field. In the late 1930s we built a chain of 19 metre-wave radar stations round the coast of Britain all the way from Orkney to the Isle of Wight.

This was the famous CH (Chain Home) early warning radar system. It was constructed in complete secrecy, was totally integrated with the RAF's system of fighter aircraft control and was fully operational to meet the attacks of enemy bombers by the start of that war.

In contrast, the current £900 million project for an airborne early warning radar system is a continuing story of delays, technical problems and mounting costs. It is already five years behind schedule. Nobody knows when it will be completed or how much more cash will be needed for further development. £430 million has been mentioned. It might even be scrapped altogether.

I note that this project bears the name of *Nimrod*, the "mighty hunter" from the Old Testament (*Genesis* 10, 8)—which would be mightily impressive if he was actually in a position to do some hunting. But it turns out, according to the Bible, that Nimrod was begotten by a character named Cush. So perhaps Cush was the one who first thought up the cushy job as a way of making a living and encouraged his son to just pretend to go out hunting. Also, of course, Nimrod spelt backwards becomes Dormin which, as everyone knows, is a tiny, sleepy creature rather like a dormouse.

For the regrettable record, the customer for this radar system is the Ministry of Defence and the contractor is GEC.

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Goodbye Berliner

So the sales of pre-recorded tape cassettes have now overtaken the sales of long-playing gramophone records. This probably doesn't worry the l.p. record companies because usually they make both and have been expecting it anyway. And they are obviously in compact disc records as well, as these are coming up fast.

The flat disc record invented by Emile Berliner in 1888 has given us all a lot of enjoyment and helped to make a lot of money for the consumer electronics sector of the industry. But its major problem has always been the mechanical friction of the stylus being dragged along in the groove. Tape cassettes avoid a lot of this playback friction and optically scanned CD records eliminate it completely.

The next leap in technology would be to get rid of the mechanical movement altogether. It is already being done in computer memories and speech or music synthesizers, where the recorded information is read out purely electronically. Any firm whose R&D department could do this for Wagner's *Ring* or even Wham's *Wake me up before you go-go* would be onto a very good thing.

Philological Footnote

Until I read a recent issue of *Siemens Components*, the technical house journal of that company, I always thought the longest word I knew was 'antidisestablishmentarianism' (28 letters). Not that it crops up more than twice a week in casual conversation. But German electronics has gone one better than English theology with 'abschaltverzögerungsschaltung' (29 letters).

The Germans are famous for their portmanteau words and they have a lot of electronics/communications terms with twenty or more letters. But when it comes to nearly thirty letters, the tight-lipped Britisher accustomed to communicating in monosyllables must feel they have gone a bit too far. For anyone interested, this word describes an electronic device giving delayed switch-off of an electrical circuit.

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CC = Common Cathode
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RDP = Right Hand Decimal Point
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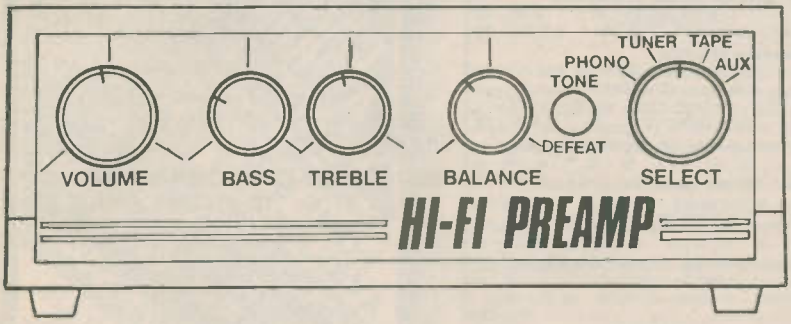
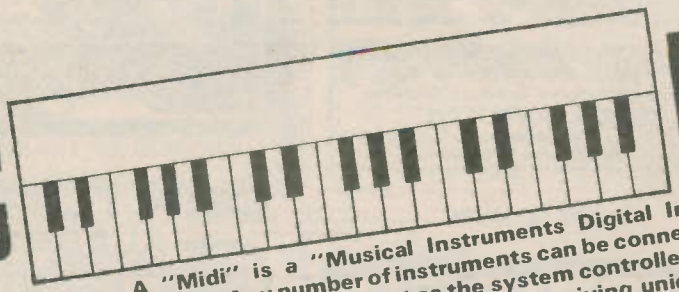


Given the vast range of power amplifiers currently available in kit or modular form it is surprising to note the relative scarcity of suitable high quality preamplifiers with which they may be used. This neat design fulfils the need.

BBC MIDI INTERFACE



A "Midi" is a "Musical Instruments Digital Interface", using computer control. Any number of instruments can be connected together, with either a pre-selected instrument as the system controller, or a sequencer. Any home computer can act as the sequencer, giving unique control. You can be the first electronic one-man band!

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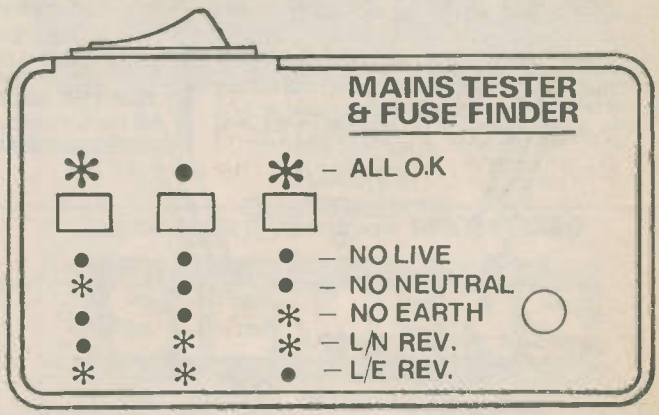

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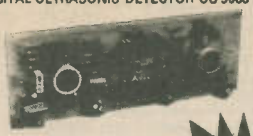

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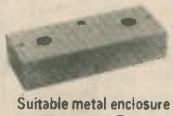

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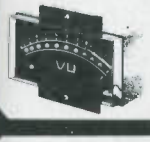

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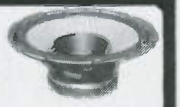

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50 oz. magnet. 2" ally voice coil. Ground ally fixing escutcheon. Die-cast chassis. White cone. Res. Freq.
25Hz. Freq. Resp. to 4KHz. Sens. 95dB. PRICE £28.60 + £3.00 P&P ea.

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12" 85 WATT R.M.S. C1285GP Lead guitar/keyboard/Disco.
2" ally voice coil. Ally centre dome. Res. Freq. 45Hz. Freq. Resp. to 6.5KHz. Sens. 98dB. PRICE £28.76 + £3.00 P&P ea.

12" 85 WATT R.M.S. C1285TC P.A./Disco 2" ally voice coil. Twin cone.
Res. Freq. 45Hz. Freq. Resp. to 14KHz. PRICE £29.80 + £3.00 P&P ea.

15" 150 WATT R.M.S. C15 Bass Guitar/Disco.
3" ally voice coil. Die-cast chassis. Res. Freq. 40Hz. Freq. Resp. to 4KHz. PRICE £54.99 + £4.00 P&P ea.

10" 60 WATT R.M.S. 1060GP Gen. Purpose/Lead Guitar/Keyboard/Mid. P.A.
2" voice coil. Res. Freq. 75Hz. Freq. Resp. to 7.5KHz. Sens. 99dB. PRICE £19.15 + £2.00 P&P.

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15" 400 WATT R.M.S. C15400 High Power Bass.
Res. Freq. 40Hz. Freq. Resp. to 4KHz. Sens. 102dB. PRICE £85.00 + £4.00 P&P.

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5" 70 WATT R.M.S. Multiple Array Disco etc.
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8" 150 WATT R.M.S. Multiple Array Disco etc.
1" voice coil. Res. Freq. 48Hz. Freq. Resp. to 5KHz. Sens. 92dB. PRICE £29.49 + £1.50 P&P ea.

10" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
1½" voice coil. Res. Freq. 35Hz. Freq. Resp. to 4KHz. Sens. 92dB. PRICE £33.49 + £2.00 P&P ea.

12" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
1½" voice coil. Res. Freq. 35Hz. Freq. Resp. to 4KHz. Sens. 94dB. PRICE £41.49 + £3.00 P&P ea.

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1" voice coil. Res. Freq. 63Hz. Freq. Resp. to 20KHz. Sens. 86dB. PRICE £9.99 + £1.00 P&P ea.

6½" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.
1" voice coil. Res. Freq. 56Hz. Freq. Resp. to 20KHz. Sens. 89dB. PRICE £10.99 + £1.50 P&P ea.

8" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.
1¼" voice coil. Res. Freq. 38Hz. Freq. Resp. to 20KHz. Sens. 89dB. PRICE £12.99 + £1.50 P&P ea.

10" 60 WATT R.M.S. Hi-Fi/Disco etc.
1¼" voice coil. Res. Freq. 35Hz. Freq. Resp. to 15KHz. Sens. 89dB. PRICE £16.49 + £2.00 P&P

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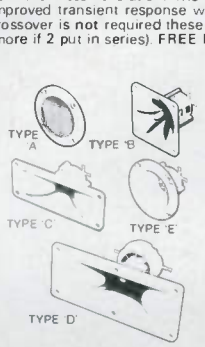

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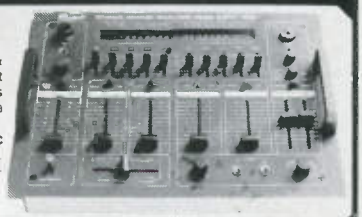

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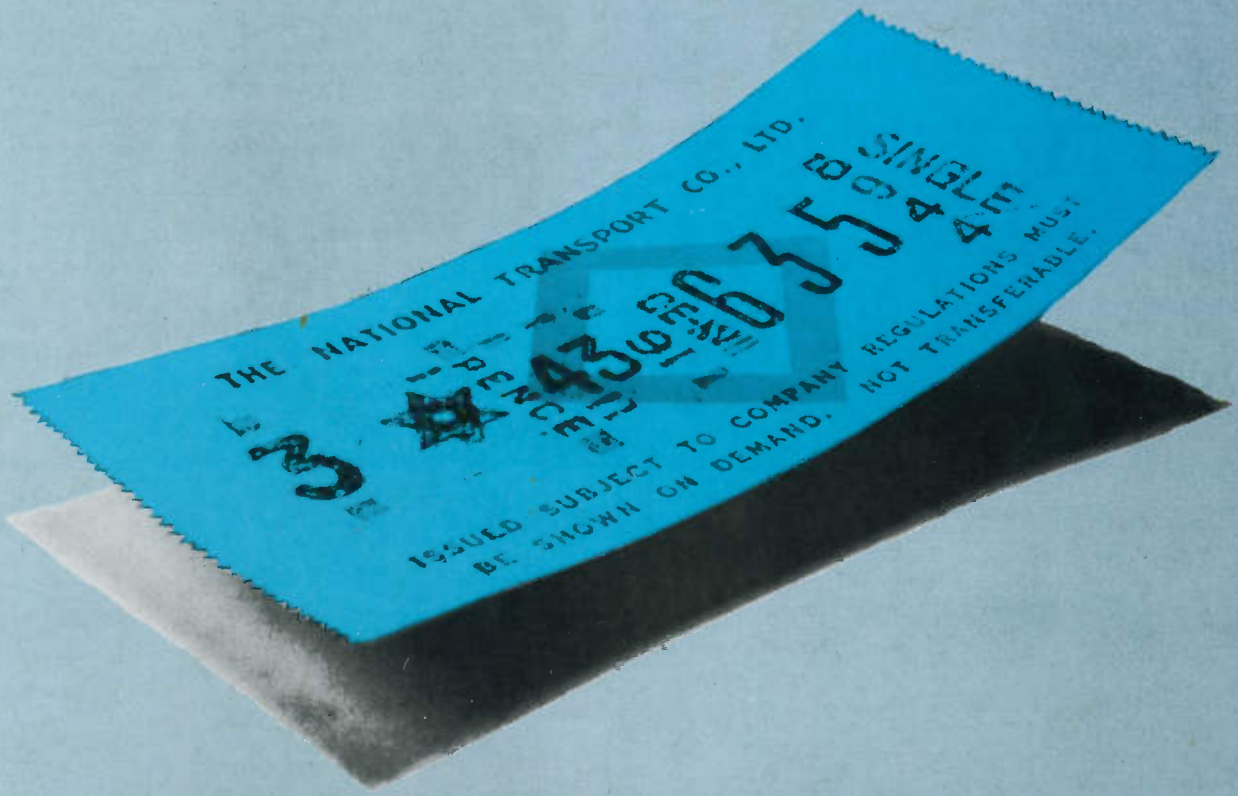

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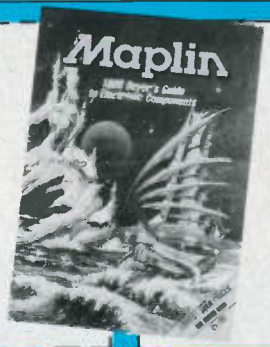

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