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PRACTICAL JANUARY 1986 · £1·25

PRACTICAL ELECTRONICS

ROBOTICS · MICROS · ELECTRONICS · INTERFACING

LOW COST...

Spectrum SPEECH SYNTHESISER & 8 BIT I/O PORT

MODULAR MIXER

Microelectronics Education Programme

ROBOTICS

Powertran's "Hebot II" and "MicroGrasp" kits offer unrivalled value for money to colleges, schools and individual enthusiasts.

Put the kit together, plug into your micro and off you go!

Hebot II can perform a bewildering variety of actions under the control of a simple BASIC program. Features include independent control of two wheels, flashing "eyes" two-tone hooter and a retractable pen.

Complete kit **£39.95** + VAT
Universal computer interface board kit **£5.50** + VAT

MicroGrasp is a fully programmable electric robot arm with closed loop feedback for positive positioning. The robot can be driven from virtually all micros.

Robot kit with power supply **£150** + VAT

Universal interface board kit **£42** + VAT

Powertran kits are complete down to the last nut and bolt, with easy-to-follow assembly instructions.

COMPUTING

Cortex II. 16 Bit. 16 Colour.

Cortex II offers the speed and power of true 16-bit processing at the same price that you might pay for some of the 8-bit games machines on the market.

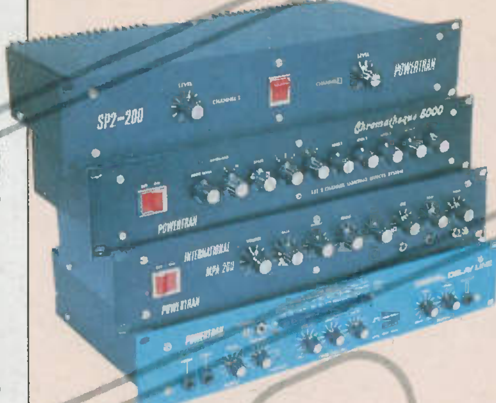
The standard kit has interfaces for TV, cassette and RS232 – others are available as optional extras. Add disc drives, printer and a monitor for a fully-fledged business system. *Price:* **£199** + VAT

TOP KITS FROM POWERTRAN

CYBERNETICS ~~LIMITED~~

MUSIC

Powertran's range of quality audio products offers top quality at low, low prices. All the products are finished in rugged metal cabinets suitable for 19" rack mounting or as free standing units.



MPA 200 100 watt mixer-amplifier. Complete kit **£40** + VAT

SP2 200 2-channel 100 watt amplifier. Complete kit **£50** + VAT

Chromatheque 5000 5-channel light show controller. Complete kit **£40** + VAT

Digital Delay Line Studio quality effects – up to 1.6s delay **£95** + VAT

Patchbay 16 pairs of jacks – for studio or stage. **£20** + VAT

Headphone Amp 2 × 3 sets of stereo phones from either one or two inputs. **£20** + VAT (metalwork and PCB's only)

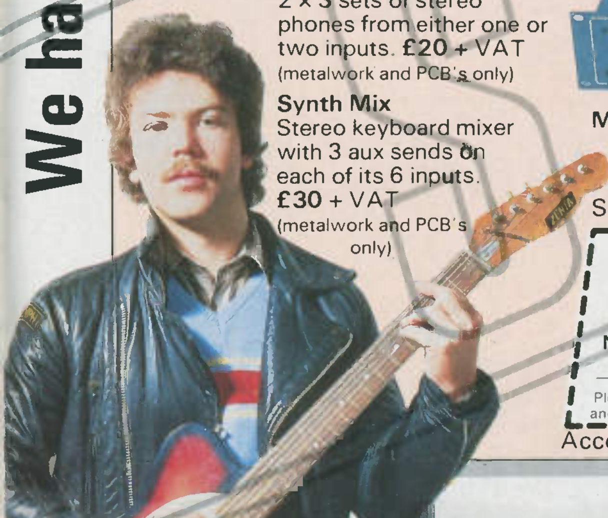
Synth Mix Stereo keyboard mixer with 3 aux sends on each of its 6 inputs. **£30** + VAT (metalwork and PCB's only)

MCS-1 MIDI-controlled sampling unit – doubles as a high quality effects unit. Complete kit **£290** + VAT

HOME SECURITY

Our Doppler Radar Alarm can detect intruders early enough (and loud enough) to offer your home *real* protection. Standard kit including two transmitters **£70** + VAT
Pair of extra transmitters **£23** + VAT

Special offer: extended kit including four transmitters **£84** + VAT



We have moved!

Send for demonstration tape to sample some of the sounds available **£2.50** + VAT

To Powertran Cybernetics Limited, Park Road, Crowborough, Sussex

Please send me the following kits ____________________

I enclose Cheque/Postal Order, value £ ____________ (Don't forget to add V.A.T.)

Name ____________________ **Address** ____________________

Please allow 21 days for delivery. Offers subject to availability. Prices apply to UK only, are exclusive of V.A.T. and correct at time of going to press. Overseas customers - please contact our Export Department.

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PE ROBOTICS MICROS ELECTRONICS INTERFACING

VOLUME 22 Nº1
JANUARY 1986

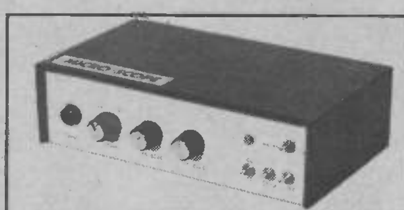
ISSN 0032–6372

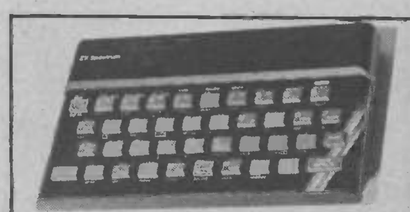
FRONT COVER

A representation of speech synthesis.
Photograph by courtesy of Mullard.

PROJECTS

INTEREST





OUR FEBRUARY 1986 ISSUE WILL BE ON SALE FRIDAY, JANUARY 3rd, 1986 ***(see page 39)***

WATFORD ELECTRONICS

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

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

TAG-END TYPE: 64V: 4700 **245p**; 3300 **145p**; 2200 **120p**; **50V:** 3300 **155p**; 2200 **95p**; **40V:** 4700 **160p**; 2200 **70p**; 3300 **85p**; 4000, 4700 **75p**; 10,000 **250p**; 15,000 **270p**; **16V:** 2200 **200p**; **25V:** 4700 **98p**; 10,000 **320p**; 15,000 **345p**.

TANTALUM BEAD CAPACITORS:
35V: 0·1µ, 0·22, 0·33 **15p** 0·47, 0·68, 1·0, 1·5 **16p** 2·2, 3·3 **18p** 4·7, 6·8 **22p** 10 **28p** **16V:** 2·2, 3·3, **16p** 4·7, 6·8, 10 **18p** 15 **36p** 22 **36p** 33, 47 **50p** 100 **95p** 220 **100p** **10V:** 15, 22 **26p** 33, 47 **50p** 100 **75p**.

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

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

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

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**.

PRESET POTENTIOMETERS

0·1W 50Ω-2·2M Mini Vert. & Horiz.	8p
0·25W 220Ω-4M7 Vert. & Horiz.	12p
3/4" Cermet Multiturn Preset 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

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**.

TRANSISTORS

AC126/7	30	BC237/8	10	BFR41/79	25	TIP29A	32	2N706A	25	2N5457	30
AC127/8	35	BC307B	15	BFR80/81	25	TIP29C	38	2N708	25	2N5458/9	30
AC141/2	35	BC308B	12	BFR98	105	TIP30A	35	2N914/5	32	2N5485	36
AC176	25	BC327/8	12	BFX29/84	28	TIP30C	37	2N918	40	2N5777	45
AC187/8	25	BC337/8	12	BFX84	35	TIP31A	38	2N930	20	2N6027	32
AC188	25	BC441	34	BFX85/86	35	TIP31C	45	2N1131/2	40	2N6109	60
AD142	120	BC461	34	BFX87/88	28	TIP32A	43	2N1303/4/5		2N6290	70
AD149	79	BC477/8	22	BFY50/51	30	TIP32C	45	2N1307	70	2SA636	250
AD161/2	42	BC516/7	30	BFY52	30	TIP33A	70	2N1613	30	2SA671	250
AF118	95	BC547/8	12	BFY53	35	TIP33C	75	2N1671B	160	2SA715	75
AF124/6	60	BC549C	12	BFY55	35	TIP34A	85	2N2160	325	2SC495/6	85
AF139	40	BC556/7	15	BFY56	35	TIP34C	105	2N2219A/20A/		2SC1061	250
AF239	55	BC558/9	15	BFY64	40	TIP35A	120	21A/22A	25	2SC1096	85
BC107/8	12	BCY41/42	30	BFY90	80	TIP35C	130	2N2369A	18	2SC1162	45
BC107B	14	BCY70	18	BRY39	50	TIP36A	130	2N2646	45	2SC1172/3	125
BC108B	14	BCY71	20	BSX20	28	TIP36C	140	2N2846	80	2SC1306	100
BC108C	14	BCY72	18	BSX29	32	TIP41A	50	2N2904A/05A/		2SC1307	150
BC109	12	BCY78	30	BSY26	35	TIP41B	52	06A/07A	26	2SC1449	95
BC109B	14	BD131/2	55	BSY95	35	TIP42A	55	2N2926G	10	2SC1679	190
BC109C	14	BD133	50	BU105	180	TIP42B	58	2N3053	25	2SC1678	140
BC114/5	25	BD135	45	BU205	160	TIP120	70	2N3054	55	2SC1923	65
BC117/8	25	BD136/7	35	BU206	200	TIP121	73	2N3055	50	2SC1945	225
BC119	35	BD138/9	35	BU208	170	TIP141	120	2N3442	140	2SC1953	90
BC140	29	BD140	40	MJ520	50	TIP142	120	2N3615	199	2SC1957	90
BC142/3	28	BD158	68	MJ521	90	TIP147	120	2N3663	20	2SC1969	165
BC147/8	12	BD245	65	MJ2955	90	TIP2955	70	2N3702/3	10	2SC2028	85
BC147B	15	BD434	70	MJE340	54	TIP3055	70	2N3704/5	10	2SC2029	200
BC148C	10	BD695A	150	MJE371	100	TIS43	50	2N3706/7	10	2SC2078	170
BC149	12	BD696A	150	MJE2955	99	TIS44	45	2N3708/9	10	2SC2091	85
BC149C	15	BF115	45	MJE3055	70	TIS88A	50	2N3710	10	2SC2166	165
BC153/4	30	BF154/8	30	MPF102	40	TIS90	30	2N3771	179	2SC2314	85
BC157/8	14	BF167	35	MPF103/4	30	TIS91/93	32	2N3772	195	2SC2335	200
BC159	11	BF173	35	MPF105	30	VK1010	99	2N3773	210	2SC2465	125
BC167A	14	BF177	35	MPSA05	23	VN10KM	65	2N3819	35	2SC2547	40
BC168C	12	BF178	35	MPSA06	25	VN46AF	90	2N3820	60	2SC2612	200
BC169C	10	BF179	40	MPSA08	30	VN66AF	110	2N3822/3	60	2SD234	75
BC171/2	12	BF184	35	MPSA12	29	VN88AF	220	2N3866	90	2SK45	90
BC173	15	BF194/5	12	MPSA55	30	VN89AF	120	2N3903/4	15	2SK288	225
BC177/8	12	BF198/9	18	MPSA56	30	ZTX107/8	12	2N3906/5	15	2SJ83	225
BC179/81	20	BF200	35	MPSA70	30	ZTX109	12	2N4037	60	2SJ85	225
BC181	30	BF224	40	MPSU02	58	ZTX212	28	2N4058	15	3N128	115
BC182/3	10	BF244A	28	MPSU05	55	ZTX300	13	2N4061/2	15	3N140	115
BC184	10	BF244B	29	MPSU06	55	ZTX301/2	16	2N4264	30	40251	150
BC182L	10	BF245	38	MPSU52	65	ZTX303	25	2N4286	25	40311	60
BC183L	10	BF256B	45	MPSU55	60	ZTX304	17	2N4289	25	40313	130
BC184L	10	BF257/8	32	MPSU56	55	ZTX320/26	30	2N4400	25	40361/62	70
BC186/7	28	BF259	30	OC23	170	ZTX500/1	14	2N4427	80	40408	76
BC212/3	12	BF394	40	OC28/36	220	ZTX502/3	18	2N4859	78	40412	90
BC212L	10	BF451	40	OC41/42	75	ZTX504	25	2N5135	30	40467	130
BC213L	12	BF494/5	40	OC70	40	ZTX531	25	2N5138	25	40468	85
BC214	10	BF594/5	30	OC72	50	ZTX550	25	2N5172	25	40594	105
BC214L	12	BFR39/40	25	OC75/76	55	2N696	30	2N5180	45	40595	110
				OC76	50	2N697	23	2N5191	75	40603	110
				OC81/82	50	2N698	40	2N5194	80	40673	70
				OC83/84	70	2N699	48	2N5305	24	40871/2	90

LINEAR IC's

555 CMOS	80	LM349	125	SP0256AL	425
702	50	LM358	50	SP8629	350
709C 8 pin	35	LM377	210	TA7120	120
710	50	LM379	495	TA7130	125
741	16	LM380	80	TA7204	150
747C 14 pin	60	LM381N	150	TA7205	90
748C 8 pin	35	LM382	130	TA7222	150
753 8 pin	185	LM384	140	TA7310	120
810	160	LM386	90	TAA900	395
9400CJ	375	LM387	120	TAA700	275
ADCO808	£10	LM389	160	TAD100	159
AY-1-1320	225	LM393	60	TBA120S	70
AY-1-5050	99	LM394CH	380	TBA540	275
AY-1-6720	210	LM558	170	TBA550Q	330
AY-3-1270	720	LM725CN	300	TBA641	290
AY-3-8910	390	LM733	65	TBA800	80
AY-3-8912	430	LM1871	300	TBA810S	95
AY-5-1317A	630	LM1889	400	TBA820	80
AY-5-3500	650	LM2907	395	TBA920Q	200
AY-5-8100	650	LM3900	45	TBA990	350
CA3011	130	LM3909	85	TCA270	350
CA3012	175	LM3911	175	TCA280A	220
CA3014	275	LM3914	265	TCA940	175
CA3018	86	LM3915	265	TCA950	00
CA3019	90	LM3916	300	TCA965	180
CA3020	210	LM13600	110	TDA1008	310
CA3023	210	LS7220	295	TDA1010	220
CA3028A	110	M51513L	230	TDA1022	400
CA3035	255	M51515L	320	TDA1024	110
CA3036	270	M51516L	430	TDA1034	350
CA3043	275	MB3712	200	TDA1054	00
CA3045	365	MB3756	440	TDA1490	350
CA3046	65	MC1204	250	TDA2002	325
CA3059	325	MC1301	110	TDA2003	190
CA3075	215	MC1310P	135	TDA2004	230
CA3080E	65	MC1458	35	TDA2006	320
CA3081	190	MC1469	300	TDA2020	320
CA3085	160	MC1488	70	TDA2030	190
CA3086	60	MC1489	70	TDB0791	420
CA3090AQ	250	MC1494	695	TL061CP	40
CA3123	165	MC1495	300	TL062CP	60
CA3130	85	MC1496L	70	TL064CN	95
CA3140	40	MC1596	225	TL071CP	40
CA3160	95	MC3302	75	TL072CP	60
CA3161E	180	MC3401	50	TL074CN	110
CA3162	540	MC3403	65	TL081CP	30
CA3189	260	MC3404	85	TL082CP	50
CA3240E	100	MC3405	150	TL083CP	75
HA1366	175	MC3423P	80	TL084CP	100
HA1388	235	MC4016	295	TL091CP	60
ICL7106	675	MF10	300	TL170	50
ICL7107	975	MFC6040	75	TL497A	185
ICL7611	95	ML924	275	TL507	110
ICL7660	250	NE515	275	TL509	110
ICL8038CC	300	NE529	225	UA2240	120
ICL8211	225	NE531	120	UA78S40	225
ICM7217A	£11	NE543	225	UAA170	180
ICM7224	785	NE544	170	UAA180	180
ICM7240	300	NE555	25	ULN2003	75
ICM7555	80	NE556DB	45	ULN2004	75
ICM7556	140	NE558	170	ULN2283	150
LA3350	250	NE560	350	ULN2803	190
LA4031P	340	NE564	420	UPC556	00
LA4032	295	NE565A	115	UPC575	275
LA4400	350	NE566	140	UPC1025H	375
LA4422	320	NE567	130	UPC1156H	295
LC7120	300	NE570	370	UPC1181	00
LC7130	300	NE571	370	UPC1182	425
LC7137	350	NE5532	150	UPC1366	195
LF347	120	NE5534	105	XR2206	365
LF351	40	OM335	650	XR2207	400
LF353	75	RC4136D	55	XR2211	575
LF355	90	RC4558	40	XR2216	675
LF356	90	SAB3209	425	XR2266	360
LF357	100	SAB3271	485	ZN409C	180
LF398	495	SAB4209	295	ZN414	80
LM10	325	SG3402	295	ZN423E	130
LM301A	30	SL490	300	ZN424E	130
LM307	45	SL924	00	ZN425E-8	350
LM308	75	SL6270	150	ZN426E-8	300
LM311	45	SN76003	350	ZN427E-8	600
LM318	135	SN76018	150	ZN428E	450
LM319	180	SN76131	135	ZN429E-8	240
LM324	45	SN76227	95	ZN459	245
LM334Z	125	SN76477	380	ZN1034E	200
LM335Z	130	SN76488	525	ZN1040E	665
LM337	250			ZNA234E	925
LM339	40				
LM348	60	SN76489	400		

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COMPUTER IC's

2102L	160	8250	950	UPD7002	440	74S287	200
2114	250	8251	325	UPD7007	725	74S288	180
2147-3	£3	8253	380	WD1691	£14	74S289	220
2516	300	8255	350	WD1770	£14	74S299	540
2532-4	300	8256A	£15	WD2143	850	74S301	350
25L32	450	8257A	400	Z80CTC 2·5	295	74S365	250
2564	£6	8259	400	Z80ACPU4M	199	74S373	375
27L08	450	8271	£45	Z80ACTC	310	74S374	375
2716-5V	300	8272	£15	Z80B	£8	74S412	380
2732	350	8279	750	Z80DART	650	74S470	325
2732A	585	8282	450	Z80ADART	800	74S471	600
27256-2	1055	8283	450	Z80ADMA	900	74S472	400
2764-250	285	8284	550	Z80DMA	795	74S473	00
27C64	800	8288	£11	Z80P10	250	74S474	400
26501	75	8748	£33	Z80AP10	315	74S475	425
27128/250n	400	8T26A	99	Z80S10-1	850	74S571	300
256K DRAM	495	8T27	150	Z80AS10	900	74S573	450
3242	675	8T31	350	Z80AS10-2	£9		
4027	95	8T95N	90				
4116-200n	100	8T97N	90				
4164-150	225	9364AP	550				
4416-2	299	9602	220				
4532-3	250	AM26LS31C	125				
4816-100ns	125	AM26LS32A	125				
4864-15	225	AM26LS33	150				
6116-150	200	AM7910	£19				
6116L-120ns	220	AY-3-1015	300				
6117-100n	575	AY-5-1013	300				
6167-6	795	AY-5-1350	388				
6264L-15	580	AY-5-3600	750				
63A03	£14	CD4724	150				
6464L-15	750	COM8017	275				
65C02	850	DM8131	275				
6502 CPU	325	DP8303	450				
6502A	545	DP8304BN	350				
6503	650	DS3647	600				
6520	175	DS3691N	350				
6522A	545	DS8820	110				
6522 VIA	340	DS8830	140				
6530 RRIOT	£11	DS8831	125				
6532 RIOT	650	DS8832	150				
6545 CRTC	899	DS88LS120	300				
6551 ACIA	525	E9364	800				
6800	220	E9365	£28				
6802	275	FD1691	£15				
6803	850	FD1771	£15				
6805	670	FD1791	£22				
6809E	650	FD1793	£23				
6810	150	FD1795	£28				
68A02	345	FD1797	£28				
6820	150	HD26501	75				
68B21	220	HD4315	250				
6821	150	HD6301	225				
6840	375	HM6845	755				
6843	800	IM6402	350				
6845	650	INS8060N	1250				
6845SP	750	M58174	825				
6846	625	MC1488	100				
6847	650	MC1489	100				
6850	120	MC14411	675				
6852	250	MC14412	725				
6854	525	MC3242	590				
68B54	750	MC3446	250				
68000	£20	MC3447P	315				
8017	275	MC3486	175				
8035	350	MC3487	175				
8080A	400	MK3886-2M	£7				
8085A	300	MM5280D	695				
8088	895	MM5303	635				
81LS95	140	MM5307	1275				
81LS96	170	MM5387A	865				
81LS97/98	140	MM58174	875				
8123	160	RO-3-2513L	700				
8131	475	RO-3-2513U	650				
8150	800	SAA5050	875				
8154	750	SFF96364E	800				
8155	380	SP0256AL2	475				
8156	380	TCM3101J	£13				
8202	£25	TMS2716-3	725				
8212	220	TMS4047	100				
8214	495	TMS4164-15	255				
8216	150	TMS4416-2	355				
8224	£3	TMS4500A	£12				
8226	£3	TMS4532-3	350				
8228	250	TMS6011	500				
8243	290	TMS9914	895				
		TMS9927	£14				
		TMS9928	£10				
		TMS9929	£10				
		ULN2003	75				

74S

74S00	40	74S153	140
74S02	40	74S157	200
74S03	40	74S158	190
74S04	40	74S162	300
74S05	40	74S163	300
74S08	40	74S168	300
74S09	40	74S169	300
74S10	40	74S174	250
74S11	50	74S175	300
74S15	60	74S181	£11
74S20	40	74S182	250
74S30	60	74S188	180
74S22	60	74S189	225
74S30	50	74S194	280
74S32	50	74S195	275
74S37	50	74S196	350
74S38	70	74S197	300
74S40	40	74S201	250
74S51	40	74S225	500
74S64	40	74S226	500
74S65	40	74S240	375
74S74	70	74S241	375
74S85	295	74S244	475
74S86	100	74S251	225
74S112	150	74S257	225
74S113	120	74S258	225
74S114	120	74S260	70
74S124	300	74S262	£10
74S132	90	74S274	00
74S133	50	74S275	00
74S134	60	74S280	00
74S135	110	74S281	00
74S138	170	74S283	00
74S139	170		
74S140	75		
74S151	140		

75

75107/8/9	90
75110	90
75119	140
75121	130
75150	115
75151	180
75154	125
75158	150
75159	140
75160	350
75161	350
75162	450
75182/3	90
75183	105
75188/9	100
75322	140
75325	165
75353	140
75361	150
75365	185
75376	95
75376	210
75450	80
75451/2	50
75454	70
75491/2	65

TTL 74

7400	22	7454	25	74198	190
7401	22	7460	25	74199	200
7402	22	7470	48	74221	95
7403	25	7472	35	74246	125
7404	25	7473	40	74247	120
7405	25	7474	38	74248	145
7406	38	7475	48	74249	172
7407	38	7476	40	74251	90
7408	25	7480	50	74259	140
7409	25	7481	175	74265	60
7410	25	7482	90	74273	150
7411	25	7483	85	74276	150
7412	25	7484	100	74278	150
7413	35	7485	100	74279	75
7414	50	7486	35	74283	110
7416	35	7489	170	74284	300
7417	35	7490	55	74285	310
7420	25	7491	65	74286	90
7421	30	7492	55	74290	85
7422	30	7493	50	74293	85
7423	32	7494	90	74297	165
7425	32	7495	65	74298	156
7426	36	7496	72	74351	175
7427	30	7497	170	74365	68
7428	30	74100	195	74366	68
7430	22	74104	68	74367	68
7432	29	74105	68	74368	65
7433	35	74107	40	74376	117
7437	29	74109	60	74390	100
7438	39	74110	55	74393	103
7440	25	74111	55	74425	60
7441	85	74112	170	74426	65
7442	65	74116	160	74490	89
7443	95	74118	100		
7444	100	74119	150		
7445	100	74120	90		
7446	100	74121	45		
7447	95	74122	50		
7448	98	74123	73		
7450	25	74125	50		
7451	30	74126	50		
7453	25	74128	55		
		74132	60		
		74136	63		
		74141	80		
		74142	230		
		74143	250		
		74144	225		
		74145	85		
		74147	130		
		74148	105		
		74150	130		
		74151	60		
		74153	70		
		74154	135		
		74155	75		
		74156	90		
		74157	75		
		74159	175		
		74160	90		
		74161	90		
		74162	90		
		74163	90		
		74164	110		
		74165	90		
		74166	130		
		74167	200		
		74170	160		
		74172	390		
		74173	100		
		74174	100		
		74175	80		
		74176	80		
		74177	80		
		74178	120		
		74179	90		
		74180	85		
		74181	230		
		74182	85		
		74184	160		
		74185	160		
		74186	70		
		74188	75		
		74190	117		
		74191	140		
		74192	191		
		74193	110		
		74194	90		
		74195	63		
		74196	120		
		74197	85		

74C

C244	150
C245	150
C373	180
C374	425
C922	420
C923	600
C925	650

74 HC

74HC00	55
74HC02	55
74HC04	55
74HC08	55
74HC10	55
74HC20	55
74HC32	55
74HC24	135
74HC51	55
74HC74	70
74HC86	60
74HC107	70
74HC109	75
74HC139	120
74HC153	135
74HC160	35
74HC161	135
74HC164	135
74HC165	270
74HC173	120
74HC174	120

74LS

LS00	22	LS27	22	LS248	100
LS01	22	LS28	24	LS249	100
LS02	22	LS30	22	LS251	55
LS03	22	LS32	22	LS253	70
LS04	22	LS33	23	LS256	90
LS05	22	LS37	22	LS257	55
LS08	25	LS38	25	LS258	55
LS09	22	LS40	22	LS259	90
LS10	22	LS42	50	LS260	70
LS11	22	LS47	75	LS261	100
LS12	22	LS48	75	LS266	25
LS13	30	LS49	95	LS273	80
LS14	50	LS51	22	LS275	350
LS15	22	LS52	25	LS279	55
LS19	45	LS54	22	LS280	180
LS20	22	LS55	22	LS283	70
LS21	22	LS63	52	LS290	80
LS22	22	LS73	28	LS292	850
LS24	50	LS74	28	LS293	75
LS26	22	LS75	38	LS294	999
		LS76	28	LS295	130
		LS78	34	LS297	850
		LS83	65	LS298	100
		LS85	70	LS299	220
		LS86	35	LS320	210
		LS90	40	LS322	360
		LS91	86	LS323	300
		LS92	50	LS324	140
		LS93	45	LS325	150
		LS95	58	LS326	290
		LS96	90	LS327	290
		LS107	40	LS347	120
		LS109	45	LS348	140
		LS112	40	LS352	115
		LS113	38	LS353	85
		LS114	36	LS355	220
		LS122	55	LS356	200
		LS123	60	LS363	140
		LS124	120	LS364	150
		LS125	37	LS365	42
		LS126	37	LS366	42
		LS132	52	LS367	42
		LS133	44	LS368	42
		LS135	28	LS373	80
		LS136	35	LS374	80
		LS138	48	LS375	55
		LS139	48	LS377	100
		LS145	90	LS378	85
		LS147	130	LS379	127
		LS148	115	LS380	310
		LS151	55	LS382	310
		LS153	65	LS384	457
		LS154	120	LS385	310
		LS155	55	LS386	50
		LS156	55	LS390	60
		LS157	47	LS393	48
		LS158	48	LS395	100
		LS160	60	LS396	300
		LS161	60	LS398	185
		LS162	60	LS399	115
		LS163	60	LS445	125
		LS164	70	LS447	75
		LS165	95	LS465	130
		LS166	88	LS467	120
		LS168	138	LS490	148
		LS169	90	LS540	100
		LS170	120	LS541	98
		LS173	80	LS624	155
		LS174	60	LS629	120
		LS175	60	LS640	150
		LS181	190	LS641	140
		LS183	186	LS645	195
		LS190	75	LS668	87
		LS191	55	LS669	85
		LS192	75	LS670	150
		LS193	75	LS673	850
		LS194	70	LS674	850
		LS195	60	LS682	250
		LS196	75	LS684	300
		LS197	75	LS687	300
		LS221	65		
		LS240	80		
		LS241	80		
		LS242	80		
		LS243	80		
		LS244	70		
		LS245	88		
		LS247	75		

CMOS

4000	20	4014	50	4440	99
4001	20	4015	40	4450	350
4002	20	4016	25	4451	450
4006	70	4017	45	4500	395
4007	20	4018	55	4501	40
4008	60	4019	35	4502	50
4009	40	4020	50	4503	45
4010	40	4021	55	4504	100
4011	20	4022	60	4505	350
4012	20	4023	20	4506	100
4013	30	4024	35	4507	45
		4025	20	4508	115
		4026	90	4510	56
		4027	30	4511	50
		4028	40	4512	50
		4029	45	4513	150
		4030	20	4514	115
		4031	125	4515	115
		4032	65	4516	50
		4033	130	4517	275
		4034	145	4518	50
		4035	70	4519	35
		4036	250	4520	50
		4037	115	4521	110
		4038	75	4522	125
		4039	270	4526	70
		4040	45	4527	60
		4041	55	4528	45
		4042	45	4529	80
		4043	45	4530	90
		4044	50	4531	120
		4045	110	4532	65
		4046	60	4534	365
		4047	50	4536	250
		4048	50	4538	70
		4049	25	4539	80
		4050	25	4541	9
		4051	50	4543	65
		4052	50	4544	150
		4053	60	4549	390
		4054	70	4553	210
		4055	70	4554	180
		4056	85	4555	50
		4057	£10	4556	50
		4059	400	4557	250
		4060	70	4558	12
		4061	£5	4559	34
		4062	995	4560	11
		4063	80	4561	104
		4066	25	4562	350
		4067	230	4566	160
		4068	20	4568	250
		4069	20	4569	175
		4070	25	4572	45
		4071	20	4580	255
		4072	20	4581	125
		4073	20	4582	9
		4075	25	4583	10
		4076	60	4584	40
		4077	25	4585	65
		4078	25	4599	155
		4081	20	40097	45
		4082	20	40098	42
		4085	60	40100	215
		4086	60	40101	130
		4089	120	40102	14
		4093	25	40103	41
		4094	70	40104	120
		4095	70	40105	220
		4096	100	40106	40
		4097	260	40107	55
		4098	70	40108	325
		4099	75	40109	100
		4160	95	40110	235
		4161	99	40114	240
		4162	99	40161	19
		4163	99	40163	75
		4174	99	40173	100
		4175	105	40174	7
		4194	105	40175	7
		4408	850	40181	220
		4409	850	40192	7
		4410	725	40193	9
		4411	750	40194	9
		4412	805	40195	80
		4415	590	40244	19
		4419	280	40245	19
		4422	770	40257	19
		4433	770	40373	22
		4435	850	40374	22

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
DA9	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

SCR's Thyristors

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

DIAC

ST2 25

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
30A/400V	525
T2800D	125

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
IL74	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

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

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

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

DIP Board 395p
Vero Strip 95p

PROTO DECs

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

VERO WIRING

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

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		LM337T	175
+24V 5A	695	LM723	30
79HG −2.25V to		TBA625B	75
−24V 5A	785	RC4194	375
LM309K	120	RC4195	160
TL497	185	78S40	225

SWITCHES

SLIDE 250V

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

TOGGLE 2A 250V

SPST	35
DPDT	48
4 pole on off	54

PUSH BUTTON
Spring loaded
Latching or Momentary 6A
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 **87p**; 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	25p	22p
14 pin	10p	35p	25p
16 pin	10p	42p	32p
18 pin	16p	52p	38p
20 pin	20p	60p	42p
22 pin	22p	65p	48p
24 pin	25p	70p	52p
28 pin	28p	80p	60p
40 pin	30p	99p	80p

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

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2× 6 way	—	75p
2×12 way	—	160p
2×15 way	—	165p
2×18 way	175p	160p
2×22 way	200p	170p
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26 way	105p	110p	115p	230p
34 way	115p	130p	135p	320p
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3-0-3V; 6-0-6V; 9-0-9V; 12-0-12V; 15-0-15V @100MA 130p
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Sranderd 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)
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1·28MHz	450
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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
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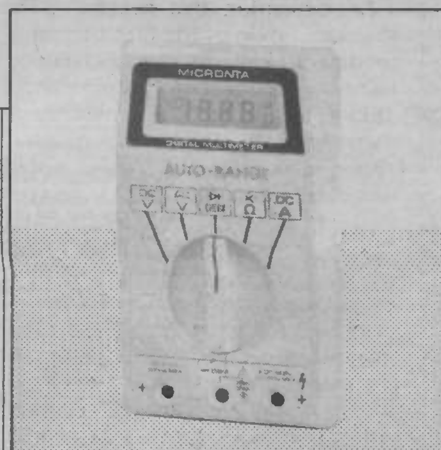

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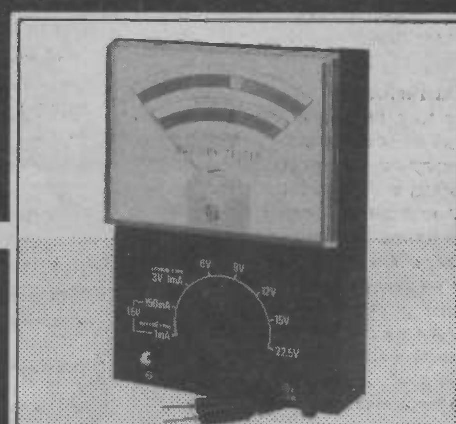

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Components are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Old Projects
We advise readers to check that all parts are still available before commencing any project in a back-dated issue, as we cannot guarantee the indefinite availability of components used. **We are unable to answer letters relating to articles more than five years old.**

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MEP, DES AND ALL THAT

BACK to my theme of electronics in education this month, with the publication of the first part of a feature looking at the Microelectronics Education Programme and, at last, a reply to earlier published items from the Department of Education and Science. While much has been done with MEP it seems that just as things were all going in the right direction, Government funding has been slashed. It appears that while Mrs. Thatcher and fellows are saying how important they feel education is, they are not prepared to invest in it in a realistic way; witness the teachers' dispute which continues to drag on at the time of writing.

A further letter on this subject, and just about the only one we have received from a student, appears in this issue and underlines the problem as I see it; while much has been achieved by people like Graham Bevis from the funding provided, this work has still not resulted in significant change in many of the classrooms.

What is more worrying is that nothing new will get on the curriculum without the funds to pay for the equipment and information required and without the salaries to attract suitably skilled teachers—although letters to PE do show there are still some very dedicated teaching staff around. So while the Government smugly says that it only undertook to get the whole thing off the ground and now it has done that it is up to the Local Education Authorities to progress things further, it fails to acknowledge that the work of MEP is not yet complete and that the funding is insufficient for all the LEA's to progress in a proper manner. When many parents are already assisting in the purchase of school essentials what hope is there of schools buying relatively expensive electronics boards?

GOOD GOVERNMENT!

The new Microelectronics Support Unit should be operational by April 1st—perhaps the date will be appropriate since as far as we can see little has been done to achieve a set up yet. Chris Patten takes pains to explain what the Government has said in White Papers and undertaken to do. He also points out what MEP and other schemes have cost, how the teachers have/will be trained etc., and how many students "will study some elements of the new technology" this year. What worries me is that while it all looks good from the Government's point of view, reaction from teachers and students shows that there is a very long way to go before they all see some of the material MEP has produced. With the close of MEP are we not failing to stoke the boiler just as the train is pulling away?

Mike Kenward

BACK NUMBERS, BINDERS & SUBSCRIPTIONS

Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at £1.25 each including inland or overseas p&p. When ordering please state title, month and/or 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.

Subscriptions
Copies of Practical Electronics are available by post, inland for £14, overseas for £16 per 12 issues, from: Practical Electronics, Subscriptions Department, IPC Magazines Ltd., Oakfield House, 35 Perrymount Road, Haywards Heath, West Sussex RH16 3DH. Tel. 0444 459188. Cheques, postal orders and international money orders should be made payable to Practical Electronics. Payment for subscriptions can also be made using a credit card.

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

CD WITH A DIFFERENCE

At the Philips headquarters in Holland, engineers have developed an amazingly comprehensive compact disc-based car navigation system. One disc can easily store all the road and street map information for the whole of the UK. Thanks to voice synthesised instructions, the driver has no need for conventional maps—just enter start-point and destination, the only other input required by the tripper could be en-route places of interest, or perhaps the most scenic route.

If the driver makes a mistake, Philips CARIN (Car Information System) will automatically find the best diversion to get back on the right road. When traffic information becomes available via digital RDS Radio Data System, CARIN will also be able to automatically allow for hold-ups and adverse weather conditions, modifying the route to allow these obstacles to be avoided.

Navigation is automatic when the car starts moving, and current prototypes monitor the car's position using 'dead reckoning' with inputs from sensors on the wheels and an electronic compass. The onboard computer can correct for errors by comparing sensor information with the digital road map loaded from the CD.

Geographical co-ordinates of every road are encoded onto the discs in two ways — either by plotting information from accurate road maps, or actual digitised inertial information, gleaned from physically driving the routes.

During the trip, the computer samples the encoded information and compares it to the vehicle's speed and direction. The optional extra monitor shown in the photograph displays the local map, and an illuminated 'blip' shows the position of the vehicle. The screen is only operable when motionless, in any case the voice synthesis tells you all you need to know. The 'player' will also take music CD's with a voice override facility for directional information.

In the longer term, satellite navigation may be incorporated, with the help of the American NAVSTAR Global Positioning System (GPS) which will be completed at the end of 1988 with 18 satellites.

Eventually it is hoped to incorporate CARIN into a car's dashboard where further sensors could provide oil, fuel and brake monitoring etc. The system is already available for between £1,800 and £1,900.

ROBOTS FOR ALL IN 30 YEARS

Information and photograph kindly supplied by New Scientist magazine.

At the recent Expo '85 exhibition at Tsukuba in Japan, visitors were privy to an impressive piece of robotics engineering. Wabot-2 the organ playing robot was the submission of Professor Ichiro Kato and his students from the Waseda University. The professor and his 50 disciples spent three years developing the musical automation which has 25 axes of movement, and can read a sheet of music with its c.c.d./camera eye in 15 seconds.

In the past, Kato has apparently been subjected to a certain amount of scepticism from his counterparts in industry, regarding his "misguided" in-depth efforts to humanise robots, they now tend to take him more seriously. Furthermore Kato firmly believes that within 30 years every home will have its own personal robot, with an ability to adapt to the environment and cope with abstract thought. Wabot-2 already does this—it can accompany a singer and, if necessary, change key mid-song to suit the singer's voice.

BOY LOST IN TIME

In 1802 the industrial exploitation of children brought about the passing of the first law in this country to regulate the conditions governing child labour. This law prohibited the employment of children under nine years old. The under fourteens were not allowed to work at night and furthermore their maximum daytime hours were restricted to 12. This law designed for 'pauper' children (those dependent upon charity) was extended to include all children in 1819.

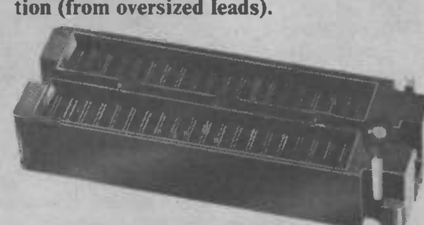
It is reasuring to know that this marked the beginning of the end for the commercial child abuser, it did didn't it? . . .

In the Health and Safety Executive's most recent report on Manufacturing and Service Industries, the following skeleton was liberated from the closet of a Cumbrian electronics company.

The case was brought to light when a visiting Fire Prevention Officer made a disturbing discovery in a room measuring fractionally more than nine feet by five feet. Therein he found, "a boy who was working near a heated diesel tank giving off copious fumes. The boy was drilling holes in printed circuit boards. The firm had given him a plastic tube to breathe through—one end in his mouth and the other end poking through an open window". The company has now "made safe" the tank and installed proper ventilation.

JUST TESTING

A new Universal Test Socket just introduced by Aries Electronics, is designed to accept all devices from 6 to 40 pins on 0·3, 0·4 or 0·6 inch centres. The socket has a plastic housing and the contact design has a normally closed arrangement which provides a consistent Normal force which prevents deformation (from oversized leads).



These test sockets accept leads from 0·015 through to 0·045 inches wide and mount onto p.c.b.s with either 0·3 or 0·6 inch centres. Contact materials are beryllium copper, available with gold or tin plating.

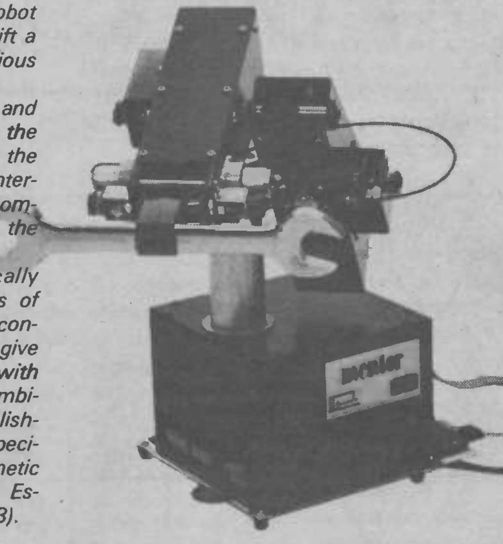
Typical prices for the tin plated types are 24 pin—£4.95; 28 pin—£5.80 and 40 pin—£7.25. These prices include VAT and p&p. From Aries Electronics (Europe), Alfred House, 127 Oatlands Drive, Weybridge, Surrey KT13 9LB (0932 57377).

Mentor lead by nose

The Mentor desk-top micro hydraulic robot has been modified so that it can now lift a weight of up to 1kg, instead of its previous capacity of 300gms.

The software has also been extended, and amongst the improvements "lead by the nose" programming is now included in the free package of programs. As well as interfaces to BBC, Commodore and Apple computers, an interface with software for the IBM PC is also now available.

Mentor is a compact, electronically powered desk-top robot giving 6 axes of movement all simultaneously servo-controlled. It has been specially designed to give smooth controlled performance coupled with a high degree of built-in toughness, a combination ideal for use in educational establishments. Prices start at £495. Brochure, specification and full price list from, Cybernetic Applications, West Portway Industrial Estate, Andover SP10 3PE. (0264 50093).



USEFUL WINTER CAR KITS

A trio of electronic kits for cars has been announced by Electronic and Computer Workshop Ltd.

The wiper delay unit kit (K2599) provides a three-step intermittent wiper timer, selected using a rotary switch. It employs a relay inserted into the car wiper control circuit. Comprehensive instructions show how the units can be fitted into virtually any existing wiper system.

Kit no. K2598 builds a 10–30 watt, mono or stereo power amplifier, designed to operate from a car's 12 volt supply. Fully compatible with the standard car radio/cassette player voltage levels (DIN45500), it has thermal/short-circuit protection.

The benefits of easy starting, efficient fuel burning and very even firing provided by transistorised ignition can be achieved with kit no. K2543. Supplied with a large heatsink for cool operation, the unit employs high voltage power Darlington transistors to produce a highly reliable performance. The wiper controller (K2599) costs £12.82, the 10–30 watt amplifier (K2598) costs £16.94 and the transistorised ignition kit (K2543) costs £12.48 All prices include VAT and p & p. The kits contain all the necessary components, a p.c.b., and step by step instructions, including application notes. From Electronic and Computer Workshop Ltd., 171 Broomfield Road, Chelmsford, Essex CM1 1RY. (0245 262149).

Briefly...

A new company has been launched, which readers may like to make a note of. Universal Semiconductor Devices can supply most 'ordinary' discrete semiconductors in addition to the following: High power/High frequency transistors; V.h.f./u.h.f.—f.e.t.s; Power Darlingtons; Germanium transistors n.p.n./p.n.p.; Unijunctions etc.—and many devices which may be "difficult to find elsewhere". Good prices and delivery are promised. For 75 pence (inc. p & p) a catalogue can be obtained from Universal Semiconductor Devices, 17 Granville Court, Granville Road, Hornsey, London N4 4EP. (01-348 9420).

● ● ● ●

The TTL Data book (Volume 3) has been published in a European edition, covering bipolar programmable logic and memory devices. Texas Instruments have used the usual format with three main sections: field-programmable logic, PROMs and RAMs, and memory based code converters. The book costs £8 (inc VAT and p & p) and is available from Texas Instruments Ltd., PO Box 50, Market Harborough, Leicestershire.

● ● ● ●

Record tokens are being given away by Sony. The £1 tokens will be exchanged for the correct number of vouchers collected from promotional packaging on audio and video tapes. Look out for them in the shops, the offer ends March 31, 1986.

● ● ● ●

A Stevenage based company, Direct Computers, has been hauled over the coals by the Advertising Standards Authority. The admonishment came after an advertising campaign which claimed that a VDU screen attachment "Somashield" would eradicate "99 per cent of harmful X-ray and ultraviolet radiation". An anonymous complainant's view that there was no evidence to prove that VDUs radiate harmfully was upheld by the ASA.

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 Brain Butler.

Second Amstrad User Show Jan. 10–12. Novotel, Hammersmith. A
Which Computer Show Jan. 14–17. NEC, Birmingham. B
Hi-Tech And Computers in Education Jan. 22–25. Barbican Centre. C
Videotex User Show Jan. 29–31. Barbican Centre. D
Electronics in Oil and Gas Feb. 4–6. Barbican Centre. B
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. Crest Hotel, Bristol. J
Electro-Optics/Laser International Mar. 18–20. Metropole, Brighton. B
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

A	Database ☎ 061-480 0171.
B	Cahners ☎ 01-891 5051.
C	BEEA & Computer Marketplace ☎ 01-930 1612.
D	Emap International ☎ 01-837 3699.
F	ASCE Ltd. ☎ 06286 67633.
G	Electrex Ltd. ☎ 0483 222888.
J	Trident Int. Ex. Ltd. ☎ 0822 4671.
L	Butterworth Scientific Ltd. ☎ 0483 31261.
N	Evan Steadman ☎ 0799 26699.

Spectrum Speech Synthesiser & 8 Bit I/O Port

G. Hodgson

Get your Spectrum/ZX81 thinking out loud for around £18

THERE have recently been a few designs published utilising the SPO256AL2 speech processor manufactured by *General Instruments*. However, this circuit, as well as incorporating an SPO256AL2, contains a Z80A PIO of which one port, port A, is dedicated to the speech i.c. and the other port, port B, is taken to a 15-pin "D" socket and so can be used as a programmable, bidirectional 8-bit I/O port.

The circuit has a very low component count using only two i.c.s, a regulator plus some other discreet components. The whole unit can be made for less than £18.

THE SPO256AL2 AND Z80A PIO

The SPO256AL2 is one of a family of speech processors produced by GI. It contains a clock circuit, micro-controller, 16K ROM, and digital on-chip filter making it a compact unit. The ROM contains the data required to produce 59 different sounds, or allophones, plus five pauses of different lengths. The required allophone is selected by placing a 6-bit address on A0 to A5 and then taking $\overline{\text{ALD}}$, allophone load, low when the data is latched into the i.c.

The Z80A PIO contains two bidirectional 8-bit ports, each of which is individually programmable. The i.c. is selected by taking pin 4, chip enable ($\overline{\text{CE}}$), low and then the relevant port register is selected using pins 5 and 6, $C/\overline{D}$ and $B/\overline{A}$ respectively, thus each port is latched. The i.c. has four operating modes for each port and port B is capable of driving Darlington transistors (1·5mA at 1·5V).

CIRCUIT DESCRIPTION

No discrete logic is required for address decoding since the PIO's internal logic will detect when it has been selected. Address line A7 is used for device selection and must be taken low for the PIO to be selected. A5 is connected to $B/\overline{A}$ and A6 to $C/\overline{D}$. Thus A5 and A6 are used for register selection:

A5	A6	A7	Port		FUNCTION
($B/\overline{A}$)	($C/\overline{D}$)	($\overline{\text{CE}}$)	decimal	hex	
0	0	0	31	1F	A Data
0	1	0	95	5F	A Control
1	0	0	63	3F	B Data
1	1	0	127	7F	B Control

Table 1. The PIO addressing details showing register/port allocations

A0 to A4 must always be high since these lines are used to select Sinclair peripherals; a logic low on one of these lines will select a certain peripheral and, if that peripheral is attached, this would lead to two peripherals trying to use the system bus simultaneously.

$\overline{\text{M1}}$, $\overline{\text{IORQ}}$ and $\overline{\text{RD}}$ are used by the PIO to detect instruction type. INT is the interrupt output from the PIO; an interrupt is generated by certain conditions on either port A or port B, more later. $\overline{\text{M1}}$ and $\overline{\text{IORQ}}$ are used to detect whether an interrupt has been acknowledged since they will both go low to indicate an interrupt acknowledge. CLK is the standard Z80 single-phase clock taken from the host computer. Pins 22 and 24, IEO and IEI respectively, are used for "daisy-chaining" Z80 peripherals. In this circuit the PIO is configured as having highest priority since its IEI pin is taken to +5V via R1. When the PIO, IC1, is having an interrupt serviced, its IEO pin will go low preventing any lower priority device from generating an interrupt. Port B, consisting of B0 to B7, $\overline{\text{BSTB}}$, BRDY, is taken to SK2, a 15-pin female D-type socket. In this circuit $\overline{\text{ASTB}}$ and ARDY are not used since Port A is operated in Mode 3 only.

A0 to A5, READY and $\overline{\text{ALD}}$ from IC2 are taken to A0 to A7 on IC1 and so complete control over IC2 is exercised by port A, IC1. The two reset lines of IC2, pins 2 and 25, are taken to the Z80's RESET line and so IC2 is reset whenever the host computer is reset. PB1 is provided to generate a reset pulse whenever it is pressed since both the *ZX81* and *ZX Spectrum* lack a reset button. IC2's internal clock is used in conjunction with X1, a 2·4576MHz crystal, to provide the clock frequency for IC2. Varying this frequency, by inserting a different crystal in the range 1MHz–3·5MHz, will alter the speed of the speech. The output from IC2, pin 24, consists of a pulse-width modulated signal which is then passed through a 5·3kHz low-pass filter formed by R2, R3 and C5, C6. This filter converts the signal into an analogue one.

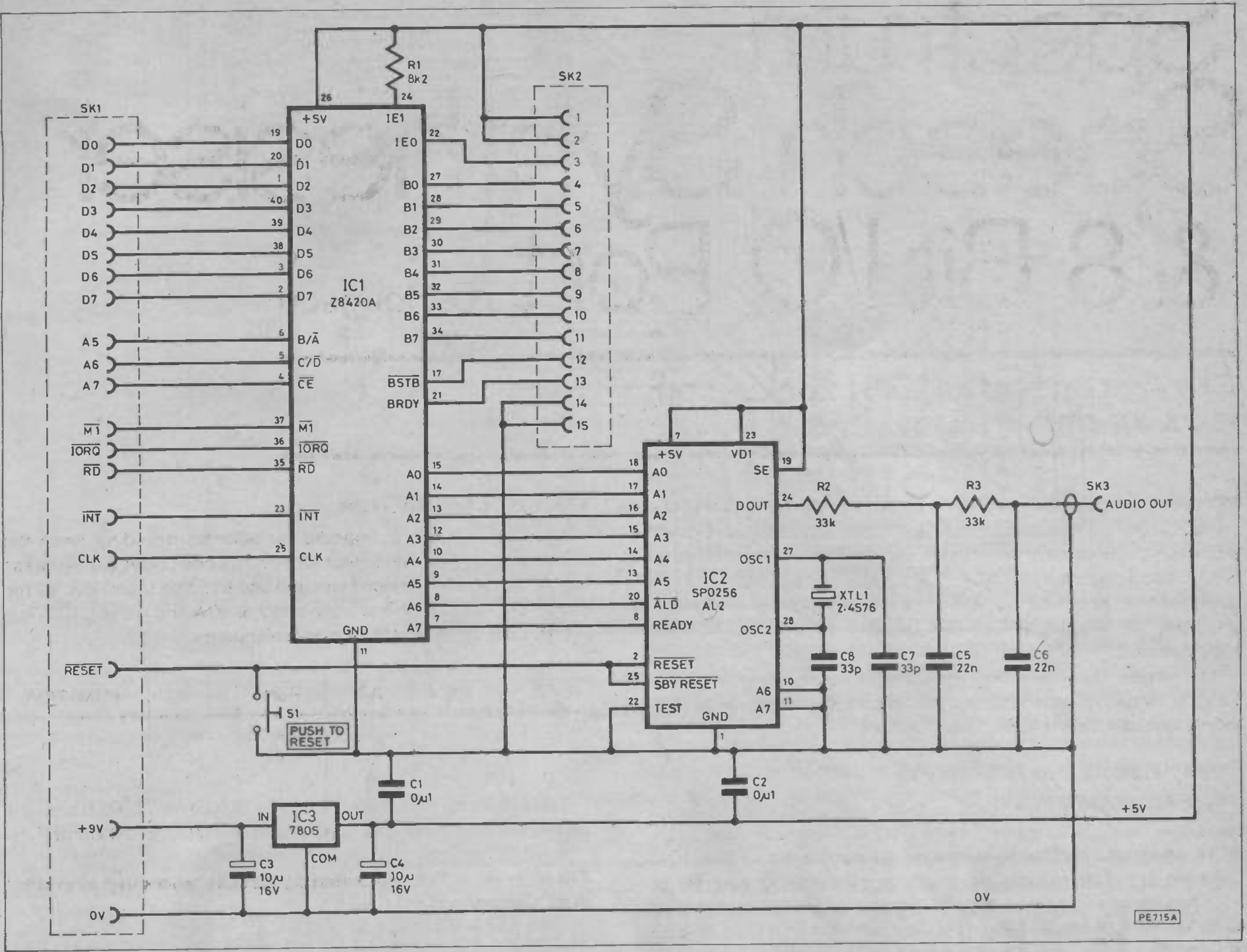


Fig. 1. Complete circuit diagram of the Spectrum, Speech Synthesiser and I/O Port

Further loading of the 7805 in either the *ZX81* or *ZX Spectrum* is not advised and so the 9V output from the power supply is fed into a 7805 regulator, IC3, in this circuit to provide power for the circuit.

C1 should be mounted as close as possible to IC1 and C2 should be mounted as close as possible to IC2 as these are decoupling capacitors, across the supply rails. SK1 is a 2 by 23-way 0·1 inch pitch edge connector.

CONNECTIONS USED

Reset connections are different for each computer and a small wire link or switch should be incorporated to get around this problem. All other connections are the same.

PROGRAMMING

Although IC1 can have each port programmed in four different modes, it has been found that mode 3 (control mode) is the most useful and, indeed, the easiest and so I shall just describe this mode. The port strobe and ready lines ($\overline{\text{ASTB}}$ $\overline{\text{BSTB}}$ ARDY BRDY) are internally inhibited in this mode but $\overline{\text{BSTB}}$ and BRDY have been made available for those who have a knowledge of modes 0, 1 and 2. The *Zilog* publication *Z80 PIO Technical Manual* describes fully the PIO and how to program it, for those who are interested.

In mode 3, each bit can be individually defined as either input or output. For interrupt control in this mode, the CPU interrupt mode must be mode 2, i.e. a machine code IM2 instruction should be executed followed by an EI instruction to enable the interrupts. If interrupts are not be be used then programming of the PIO can be accomplished quite easily.

COMPONENTS . . .

Resistors

R1	8k2
R2,R3	33k (2 off)
All resistors ¼W 5%	

Capacitors

C1,C2	100n disc ceramic (2 off)
C3,C4	10μ 16V electrolytic (2 off)
C5,C6	22n polyester (2 off)
C7,C8	33p ceramic (2 off)

Semiconductors

IC1	Z8420A (Z80A PIO)
IC2	SPO256AL2
IC3	7805

Miscellaneous

X1	2·4576MHz crystal
S1	push-to-make switch
SK1	2 by 23-way 0·1" edge connector
SK2	15-pin female D-type socket
SK3	Phono socket

Printed circuit board PE–023 available from the PE PCB Service; suitable heatsink for IC3.

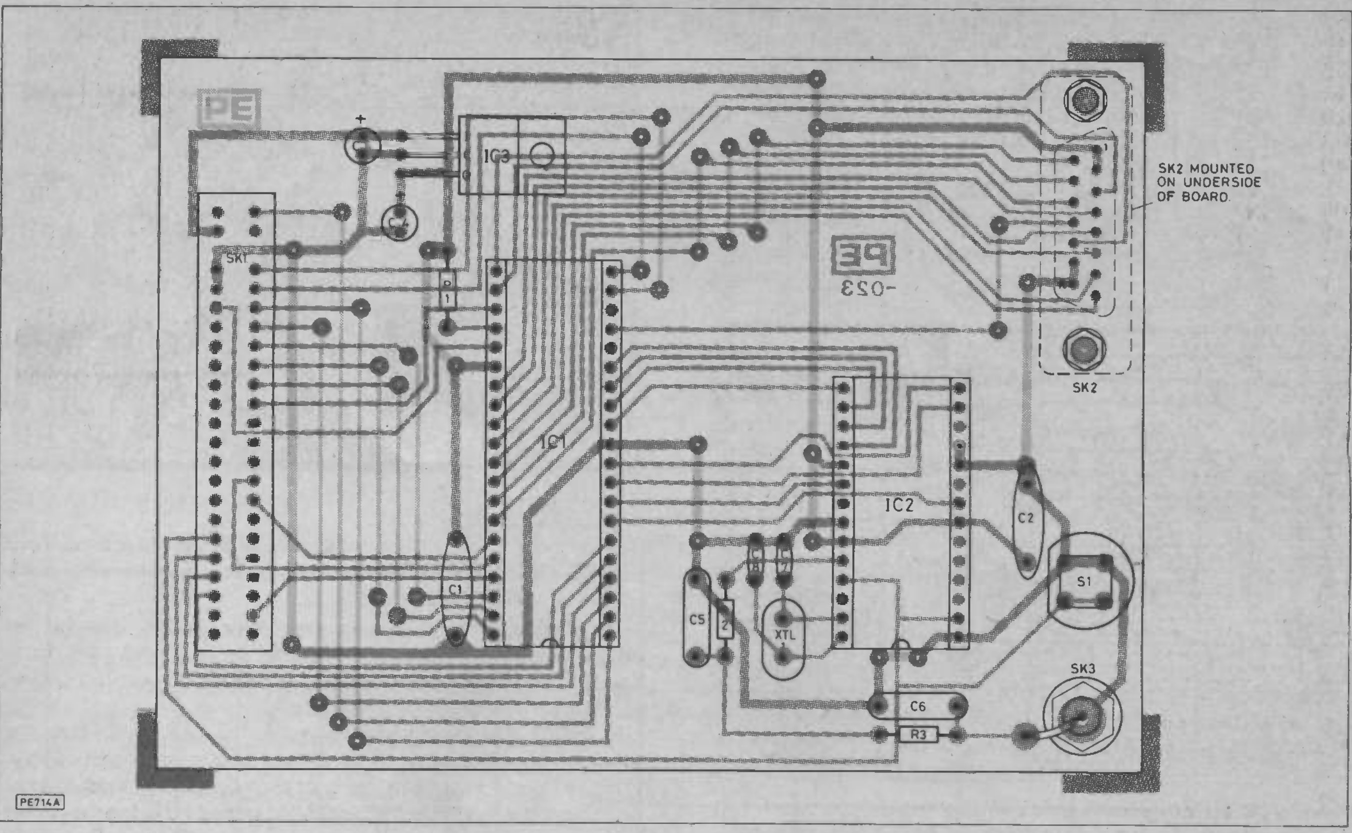


Fig. 2. P.c.b. design and layout

PIO PROGRAMMING

Port A

OUT 95, 255	Selects mode 3 for port A
OUT 95, x	x defines input and output bits: 0 sets bit to output, 1 sets bit to input, e.g. 255 would set all bits to input

Port B

OUT 127, 255	Selects mode 3 for port B
OUT 127, x	x defines input and output bits: 0 sets bit to output, 1 sets bit to input; e.g.

	D7	D6	D5	D4	D3	D2	D1	D0
77 =	O/P	1/P	O/P	O/P	1/P	1/P	O/P	1/P
	0	1	0	0	1	1	0	1

As interrupt mode 2 is rather hard to implement on a *ZX81* or *ZX Spectrum* it is not practicable to use PIO interrupts. Nevertheless, it can be done and that is why the PIO INT line is connected.

Programming the SPO256AL2 is very straightforward. When READY is high the i.c. will accept an allophone and so to send an allophone to the SPO256AL2 a suitable program can easily be constructed.

SOFTWARE

This is a small sample of software for driving the SPO256AL2; and is of a skeletal nature. The programs may be expanded, of course.

ZX SPECTRUM

```
LD A,255
OUT (95), A          Port A mode 3
LD A, 128
OUT (95), A          A0 to A6 output, A7 input
IN A, (31) (LP1)
BIT 7, A             Is READY high?
JR Z, (LP1)          Jump back if READY low
LD A, (23728)        Fetch allophone code
RES 6,A              ALD must be low
OUT (31), A          Send allophone
SET 6,A              Take ALD back high again
OUT (31), A
RET                  Back to BASIC
```

The allophone to be sent should be POKEd into 23728 which is an unused location in the system variables.

A BASIC program to poke the machine code into RAM is:

```
10 clear n             (decide on a value for RAMTOP)
20 FOR a=n+1 TO n+ 26
30 READ b: POKE a,b: NEXT a
40 DATA 62, 255, 211, 95, 62, 128, 211, 95, 219, 31, 203,
   127, 40, -6, 58, 176, 92, 203, 183, 211, 31, 203, 247,
   211, 31, 201.
```

An allophone can then be sent using:

```
POKE 23728,x
RANDOMIZE USR (n+1)
```

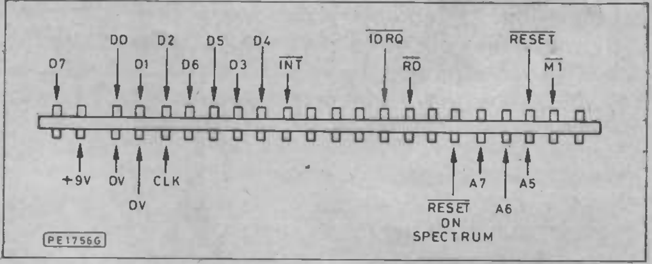


Fig. 3. The Spectrum and ZX81 edge connector

ZX81

The machine code program is the same for the *ZX81* as that for the *ZX Spectrum;* however, location 16507 is used to hold the allophone code. Again this is an unused location in the system variables. Thus the instruction LD A, (23728) becomes LD A, (16507) [5812364].

The basic program is different since READ? DATA and CLEARn are not available on the *ZX81*:

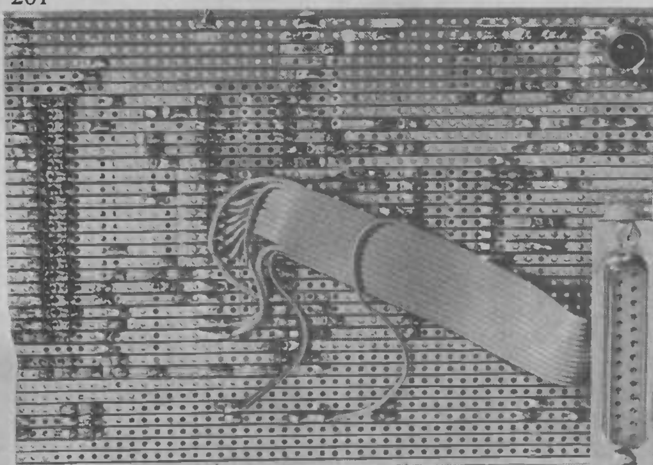
```
 10 REM XXXXXXXXXXXXXXXXXXXXXXXXXX
(26 X's)
 20 FOR A = 16514 TO 16539
 30 INPUT B
 40 POKE A, B
 50 NEXT A
```

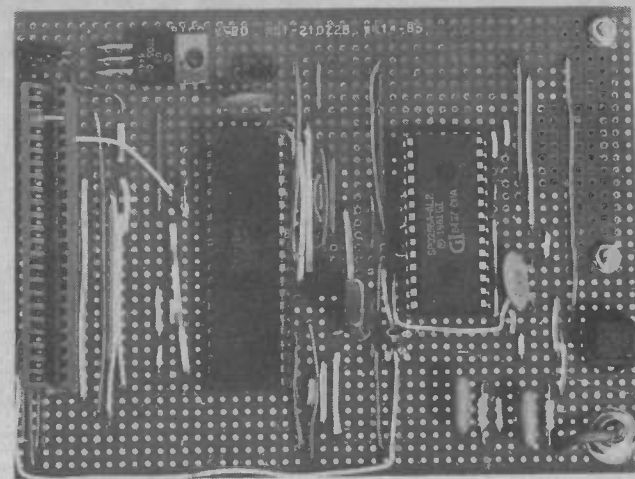
The above program should be RUN and the following 26 bytes entered.

62	255	
211	95	
62	128	
211	95	
219	31	
203	127	
40	250	
58	123	64
203	183	
211	31	
203	247	
211	31	
201		

When this data has been entered, lines 20–50 may be deleted but line 10 must be kept since it is used to hold the machine code. Note also that line 10 must be the first line in ANY program.

An allophone can then be sent using:
POKE 16507, x
RAND USR 16514





Photos illustrating both sides of the prototype model of the Spectrum Speech Synthesiser and 8-bit I/O Port. The prototype was built on Veroboard but the construction is similar to the p.c.b. design

CONSTRUCTION

The prototype model of the Spectrum Speech Synthesiser and I/O Port was built on a small Veroboard as shown in the photographs. Because we think that this project will be very popular, we have designed a suitable p.c.b. of similar size to the prototype which is shown in Fig. 2.

Construction should start by assembling the components on the p.c.b. in the normal way, resistors and capacitors first. Next, the i.c. sockets and the regulator should be mounted, together with the switch and the crystal.

Provision has been made on the p.c.b. for the D-type connector to be mounted directly on to the p.c.b. or wired accordingly. When all the components have been mounted, all solder joints and connections should be carefully checked for solder splashes and dry joints. Finally, the two d.i.l. i.c.s should be fitted in to their sockets making sure they are the right way round.

The project should be carefully connected to the computer edge connector (Fig. 3) and the Speech Synth And I/O Port may be used as described previously. You will probably find that further development of the computer software will enable better results. ★

Microelectronics Education Programme

Part 1 Graham Bevis & Michael Page

THE National Electronics Council is a prestigious body representing many interests—government, the armed forces, the electronics industry and consumers—each year it publishes a Review of developments and activities taking place. In the foreword to this year's Review the Prime Minister writes:

"The world of electronics and information technology is always exciting and always changing. Microprocessors, computer-aided design and manufacture, robotics, and the prospect of a "fifth generation" of computers, all these develoments present our country with a challenging opportunity.

If we seize it, we can compete in the markets of the world, including the market here in Britain, create new jobs and increase our prosperity. If we fail, Britain can only slip back.

The skills required are many and various. Conceiving new products and bringing them to the market; designing new equipment at the forefront of development; manufacturing it efficiently and economically. New technology, though, is not just for specialists—people at all levels in industry and commerce need to appreciate what it can do, and acquire the facility to use it. So we need to make sure that young people in particular get the education and training in new technology that they need. Government, the education service, industry and commerce all have a part to play.

The opportunities for making a career in electronics and information technology are there. I hope that increasing numbers of young people will think seriously about making the most of them, for Britain's benefit as well as their own."

That statement is a reflection of the view which determined the nature and direction of the work of the Electronics and Control Technology (ECT) domain within the Microelectronics Education Programme (MEP).

Funded by the central education departments of England, Wales and Northern Ireland, MEP was set up in 1980, initially for four years but later extended until March 1986 when it will cease to exist. MEP's place will be taken by a small scale operation, termed the Microelectronics Support Unit, whose nature and scale has yet to be defined.

GENERAL AIM

The Programme's general aim has been to help educators become better able to prepare children for life in a society in which devices and systems based on microelectronics are becoming commonplace and pervasive. In this context it is perhaps worth noting that it says microelectronics and not microcomputers.

That statement formed a very satisfactory unifying concept for all the varied activities involved. They ranged from introducing ways of using the new technology to improve general teaching procedures to teaching about microelectronics itself in the many technology courses which are now part of the curriculum of an expanding number of schools and colleges.

The work of MEP and ECT has implications for the general curriculum of all and has produced developments in schools which have a significant bearing on the issue of skilled manpower shortfall at every level of IT activity in commerce and industry.

At the beginning of MEP relatively few pupils studied electronics or electronic systems as part of an examination course. Even fewer were fortunate enough to experience a practical course at an awareness level as part of their basic education. Since MEP began various reports—Finniston, Alvey, and the Butcher/Baker inquiry into the problem of engineering and technology skills shortages have provided a very profitable background to the debate about education and new technologies. We now, at least, have some widely recognised questions that educators have to consider:

(a) What is the knowledge of technology that all pupils should acquire?

(b) What are the skills and attitudes required for young people to develop into confident and competent adults in a world dominated by new technology?

(c) How do we encourage more young people to look to future careers in engineering, commerce and industry?

THE PROGRAMME'S WORK

MEP has been facing many of these questions right from the start of its work. But it is in the nature of a dynamic situation, like that of which microtechnology is a part, that answers formulate themselves and evolve continuously as experience grows.

MEP was fortunate in being faced with an education system which was already recognising the new demands being placed on it and was prepared for change. Some individuals and schools were adopting locally defined solutions, borne out of particular interest or expertise.

However, there were—and still are—some significant difficulties.

The current curriculum is overfull so how can new ideas and topics be introduced? By the introduction of new subjects into the curriculum or by the insertion of appropriate elements into existing provision?

And what about the teachers? How do you enable a teaching profession which is largely devoid of any pre-service training in aspects of an information based society to equip itself to meet the new demands being placed on it? What new skills and knowledge should all teachers develop? How will they achieve this? What new skills and knowledge should specialist teachers develop? How?

The Programme has tried to cover most of these issues. It has undertaken both Curriculum Development (CD) activity and In-Service Training (INSET) work associated with aspects of micro-technology throughout the 5–18 age range.

As well as the ECT work which is the main subject we're looking at in this article, you might be interested to know that other domains exist to consider the computer as a tool for learning, for computer studies, for communication and information systems, and for special eduction (that is for those with particular needs through mental or physical disability).

Clearly, the nature of the provision is varied. Work for and with teachers of primary children will be very different to that required for teachers of sixth form pre-university students of technology. The output of the Programme has been quite remarkable.

There are now more than 2000 items available for teacher or classroom use and these include software, devices, video tapes, case studies, and so on. Every maintained school in the three countries where MEP works has been sent the Programme's catalogue (July 1984) and supplement (October 1985) through the Local Education Authority (LEA) mailing system.

MEP	Microelectronics Education Programme
ECT	Electronics and Control Technology
CD	Curriculum Development
INSET	In-Service Training of teachers
LEA	Local Education Authority
MFA	Microelectronics For All
CDT	Craft Design and Technology

Abbreviations used in this article

THE ELECTRONICS AND CONTROL TECHNOLOGY DOMAIN

In 1980 ECT began as a "cinderella" in the MEP operation. Its purpose and potential contribution was little understood by educational administrators, both inside the schools themselves or in the power houses of the LEAs and the Department of Education and Science. How often have we heard the statement (it is not an argument) "we do not need to enable our children to understand anything about microelectronics technology anymore than we need to teach them about the intricate principles and operations of the internal combustion engine".

It took some time, following the many educational conferences, set up both nationally and regionally by MEP, and with not a little input from industrialists worried about IT skills shortfalls, to begin to establish an appreciation that:

(a) Microelectronics is increasingly pervasive in its influence on the world of work, leisure, education, the daily organisation of our individual lives and the way in which society is organised and controlled. Therefore, in a democratic society, all citizens should be well enough educated about the nature and capabilities of this new technology in order to be able to intelligently influence its adoption, application and development.

(b) A practical study of microelectronics has a very great deal to offer the basic educational process at all levels of ability and age. The subject is highly motivating because it is obviously relevant. It readily lends itself to a student-centred practical approach, which enables personal development in a wide range of skills, aptitudes and attitudes—particularly those of communication skills within working groups. It develops the ability to think logically, to learn and to apply knowledge to the solution of practical problems, to choose and implement a solution, to evaluate it and, if necessary, improve this solution in the light of experience.

A PROSPEROUS NATION

Couple these arguments with the absolutely clear fact that, if we are to survive as a reasonably successful and prosperous nation, we must be able to identify and stimulate those special pupils who have imaginative and creative talents, and to encourage them to become the engineers and technicians of a successful manufacturing-based economy, then you have no choice but to accept the fact that some practical experiences of microelectronics should be part of the curriculum of all pupils from 5–16 years.

These experiences should enable the development of an awareness of the processes, applications and potential of IT systems and should develop skills appropriate to life in general and to future employment, especially for those inclined to pursue technologically related careers.

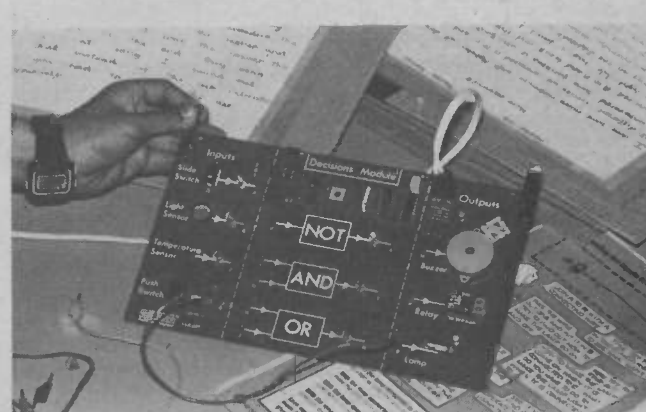
SEEING THE LIGHT

The problems of initial perception, described above, meant that at the beginning of MEP the ECT domain was established with the purpose of providing INSET only for the specific courses which included electronics or microelectronics. At this time appropriate examination courses at 16+ and 18+ could be identified as control technology, modular technology, electronics, electronic systems, and in a small measure, some courses in physics.

However, for the more specialist courses, the number of candidates were few and so the INSET requirement in any MEP region (a grouping of nine or 10 LEAs) was limited. Given this situation, together with the fact that the teachers requiring training generally had limited knowledge and experience in this field and that they were so thin on the ground that they could only be allowed out of the school for short periods, then the only INSET model possible was one of small modules of individualised practical learning activity.

This helps to accommodate the above parameters and the fact that teachers, like pupils, learn at distinctly different rates and therefore cannot be satisfactorily "class taught".

Quite soon after beginning this programme of INSET, it was clear that with all the attendant problems described above plus the fact that very little curriculum development had been done in the ECT field, the task of the intending ECT teacher was well nigh impossible. It was also clear that many teachers felt it was far more



important to provide all pupils with some experience and knowledge of IT systems than to provide a specialist technical education for a few.

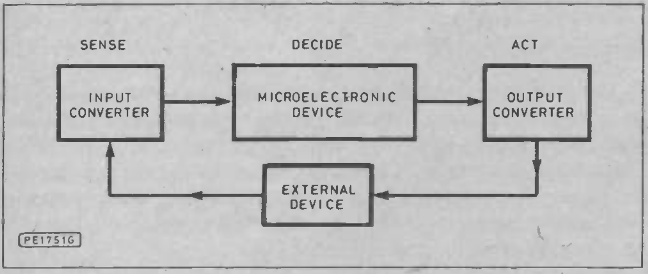
Out of the feedback from teachers on courses, the MEP ECT coordinators perceived a need to develop a highly supportive, practical course as an introduction to IT systems. This has now evolved as the MEP Microelectronics For All (MFA) scheme, and is described later.

Although the need was perceived, at that time there were no centres available to ECT for curriculum development activity. There were two models by which small scale curriculum developments were occurring. One, by commissioning the entrepreneurial teachers who had "done their own thing" to describe and document their work so it could be used by others. The other route was to use the MEP regional structure, which had a general responsibility for CD, to coordinate a specific development.

It fell to the MEP Greater Manchester and Lancashire Region to develop MFA. It was in this MEP Region that there was just the right blend of aspirations and experience of a significant group of teachers who had already tried an MFA approach for themselves. This, together with a sympathetic steering group of LEA advisers and an ECT coordinator with his base in the supportive and appropriately expert University of Salford, was the recipe for the production of a very innovative resource.

WHAT MFA IS ALL ABOUT

The MEP/MFA course has been designed as a low cost practical course which introduces the principles underlying information technology and demonstrates the action of basic simple IT Systems, illustrated below.



There are three basic MFA modules and these can be connected together to form a flexible demonstration system. All the modules are arranged so that information enters the system on the left hand side.

On the decisions module there are four two-state input devices. The light sensor indicates whether it is dark or light. The temperature sensor detects a rise above ambient temperature. A slide switch and push switch provide the other two information inputs. If the light sensor output is connected to the buzzer it sounds until the sensor detects darkness and causes it to be turned off.

With this module pupils first explore the interaction of input sensors and output devices before discovering ways of using more than one piece of information to control output devices. They are then in a position to be able to use their new found knowledge and solve simple problems given to them or conceived by themselves.

They can then, with the other two basic modules, progress through a similar structured exploration of the processes of counting and remembering, leading to work on simple stored sequence control systems. This leads directly to work with a microcomputer as the "control element" in an IT system. For this work there is an interface designed to lead directly from the initial MFA experience. As well as enabling the micro to be part of an electronic system, there is integrated software which further illustrates the IT systems being demonstrated.

APPRECIATION AND APPLICATION

Having developed an appreciation of the principles, structure and operating processes of IT systems, the pupils are then encouraged to turn their thoughts to the applications of IT. These include those around them in their everyday environment, and those not generally seen but important in their effects. From this the pupils begin to develop the all-important appreciation of just what it is that silicon chip systems can do and, equally importantly, what they cannot do.

MEP is currently working with the BBC to produce three TV programmes aimed at addressing these questions by observation of real-world systems at work. Furthermore, a joint initiative by the BBC and MEP is facilitating the production of learning materials for older readers. This will provide the details of particular IT systems and describe the effects of the system on the work of people employed, either in the job situation itself or the nature of the product (in the broadest sense) produced by the employee.

WHAT'S NEXT MISS?

Having experienced MFA, many pupils wish to study the subject further, either for interest and enjoyment or because they have decided to pursue a career in the IT industry. For these pupils there needs to be a more extensive microelectronics curriculum. Therefore, the MEP/ECT domain has been engaged in developing very specific, highly-supportive learning packages for some of the many specialist areas of the subject which require it.

As a result of the success of the convincing MFA scheme and the need for a much wider range of activity, two national development centres were established, at Salford and in Sunderland, in September 1984. This is somewhat late in terms of the lifetime of MEP, but with the benefit of the background of four years' debate about, and developing experience of, the needs of the microelectronics curriculum and its associated INSET needs.

The Salford Electronics Education Development Unit, based at Salford University, was established to continue the development of the Microelectronics For All scheme, in terms of both hardware and pupil materials. It is enabling the MFA approach to be used at examination level in Craft Design And Technology (CDT) and science courses. Furthermore materials are being produced that are appropriate to sixth form general studies courses. The work of the Salford Unit is complemented by the very strong and productive links of the Greater Manchester and Lancashire MEP Region and the many practising teachers experienced in microelectronics education in that area.

Further north, the Sunderland Evaluation and Development Centre has been established partly to continue the very valuable and necessary work in the evaluation of hardware and curriculum packages and the resulting provision of advice and information to teachers of microelectronics. It is also involved with the development of highly innovative teaching materials in terms of their content, concept and place in the curriculum.

Projects complete or in hand include the "Analogue Sensor System", "Communications For All", and the "Compleat Meteorologist". The Centre benefits from being placed within the grounds of Southmoor School, Sunderland, and enjoying the support of the far-sighted and well resourced "Microelectronics Development Programme" of the Sunderland education authority. The MEP Centre shares premises and staff with the LEA's own Microelectronics Centre.

APPROPRIATE INSET

Many factors have encouraged schools and colleges to offer specialist courses at 16+ and 18+ in electronics or microelectronics or technology. Most of these courses are defined by new syllabuses, largely unsupported by an appropriate curriculum, or even advice on how best to teach the syllabus to meet the requirements of the examination at the end of the course.

The many teachers charged with responsibility for these courses find themselves in the position of having to define their own approaches and strategies when their own knowledge and experience in these subject areas is often at the stage of early development.

Frequently the practical scheme of work, which is the main part of the teacher's INSET experience, is equally applicable to the learning situation for the student at school. For both the teacher and the pupil there is the need to learn about the theory and concepts of the subject and to learn about the practical issues relating to its implementation. In any case electronics is a practical discipline and the best way to learn, as in many subject areas, is by practical experimentation designed in the first instance to illustrate principles and ideas and then to lead on to investigative problem solving activities.

GETTING THERE

Against a background of having begun the INSET programme in the MEP Regions with mostly introductory courses, the work has now moved on to the development of highly-detailed distance-learning packages which are tailored to particular hardware and approaches. The student's guide contains details of the theory and concepts to be explained by following practical exercises. Thus the study rate is self determined and allows for variation in previous experience and rate of learning. It also enables teachers to develop their knowledge in the subject at a rate and time convenient to them. The package course also serves as an encyclopaedic "aide memoire" which can be returned to as a refresher when the need arises.

Some of the hardware and practical exercises provided for the teachers will be appropriate for their pupils, depending on the level of study. There is a wide range of course topics for which development work on distance learning packages is in progress or planned. Many others will be needed as the level and extent of microelectronics technology courses in schools expands.

Clearly, great demands are being made on the teachers and, perhaps, the pupils. But the reported experience from teachers and pupils in this field is all the same, one of considerable enjoyment, satisfaction and interest in this work. The motivation is unquestionable. It is after all motivation which determines achievement in all learning, even more so than intelligence itself.

NEXT MONTH: Graham Bevis and Michael Page will be looking in more detail at the Microelectronics For All material and describing what may be happening when the government money for MEP runs out at the end of March and the new Microelectronics Support Unit hopes to start work. We also hope, in future issues, to be carrying some constructional projects that are supported by sound curriculum needs and teacher training materials.

If you would like an information folder which contains full details of the MEP/ECT domain and its teacher-training materials, then send a large (C4) self-addressed envelope stamped with 45p-worth of stamps PLUS 50p in unattached stamps, to Mrs Beth Bevis, Ronsella, Lordswood, Highbridge, Eastleigh, Hants SO5 7HR. It would be helpful, if you are a teacher, to say in which LEA you teach.

D.E.S. REPLIES

The Minister for Education and Science has now replied to our September* Editorial *which included the paragraph below:

While in no way wishing to get involved in politics, it is all too easy to blame the teachers when a continuing lack of investment in training, staffing and facilities, at Government level, is not allowing education in the UK to keep up with progress and the new demands of industry. Education which has, for many years, had a worldwide reputation for excellence. Perhaps the state schools should follow the lead given by the independent Schools Microelectronics Centre?

Copies of this and other leaders and of the letters we have received have been forwarded to the Department of Education in the hope of a reply—Ed.

In your editorial in the September edition, you reported that you had sent a copy to the Department asking for a response. I am now replying.

In our White Paper "Better Schools", published last March, we said that, "The Government believes that all pupils should follow a broad, balanced and suitably differentiated curriculum until age 16; that such a programme should contain a strong element which relates to the technological aspects of working life". We amplified this in our Science Policy Statement for the 5–16 age group also published in March. The Government's position is therefore quite clear and we have sought to provide a stimulus to educational establishments through a substantial number of initiatives.

The Microelectronics Education Programme, established in 1980, aims to help schools to prepare children for life in an increasingly technological society through the development of software and devices, the provision of teacher training courses and an information network covering the country. Some £23m will have been spent on this Programme by its close in March 1986. The Programme is to be succeeded by a Microelectronics Support Unit which will provide further help, mainly through training and trainers, and providing a central information source. The Micros in Schools schemes, started at the same time, have been successful in ensuring that there is a microcomputer in every school. The 5,000 secondary schools now have an average of 12 micros per school; the 20,000 primary schools now have on average 2 micros per school.

The Technical and Vocational Education Initiative aims to stimulate the provision of practical and applicable elements within the curriculum for 14–18 year olds through pilot projects mounted by the LEAs but funded by Government. Almost £250m is being spent on the Initiative over a 9 year period.

An Educational Support Grant Scheme aims to encourage the use of information technology in non-advanced further education especially for those not specialising in IT subjects. The Government is spending £9m on this scheme in 1985/86, and a further £6m in 1986/87 with continuing substantial sums through to 1990. We have recently announced another project to facilitate the purchase of software by schools.

Finally, the British Schools Technology initiative aims to bring practical technology into all CDT courses and, by the end of the academic year 1986, will have conducted in-service training courses for some 10,000 teachers. The local authorities themselves, who are responsible for the details of the curriculum within the schools, have added much to these sums.

The position now is that more than half of secondary schools mount courses on information technology for their pupils. Topics associated with new technology are to be found in many examination syllabuses—computer studies, robotics, electronics, computer graphics—at 16, 17 and 18 years. Over 130,000 students will study some elements of the new technology to public examination level in school this year.

Of course, there is still a long way to go to introduce technology thoroughly into the education system and we cannot be complacent. But both in its public statements and its various initiatives, the Government is providing the clearest of leads on the way forward.

CHRIS PATTEN

Thank you for your response. I feel it is worth pointing out that total Government spending on education is around £10,000 million a year, so the £5 million (approx) a year for MEP spending can be put in perspective—Ed.

Readout...

Twenty Years of Stagnation in the U.K.

Sir—Your correspondents' letters in *Readout* in your September issue have covered this matter as far as schools are concerned fairly well. As a 73-year-old hobbyist of only 3 years at electronics, I am concerned, from my experience, at what more can be done to help ex-students who wish to extend their knowledge of electronics. For example take the case of an unemployed person who has passed O-level Physics and thinks that with further knowledge of electronics he might get a job as an electronics engineer or a teacher.

Having had my interest in the subject excited by my grandson's Electroni-Kit, I found a copy of *Everyday Electronics* for Nov. 1982 in a local stationers. (This shop no longer stocks this magazine. Special orders only.)

I realised that *Teach-In '82* could help me, obtained the October '82 issue for the start of the series and put in an order for *E.E.* W.H. Smith can now order *P.E.* for me as well, but *few stationers in provincial towns stock these magazines* i.e. it is not easy to buy purely electronic know how in magazine form from the shelves in the first instance. The same applies to books. I found one book (no choice) on electronics in a large book shop near here, and that was first printed in 1972 with little revision since the advent of transistors and i.c.s.

I obtained an Electroni-Kit and followed up an advert: for The British Amateur Electronics Club. They were most helpful and for 6 months I corresponded with another member who taught me a lot. I discovered one small electronics component shop in Salisbury which stocks Babani Books. Then I was able to buy these books off the shelf, after looking at their contents which no resumé in a catalogue can really tell you. The local bookshop took three months to obtain two Babani books for me.

My point is that in the provinces it is very difficult to buy books or magazines about electronics and enough to discourage any ex-student seeking further education. Public libraries hold a few volumes.

How many courses on electronics are run for evening classes during the winter? *P.E.* advertises two correspondence courses and one college. How can you "spread the Gospel"? I think in a way that too much has been said about computers too soon, because a market was there for a new sort of toy for children. You can buy numerous computer magazines, but do they teach you electronics—computers, radio, TV, discos and they use them like cars which you can drive without knowing what a sparking plug is.

I suppose it boils down to education but it is young persons with some knowledge of the subject you want to capitalise on now to produce teachers of future students.

Dr. R. G. Ticehurst,
Gillingham,
Dorset.

Lack of Guidance

Sir—Further to your July '85 editorial I would like to add my own comment to the shortfall of potential engineers in this country. I myself am currently studying on the 2nd year of a two-year OND in Technology (Engineering) at Cornwall College.

On leaving school I was somewhat surprised to learn that of the 100 or so students capable of going on to a technical further education, only 25 did so, the remainder going for arts-based courses or none at all. When asked why, many came up with such comments as "not my scene" or "too much like hard work" or even "girls can't do physics"(!).

Perhaps this is as a result of parental "guidance" or more likely a complete lack of understanding and information on the subject of Engineering in general. Thinking back to my time at school only just over a year ago, the careers service seemed positively biased *against* Engineering—there was simply no information on such subjects.

Your comment in the July '85 edition that "*PE* could be said to be doing more for industry than our educational system" is perhaps a little far-fetched. However, if one were to enquire at any secondary school in the area I think that they would be hard pushed to supply any textbook containing much more than simple Ohms law except perhaps the few magazines such as *PE* left after government cuts.

From what I can recall of my time at school, the interest was most definitely there in the students but a lack of resources and free staff time prevented anything more than letting us use the very limited computing facilities for perhaps one lunchtime a week. This was the closest I came to doing anything more than Ohms law at any time during my compulsory schooling.

I feel sorry for the large number of students staying on at school for "A" levels in technical subjects when just a few miles down the road there is a fully equipped Further Education College which has a severe lack of good student material although it has some of the best resources in the county.

The principal source of the problem as I see it is in two main areas. Firstly in the lack of guidance and information given to pupils in schools, especially concerning "options" and choices for further education. Second, the sooner a common core curriculum is introduced for both sexes and all ranges and abilities the better. It cannot be right that by the time a person has reached the age of 14 or so a large range of careers and jobs are already unobtainable.

As to your comment in the September '85 *Editorial* that "not one student has written" to you I would hazard to suggest that the present feeling of apathy in students today is due, in part at least, to the feeling of being unable to exert any influence in any particular direction and being a very small cog in a very large educational system.

Richard Freeborn,
Truro, Cornwall.

Congratulations

Sir—Congratulations on *Practical Electronics'* 21st anniversary! I appreciate all the enthusiastic help and support you and Fred Bennett (*PE*'s founding Editor) have given the British Amateur Electronics Club, since we started in 1966, in your leading magazine for electronics enthusiasts.

It was Fred, of course, who first realised that amateur electronics needed its own magazine, and both you and he have kept abreast of the times, and always given your readers what they wanted, even before they knew what it was themselves! Naturally, electronics comes first with me, but I have a BBC computer, and find your articles on it very helpful, so thanks and congratulations on knowing what I want!

With best wishes, and I am looking forward to *Practical Electronics'* 25th anniversary, not to mention *Everyday Electronics'* 21st!

Cyril Bogod,
British Amateur Electronics Club.

Modular Mixer

Part 1 **John M.H. Becker**

Clever connections allow countless combinations of mono or stereo signal controllers—selective filtering and panning facilities

THE design described here consists of a modular mixer permitting a wide variety of channel combinations to be assembled, and in which the majority of the signal paths are voltage controlled. As an example, two complete 4-input combinations for producing both mono and stereo mixers are described in

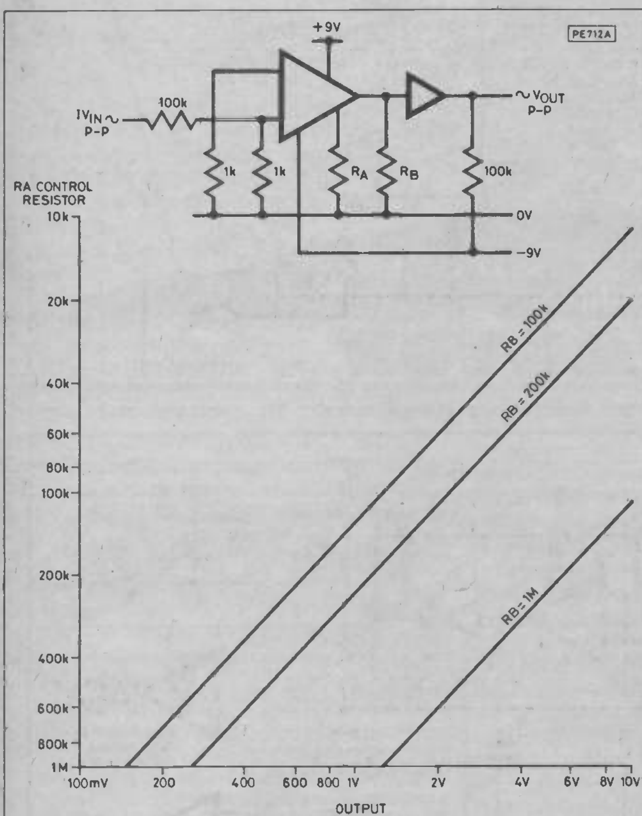


Fig. 1. Gain test—circuit and graph

detail. Each example provides variable control of the input gains and levels, selective filtering of the composite mix, and final output level control. The stereo mixer additionally provides echo send and prefade outputs, plus facilities for panning the inputs between the output channels. Other combinations can be readily assembled.

VOLTAGE CONTROL

The purpose of using voltage control is to minimise the number of signal routing leads normally associated with multi-control units. This not only reduces the number of wires, but also reduces the possibility of interaction.

With the exception of the filter mode selection all signals are controlled indirectly throughout the units. To achieve this the main chip used is the highly versatile transconductance amplifier (TCA), type 13600, available in several manufacturing prefixes such as LM and XR. This can be used in many configurations where voltage or current control of signal strengths is required.

In this circuit it is used as a VCA for amplitude control, and as a VCF for frequency response control. The chip consists of two programmable TCA's, and two uncommitted high impedance buffers. A low level signal may be applied to either the inverting, or non-inverting inputs, and the signal strength present at the output is then related to the amount of current seen at the control node, and the value of the load resistor.

Fig. 1 graphically shows the results achieved on testing individual 13600s when varying the load and current control resistors. In practise a compromise has to be made between the ratio of high gain via the load resistor, to an increase in noise levels, and the ratio of the high gain via the control node and an increase in current consumption. On test, with R_B at 100k, this varied from 0·5mA with R_A at 1M, to 5·9mA with R_A at 10k. The noise levels were too low to significantly take readings.

Unlike an ordinary op-amp such as the types 072, 082 etc, the 13600 is happier processing low level signals, and it is usually desirable to provide attenuation immediately prior to the input. Naturally, exceeding the optimum signal level will produce overloading, though the effect of this results in a less pronounced change to a waveform than that associated with normal clipping. Photos 1 to 3 show an input signal in the upper trace and show a normal clipped output overload found with op-amps like the 082, 324, 741 etc. Photo 2 shows the effect of overloading the input of the 13600.

Although distortion still takes place it appears and sounds less harsh than that of a clipped waveform. The 13600 includes a distortion linearising input for higher level signals, but the use of this was not considered necessary in these units under the conditions normally expected. In the circuit to be described, IC2 is content to receive an output from IC1 of 2V before overloading occurs. The high impedance buffers enable the gain to be unaffected by subsequent loads being driven.

INPUT STAGES

Two options of variable gain input stages are shown in Fig. 2a and Fig. 2b. In each the phase polarity is maintained by using the non-inverting input ports, and the gain is dependent upon the ratio of the feedback resistance to the resistance on the inverting input ports. In Fig. 2a this is constantly variable by VR1, whereas in Fig. 2b the gain range is switch selected between high and low. In both the gain spread is about from X1 to X50.

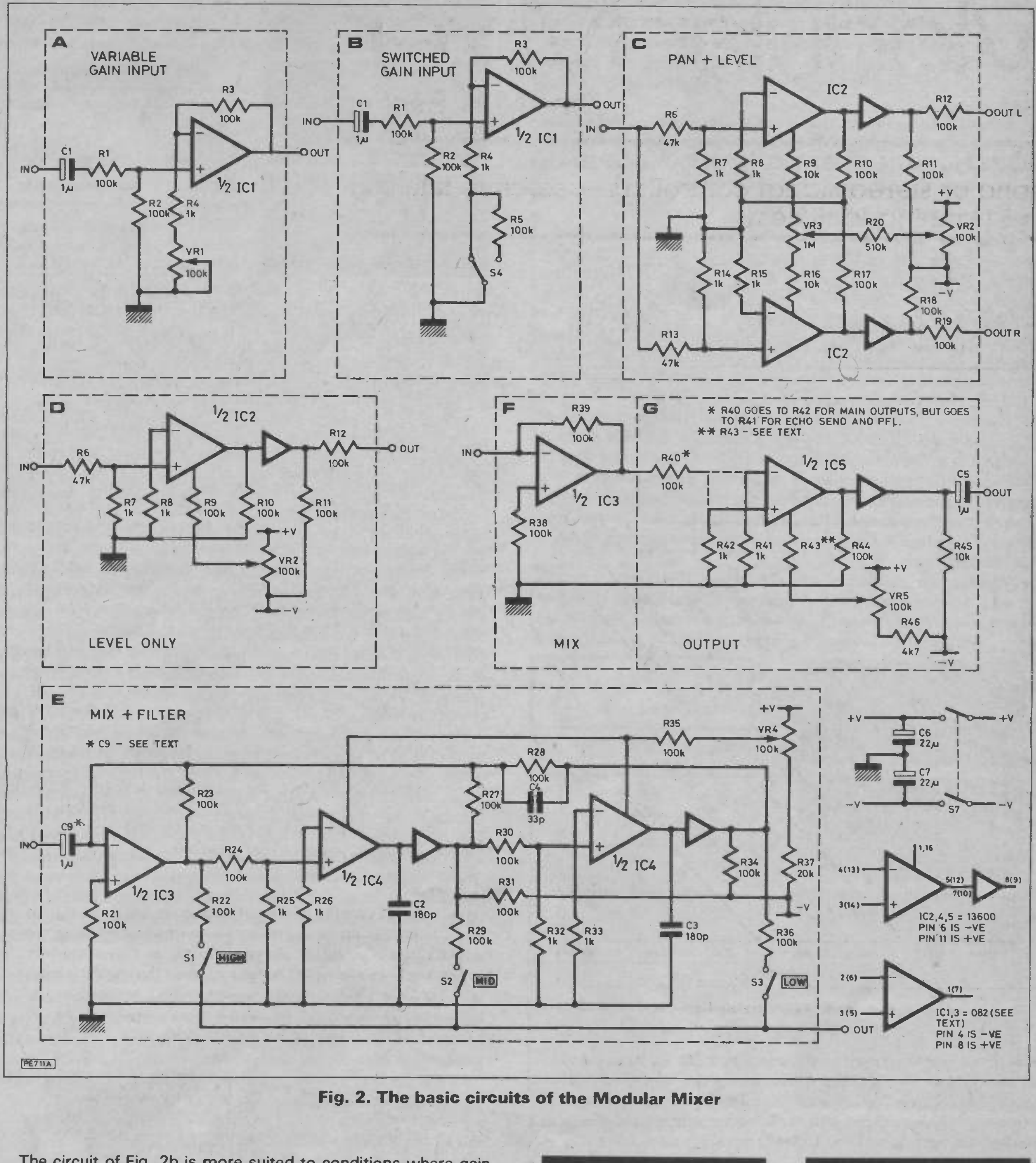


Fig. 2. The basic circuits of the Modular Mixer

The circuit of Fig. 2b is more suited to conditions where gain change versatility is less important, or when front panel space is insufficient to allow extra pots to be mounted. The i.c. used is a normal BIFET dual op-amp, and may be any of the 062, 072, 082 series, available with various prefixes such as TL and RS. The 082 is the standard version, 072 is low noise, and 062 a low power consumption version.

LEVEL CONTROL

The basic level control VCA consists of one half of the 13600, that is, one TCA and one buffer. Phase polarity is again maintained and the output level is fully controllable from nil to maximum by VR2. The amplitude level is dependent upon the voltage present at the wiper of VR2, which modifies the current through the resistor in series with the control port. Fig. 2d shows the circuit for a normal level control without panning facilities.

Photo 1

Photo 3

Photo 2

Photos 1–3 show the appearance of input overload distortion.
1. Triangle clipping.
2. Using the 13600 (note smoothness).
3. Sinewave clipping.

Fig. 2c shows two level controls coupled is such a way that the control voltage can be swung between the two by VR3, so that when one is up the other is down, and in the midway position equal emphasis is given to both outputs. Each output can be taken to a dedicated busline so that the signal can be routed to the desired left or right channels. In this configuration, a channel separation of around −40dB is maintained at either full left or full right swing.

At full swing the output level is approximately twice the original input level, and at the midway position is around three quarters of the original. In the circuit of Fig. 2d, the maximum output level is around three times the original.

VOLTAGE CONTROLLED FILTER

One of the many advantages of the 13600 is that it can readily be used as a VCF with only minor changes to the VCA circuit mode. The circuit in Fig. 2e is similar to the one used in the author's *PE* Filter-Shift Phaser in the October 1984 issue. In that instance only band pass filtering was required, but here the full facilities of low pass, band pass, high pass and notch filtering are needed. These four functions provide a wider variety of frequency modification than a normal tone control, especially in conjunction with the response control provided.

The circuit consists of the inverting mixer stage around half of IC3, and the full 13600. The signal from any previous stage is brought in to the mixer stage and to the first TCA. In response to the signal C2 then charges or discharges at a rate set by the current present on the first control node thus mopping up some of the higher frequencies. The charge is buffered by the high impedance stage IC4b, from whence part is fed back via R27 and controls the gain.

Without the addition of the next stage, the resultant output from IC4b would thus be a low pass signal, with the cut-off region set by the charge rate of C2. However, the resultant signal is fed on to the next TCA where C3 charges and discharges at the rate set by the current on the second control node, so eliminating more of the higher frequency content. Buffered by IC4d, selective feedback of this part of the signal is also made. The effect is then that IC4d and IC3 respectively produce low and high pass outputs, where only frequencies below and above the set points are passed through unattenuated.

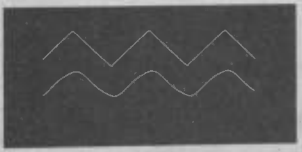
The output at IC4b thus becomes the band pass output consisting of those frequencies between the high and low pass ranges. The gain, and so the tightness of the band pass width, is determined by the feedback value of R27, which in this case is set for unity. In some other circuits it is possible to make this feedback resistance a variable panel control in order to vary tightness of the filtering, though this facility is not offered in the circuits shown.

The frequency regions at which the cut off points occur is variable by changing the amount of current flowing at the two control nodes, as set by the voltage on the wiper of VR4 in conjunction with the value of R35. R37 raises the threshold level controlling the minimum frequency response. Switches S1 to S3 allow any combination of the frequency pass outputs to be selected. On its own, each switch passes only the frequencies within the relevant band.

With all of them on, a basically uncorrected signal is produced by adding all three parts back together. With S1 off, treble-cut is given, and the output level is the same as that from the preceding stage. With S3 off, bass-cut results. With all three off, nothing results! However, with only S2 off, notch filtering occurs, allowing only frequencies to either side of the set region to pass through. This permits selective attenuation of the mid range.

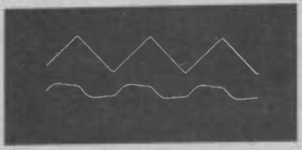
VR4 is used to set the desired frequency range for any of the combinations, though of course it will have no apparent effect when all three switches are on together. By judicious use of the filter controls, tone control of the output signal is achieved, and its characteristics modified.

Photo 4 to Photo 10 shows the effect of various switched filter settings upon a single frequency. Note in particular how a sharp waveform is modified to become a more mellow sounding tone by smoothing off the edges. Photo 11 to Photo 13 shows the effect of the tone control upon a band pass region. Photos 14 and 15 show the clarity of the overall signal response as low as 10Hz, and as high as 30KHz.



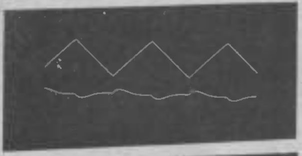
S1	S2	S3
↑	↑	↓

Photo 4



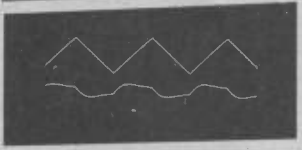
S1	S2	S3
↑	↓	↑

Photo 5



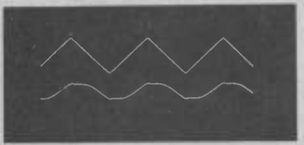
S1	S2	S3
↓	↑	↑

Photo 6



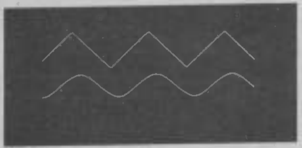
S1	S2	S3
↓	↓	↑

Photo 7



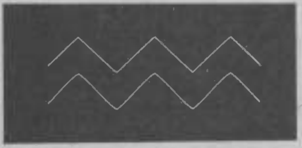
S1	S2	S3
↓	↑	↓

Photo 8



S1	S2	S3
↑	↓	↓

Photo 9



S1	S2	S3
↓	↓	↓

Photo 10

Typical effects of filtering triangle waveform

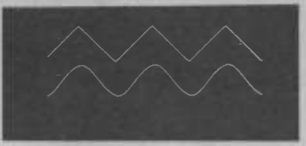


Photo 11. Bandpass

S1	S2	S3	Tone
↑	↓	↑	↓

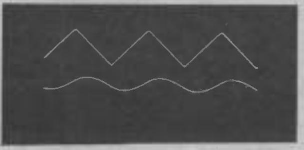


Photo 12. Below bandpass

S1	S2	S3	Tone
↑	↓	↑	↗

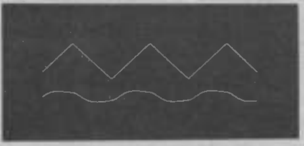


Photo 13. Above bandpass

S1	S2	S3	Tone
↑	↓	↑	↖

OUTPUT MIX & LEVEL CONTROL

This is a multipurpose circuit that can be used to mix signals from any stage, and to allow control of the final output level. Half of IC3 is used as the mixer and inverts the phase. It is followed by a VCA stage similar to that in Fig. 2d, and VR5 varies the current through R43, and thus the output level with a maximum gain of 3. R46 raises the initial current to a minimum threshold point.

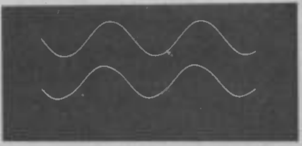


Photo 14. 10Hz

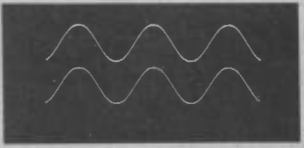


Photo 15. 30kHz

VC4 Mixer waveform retention

The final output can be fed to any other equipment, such as main or monitor amplifiers, or echo and other effects units. A choice of signal phase polarity setting is allowed for by being able to take the output from IC3 to either the inverting or non-inverting inputs of the VCA. The phase of the signals from the circuits shown in Fig. 2a to Fig. 2d is the same as that which they receive, whereas the output from the filter is inverted. In order to retain the original phase, R40 should be connected to R41, and thus the inverting input of IC5, for outputs directly from any of the circuits shown in Fig. 2a to Fig. 2d prior to the filter in Fig. 2e. When the output follows the inverted signal from the filter, R40 is connected to R42, and thus to the non-inverting input of IC5. In many instances failure to observe phase polarity may not be noticeable, though in other cases it could result in signal reduction caused by two antiphase signals cancelling each other.

CIRCUIT COMBINATIONS

From the above, it will be seen that a wide variety of circuit configurations can be put together to produce a mixer with as many input, output and filter networks as required. Practical examples of two such combinations are described in detail below, but other combinations, such as more inputs into the shown outputs, or into additional outputs, can be used.

Each input channel can also be given its own separate filter circuit immediately after either the gain or level control stages, though when following the input gain stage, C9 should be replaced by a 100k resistor.

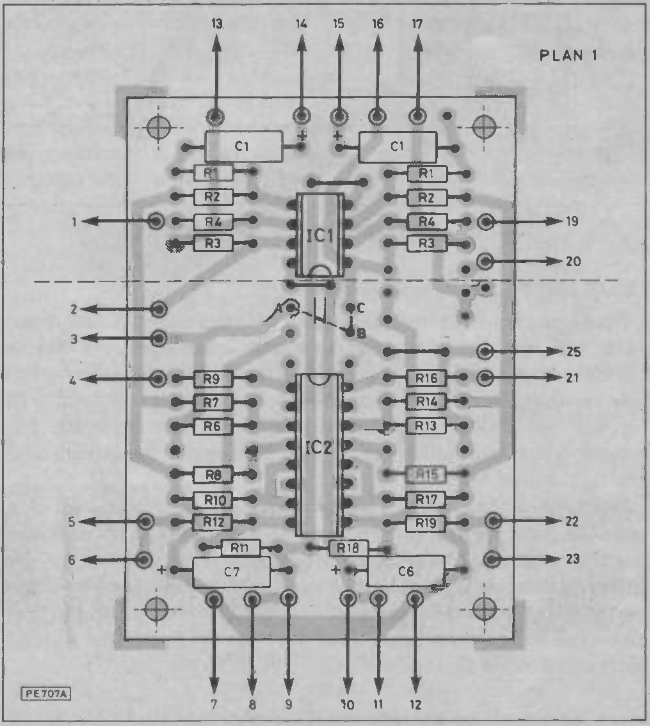
POWER SUPPLY

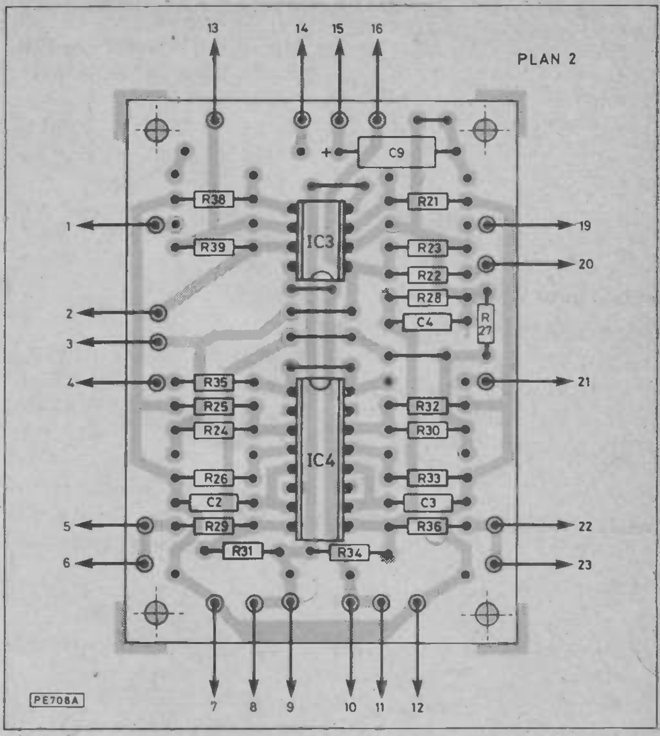
The modules are extremely versatile and economical on the voltages and currents required. The voltage range can be any between +5V/0V/−5V and +15V/0V/−15V, enabling them to be powered either by two 9V batteries, or stabilised power supplies within the above ranges. Using 082s the four input stereo unit draws about 25mA from a +9V/−9V supply. The mono unit draws about 15mA. Virtually all of this is taken by the 082s at around 4mA to 5mA apiece, using 062s the consumption per p.c.b. will only be microamps.

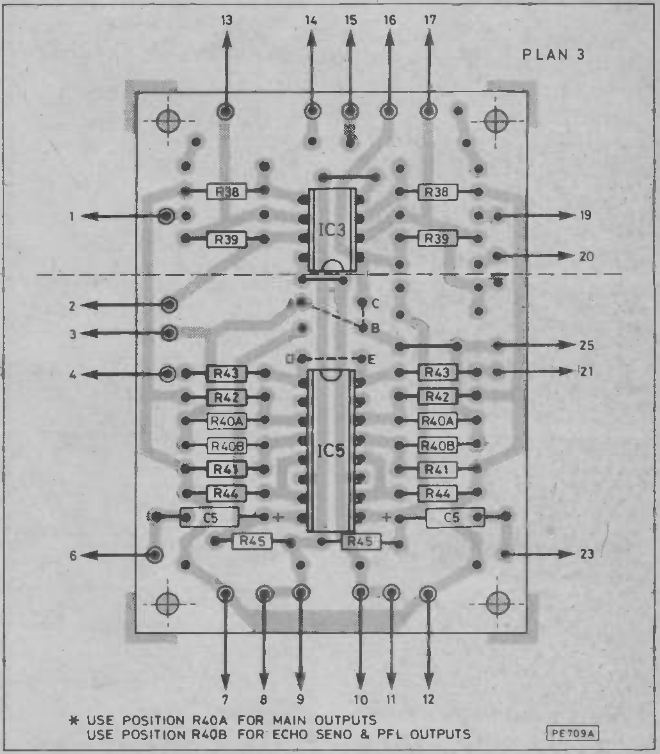
All measurements quoted were taken using a +9V/0V/−9V supply and may vary with other supplies, and also in accordance with normal component tolerances. Where relevant, they are all peak to peak.

PRINTED CIRCUIT BOARDS

Examination of the circuits using the 13600 reveals that there are many similarities between each of them, and with only minor changes one circuit can be transformed into another. The same







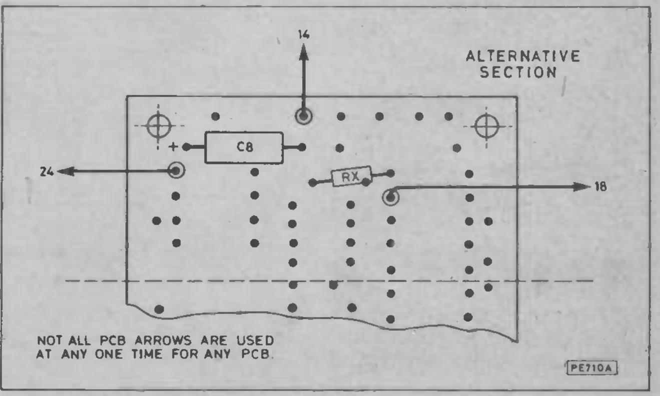


Fig. 3. P.c.b. plan layouts—Note: not all p.c.b. arrows are used at any one time

COMPONENTS . . .

VC4–1 MONO MIXER (4 CHANNELS)

Resistors

R1–R3, R5, R9–R12, R21–R24, R27–R31, R34–R39, R38–R40, R44	100k (52 off)
R4, R7, R8, R25, R26, R32, R33, R41, R42	1k (20 off)
R6, R43 (see text)	47k (5 off)
R37	20k
R43 (see text)	390k
R45	10k (2 off)
R46	4k7
All resistors ¼W 5%	

Capacitors

C1, C5	1µ 63V electrolytic (6 off)
C2, C3	180p polystyrene (2 off)
C4	33p polystyrene
C6, C7	22µ 16V electrolytic (2 off)

Potentiometers

VR2, VR4, VR5	100k mono rotary (6 off)

Semiconductors

IC1, IC3	TL082 (3 off) (see text)
IC2, IC4, IC5	LM13600 (4 off)

Switches

S1–S4	min s.p.d.t. (7 off)
S7	min d.p.d.t.

Miscellaneous

P.c.b. clips (16 off); knobs (6 off); p.c.b, (4 off); 8-pin i.c. socket (3 off); 16-pin i.c. socket (4 off); mono jack socket (6 off); box 230mm × 130mm × 55mm; feet (4 off)

VC4–2 STEREO MIXER (4 CHANNELS)

Resistors

R1–R3, R10–R12, R17–R19, R21–R24, R27–R31, R34–R36, R38–R40, R44, R47, R48	100k (83 off)
R4, R7, R8, R14, R15, R25, R26, R32, R33, R41, R42	1k (36 off)
R6, R13, R43	47k (11 off)
R9, R16, R45	10k (12 off)
R20	510k (4 off)
R37	20k
R46	4k7 (3 off)
All resistors ¼W 5%	

Capacitors

C1, C5, C8	1µ 63V electrolytic (9 off)
C2, C3	180p polystyrene (4 off)
C4	33p polystyrene (2 off)
C6, C7	22µ 16V electrolytic (2 off)

Potentiometers

VR1, VR2, VR4, VR5	100k mono rotary (12 off)
VR3	1M mono rotary (4 off)

Semiconductors

IC1, IC3	TL082 (5 off) (see text)
IC2, IC4, IC5	LM13600 (8 off)

Switches

S1–S3, S5, S7	min. d.p.d.t. (8 off)
S6	min. s.p.d.t. (4 off)

Miscellaneous

P.c.b. clips (32 off); knobs (16 off); p.c.b. (8 off); 8-pin i.c. socket (5 off); 16-pin i.c. socket (8 off); mono jack socket (5 off); stereo jack socket (2 off); box 280mm × 195mm × 90mm; feet (4 off).

applies to the op-amp stages around the 082 i.c.s. These similarities enable a general purpose p.c.b. to be used that caters for all the combinations of components within the various circuit configurations. This p.c.b. holds one 082 i.c. and one 13600.

The positioning of the components and their values determines the function that a particular board will perform. It will also be seen that by using a spare section of one i.c. on one board, a link can be made across to another board reducing the total i.c. count and minimising cost. In Fig. 3 the main p.c.b. variations are shown. Plan 1 consists of two stages for either input gain circuits (Fig. 2a or Fig. 2b), and two stages for either one pan and level control (Fig. 2c), or two separate level controls (Fig. 2d). Plan 2 consists of an entire VCF circuit, and a spare mixer stage (Fig. 2f). Plan 3 consists of two output stages (Fig. 2g), and two mixer stages (Fig. 2f). In some cases only the lower section of Plan 1 and 3 needs to be used, leaving the upper section empty. This enables miscellaneous components such as C8 from an echo return input, or one of the level biasing resistors R37 or R46 (Rx) to be mounted there.

From the p.c.b. block diagrams for the two practical examples, it will be seen which configuration plans are needed to construct mixer variations other than those shown in detail. The interwiring of such alternative combinations can also be seen from the wiring charts of the main examples.

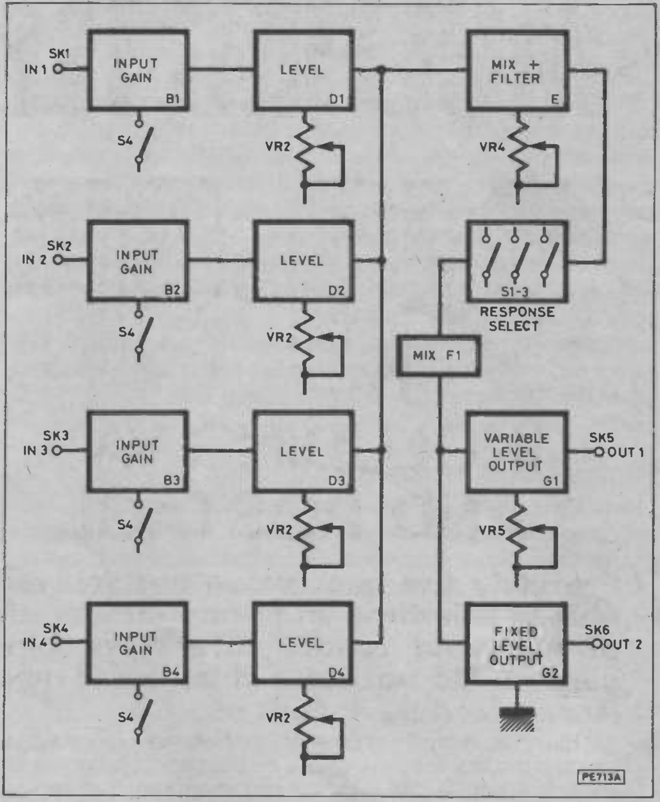


Fig. 4. Block diagram of the VC4–1

FOUR INPUT MONO MIXER

Fig. 4 shows the block diagram for constructing a four input mixer with switched gain, separate level controls, and a master filter, feeding to two outputs, one at a fixed output level, the other fully variable. The individual circuit blocks used are four circuits of Fig. 2b, using switchable gain settings, four circuits of Fig. 2d, providing individual level control, one filter stage, one mixer stage and two output stages.

Front panel space of the box used prevents the use of a separate level control for the second output stage (though one could be mounted on the back). This output is more suited for use with a monitor, and produces a maximum output level of 1V when being fed by one channel, with the output of IC1 at 1V and VR2 at maximum. Otherwise, apart from the level difference the second output delivers a signal identical to that from the first.

Next Month: 4-Input Stereo Mixer, more constructional details and final checking and testing procedures.

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Introduction to MICRO SYSTEMS

MICHAEL TOOLEY BA **DAVID WHITFIELD** MA MSc CEng MIEE **PART 4**

Last month, in Part 3 of this series, the business of getting a microprocessor system up and running was considered in some detail. Having got the basic system going, the way in which the micro communicates with the outside world needs to be examined. First, however, an overview of the start-up procedure.

START UP OVERVIEW

Having looked at each of the stages in starting up a micro system, it is useful to review the overall process to see how the various pieces fit together. One of the best ways of doing this is to follow the CPU's actions after a power-up reset. This is most easily illustrated by watching the progress through the address map of the system. In effect, this is the same as watching the value of the program counter (PC). Two snapshots of the memory map for the example system introduced in Part One are shown in Fig. 4.1 and Fig. 4.2.

The action after switch-on is shown in Fig. 4.1, where the CPU accesses the start address for the reset routine by putting values of FFFE and FFFF on the address bus, and then jumps to the address contained in these two locations. As mentioned, the ROM is located at address C000 to C3FF, but the partial address decoding causes FFFE/FFFF to access C3FE/C3FF, respectively. In the snapshot, we assume that the reset routine starts at C000. The first action in this routine is shown as setting up the stack pointer to locate the stack at the top of the RAM (007F). The CPU then steps through the routine to configure the peripherals (PIA and ACIA). At the end of this routine, interrupts are enabled, and the CPU starts executing the main loop of the program.

A general view of the type of main loop to be found in such a system is shown in Fig. 4.2. This is typically an outer loop which repeats as the CPU goes through a sequence of looking at the inputs from the outside world, and taking any necessary action by setting outputs. At the point indicated, the program has branched two-deep into subroutines, and the stack shows that the two return addresses have been automatically pushed onto the stack.

At one point during the second subroutine, a third subroutine call was made, but since then a return (RTS) has been executed. The return address for this third-level subroutine is still on the stack (a pop does not delete anything from the stack), but the SP indicates that it occupies the next free locations on the stack, and hence will be over-written by any subsequent stack push, e.g. the PSHA instruction about to be executed to temporarily save accumulator A's contents on the stack.

This brief overview of the workings of a micro system from start-up will, it is hoped, help to consolidate the earlier discussions. To look at some practical applications, however, we will need to look at how the micro relates to the outside world through its peripherals.

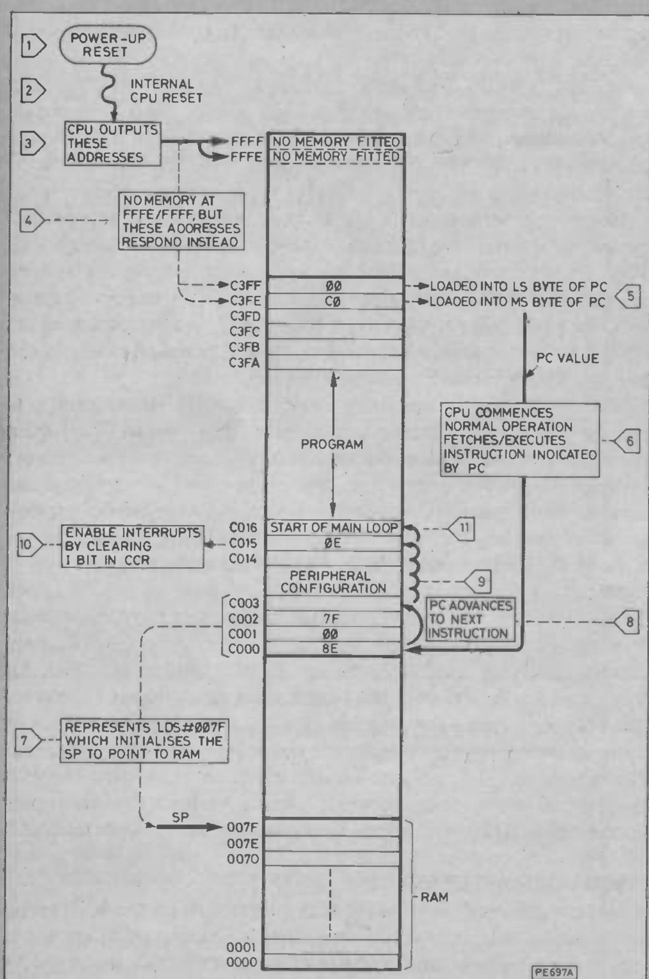


Fig. 4.1. CPU action after switch-on. The reset routine start address is located at addresses C3FE and C3FF

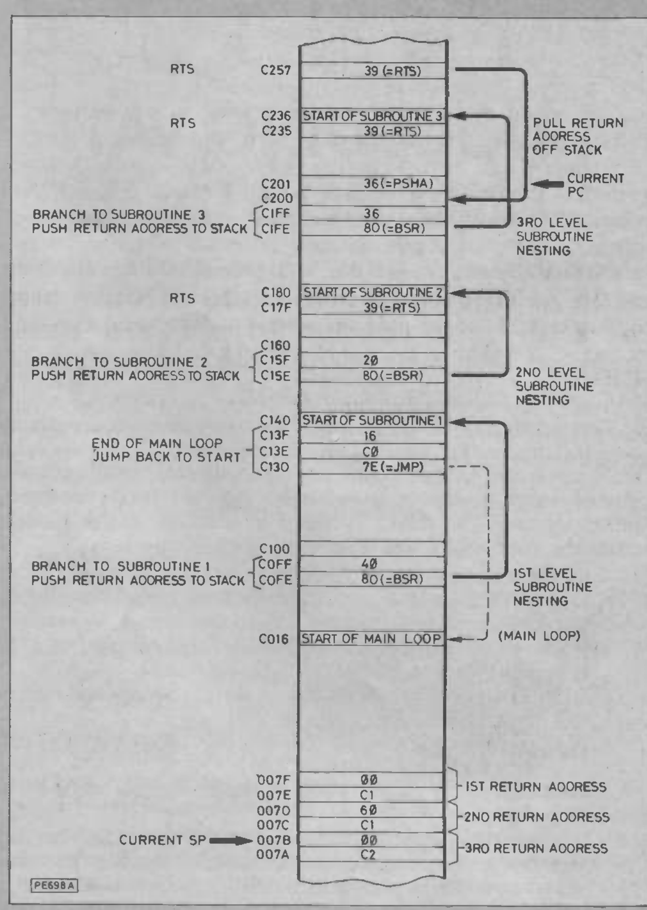


Fig. 4.2. Diagrammatic representation of a microprocessor system's actions, some time after start-up. Two subroutines have been partly-executed, and the program is currently completing subroutine number two, having executed the whole of subroutine three

INTERRUPT-DRIVEN SYSTEMS

Interrupt-driven systems represent an important category of systems in the field of control applications. However, understanding the workings of interrupts involves a significant change to the way in which we think of the working of such a system. Do not despair, therefore, if what follows seems a little difficult to follow at first; all should become clear in due course.

To date, we have thought of the CPU as being at the heart of the system, working its way logically through the control program. At each point in the program (particularly at the decision branches), it is possible to predict the system's subsequent behaviour simply by looking at the preceding sequence of instructions and the values of data in the various locations. Some of these locations may well form part of peripheral controllers, rather than be data stored in RAM, but it is still true that these locations will only be examined at the instigation of the control program. If the programmer chooses not to look at a particular memory location or peripheral register, then there is (as yet!) no other way to gain the attention of the CPU. Thus the CPU traces a continuous thread through the control program.

The introduction of interrupts to the scene, however, means that we also need to take account of the behaviour of the outside world when trying to determine the way in which a system will behave. No longer are the sequence of instructions in the program and the value of data the only factors affecting the system's behaviour at any instant. In addition, we must also consider the occurrence, or otherwise, of any external events which could give rise to an interrupt.

INTERRUPT PROCESSING

When an interrupt signal is recognised by the CPU, it causes the processor to stop what it is currently doing (usually at the end of the current instruction), and save its current status on the stack. The CPU then jumps to a special routine (known as an interrupt handler) which handles the necessary processing for the interrupt. The exact details of this processing will depend on the nature of the interrupt, and on the design of the system.

When the processing in the interrupt handler is finished, the CPU status prior to the interrupt is restored, and processing resumes from the point at which it was interrupted. The interrupted processing will thus proceed, unaware of the interruption.

The effect of an interrupt can thus be thought of as being similar to inserting a temporary subroutine call into the normal flow of the program. The previously continuous thread of the control program has been interrupted to perform some other task, one which does not necessarily bear any relation to the processing in hand at that time. The position of this notional subroutine call is determined only by the value of the program counter at the instant that the interrupt occurs. This effect is illustrated in Fig. 4.3.

But why, you may well be asking by now, should we want to use an interrupt—surely a subroutine call is just as good? The short answer is that interrupts allow us to design a more flexible system, and to make much better use of the available processing power of the micro. Interrupts allow the system to spend time examining and controlling input or output events *only* when they occur, allowing the rest of the micro's time to be devoted to other useful tasks.

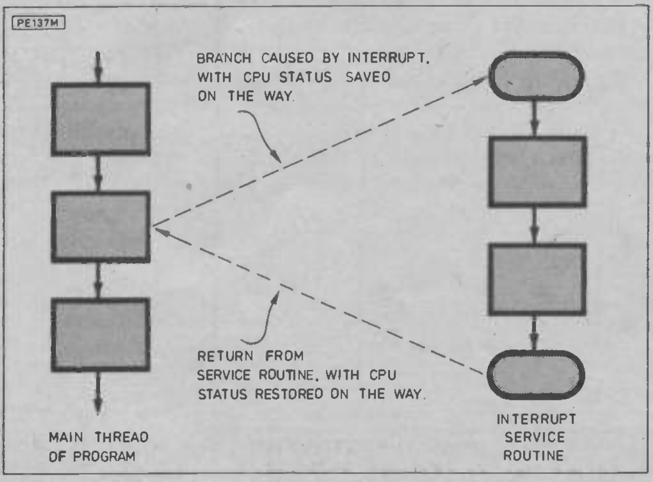


Fig. 4.3. Interrupt handling: the main program is suspended while the interrupt service routine is processed

The alternative to using interrupts involves the control program checking for the occurrence of an event at regular intervals. The interval between this checking (or *polling* as it is often called) needs to be at a minimum of half the time within which a response is required from the system. Thus, if an event occurs once a second, it is necessary to check at least every 500ms if we are to make sure that an event will not be missed.

However, if the event in question only occurs infrequently, but in bursts, this can easily result in quite a significant amount of wasted processing. It also means that the design of such a system becomes rather more complicated than would be the case if some other method could be found to attract the CPU's attention to the occurrence of an event.

INTERRUPT vs. POLLED

At this point, it is becoming clear that a brief practical examination of the use of interrupts is necessary in order to clarify their potential usefulness. We will take as an example, therefore, a 6800-based system designed to control a cash register.

It is not uncommon for such machines to keep a track of the date and time for printing on the sales receipts. However, to save on hardware (in what is a highly competitive market), a complete calendar and clock in hardware is not usually included in the system. Instead, a very basic source of clock "ticks" is provided. This is typically a one-tick-every-second square wave derived from a crystal oscillator and a divider chain, with the remaining functions performed in software.

If interrupts are not used, the cash register program will need to keep looking at the clock input to see if it has "ticked" since it was last checked. If it has, then the software clock (which is used by the other parts of the program) will need to be updated; otherwise no action need be taken. The problem which quickly becomes apparent with this approach is that the control program *as a whole* needs to be designed to keep looking at the clock input, no matter which branch or loop it is currently executing. This clearly makes the whole process rather inelegant to say the least, and results in a control program which is very complicated and/or inefficient to implement.

However, if we use a clock interrupt as an alternative approach, it is possible to produce a much more elegant and efficient design. The first step is to arrange for the clock to cause an interrupt every time it ticks. The exact arrangement will depend on the configuration of processor and peripheral devices being used; the discussion of the 6821 PIA device a little later will examine a practical example of a suitable arrangement for a 6800 system.

The next step is to provide an interrupt handler whose job it is to handle the clock interrupts whenever they occur. The main processing of this service routine will be to check that the interrupt is indeed from the clock. If so, the routine will acknowledge the interrupt and update the software clock kept in a pre-determined group of memory locations. The final step will then be to restore the state of the CPU registers, and return to the main program.

With this type of approach, there is no need to poll the clock input, and no requirement for the remainder of the control program to worry about servicing the clock. All that has to be done is for the interrupt service routine to be set up at initialisation, with the appropriate start value for the clock's current setting in the selected memory locations. The main program can then simply use the clock time whenever required, and need never be aware of the interrupt being serviced. The only noticeable effect to an outside observer will be that whenever an interrupt is being serviced, the interrupted section of program will appear to run rather slower than normal.

6800 USER INTERRUPTS

A description of the working of the interrupts on the 6800 serves to round off our necessarily brief look at interrupts. There are in effect three types of hardware interrupt on the 6800: Reset ($\overline{\text{RES}}$), Non-Maskable Interrupt ($\overline{\text{NMI}}$), and Interrupt Request ($\overline{\text{IRQ}}$). Most of our previous discussion, however, relates to only one of these types, the user interrupt ($\overline{\text{IRQ}}$). For completeness, we should mention that there is also a software interrupt (SWI), which is initiated by executing an SWI instruction; this is provided for applications which are rather beyond the scope of this series.

All of the hardware interrupts in the 6800 are activated by a logic 0 level on the appropriate CPU pin. The various interrupts are listed above in decreasing order of precedence, e.g. the reset interrupt takes precedence over the other two. The $\overline{\text{RES}}$ interrupt was dealt with last month in some detail, and while it is not a true interrupt in the sense that we have been using, many of its characteristics are the same. The other two interrupts behave in essentially similar ways, the only real difference between them being that the programmer cannot choose to ignore (*mask out*) an $\overline{\text{NMI}}$, whereas this can be done for an $\overline{\text{IRQ}}$.

The 6800 system is designed to look for the start address of the various interrupt service routines at defined locations in the highest memory addresses (between FFF8 and FFFF). The fixed arrangement of memory and start addresses assumed by the CPU is shown in Fig. 4.4. Thus, following the detection of a logic 0 level on the $\overline{\text{IRQ}}$ input, the CPU completes the execution of the current instruction, and then tests the interrupt mask (the I bit in the Condition Codes Register (CCR)). If the mask bit is set to logic 1, the interrupt is ignored, and the program continues execution. If the mask bit is clear, the interrupt sequence proper then begins.

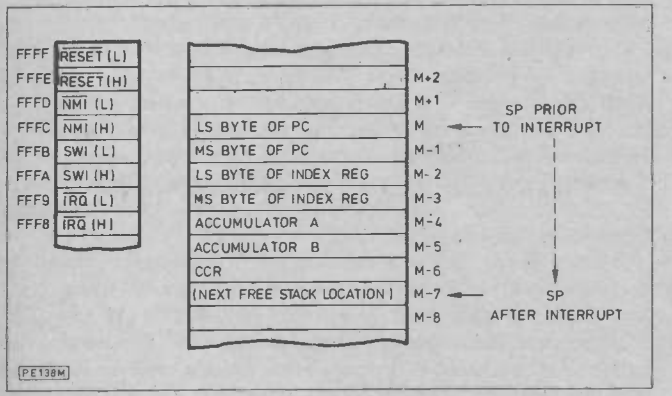


Fig. 4.4. Left, location of interrupt service routine addresses. Above, stack contents after an interrupt

The CPU status is first pushed onto the stack. This uses 7 bytes to save the contents of the Program Counter (PC), the Index Register (IR), the two accumulators (A and B), and the CCR, as shown in Fig. 4.4. The next step is to set the interrupt mask, thereby preventing any subsequent interrupts from interrupting the service routine currently in progress. The CPU then fetches the start address for the $\overline{\text{IRQ}}$ interrupt service routine from locations FFF8 and FFF9, and processing continues from the address indicated. This technique of getting the start address from locations permanently assigned by the CPU is known as *vectoring*, and is widely used by micros.

In some cases, it may be desirable to clear the interrupt mask at some point in the service routine (using a CLI instruction). This will allow further interrupts to be recognised during the processing of the first, thereby allowing a system to be implemented which can handle multiple interrupts. The saving of CPU status at each interrupt means that the interrupts will be stacked (a process known as *nesting*) up to a limit determined only by the amount of stack space available. All of the nested interrupts in such a scheme will eventually be serviced on a last-come-first-served basis.

On the other hand, if a CLI is not executed during the service routine, interrupts will not be nested, and each interrupt will be processed to completion before the next is recognised.

At some point during the interrupt service routine, and *before* interrupts are re-enabled during the routine if this is required, the interrupt request must be reset at source. Otherwise the same event will cause a further interrupt to be recognised for the same event. Thus, in our example, the interrupt could be caused by a rising clock edge setting the output of a flip-flop to a logic 0. This output would be connected to the CPU's user interrupt pin. Remembering that the CPU recognises a logic level (not edge), it is clear that this flip-flop must be reset (output to a high) by the service routine before interrupts are enabled if repeated false interrupts are to be ignored.

At the end of the service routine, an RTI instruction must be executed. This pops the register contents from the stack, thereby restoring the state of the CPU prior to the interrupt. Processing then resumes from the point at which it was interrupted.

In a system where there is only one peripheral capable of generating an interrupt, the source of any interrupt is known, and servicing can begin immediately. However, although the 6800 has only one interrupt line for user interrupts, many systems will have more than one possible source of interrupt. Not only does the CPU then have to be able to decide on which device requires service when an interrupt does occur, but it must also be able to handle the situation whereby more than one device is requesting service at the same time.

In this introductory series, we can do little more than introduce the concept of organising interrupts in order of importance (priority) so that the most important is dealt with first. Suffice to say, however, that many systems make use of special purpose peripheral chips as well as software to handle interrupting devices to any level of sophistication. In any circumstances however, the objective remains the "simple" one of getting each interrupt serviced correctly, preferably in order of their importance.

6821 PERIPHERAL INTERFACE ADAPTOR

The 6821 Peripheral Interface Adaptor (PIA) is one of the range of support chips which provides a very flexible means for interfacing parallel peripheral equipment to a 6800-based system. The peripheral side of the interface provides two parallel 8-bit buses and four control/interrupt lines. The pin connections are shown in Fig. 4.5, while Fig. 4.6 shows the internal architecture.

The 16 data lines, PA0 to PA7 and PB0 to PB7, can each be configured separately as either an input or an output, all under program control. This allows any combination of input and output lines to be established. The four control/interrupt lines (CA1/2 and CB1/2) may be configured to act in one of several modes for handshaking with peripheral equipment. This includes using them for generating interrupts to the CPU.

Internally, the 6821 contains two very similar but independent sections ("A" and "B"). Each section comprises an output register, a control register, and a data direction register. Data is transferred from the CPU via the data bus buffers and bus input register to the output registers (and hence to the outside world) during a CPU write operation. Where a particular PIA data line has been programmed as an output, data will be then transferred to this line from the corresponding data bus line. Where a particular line has been programmed as an input, a CPU read operation will cause data to be transferred to the data bus, and hence to the CPU.

The data direction registers allow each data line to be separately configured as either an input or an output. The control registers allow the CPU to establish and control the operating modes of the peripheral control lines (CA1/2 and CB1/2). In addition, they provide flags to indicate when an interrupt has occurred.

A basic programming model for the 6821 is shown in Fig. 4.7, and

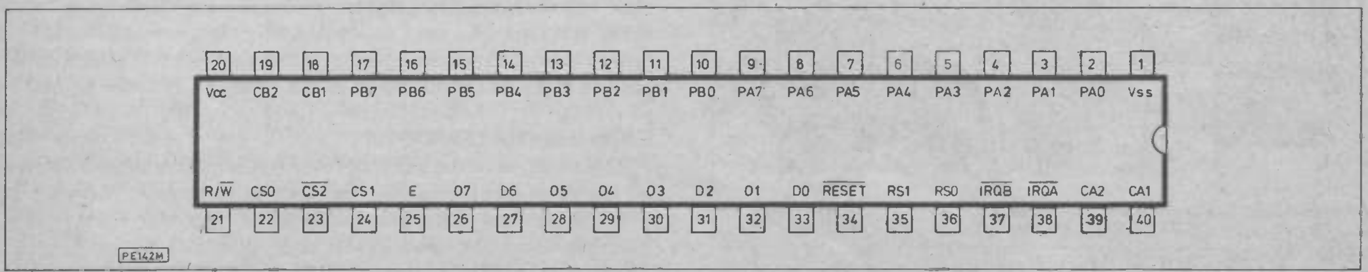


Fig. 4.5. Pinout for the 6821 Peripheral Interface Adaptor

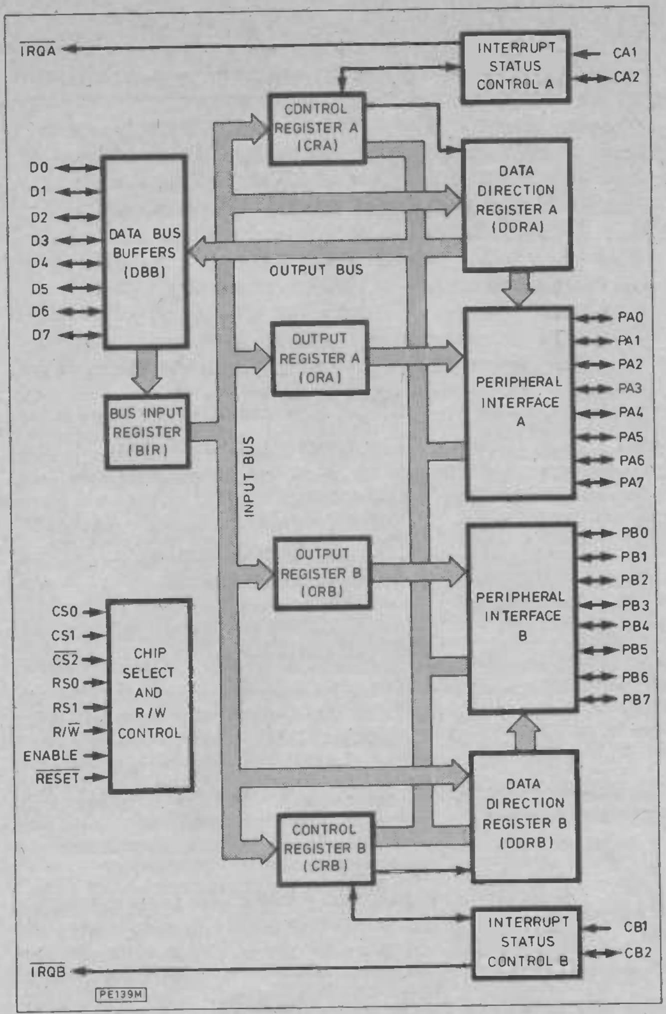
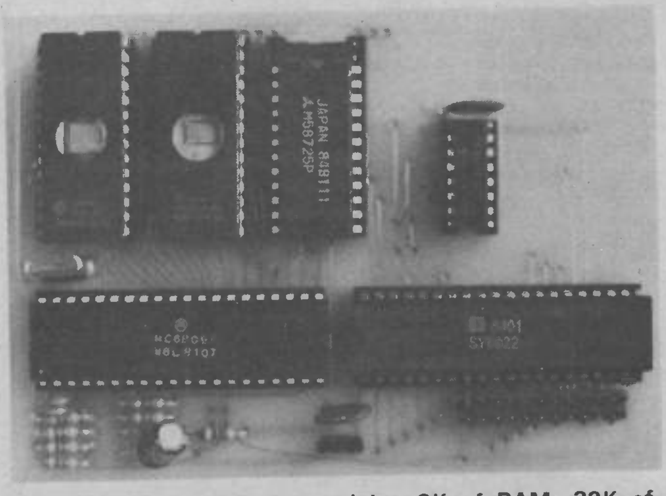


Fig. 4.6. Internal architecture of the 6821 PIA. This chip provides two 8-bit I/O buses

this identifies the various registers available to the programmer. The three registers in each half of the PIA make use of only two memory addresses. One of these two addresses is reserved for the control register. The register indicated by the second address of each pair is determined by the setting of bit 2 in the corresponding control register; 0=data direction register, 1=output register. In the data direction register a bit is set to a 0 to make the corresponding line behave as an input, and to a 1 for it to behave as an output. All 8 lines are configured at the same time for input/output, by the CPU writing a one-byte value to the corresponding address, remembering to first set bit 2 of the control register to a 0.



A microcontroller board containing 2K of RAM, 32K of EPROM, and a 6522 Versatile Interface Adaptor. The CPU is a 6809, an enhanced version of the 6800 containing on-chip clock circuitry, pseudo 16-bit architecture, and more than 100 instructions in its basic repertoire

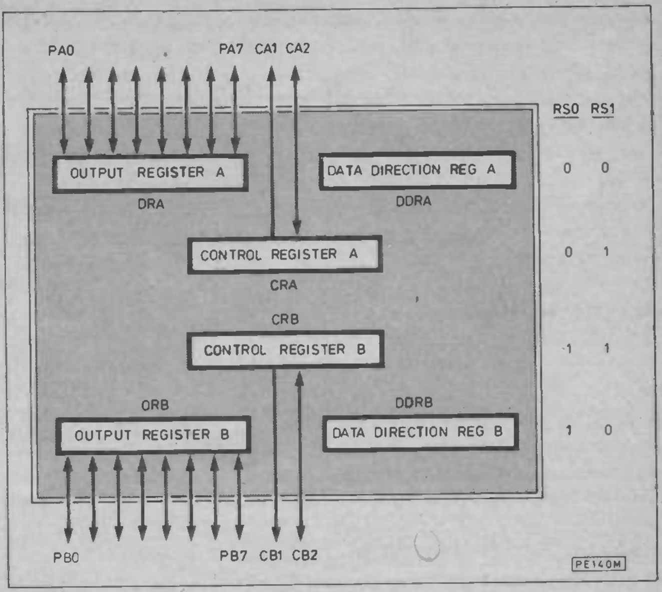


Fig. 4.7. Programming model for the 6821 PIA

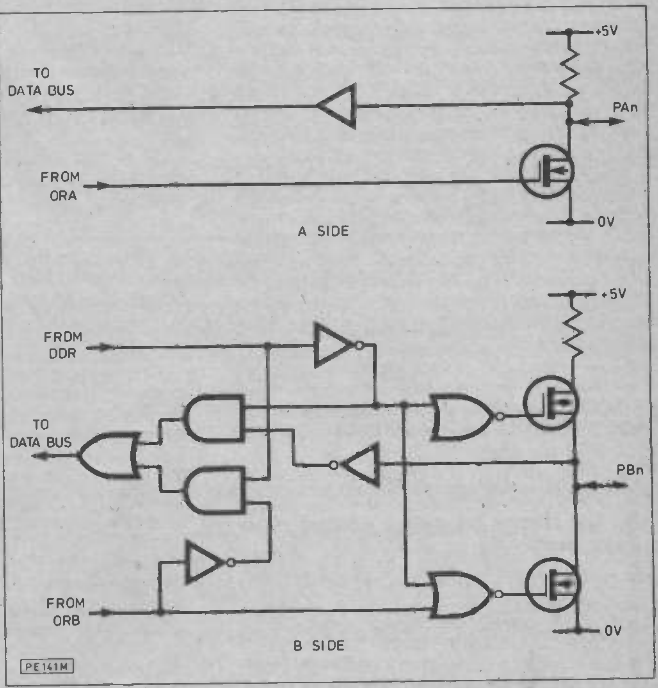
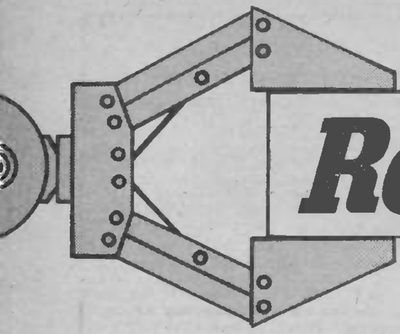


Fig. 4.8. Data transfer via the PIA, "A" and "B" sides

Both "A" and "B" sides will drive two TTL loads on each data line being used as an output. One of the only differences between the "A" and "B" sides of the PIA concerns the data input characteristics. The output stages for "A" and "B" sides are shown in Fig. 4.8. The circuitry on the "B" side adopts a tri-state (high impedance) condition on input, whereas the "A" side inputs are taken high by internal pull-up resistors. "A" side signal sources therefore require an impedance to 0V of 1k or less to assume the low state. The logic 0/1 levels are <1·4V/>1·6V for "A" and <0·7V/>3·0V for "B". The "A" and "B" sides are otherwise identical.

The PIA is configured to respond as a particular set of four addresses by driving the select inputs from a suitable address decoding arrangement. Thus, whenever an address in the correct range is output by the CPU, the PIA is enabled. The other inputs from the control bus to the PIA ensure that the correct bus phases are used. Thus, for example, a PIA could be configured to be enabled whenever an address in the range 1000 to 101F is output on the address bus. The lowest two address lines will then usually be used to drive the PIA's register select inputs (RS0 and RS1) directly. The correspondence between these select lines and the PIA registers is included in Fig. 4.7. In our example the PIA registers would then typically be accessed by the program as addresses 1000 to 1003.

NEXT MONTH: Setting up the PIA, generating a clock interrupt, and an introduction to the 6502.



Robotics Review

Nigel Clark

ONE of the pioneering names in pérsonal robotics in Britain has disappeared almost completely from the market. **Powertran Cybernetics** has moved from its long standing home in Andover, Hampshire, to Crowborough in Sussex alongside its parent company **Feedback Instruments** and at the same time most of Powertran's robots have been merged with those of Feedback.

The Genesis and Micrograsp names will disappear but the machines will continue in different guises sold by Feedback as will the recently-launched Ivax Scara robot. That will leave Powertran with Hebot II, the computer-controlled turtle-like mobile as its only stake in the robot market, alongside its other interests including musical equipment and home security devices.

The Genesis P101 and the bigger P102 were the first small robots to be powered hydraulically. A five axis standard arm it could lift 2·5kg and had its own controller based on a 6802 processor. The P101 had 2K of memory allowing eight sequences of 32 moves each to be stored with the P102 being able to store eight sequences of 64 moves.

They were sold as kits at prices of about £1,400 for the smaller machine and £1,800 for the larger. Feedback sold the machines made up as the HRA 933 and HRA 934 for about £2,700.

. . . a flurry of sales about two years ago . . .

Mr Jack Hale, managing director of Feedback, said that for some time sales of the kits direct to consumers had only been a small part of Powertran's output. There had been a flurry of sales about two years ago when colleges preferred to buy at the lower prices but since then most of the kits had been going to Feedback in this country and the States to be made up and sold as complete systems.

"We thought it would be better to put the whole production under one roof where we could produce complete robots for only a little more than the cost of the kits and sell them under the Feedback name along with our other educational products which would allow us to provide the full back-up service which our customers require," Hale said.

They have dispensed with the smaller machine and will only be selling the HRA 934.

The cheaper, mechanical arm, Micrograsp, which has four axes is powered by servos with potentiometers and costs about £400, will be substantially upgraded.

"The original machine was designed down to a price which resulted in a number of features we did not like, such as the gripper and the power system," Hale said. He added that in all there would be between 40 and 50 changes resulting in a machine costing about £1,000 and having a much longer life than the original Micrograsp.

After all the changes Feedback would have a broad range of arms with the Pedro Scara arm at the top of the range, costing about £5,500, followed by the IVAX, the Genesis/HRA and the upgraded Micrograsp. Powertran will continue the sell the Micrograsp kits until present stocks run out.

The expected launch of two more imported toys by **CGL** of Essex has been postponed until next year. It had been intended to put Charles and Armstrong 800 on sale during the summer but the company decided to wait so that it could unveil them to the retail trade at the toy fairs in the first few months of 1986 in order to catch the Christmas market next year.

The rest of us will be able to catch glimpses of them at the computer shows during the year.

. . . infra-red controlled from a hand-held keyboard . . .

Charles is a more complex version of the popular George Compurobot, a battery-powered mobile which can be programmed to carry out a number of moves using the membrane keyboard on its top. To give it added interest it has a siren and flashing lights. Charles has the extra facility of being infra-red controlled from a hand-held keyboard.

Armstrong 800 is a conventional arm with gripper which can be programmed and is infra-red controlled.

CGL says that no prices have been fixed as the import price is set in dollars so the UK retail price depends on the level of the exchange rate. However, they are both simple devices, in robot terms, and are likely to be in the range of £50 to £100.

At the same time as arms are having their capabilities expanded by the creation around them of work cells of varying complexity, turtles are being enhanced by the provision of increasing amounts of software. When most were launched they came with sufficient software to allow them to be controlled by a micro, usually using some form of Logo and little else.

Clwyd Technic's Trekker was the first machine to give equal importance to the software and was packaged from the start with a wide range of programs and documentation.

Valiant Designs, builder of the Valiant Turtle, is now developing a series of microworlds which can be explored using the turtle, nicknamed Myrtle.

. . . a big help to the many people who buy a turtle . . .

At the moment there are two on which most of the development work has been completed, provisionally titled Treasure Map and Time Machine. Although written in the form of games they are intended to be educational. Treasure Map involves following a set of map instructions and Time Machine is concerned with learning geometry by meeting its creators.

In addition Valiant is considering a general package of about 50 ideas for uses of the turtle. That would be a big help to the many people who buy a turtle or arm because it is the latest in modern technological aids but then find they do not know what to do with them.

There are further developments for the Zero II, the turtle-like mobile from **IGR,** launched at the beginning of the year at less than £100. Interfaces are now available for the Atari 800 and Research Machines as well as the original BBC B, Spectrum and C64. And versions are being developed for the Apple and IBM PC in response to interest in the versatile device from the States.

Robin Bradbeer of IGR said that as expected when it was launched a number of third party companies have shown an interest in developing software and hardware to be added to it. IGR is also looking for people to produce the bump sensors and hole sensors which are in prototype but are not being produced in numbers because of lack of time.

Finally for the DIY enthusiasts there is a book, published by **Beaver Books,** entitled Make And Program Your Own Robot (£2.95). Written by Michael Clark (no relation) it details seven projects for building your own devices from Lego. It is available through **Commotion** of Enfield.

George, Charles and Armstrong 800

Drill Control Unit

William Woodard

Clever control circuitry takes the drudgery out of drilling, providing high torque and high current

MANY readers will have small low voltage drills for making printed circuit boards using drill bits as small as 0·6mm up to 1·0mm in diameter and driven by mains power supply units giving between 12V and 18V output. Most of these small drills give about one thousand revolutions per minute per volt and whilst the top speed is necessary for the smaller bits some speed control is desirable for drilling larger holes. P.s.u.s suitable for the smaller drill with speed control have been around for some time supplying about 2A for normal running and up to 4A to safely deal with extra current taken when the motor stalls.

Model makers are the largest group using these drills and often adapt them for other purposes. Many modellers make up a mini workshop with electric tools such as circular saw tables, jig saws, sanders and lathes as well as mini drill stands.

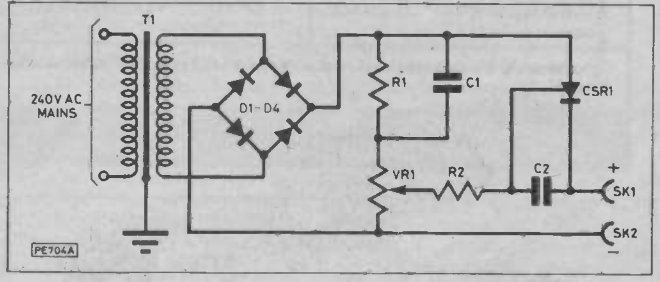


Fig. 1. Conventional control circuit

These tools require a bigger motor to cope with the more ambitious projects and this requires a more powerful p.s.u. Many of these tools have motors rated at 100W, not far short of one eighth horse power, requiring 8A when fully loaded and something in excess of this when the motor is stalled.

The speed control project described here has been well tested in practical use running circular saws etc., and is capable of supplying a 100W motor, maintaining full torque at low speeds. It seems quite happy to stand the excess current of a stalled motor whilst a fuse is making up its mind to blow. It's quite simple to build and does not cost an arm and a leg!

CONVENTIONAL CIRCUITS

As a matter of interest an earlier conventional circuit is shown in Fig. 1. It is quite adequate for the smaller drills and units employing this circuit can be obtained cheaply on the surplus market. At high currents the most highly stressed components are the rectifiers because they have a low thermal inertia and the current through a stalled motor can be many times the average current. They can be called upon to dissipate as much as 12W when used with the larger drills and this makes them hot and bothered.

IMPROVED PERFORMANCE

So what is required from a p.s.u. for improved performance? Economy and simplicity in design, and reliability as in all designs, should be taken for granted although very often they are not. Also:

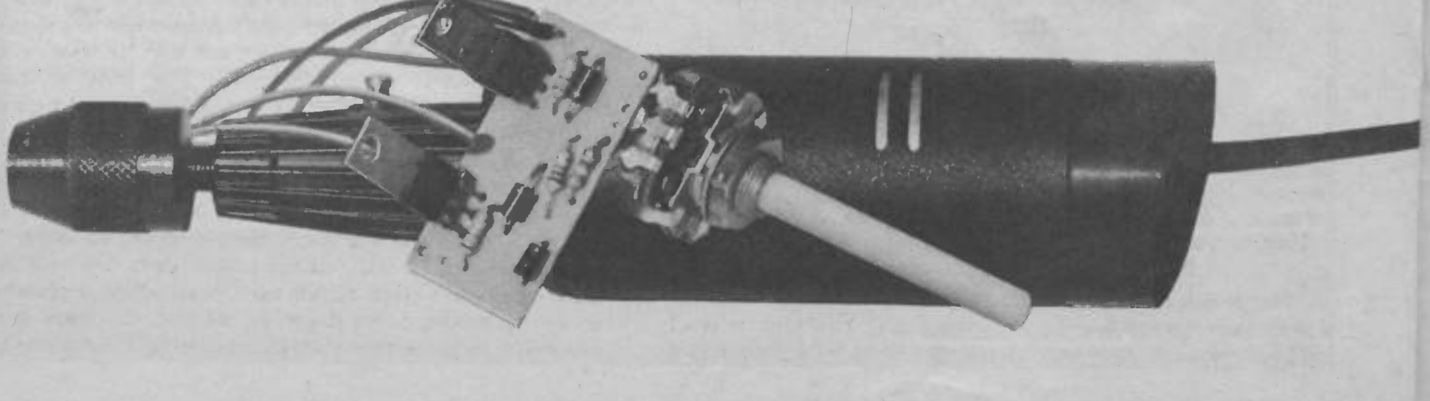
a) Full torque available at all speeds.
b) A large speed range.
c)The ability to accept overloads.
d) Maximum efficiency.

An improved circuit is shown in Fig. 2, and it is seen that it employs two thyristors, and the power rectifiers have been dispensed with. Thyristors being larger than diodes have a greater thermal capacity and the type used can handle an average current of 4A and a higher peak current with a square inch or so of heat sink. Comparing the two circuits the overall heating has been reduced by 60 per cent and the thyristor loading is now shared between the two components.

A small disadvantage is the need for a centre tapped transformer in that the regulation is not as good as a bridge circuit with a single winding transformer. But, there is a trade off in that there is only one volt lost in the rectification circuit instead of three volts as in the bridge plus thyristor arrangement. Perhaps worse is that centre tapped transformers cost a little more. (A good engineer must be very cost conscious!) The two diodes included in the circuit carry only small currents but 1A diodes are specified to take care of any current spikes.

Because of the intermittent nature of the load it is not necessary to have a continuously rated transformer. For a duty factor of 40 per cent averaged over say 15 minutes (that is the tool being used at full power for 40 per cent of the time) a transformer rated at 4A is suitable for most applications. This is born out in practice.

Most of the drills are given a rating af 12V for some 12,000 to 15,000 r.p.m. but it's usual to provide a transformer with secondary windings giving 15V. This will give a maximum no-load voltage a little higher than 12V across the motor terminals with the control turned to maximum, but with the control turned down the speeds and voltages will be approximately proportional to the angle through which the control is turned.



CIRCUIT OPERATION

Looking at Fig. 2, and following the circuit from the transformer it appears as a standard bi-phase rectifier except that the rectifiers are thyristors. To put these into conduction a positive potential on the gates relative to the cathode is required and this provided by the resistors R1 and R2.

A potential divider is formed by the resistor chain VR1, R3 and either R1 or R2 depending on which diode is conducting. This controls the voltage on the gates during the positive half of the cycle on the anode and therefore the degree of conduction of the thyristor.

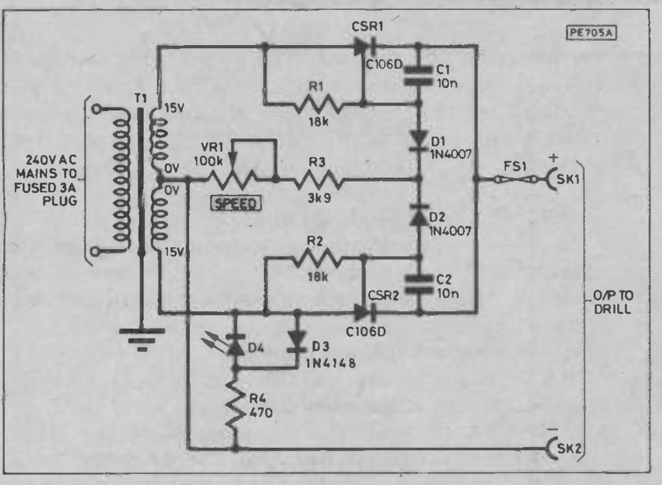


Fig. 2. Complete circuit diagram of the Drill Control Unit

The diode connected across the l.e.d. is there to limit the negative voltage that would otherwise impair its operation since it is fed from the a.c. line. A signal diode is adequate because the current is limited to 20mA by R4.

Depending on the setting of VR1 the thyristors conduct for a number of cycles and then stop conducting until the speed drops enough to start again. This mode of operation has the great advantage of not producing interference pulses on the mains as would be the case if thyristors were used to vary the conduction angle by chopping each half wave. It saves the cost of interference suppressors and simplifies the circuit.

A minor disadvantage is that irregular running occurs at very low speeds when the motor is running free. This is minimised by pre-setting the minimum speed to about 300 r.p.m. by including R3 in the control circuit. This still allows a useable speed range of 40 to 1 or more.

The authors own set up consists of a mini-drill with drill stand and a mini circular saw table. With these tools, some etch resist transfers, pens and etchant solution, it is very simple to make small p.c.b.s—rather more convenient than strip board.

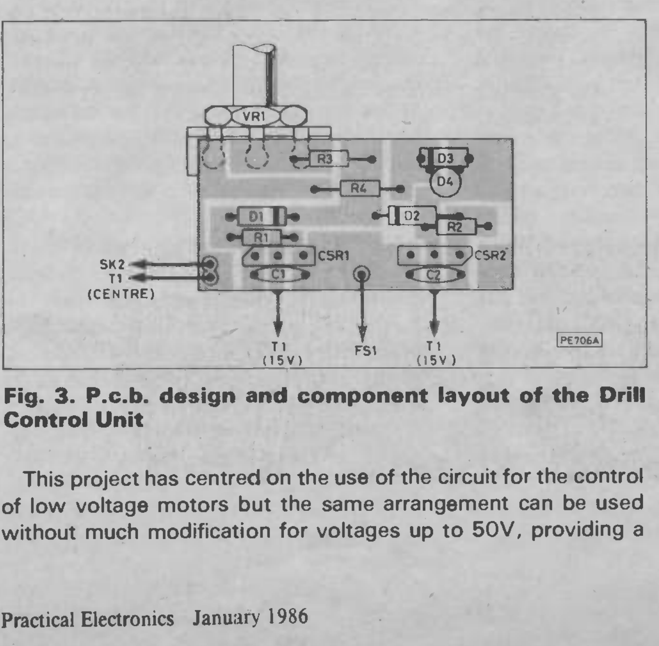


Fig. 3. P.c.b. design and component layout of the Drill Control Unit

This project has centred on the use of the circuit for the control of low voltage motors but the same arrangement can be used without much modification for voltages up to 50V, providing a centre tapped transformer is available. The resistors R1 and R2 should be uprated to ½W, the capacitors changed to a higher working voltage and the resistor in series with the l.e.d. changed to a suitable value.

COMPONENTS . . .

Resistors

R1,R2	18k (2 off)
R3	3k9
R4	470
All resistors ¼W 5%	

Capacitors

C1,C2	10n 100V ceramic (2 off)

Potentiometer

VR1	100k 1W log

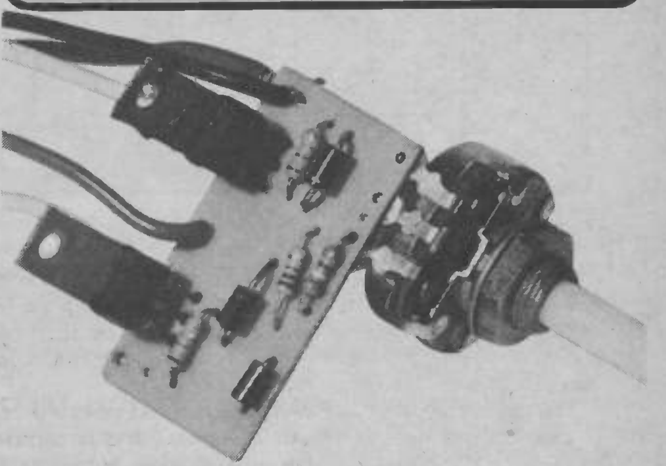
Semiconductors

D1,D2	1N4007
D3	1N4148
D4	0·2" l.e.d.
CSR1,CSR2	C106D (2 off)

Miscellaneous

T1 15-0–15V secondary, 1A continuous rating for small drills up to 40W, 4A rating for drills up to 100W; p.c.b.; wire; cable; solder; sockets; fuse, etc.

Constructors' note: A full kit of parts for the Drill Control Unit is available from: **Croydon Discount Electronics, 38 Lower Adiscombe Rd., Croydon, Surrey CR0 6AA. ☎ 01-688 2950.**



CONSTRUCTION

It may be convenient to mount the p.c.b. shown in Fig. 3, on the potentiometer; it is small enough to do this and the layout has been designed with this in mind, otherwise the potentiometer can be wired.

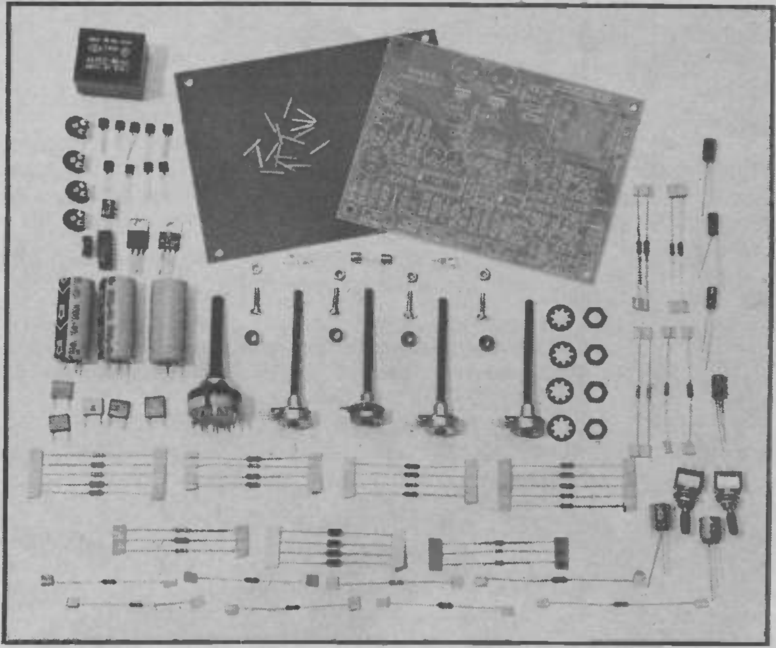
For convenience the resistors and diodes are the first to be inserted into the board which is then inverted on to a piece of sponge for soldering. This prevents the components falling out again. The l.e.d. and the thyristors can then be inserted and soldered in place. Don't forget to check for dry joints and solder bridging the tracks and make sure that the diodes and thyristors are inserted the right way round.

Since the circuit is called upon to carry high peak currents the wiring from the transformer and to the drill should be reasonably heavy to minimise volt drop. Wires of 0·75sq.mm (6A) will be adequate. When everything has been checked, the p.c.b. and transformer may be mounted in a suitable case. The case used, depends on the type of transformer chosen which is dependent on the load likely to be driven by the unit. If a large load is envisaged, larger heatsinks will be required for the thyristors. ★

FIXED AND SWEPT FREQUENCY SIGNAL GENERATOR

KIT REVIEW

STEVE TAYLOR *



SPECIFICATION

Frequency Range: 1Hz to 600kHz in intermediate ranges
Frequency Ratio: 1:100
Waveforms: Sinusoidal, Triangular, Square
Output voltages: Sine/Triangular variable (1V r.m.s. max)
Square wave 12V
Saw tooth voltage: 5V p-p
Distortion: 0·5% (max)
Rise time: square wave—100ns
Sweep frequency: 0·1Hz–100Hz
Sweep ratio: 0–1:1000
Sweep drive: linear, logarithmic, manual
Synch. pulse voltage: 5V p-p (TTL)
Dimensions: 130mm x 100mm
Supply voltage: 240V 50Hz

MICROPROCESSORS, robotics, radio, model control, audio, video ... each an aspect of "electronics", and each with its own distinct types of circuitry and hardware. However, everyone actively involved with the nuts and bolts of electronics will quickly find that after the soldering iron, multi-range meter and a simple oscilloscope, they need some other test equipment.

Nothing too sophisticated you understand, perhaps just (open your wallet) £500 worth of audio distortion analyser? £2,000 worth of digital logic analyser? Or can we stretch to just £12,000 worth of r.f. spectrum analyser? Well, before mortgaging the BMX or the BMW, why not try some d.i.y.?

Now available, for the "small" electronics workshop, for schools and colleges, for the hobbyist and all who suffer budget restrictions, is a range of test gear kits which can be used individually or can be combined for more complex tests and measurements, at prices ranging from £6 to £60.

A VERSATILE SIGNAL SOURCE

The Swept-Frequency Generator kit (see circuit in Fig. 1) was chosen for this review because the finished item is so versatile and useful as a source of square, sine, sawtooth and triangular waveforms of adjustable height and frequency. Furthermore it can be made to sweep repeatedly through a wide range of frequencies up to 1MHz. And, with its variable internal sweep function, which can either apply sync. pulses to, or be synchronised from, external equipment, the generator can be coupled to a single beam 'scope to form a basic, but useful whole-spectrum display of frequency responses.

TYPICAL APPLICATIONS

1. Digital. For microprocessor and digital work the square wave and sync. outputs are a convenient source of variable frequency clocking signals or, by synchronising the module to an external clock, adjustable-period delay signals can be obtained.

As a source of fast rise-time sync. or clocking signals it is best to buffer the output to match it to the external circuitry, particularly for driving five volt TTL. A suitable buffer circuit is shown in Fig. 2.

2. Waveform Synthesis. For the music synthesiser buffs, the ramp, square and sine outputs can be used for tone creation and envelope shaping. The sawtooth and square outputs are low impedance drives, which are ground-referenced and can be used directly to drive most external circuits. For minimum distortion, the sine/triangular output should be treated as a one kilohm source and to avoid loading effects it may need buffering in a simple emitter follower stage as shown in Fig. 3.

Tremolo and reverse (downward) sweep effects can be applied directly to the "Lin 2" pin on the board, with the log/lin switch in the centre position. The rotary range-change switch supplied with the kit has a spare switch action which, as shown in Fig. 4, can be used to automatically connect the "Lin 2" pin to external equipment when the switch is in the centre (fixed frequency) position.

3. Radio and Telecomms. The r.f. and communications applications include checking channel bandwidth and dynamic range, c.w., RTTY and modem filter response measurements, audio FSK generation and variable-width r.f. "comb marker" generation.

Speech processing and compression circuits can be checked using the fixed frequency sinewave output and the "Level" control. The overall channel bandwidth can be found by monitoring the channel output while applying a "log" swept sinewave to the input, using Range 2 (10Hz–10kHz). A similar technique is used to check audio filter responses.

Care should be taken with active filters, or where there are "gain blocks", to avoid exceeding the dynamic range, or hitting the supply rails. As a general rule tests should be made with as low a signal level as practical. Even entirely "passive" LC filters can suffer from saturation effects! As shown in Fig. 5 (and described below), with careful use of a 'scope to monitor the output level, it is possible to display the swept frequency response in a form such that the 3dB points can be determined by noting the frequency

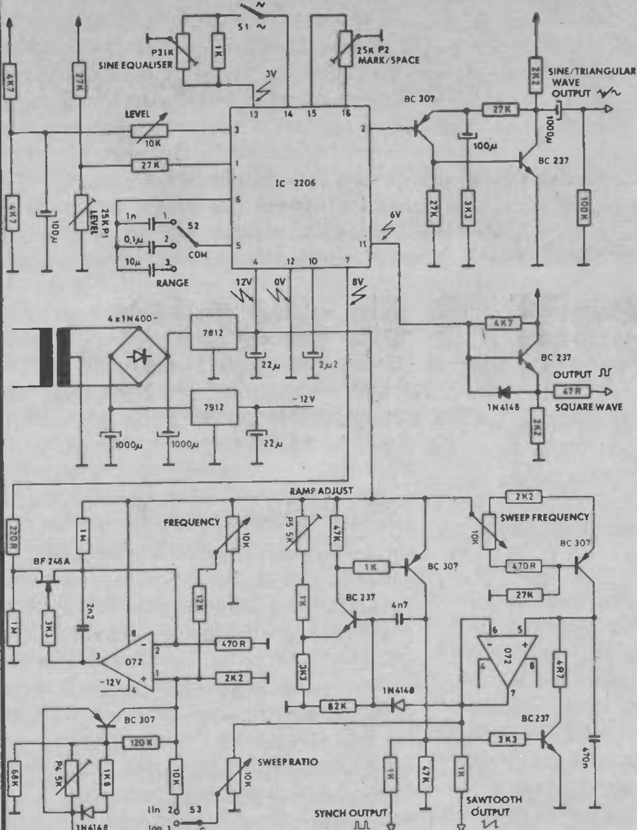


Fig. 1. Circuit diagram of the kit as shown in the instruction leaflet

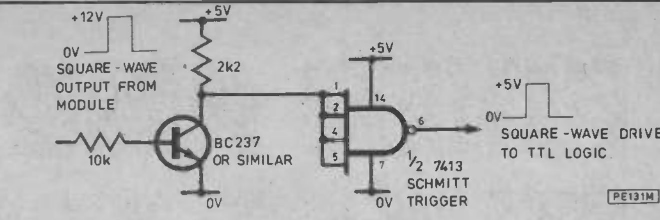


Fig. 2. Buffer circuit to drive 5V TTL from the generator's 12V square-wave output

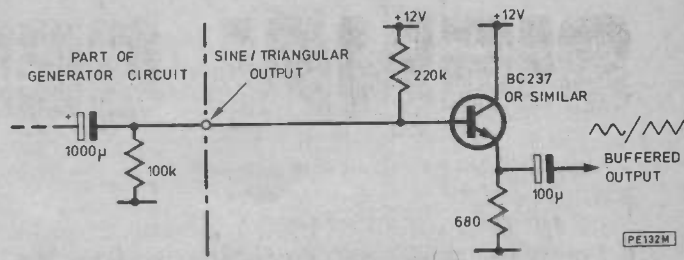


Fig. 3 (above). Buffer stage to isolate and reduce the output impedance of the sine/triangular source

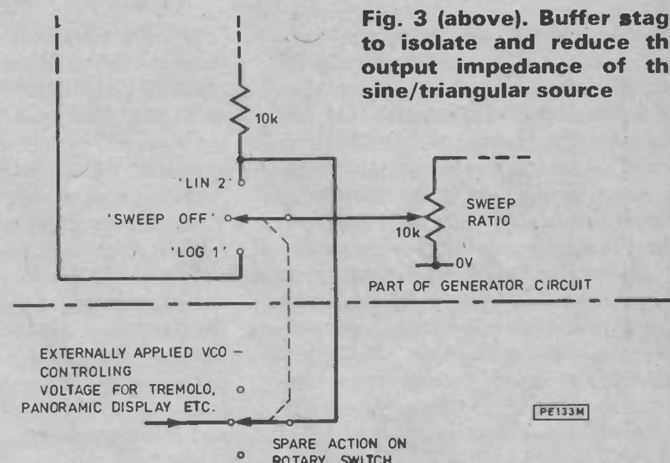


Fig. 4 (right). Additional switch function giving access to the VCO control circuit

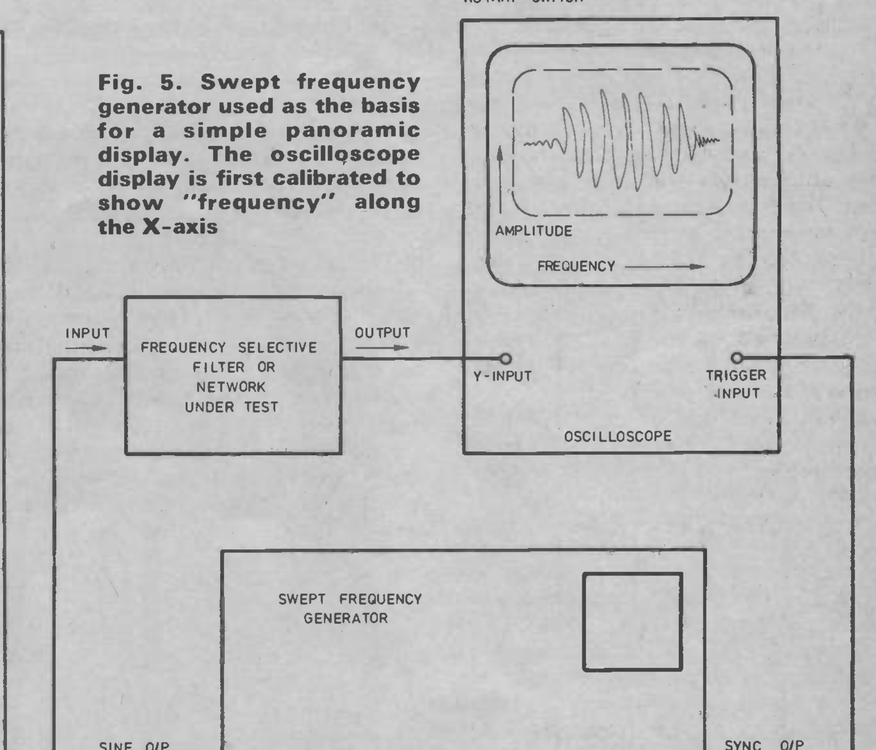
at which the peak-to-peak voltage falls to 71 per cent of its mid-band (or maximum) level. The X (horizontal) axis of the 'scope which is normally calibrated in "time" can be re-calibrated in "frequency". Fig. 6 shows a practical example of a frequency/voltage plot relating the generator output frequency to the "Lin 2" pin voltage.

The set-up shown in Fig. 5 is easy to calibrate, requires no sophisticated test gear and is surprisingly effective. Being a continuous panoramic display it can be left scanning to show immediately the results of cut-and-try circuit engineering, tone control adjustments or filter component changes.

For modem, AMTOR, RTTY and other frequency/shift (FSK) experimental work, apply a low level square wave to the "Lin 2" pin on the board, and adjust both the "Frequency" setting pot and the amplitude of the applied square-wave. A typical relationship between the output frequency and the voltage at "Lin 2" pin is shown in Fig. 5. Due to component variations between modules these curves should be used as a guide only.

If you are experimenting with modems or speech networks remember that it is both dangerous and illegal to connect this, or any non-approved apparatus (including test equipment) to BT telephone lines. Offenders can be detected with inevitable disconnection of service. Re-connection cannot

Fig. 5. Swept frequency generator used as the basis for a simple panoramic display. The oscilloscope display is first calibrated to show "frequency" along the X-axis



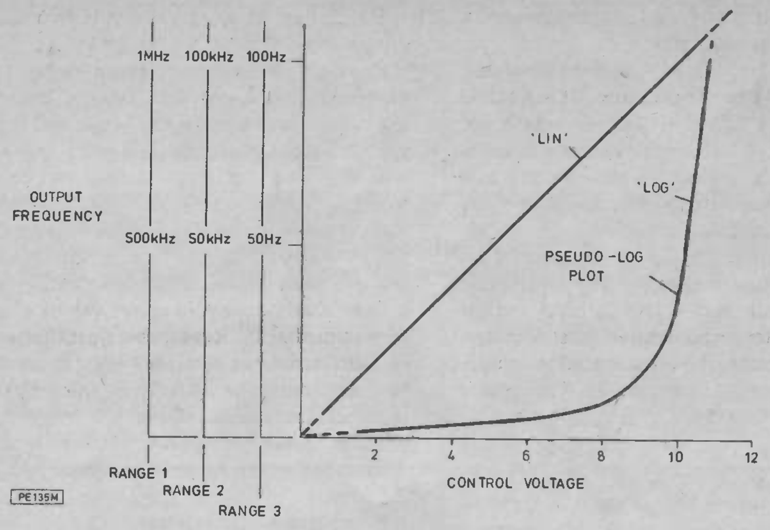


Fig. 6. Typical output frequency for each range, versus "lin" and "log" input control voltages

then be guaranteed simply by paying the court fine and offering to pay the BT connection charge.

4. Video. Video experimenters will find their own mind-blowing uses for the rámping and square-wave switching waveforms. The sweep function can be synchronised to external timebases, or line or frame sync. pulses, by setting back the "sweep Frequency" pot so that the module's own sweep repetition rate is slightly less than the external rate. Then by applying a positive-going sync. pulse to the "sync. output" pin, triggering will occur at the input rising edge.

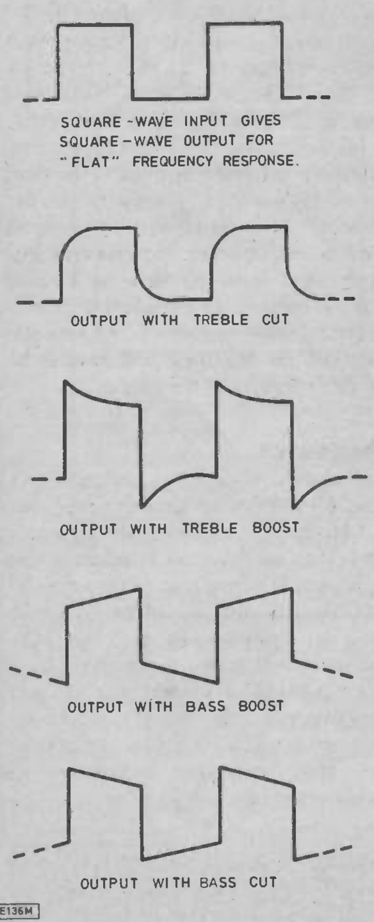


Fig. 7. Use of square-wave signal to indicate frequency response of amplifiers, tone control circuits, graphic equalisers, etc.

5. Audio. Audio enthusiasts will find the fixed and sweeping facilities invaluable for checking the ultimate frequency and phase responses, throughout the audio and supersonic ranges, of amplifiers, filters, graphic equalisers etc. As shown in Fig. 7, fixed frequency square-wave testing of amplifiers gives an immediate indication of the frequency response by the degree of "overshoot" or of "droop". The effect of introducing, or changing the setting of, bass and treble controls can be seen immediately, and the centre point (i.e. no cut, no boost) can be identified by noting the setting where the output wave form is truly rectangular and undistorted.

CONSTRUCTION

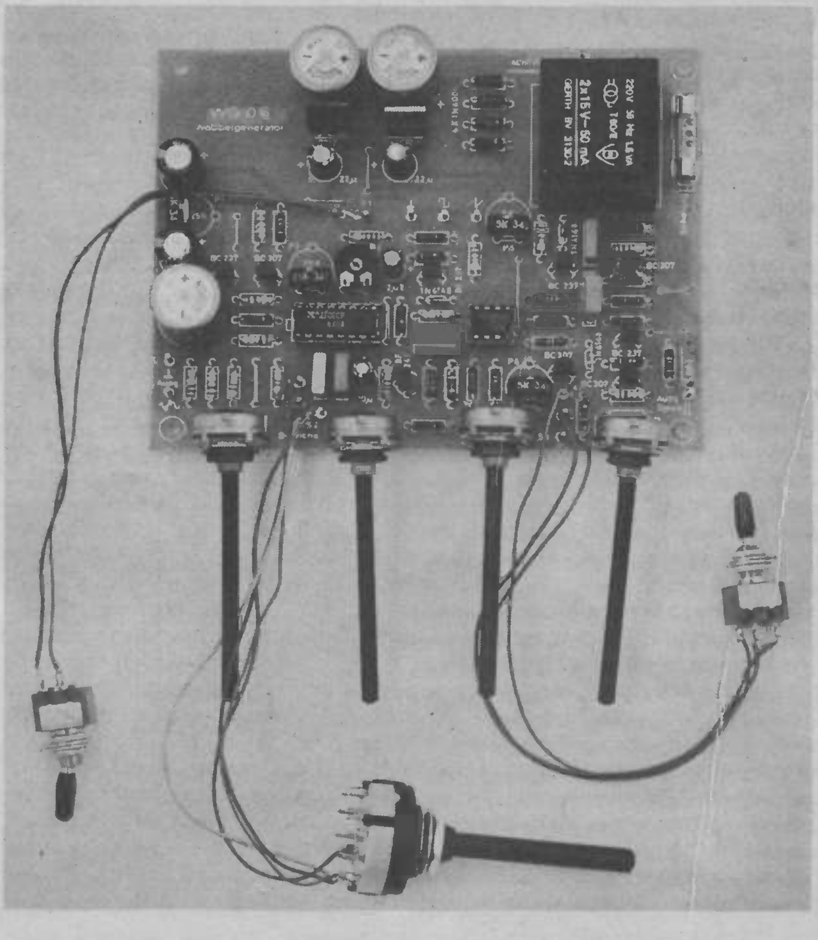
The well presented and carefully packed kit comes complete with all the components, hardware, assembly instructions and simple setting-up procedure to produce the fully working, mains powered module. There is even a plastic base plate to protect unwary fingers from the on-board 240V. For the complete novice, there is a sheet showing illustrations of all the components, each one identified by name, by picture and by symbol. From a reproduction of the top legend we learn that "Wobbelhub" and "Wobbelfrequenz" in "foreign" mean "Sweep Ratio" and "Sweep Frequency".

The more experienced constructor will appreciate the quality of the kit with its clear top legend and solder-resisted p.c.b. This makes the assembly very straightforward, with all the components of Fig. 1 mounted on a single 130mm × 100mm p.c.b. However, a few words of caution.

Check that each component is correctly positioned and oriented in the board before wielding the soldering iron. Mistakes can be corrected afterwards, but probably at the expense of the p.c.b. track, or the component itself. Finally check the finished assembly and solder-work before switching on! Active devices can be swiftly and silently destroyed if incorrectly connected. Likewise for electrolytic capacitors . . . except that they tend to be noisy and spectacular!

Above all, remember that there is full mains voltage on the p.c.b. tracks under the transformer and the mains input fuse. Although there is a protective plastic cover, the experienced constructor will already have covered the live tracks with insulating

Photograph of the complete kit showing all components supplied



tape. The less experienced constructor should learn to do likewise!

The finished module will look like that shown in the illustration, with four on-board pots and, on flying leads, one rotary switch and two toggle switches. After setting up, the module can be housed in a case (the DX1 or AE1 cases from Cirkit are ideal), or it can be included in a larger composite piece of test equipment which might include an accurate digital frequency meter.

OPERATION

Referring to Fig. 1, at the heart of the circuit is a waveform generator based on the XR2206. This i.c. has two frequency adjustable outputs. One gives a sine or triangular waveform (switch selectable via S1), the other gives a square waveform. The sine/triangle waveform is also adjustable for level. Both outputs are buffered to give a low impedance, and in the case of the sine/triangular output, an a.c.-coupled output. The three position rotary switch selects the required frequency range:

Range 1 1kHz to 750kHz
Range 2 10Hz to 10kHz
Range 3 0·67Hz to 125Hz

The circuitry around pins 5, 6 and 7 of the TL072 dual op-amp produces a sync. pulse for external use and a sawtooth waveform which, after conditioning in the log/lin circuitry around pins 1, 2 and 3, is applied to pin 7 of the XR2206 to produce an "upward" swing in the output frequency. Toggle switch S3 selects the log. or lin. sweep function. The centre (off) position disables the sweep function, so that the output frequency remains constant. The four pots control:

1. "Level", the output signal level.
2. "Frequency", the output frequency, or in the case of sweep operation, the starting frequency.
3. "Sweep Ratio", the span of the increasing frequency sweep.
4. "Sweep Frequency", the repetition rate of the sweep.

SETTING UP

The setting-up procedure involves adjusting presets P1 to P5 as follows:

A. Sine Wave Purity. With "sine wave" selected (using S1), the sweep switched off (S3 in its middle position) and the "Frequency" pot set to give a tone of about 1kHz (the second B above middle C on the parlour piano), adjust P2 and P3 for minimum distortion of the output waveform. The distortion can be checked in several ways, e.g.:

1. Display the waveform on a 'scope and adjust for "best shape", using your own judgement or by comparing the shape with that derived from another oscillator. This method has given results of 0·75 per cent distortion.
2. Monitor the output on a pair of headphones (do not load the module's output with anything less than two kilohms). Adjust for "purest tone" with the minimum of high frequency components. The purest tone will sound the smoothest and softest. With care, this method has given results of 0·72 per cent distortion.
3. Using a Harmonic Distortion Analyser, simply tweak for a minimum. This method has given a figure of 0·6 per cent t.h.d. distortion (−43dB) on the lowest frequency range, which is approaching the best which can be achieved (0·5 per cent) with the sine shaper techniques employed.

For audio distortion measurements an input signal from a source with better than 0·01 per cent t.h.d. would be ideal, but for work on filter responses and most commercial (or amateur) communication equipment a level of 0·5 per cent to 0·7 per cent is useful.

B. Output Level. With the "level" pot at maximum (fully clockwise) adjust P1 to give an output of one volt r.m.s. at about 50 or 100Hz on a decent multimeter, or, at say 1kHz, 2·8V peak to peak on the 'scope.

C. Sawtooth Waveform. Adjust P5 for the most accurate sawtooth output. This is not a critical adjustment and the preset can be left at minimum resistance, i.e. at 100 per cent of full travel, to give the widest frequency sweep. Purists can adjust the preset for a maximally straight ramp on the sawtooth waveform.

D. Logarithmic Sweep. The logarithmic law is based on a combined "softened" diode and transistor forward current transfer law. It is only an approximation to a true log law, but the simple circuit used here has the advantage that both log. and lin. laws can be adjusted to cover the same overall frequency range. Preset P4 should be set so that with the frequency control set to a minimum the frequency sweep covers the same span as for the linear sweep. This can be done by going through the setting-up sequence detailed in "Panoramic Display" below.

With these setting-up procedures completed the module is ready for use as a piece of test gear.

PANORAMIC DISPLAY

To use the unit to give a simple panoramic display, the variation of generator output frequency with sweep voltage is determined by grounding the base of Q9 and then, by the use of the "Sweep Ratio" pot., setting the voltage at the "Lin 2" pin at a number of points between 0V and +12V. At each point the frequency can be measured, using the 'scope (frequency is the inverse of the period of one cycle), or more accurately with a suitable frequency meter.

Then, with the 'scope triggered from the module's sync. output and displaying across the screen one full sawtooth waveform from the "LIN 2" pin (*not* from the sawtooth output pin), the 'scope X axis (horizontal) can be calibrated or marked in voltage, by reading off the trace against the normal vertical (Y) voltage axis. (Note: on some 'scopes it will be possible to set the X-axis scale most conveniently to one volt/centimetre). This calibration can then be converted to "instantaneous output frequency" by reference to the frequency/voltage relationship recorded above, which, being similar to Fig. 6 will give a calibration close to 10Hz/cm for Range 3 (or 100Hz/cm for Range 2, or 1kHz/cm for Range 1).

Finally, with the set-up shown in Fig. 5, the output from the network, or filter, under test can be displayed on the 'scope and the point by point variation in overall amplitude can then be seen across the full frequency span.

With this display the qualitative effects on the "shape" of the response curve, of changes made in the circuit or network, or in individual component values, can now be seen immediately. Reasonable quantitative measurements can be made (with the accuracy determined principally by the limitations of the 'scope display) with more accurate, single frequency measurements undertaken when the response shape is as required.

If necessary, the starting and finishing frequencies for the scan can be altered by adjusting the "Frequency" pot and P5, the "Ramp Adjust" preset.

Because the vertical axis of the display is linear, rather than logarithmic, the dynamic range will be somewhat limited for showing ultimate out-of-band filter responses, although careful and cunning use of the 'scope's "Y"-input range switch will usefully expand the vertical scale to show the more attenuated parts of the response.

Also since the control-voltage/output-frequency relationship is linear (as shown by Fig. 6), then a logarithmic frequency sweep along the X-axis can be achieved by applying a logarithmic voltage sweep to the "Lin 1" pin.

It is of course possible to calibrate the X-axis using the on-board log-response circuit via the "Log 1" pin on the module, instead of the "Lin 2" pin, in the above calibration procedure. This will give a non-linear, pseudo-logarithmic horizontal frequency calibration which could be more useful than the linear calibration. To show the classic "text book" filter response shape around the 3dB points however, requires true log-log axes. And it would then be nice to display the response as a single line, in true panoramic display manner . . . All interesting possibilities, but these will have to be left to the ingenuity of the reader.

KIT SUPPLIER

The complete kit at £41 (catalogue stock number 41-01400), the recommended case at £7.50 (type AE1, catalogue stock number 21–06241) or the low-cost alternative case at £5.30 (type DX1, catalogue stock number 21–06010), available by credit card telephone order, or by mail order, from Cirkit, Park Lane, Broxbourne, Herts EN10 7NQ. Tel. (0992) 444111. All prices plus VAT and 60p postage per order (for UK orders—overseas readers contact Cirkit for postage charges etc.), knobs and sockets are not included in the kit.

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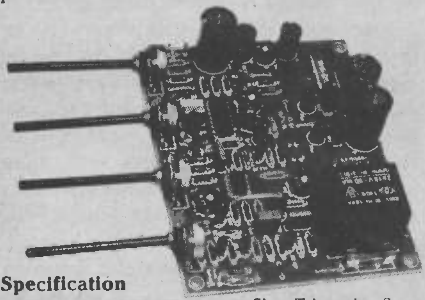
Make it with Cirkit

Swept frequency generator

As featured in this issue of Practical Electronics. A versatile and interesting piece of test equipment for testing amplifiers, digital and switching circuits. Supplied as a kit of parts with PCB, all components, pots and mains transformer.



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SPACE EXPLORERS

The international Comet Explorer, *ICE*, reached its target—Comet Giacobini-Zinner—on 11 September last and has been very successful. It entered the tail 4,890 miles behind the nucleus and rushed through the tail at 45,000 miles per hour. The lack of damage due to tiny meteoritic particles and "dust" was pleasingly reassuring—an omen for Giotto?—and the tail was somewhat broader than had been expected. The magnetic environment was exactly as predicted.

Though the Americans will remain disconsolate about the cancellation of their Halley probe they will at least gain some satisfaction from *ICE* particularly if they manage to recover it in July 2012—as seems possible and which will, if achieved, be a notable "first".

The Russians too have had successes with their *Vega* probes which by-passed Venus en-route to Halley's Comet and dropped probes into the atmosphere of that forbidding planet. On 11 June *Vega 1* dropped a capsule which divided in two; a "lander" which came down north of Aphrodite Terra (one of Venus's two major uplands) and a balloon, which was carried 6,000 miles from the night to the day side and was wafted up and down by winds of several feet per second.

When *Vega 2* dropped its capsule on 15 June the lander came down in Aphrodite Land and identified a rock called anorthosite-troctolite, which on Earth is rare but is abundant on both the Moon and Mars. The interesting point is that the Earth samples are much younger than the lunar or Martian ones. What age are those of Venus? As yet we do not know.

ASTRONOMICAL DECISION

Financial restrictions are having their effect upon astronomy and all associated sciences—that is to say, those which cannot be taxed and which cannot be used to kill people.

The latest casualty is the great 100-inch Hooker reflector at Mount Wilson in California. It came into operation in 1917, and for more than thirty years it was not only the largest and most powerful telescope in the world, but was in a class of its own. With it, in 1923, Edwin Hubble made the observations of short-period variable stars which proved that the so-called "starry nebulæ" were independent galaxies, far beyond our own Milky Way system.

THE SKY THIS MONTH

This year ends with a moderate display of planets. Venus is still a morning object though by now it does not rise very long before the Sun and it is so nearly "full" that small telescopes will be hard pressed to show its phase.

On 4 December Venus is less than 2 degrees south of Mercury, which is above the first magnitude and may be visible with the naked eye. Jupiter is a brilliant evening object, in Capricornus, but it is inconveniently low as seen from Britain, and by the end of December its angular distance from the Sun is only 40 degrees.

Saturn is badly placed though by late December it has emerged into the morning dawn and on the 17th it will be close to Mercury. Mars passes from Virgo into Libra—early in the month it is near Spica—but even at the end of the year its magnitude is no brighter than 1·7 so that it can easily be mistaken for a red star.

Uranus is badly placed for observation but interest in it is mounting as Voyager 2 *draws in towards it. I will have more to say about it next month!*

Two meteor showers occur this month. The Geminids, with a ZHR or Zenithal, Hourly Rate of almost 60 are active between December 7 and 15 with their maximum on the 14th; the Ursids extend between 17 and 24 December, peaking on the 22nd with a ZHR of about 12.

To refresh your memory, the ZHR is the number of shower meteors which would be expected to be seen by an experienced observer under ideal conditions, with the radiant at the zenith. As these conditions are never attained the actual observed shower rate is always rather lower than the theoretical ZHR.

The Ursids are associated with the famous periodical comet P/Tuttle. The Geminids have no known parent comet. The orbit is much the same as that of the remarkable "sun-grazing" asteroid Phaethon discovered by the Infra-Red Astronomical Satellite in 1983 and there have been suggestions that Phaethon is in fact a dead comet.

Personally I am very dubious, if only because spectroscopic observations indicate that Phaethon is rocky rather than icy, but it is certainly strange that there is no known "Geminid comet". Of course this situation is not unique. Neither is there a known parent comet for the Quadrantid meteors which can be very spectacular for a few hours around 3 January; sometimes the ZHR can exceed 100.

HALLEY'S COMET

However, the main attention this month must be on Halley's Comet. In fact, the period from December through to mid-January represents the only real chance of seeing the comet from Britain with the naked eye.

This is one time when even the most enthusiastic lunar observer (such as myself) is not pleased to see the Moon in the sky; and unfortunately the Moon is full on 27 December, so that during the last week of the month it will tend to drown the comet.

It is always dangerous to make exact predictions about comets (remember Kohoutek!) and the magnitudes given in the following table may be very much on the optimistic side but at least the positions are correct. It is seen that by the end of December the comet is still more than 50 degrees away from the Sun.

Date	R.A. h	R.A. m	Dec. ° ′	Magnitude	Solar elongation degrees
Dec. 1	1	5·3	N. 13 39	5·7	132
Dec. 11	23	40	05 59	5·6	99
Dec. 21	22	48	00 51	5·6	75
Dec. 31	22	17	S. 02 19	5·4	57

This is clearly the right time to take photographs of the comet. Various detailed publications have been produced but it is true that fairly elementary equipment can be used to take reasonable pictures—and the next opportunity will not come for more than seventy years.*

Early observations, carried out by astronomers at the observatory on Tenerife, have shown that the comet's coma is larger than expected—in early October it was 9 minutes of arc across instead of only 1·2 minutes of arc, as had been predicted. If this is an indication of what is to come, then Halley may well be more of a spectacle than has been feared.

During December the track carries the comet through Pisces into Aquarius and by the end of the month it will be close to the star Gamma Aquarii; the distance from Earth will then be over 80,000,000 miles. Even when the comet is at its nearest to us, in early April 1986, it will not come much within 40,000,000 miles, as against less than 15,000,000 miles at the last return—1910.

*Such as *The Return of Halley's Comet*, by Patrick Moore and John Mason published by Patrick Stephens Ltd. (paperback).

Mount Wilson has other instruments too: for instance the 60-inch reflector, which was the first of the "modern-type" great reflectors, and two major solar towers, as well as the horizontal Snow solar telescope. Now it has been decided to cut off all their funds and to close the observatory down. The official reason is that the seeing conditions there have deteriorated markedly because of the spread of Los Angeles. This is true enough; but there is still a tremendous amount of important work for the telescopes to do.

It is wrong to believe that the annual cost is great by national standards. If compared with (say) the cost of a nuclear submarine, or even a helicopter, it is absolutely negligible. The loss to astronomy is great—and there are many who look back to the 100-inch with feelings of real affection.

Can we hope for a change of heart? Various ideas are under consideration but at the moment it cannot be claimed that the outlook is very bright. So for the moment, at least, the great telescope has come to the end of its career. On 25 June it was turned to the sky for perhaps the last time and now the observatory is boarded up with cobwebs gathering inside the dome.

Surely there is something wrong with the modern world!

SUNSPOTS

During much of 1985 the Sun has been comparatively inactive and there have been many "spotless" days. However, calculations by D. R. Whitehouse indicate that we are not yet really close to actual minimum which he times for the early spring of 1988. This will mean that maximum will occur in the autumn of 1991.

These forcasts are necessarily uncertain by a month or two either way but they are not likely to be very wide of the mark so that through 1986 and 1987 we cannot expect major groups with their associated phenomena such as aurorae.

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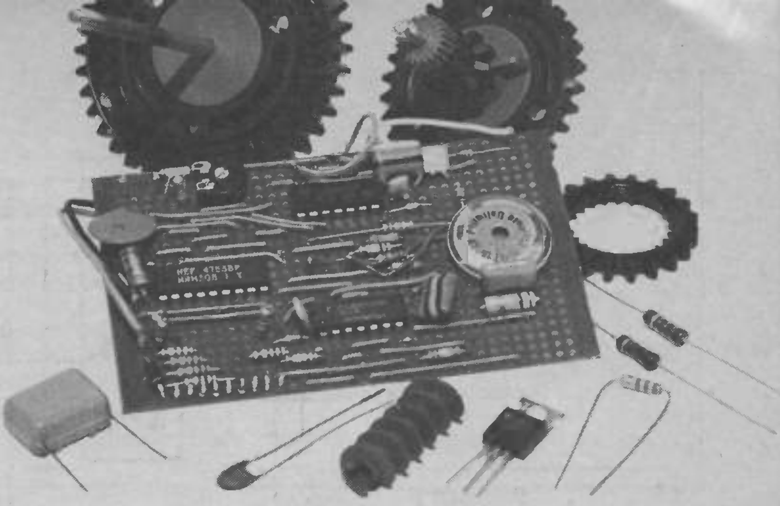
PE BAZAAR JANUARY '86

Experimenting with ROBOTS

Sam Withey Part 5



WITH a growing interest in robotics amongst home computer users and schools there is an increasing need for simple, safe, reliable, motor controllers. Whilst stepper, or stepping motors are essential for accuracy in line plotting and automatic control modes, the fundamental practice in keyboard controlled applications can be achieved though the use of simple low voltage, permanent magnet, d.c. motors of the kind used in toys and models.

The interface described here is not only suitable for driving these motors in forward and reverse directions, but is also a standard interface for controlling bi-polar stepper motors.

The next generation of electronics and computing will make extensive use of optical transmission systems due to their high degree of reliability, speed and comparative low cost. This is effectively an extension of opto-isolator techniques, the simple infra-red l.e.d. being replaced by the laser and the plastic casing replaced by a fibre-optic coupling. Because of their proven reliability and in keeping with the earlier recommendation that the host computer should be optically isolated from any external electrical devices, this interface uses opto-isolators on the computer output and inport ports, but provision is made for disabling the outputs by bringing the normally logic '1' state to ground potential in applications where purely mechanical micro switches are used as limit switches.

CIRCUIT DESCRIPTION

The principal components of the interface consist of two p.n.p. and two n.p.n. transistors arranged as an "H" bridge (Fig. 2). The interface is capable of driving two small d.c. motors or one bi-polar stepper motor in c.w. or c.c.w. direction, the direction being determined by the logic signals present at the base of transistors TR1 to TR4 and TR5 to TR8. The direction of rotation of a d.c. motor is changed by reversing the polarity of the electrical field and transistors TR1 and TR4 can be represented by switches S1 to S4 in the schematic in Fig. 1.

It can be seen that current can only flow through the motor coils when switches S1 and S2 are both closed, or it will flow in the opposite direction when switches S3 and S4 are both closed. Any other arrangement would bring about a short circuit between the +ve and −ve lines.

The n.p.n. transistors TR1 and TR3 (TIP35) conduct when a logic '1' is placed on their base pins, whilst the p.n.p. transistors, TR4 and TR2 (TIP36) conduct when a logic '0' is placed on their bases. As the bases of TR1/TR4 and TR3/TR2 are coupled together, only one transistor of each pair can be turned on at any time no matter what logic state exists at their common base junction. The commoned emitters of TR1/TR4 and TR3/TR2 are connected across the commutator of the motor M1. The table indicates the performance of the motor in accordance with the truth table of the logic state on the bases of the transistor pairs.

Base Logic	TR1/TR4	Base Logic	TR3/TR2	Motor direction
0	On/Off	0	On/Off	Stop
0	On/Off	1	Off/On	Forward
1	Off/On	0	On/Off	Reverse
1	Off/On	1	Off/On	Stop

It can be seen that the transistor switches respond in the same manner as the mechanical switches, i.e. TR1/TR2 ON causes the motor to rotate in one direction, whilst TR3/TR4 ON causes the motor to rotate in the opposite direction. However, due to the use of n.p.n. and p.n.p. transistors in series, the possibility of a short circuit is removed. Transistors TR5/TR6 and TR7/TR8 behave in the same manner.

Whilst transistor types TIP35/36 are used here, providing up to 1A, types TIP31/32 can be used if up to 3A is required. In the same way, more powerful transistors can be used externally, but the protection diodes should be upgraded to a suitable value.

Diodes 1 to 4 and 5 to 8 protect the transistors from damage by back e.m.f. generated by the motor coils in the short period when the motors stop rotating.

OPTO ISOLATORS

The transistors of the opto isolators are held high at logic '1' by a resistor between their collectors and supply. With D0 to D3 set as outputs the transistors cannot be turned on. By bringing the cathodes of their l.e.d.s low relative to anode either by placing a logic '0' on the respective data line, or with a micro switch, pulling the data line low, the l.e.d.s is turned on. This turns on the transistor, bringing its collector low. This changes the logic state at the bases of the coupled motor driver transistors.

Where electrical signals provide inputs D4 to D7 are set as inputs and held high by a resistor (the author used 1M to limit current drain on computer supply) until a signal on the l.e.d. of the opto isolator turns the associated transistor on, bringing its collector low to logic '0' providing an active input.

NOTE: In applications, where limit switches are used to turn off a motor, care must be taken to ensure that the switch is connected to the data line normally set at logic '1' to run the motor.

CONNECTION TO THE COMPUTER

Quad-opto-isolators are used to protect the computer I/O port from accidental short circuit at the motor drivers. Should initial experiments only concern the driving of a single d.c. motor and dual opto-isolators be available, these may be inserted at pin 1 of the sockets. Also, two dual opto-isolators are pin compatible with the quad pack and can generally be mounted in the same socket in tandem.

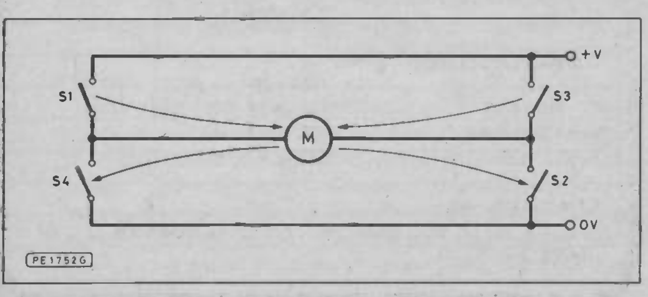


Fig. 1. Straightforward switch equivalent of the motor driver

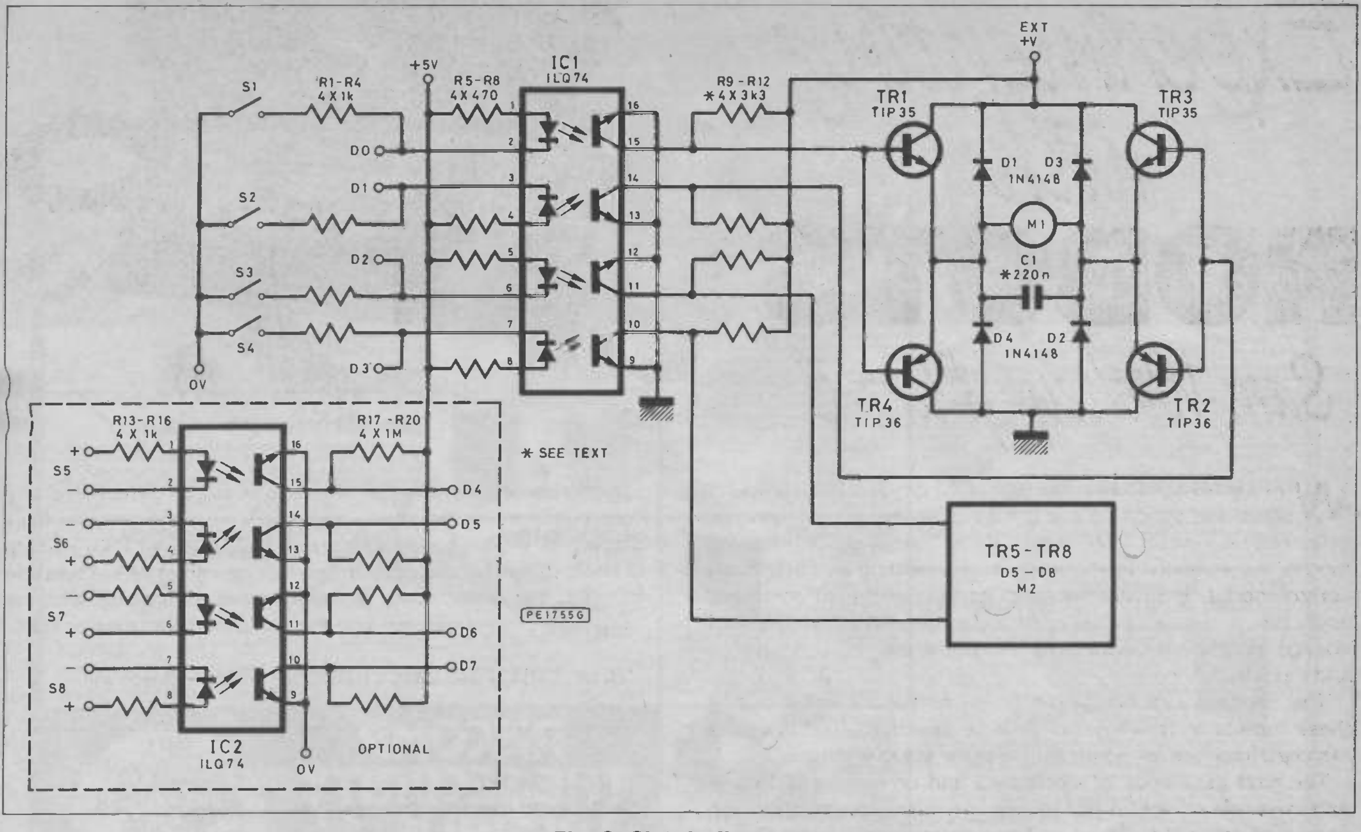


Fig. 2. Circuit diagram

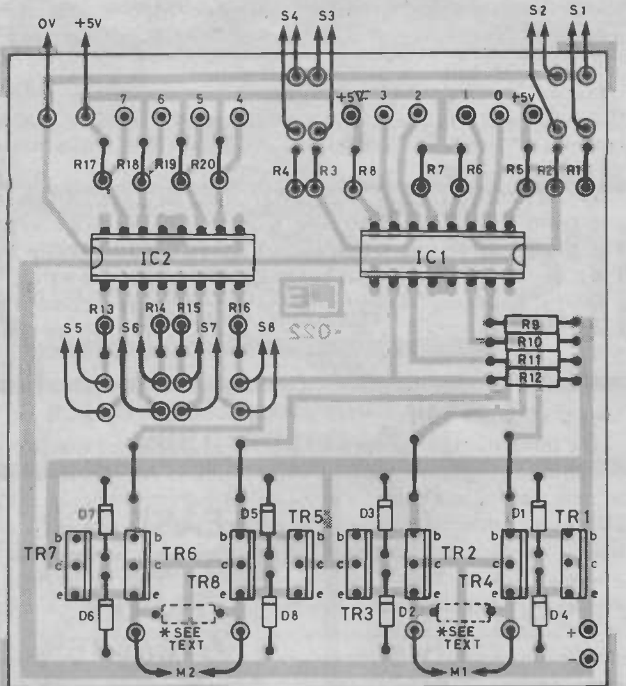


Fig. 3. Component layout (actual size)

Pins are also available for use with non-electrical switches, such as miniature micro-switches, for processing input signals, where a standard technique of disabling the outport of the computer port is brought about by grounding the output signal through a 1k resistor. Provided care is taken, this should not be in any way dangerous as no external power supply is involved.

Provision is made for opto-isolated inputs should they be required, but for most applications signals for stopping motors are derived by grounding the relevant port set at logic '1' for output.

In the component layout bits 0 to 7 are numbered from right to left, with bits 0 to 3 set as outputs (with provision for pins to ground the signals numbered S1 to S4) and bits 4 to 7 set as inputs. There is nothing to prevent the user reversing the order of these functions to facilitate the wiring to individual computers. The opto-isolated input switch pins are numbered S5 to S8. In order to keep the size of the board down to a minimum size most of the resistors are mounted vertically.

CONSTRUCTION

All components are mounted on a p.c.b. as shown in Fig. 3. It is suggested that 16-pin d.i.l. sockets be used for the opto-isolators. Ensure that the i.c.s are inserted the correct way around (Pin 1 is indicated by an indenture. Also, there is usually a half circle or slot cut out of the plastic case between pin 1 and pin 16). After ensuring that the diodes are correctly polarised, cathode distinguished by black or broad yellow band, the greatest care must be taken that n.p.n. transistors are inserted in position for TR1, TR2, TR5 and TR6 and p.n.p. transistors for TR3, TR4, TR7 and TR8. These all face in the same direction and care should be taken that the first one to be inserted is the right way round.

COMPONENTS . . .

Resistors

R1–R4, R13–R16	1k (8 off)
R5–R8	470 (4 off)
R9–R12	3k3 (4 off)
R17–R20	1M (4 off)

Capacitors

C1	220n (see text)

Semiconductors

D1–D4	1N4148 (4 off)
TR1, TR3	TIP35 (2 off)
TR2, TR4	TIP36 (2 off)
IC1, IC2	ILQ74 (2 off)

Miscellaneous

P.c.b. No. PE022 available form *PE PCB Service*. D.c. or stepper motor

Next month: Testing, software and applications.

BBC Micro Forum...

David Whitfield MA MSc CEng MIEE

THIS month it is the turn of the serial data port to come under scrutiny.

RS423 PORT

The RS423 port is one of the truly general purpose data I/O ports provided on the *BBC Micro*. It is a serial interface which provides an improved version of the widely used and somewhat better known RS232C standard. The differences between the RS232C (also referred to as V24) and the RS423 standards are generally concerned with improving the earlier standard. For our purposes, however, the RS232C and the RS423 standards may be considered as compatible.

The serial port is essentially two serial data channels, one for output and one for input, with additional signals for controlling the flow of data. The two channels may be separately configured in various different ways by means of a number of *FX or OSBYTE calls. This degree of support for the RS423 port from the MOS allows it to be used for a great variety of purposes. These include: connecting a modem, connecting a serial printer, as a replacement or supplement for the keyboard, as an output in place of (or as well as) the display. The latter two applications can even open the way for using the *BBC Micro* as an intelligent terminal to another (possibly remote) computer. The RS423 system can also be used to control the cassette port.

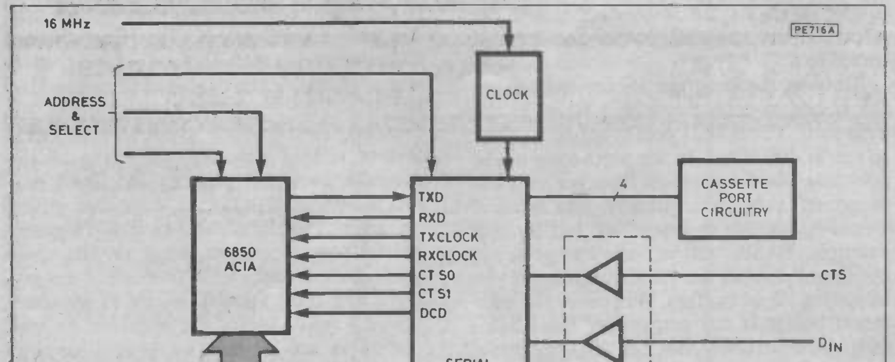


Fig. 1. Serial port configuration

The basic configuration of the hardware behind the RS423 port is shown in Fig. 1. This shows that there are three main components involved in the serial port: the serial ULA, the 6850 ACIA (Asynchronous Communications Interface Adaptor), and the RS423 buffers. The first two elements are also involved in the cassette interface, explaining why the two interfaces are so closely related. The ACIA is responsible for changing data from parallel format (as used inside the micro) to serial format, and vice versa. The serial ULA provides the clock signals that determine how fast the ACIA sends and receives data (known as the baud rate). It also selects where the ACIA takes its input from, and where it sends its outputs to (i.e. cassette or RS423 buffers). The buffers provide the necessary line driving and level conversion to the RS423 standard.

THE CONNECTOR

The RS423 port connector on the *BBC Micro* is a rather unusual type for computer applications; indeed, it was introduced for use with headphones in hi-fi systems. The connector used is in no way similar to the industry standard 25-pin D-type connector used for RS232C. Instead, it is a DIN 5-pin socket, but with the pins not in either of the two usual arrangements. The arrangement is of the 'domino' type, with the connections as shown in Fig. 2. This figure also shows the correspondence between the pins of the *BBC Micro* connector and the standard RS232C connector. It is important to take particular note that this diagram shows the socket as viewed from the back of the micro.

Incredible though it may seem, it is actually possible to insert the plug into the RS423 connector either way round (!), without any difficulty at all. As you might guess, however, there is only *one correct way* to fit the plug for the port to work correctly. It is a wise precaution, therefore, to mark the plug to identify its orientation. A good way to do this is with a white spot (e.g. of Snopake) to denote which way should be 'up' when correctly inserted. This simple precaution can save many frustrating wrong connections!

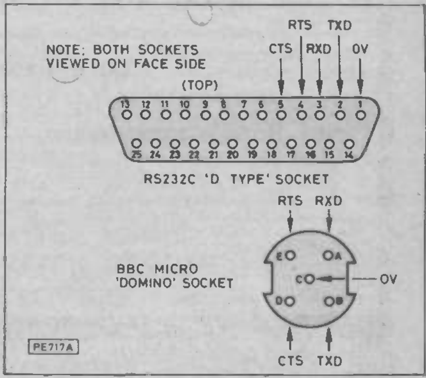


Fig. 2. RS423 connector

Pin	Signal
A	Data In (D_{IN})
B	Data Out (D_{OUT})
C	Ground (OV)
D	Clear to Send (CTS)
E	Request to Send (RTS)

Table 1. RS423 signals

RS423 SIGNALS

Signals on the RS423 port use levels of approximately +5 volts and −5 volts to represent the logic levels 0 and 1, respectively. The signals carried on the connector are identified in Table 1. As can be seen, the RS423 port on the *BBC Micro* only uses a (popular) subset of 5 signals from the possible 25 contained in the full V24 specification. These 5 signals, however, are more than enough for the vast majority of micro applications. In fact, many applications make do with only three of these connections.

The data in (D_{IN}) and data out (D_{OUT}) lines are the ones actually used for transferring data to and from the micro, respectively. Data is transferred serially along these lines, using a stream of bits to represent each byte or character. A number of different arrangements of bits can be used in different types of applications. Overall, each character is sent as a series of data bits, sandwiched between a start bit (indicating that a character is to follow) and one or more stop bits. In addition, a parity bit may also be added to the bits representing the character. This optional parity bit allows the receiving end to detect whether there has been an error on the link.

The various arrangements which are possible with the *BBC Micro* are listed in Table

2, and a typical data waveform is shown in Fig. 3. From this we can see that a character sent along a serial link may be represented by up to 11 bits. The number of bits sent per second is the Baud rate, and the conversion from Baud rate to character rate thus depends on the format being used.

Clear to send (CTS) is a signal to the micro from the equipment on the other end of the link to indicate that it is OK for the micro to send data. Request to send (RTS), on the other hand, is a signal *from* the micro which indicates to the equipment on the other end of the link that the micro is ready to receive data. Both CTS and RTS are active low, i.e. the micro sets RTS low when ready to receive data.

Start Bit	Data Bits	Parity	Stop Bits
1	7	Even	2
1	7	Odd	2
1	7	Even	1
1	7	Odd	1
1	8	None	2
1	8	None	1
1	8	Even	1
1	8	Odd	1

Table 2. RS423 word formats

Before looking in any more detail at the program in Listing 1, we need to know something about the way in which the MOS can be used to configure the serial port. Table 3 shows the *FX calls which are used to set the receive and transmit Baud rates; for use from assembler, OSBYTE calls

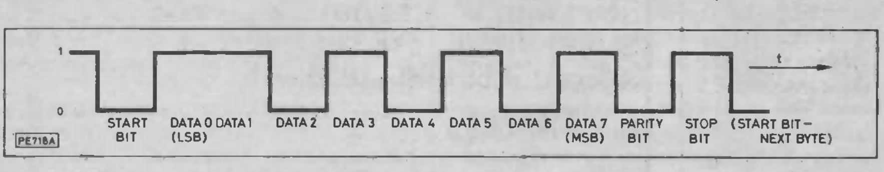


Fig. 3. Serial data waveform

Listing 1. RS423 demonstration

```
 10 REM 60-character RS423 Terminal Demonstration
 20 REM ----------------------------------------
 30 :
 40 ON ERROR GOTO 210
 50 MODE 3
 60 *FX 7.3
 70 *FX 8.3
 80 *FX 229.1
 90 OSBYTE = &FFF4
100 :
110 L%=0
120 REPEAT
130   A%=138: X%=2: REM i.e. OSBYTE 138
140   *FX2.2
150   IF ADVAL(-1)>0 AND ADVAL(-3)>0 Y%=GET:
      CALL OSBYTE
160   *FX 2.1
170   IF ADVAL (-2)>0 Char%=GET: VDU Char%:
      L%=L%+1: IF Char%=13 VDU 10: L%=0
180   IF L%=60 VDU 10: VDU 13: L%=0
190   UNTIL FALSE
200 :
210 ON ERROR OFF: PRINT '"ERROR AT LINE  ":ERL
220 *FX 2.2
230 *FX 229.0
```

Baud Rate	Receive	Transmit
75	*FX7.1	*FX8.1
150	*FX7.2	*FX8.2
300	*FX7.3	*FX8.3
1200	*FX7.4	*FX8.4
2400	*FX7.5	*FX8.5
4800	*FX7.6	*FX8.6
9600	*FX7.7	*FX8.7
19200	*FX7.8	*FX8.8

Table 3. *FX calls to control RS423 Baud rate

Call	Input Selected	RS423 State
*FX2.0	Keyboard	Disabled
*FX2.1	RS423	Enabled
*FX2.2	Keyboard	Enabled

Table 4. Output stream control

KEYBOARD VIA RS423

Rather than just list the *FX calls and other facilities available to control the serial port, it is probably more meaningful to look at how to use it in a practical situation. I will start, therefore, with a simple demonstration of use of the link to connect the *BBC Micro's* keyboard to the micro. Confused?... read on!

As already mentioned, the RS423 port can be used as the input stream to the micro instead of the keyboard. In addition, the RS423 port can be used as the destination for the output stream, e.g. as the destination for output from a program. What this demonstration does, therefore, is to use the MOS to direct the keyboard character stream to the program (as for the normal configuration) while also enabling the RS423 port. The program then re-directs the keyboard characters to the RS423 output. At the same time, the program checks the serial port for incoming characters. Any incoming characters are then output to the screen. Effectively, the normal direct link from keyboard to display is broken, and then re-made via the serial link. In order for the program in Listing 1 to run, it is necessary for links to be placed between D_{IN} and D_{OUT}, and between CTS and RTS. Routing the character stream in this way within a single micro is only useful as a demonstration, but if you have two micros, there are some interesting possibilities which become possible.

should be made (to FFF4) with A = 7 or 8, and X = 1 to 8, as appropriate. Control of the input stream is by *FX2, and the effects of the various options are detailed in Table 4.

Running the program should then cause the screen to echo everything typed at the keyboard. The RS423 port is actually set up to run at 300 Baud. In the main loop of the program, multi-statement lines are used for speed of execution. Ideally this section would be written in assembler, but for this example, BASIC will suffice. The program continually scans the RS423 input and the keyboard input buffers. Whenever the keyboard buffer is not empty *and* the RS423 output buffer is not full, the next character is taken from the keyboard buffer and placed in the RS423 output buffer. Whenever the RS423 input buffer is not empty, the next character is removed, and output to the screen. Note the use of ADVAL to determine the state of the various buffers.

TERMINAL INTELLIGENCE

As a limited example of the processing which an intelligent VDU could perform, the program outputs a carriage return and line feed whenever a carriage return is encountered. In addition, a software controlled line length is implemented rather than use the default line length of 80 characters for mode 3. This may be altered by changing the value of L%. In a full-scale emulation of an intelligent terminal, there would be many more such features provided, e.g. allowing user set-up of Baud rates, and support of ESCAPE sequences. The ESCAPE key is here disabled by the program, and so BREAK should be used to stop it running. With this in mind, it is important to save a copy of the program before *running* it for the first time.

Having this basic framework set up, it is clearly possible to explore many variations on the theme. For example, it is not necessary to have a simple direct link between D_{IN} and D_{OUT}. Instead, this could be to another micro, or even via an infra-red link (as used in remote control applications). The field of added intelligence for the terminal is limited as ever by ingenuity of the programmer. The production of a graphics character set is an example of such an interesting application; machine code is likely to be an absolute *must* for this type of job. Any offers for further applications?

I would be delighted to hear from readers with suggestions, hints for inclusion or problems, but would like to stress that any reply will only be through this column. Correspondence should be addressed to "BBC Forum Letters", at P.E.'s editorial address.

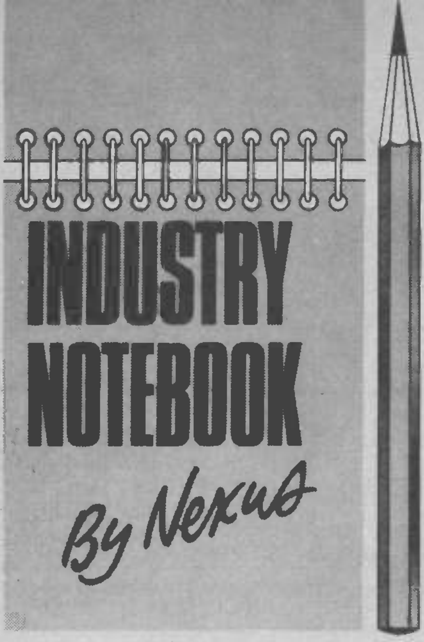
Book Corner

This month, a book on very much the same theme as this column. **Practical Hardware Projects** by *Joe Telford* is a book of 33 practical projects for the *BBC Micro*. Published by Century Publications at £8.95, this 158 page book is primarily aimed at those coming into the field of electronics from computing.

The first section of the book is a useful introduction to the practical skills required in the construction of hardware for interfacing to the *BBC Micro*. This instructional information covers tools, soldering, electronic components, tools and programming for I/O. The second section contains the projects, conveniently grouped into chapters of related projects, such as analogue projects, user port projects, etc. Each project is organised in the same manner, giving an overall description, circuit diagram, brief theory, constructional details, program listing and notes (including suggestions for applications). Many of the later projects make use of the earlier ones, and beginners are advised to work their way sequentially through the text. The projects culminate in ideas for building your own robot buggy.

In the presentation of each project, line drawings are used to illustrate all important points. It must be said, however, that these are indeed little more than very simple line drawings, and it is a great pity that a few photographs were not added in the early sections; these would have been of great value to real beginners. The listings of programs, on the other hand, are produced to a very high standard, with daisywheel output (after the style of the *BBC Micro User Guide*) used throughout.

Verdict: A useful and interesting introduction to practical hardware projects.



Pioneer

The impending closure of the GEC McMichael factory at Slough revives many a memory. Leslie McMichael was an outstanding example of an amateur experimenter developing an absorbing interest into a business.

He had begun experimenting with "wireless" as early as 1902 but it was 10 years later that the bug really bit hard after he had met a handful of other hobbyists and helped form, in 1913, the London Wireless Club, later the Wireless Society of London and today flourishing as the Radio Society of Great Britain.

He founded McMichael Radio in 1921 after serving in the Royal Flying Corps and the Royal Air Force. His partner was another pioneer experimenter, Rene Klein. Neither man had been professionally engaged in electrical or electronic engineering, Klein being in the family business of egg merchants and McMichael a laundry manager.

McMichael radio sets in the 1930s had the same reputation as Rolls-Royce in cars. They were distinguished by having a pair of loudspeakers in a heavy wooden cabinet giving superior "tone" which is how hi-fi was described in those days. Internally they were massively engineered and a feature was the pure copper screens, approaching 6 inches in diameter, enclosing each of the r.f. coils.

In 1939 production was switched to war work and when peace came the factory continued to manufacture defence and professional quality electronic equipment. An attempt to revive the McMichael name in the domestic radio and television market in the 1950s was not successful and the company stayed in the professional field.

It would be a pity if the McMichael name should be lost in the reorganisation now going on. Leslie McMichael died in 1951 aged 67 and deserves to be remembered not least for the start his company gave to many a young electronics enthusiast seeking employment in the industry.

Engineers?

The shambles at this year's Trades Union Congress confirmed my pessimism that the squabbles inherent in leftist politics can never be contained. The AUEW was at the centre of the storm and the press had a field day. Unhappily, journalistic licence tends to shorthand the Amalgamated Union of Engineering Workers to the single word "engineers" which naturally gets up the nose of real engineers, particularly as The Engineering Assembly was having its first national forum in Birmingham at the same time as the TUC brothers were scrapping at Blackpool.

To put the record straight anyone can call himself an engineer but to be recognised professionally it is accepted that one should be Chartered and belong to a professional institution in the rank of Chartered Engineer, Technician Engineer or Engineering Technician, each requiring not only a degree, or lesser but still demanding qualification, but also working experience in one's field. An engineering worker needs no qualification to join the AUEW other than to be occupationally in the engineering industry, many members of course being craftsmen or foremen but not engineers as understood today.

I noted with interest that the IEE enrolled its 1,000th woman engineer this year. It sounds great until you realise that this is the grand total since the IEE enrolled its first woman member, reluctantly it's said, back in 1899. But the pace is quickening. Women membership has doubled since 1981 but is only 1.5 per cent of the total.

Power Play

Reverting for a moment to the TUC, the defence of vested interests is as intense as ever. The miners detest nuclear energy and would have it abolished. The electricians love it and want it expanded. The reason is simple. The mining unions are losing members at an alarming rate. The electricians argue that 40,000 people work directly in nuclear power generation and indirectly, in construction of new equipment and other services, 120,000 workers are involved.

The Social Democratic Party staged its conference at Torquay with a certain style and a refreshing freedom from acrimony. All the same I was disappointed that the debate on high technology, *Focus on the Future*, had such a lowly position, being squeezed in at the last moment before the Leader made his closing speech.

The proposal that 20 per cent of all honours should go to innovators was rejected. One speaker, clearly out of touch, suggested that ICL should co-operate with Japanese companies. This has already happened.

Jobs

The TUC and all the political parties had much to say on unemployment during the conference season. For the highly skilled there is no problem. Of the solutions to unemployment for the semi-skilled or unskilled one looks in vain.

Except, perhaps, to the United States where over six million new jobs have appeared and unemployment has fallen to about seven per cent compared with a rise in Europe to about 11 per cent and in the UK alone to 13 per cent. The American success, in part at least, might be attributed to two characteristics. One is the attitude, encouraged from childhood, that all men are equal and the prize of becoming president of the nation or of a business corporation is open to all. In short, personal enterprise get-up-and-go is virtuous in a free society.

The other is a preference for job security rather than wage rises which, in times of difficulty, results in acceptance of wage freezes and in some cases wage cuts. Workers in US industry between 1972 and 1984 have had a fall in wages of about 13 per cent in real terms although money wages rose by 115 per cent in the same period. In contrast the UK worker looks to the government to create employment and demands wage increases in both money and real terms with scant regard to the trading environment in which his company has to operate.

Many people appear to believe that the job market is static. It may come as a surprise to them that in adult employment some 350,000 people change jobs every month, over four million a year. So there does exist a dynamic market of sorts although the figure for the jobless, everyone now agrees, will not see a substantial fall in the near term, perhaps never.

Too gloomy a view? Not when you consider another 750,000 expected entrants to the labour force in the next five years. You need to run fast to stand still in an intractable situation.

PC News

Sinclair QL personal computers are in the shops at huge discounts highlighting the decline in the home and hobby market. Apricot is reported to have unsold stocks, Commodore rumoured to be talking with bankers. But the remarkable Alan Sugar has taken up the challenge with what has the appearance of a professional product at a consumer price.

I refer of course to the Amstrad PCW8256, the complete package, computer, monitor, disc drive, printer and word-processing software for £399 + VAT. Most of the package is UK-designed but, you've already guessed, it's made in Korea.

The Amstrad model will appeal to the small business user as well as the hobbyist but at the higher priced professional end of the market at least one analyst is forecasting as much as a five-fold increase in PC sales in Western Europe by 1990 with IBM retaining a dominant position. Prices will come down but not so dramatically as in the home and hobby market.

At the far extreme of the supercomputers, the massive number-crunchers, the Crays and Cybers, there is still strong demand in research and defence applications although sales are mainly one-offs.

In the general mainframe business ICL is working on feasibility studies for a network for the UK Social Services. The network is planned to have 19,000 terminals in 500 local offices and is expected to cost £140 million. The computers themselves will cost some £30 million.

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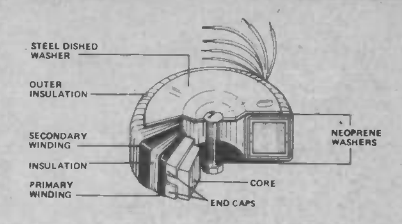

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	03013	15+15	0.50
	03014	18+18	0.42
	03015	22+22	0.34
	03016	25+25	0.30
	03017	30+30	0.25
30Va Regulation 18% Size A B C 70 35 37 0.45 Kgs Mounting bolt M5 x 50	13010	6+6	2.50
	13011	9+9	1.66
	13012	12+12	1.25
	13013	15+15	1.00
	13014	18+18	0.83
	13015	22+22	0.68
	13016	25+25	0.60
	13017	30+30	0.50
50Va Regulation 13% Size A B C 80 40 43 0.9 Kgs Mounting bolt M5 x 50	23010	6+6	4.16
	23011	9+9	2.77
	23012	12+12	2.08
	23013	15+15	1.66
	23014	18+18	1.38
	23015	22+22	1.13
	23016	25+25	1.00
	23017	30+30	0.83
	23028	110	0.45
	23029	220	0.22
	23030	240	0.20
80Va Regulation 12% Size A B C 95 40 43 1.0 Kgs Mounting bolt M5 x 50	33010	6+6	6.66
	33011	9+9	4.44
	33012	12+12	3.33
	33013	15+15	2.66
	33014	18+18	2.22
	33015	22+22	1.81
	33016	25+25	1.60
	33017	30+30	1.33
	33028	110	0.72
	33029	220	0.36
	33030	240	0.33
120VA Regulation 11% Size A B C 95 45 50 1.2 Kgs Mounting bolt M5 x 50	43010	6+6	10.00
	43011	9+9	6.66
	43012	12+12	5.00
	43013	15+15	4.00
	43014	18+18	3.33
	43015	22+22	2.72
	43016	25+25	2.40
	43017	30+30	2.00
	43018	35+35	1.71
	43028	110	1.09
	43029	220	0.54
	43030	240	0.50

TYPE	SERIES NO.	SEC. VOLTS	R.M.S. CURRENT
160VA Regulation 8% Size A B C 110 45 50 1.8 Kgs Mounting bolt M5 x 50	53011	9+9	8.89
	53012	12+12	6.66
	53013	15+15	5.33
	53014	18+18	4.44
	53015	22+22	3.63
	53016	25+25	3.20
	53017	30+30	2.66
	53018	35+35	2.28
	53026	40+40	2.00
	53028	110	1.45
	53029	220	0.72
	53030	240	0.66
225VA Regulation 7% Size A B C 110 50 55 2.2 Kgs Mounting bolt M5 x 60	63012	12+12	9.38
	63013	15+15	7.50
	63014	18+18	6.25
	63015	22+22	5.11
	63016	25+25	4.50
	63017	30+30	3.75
	63018	35+35	3.21
	63026	40+40	2.81
	63025	45+45	2.50
	63033	50+50	2.25
	63028	110	2.04
	63029	220	1.02
	63030	240	0.93
300VA Regulation 6% Size A B C 110 57 62 2.6 Kgs Mounting bolt M5 x 60	73013	15+15	10.00
	73014	18+18	8.33
	73015	22+22	6.82
	73016	25+25	6.00
	73017	30+30	5.00
	73018	35+35	4.28
	73026	40+40	3.75
	73025	45+45	3.33
	73033	50+50	3.00
	73028	110	2.72
	73029	220	1.36
	73030	240	1.25
500VA Regulation 5% Size A B C 135 60 65 4.0 Kgs Mounting bolt M8 x 70	83016	25+25	10.00
	83017	30+30	8.33
	83018	35+35	7.14
	83026	40+40	6.25
	83025	45+45	5.55
	83033	50+50	5.00
	83042	55+55	4.54
	83028	110	4.54
	83029	220	2.27
	83030	240	2.08

TYPE	SERIES NO.	SEC. VOLTS	R.M.S. CURRENT
625VA Regulation 4% Size A B C 140 70 75 5.0 Kgs Mounting bolt M8 x 90	93017	30+30	10.41
	93018	35+35	8.92
	93026	40+40	7.81
	93025	45+45	6.94
	93033	50+50	6.25
	93042	55+55	5.68
	93028	110	5.68
	93029	220	2.84
	93030	240	2.60

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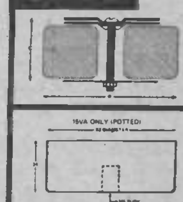

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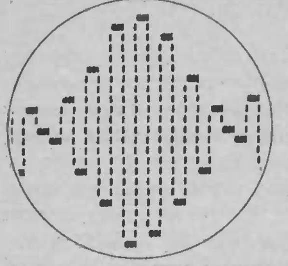


Micro-Scope

John M.H. Becker Part 2

Computerised circuit tester for audio to visual display on Commodore PET or BBC

In Part 1 of this article, we discussed in detail the circuit operation of the Micro-Scope and to get you going on constructional aspects, we included the p.c.b. design and the components list.

CONSTRUCTION

As this project is aimed at the fairly advanced hobbyist, it is felt that little need be said about p.c.b. assembly as it is very straightforward. The wiring diagram of Fig. 5 illustrates how the controls should be connected to the p.c.b. and Fig. 6 shows the various computer ports which may be used with this project.

The following text continues with the application details of the Micro-Scope and should be followed in conjunction with the complete program listing which is available from our editorial offices (see Constructors' Note).

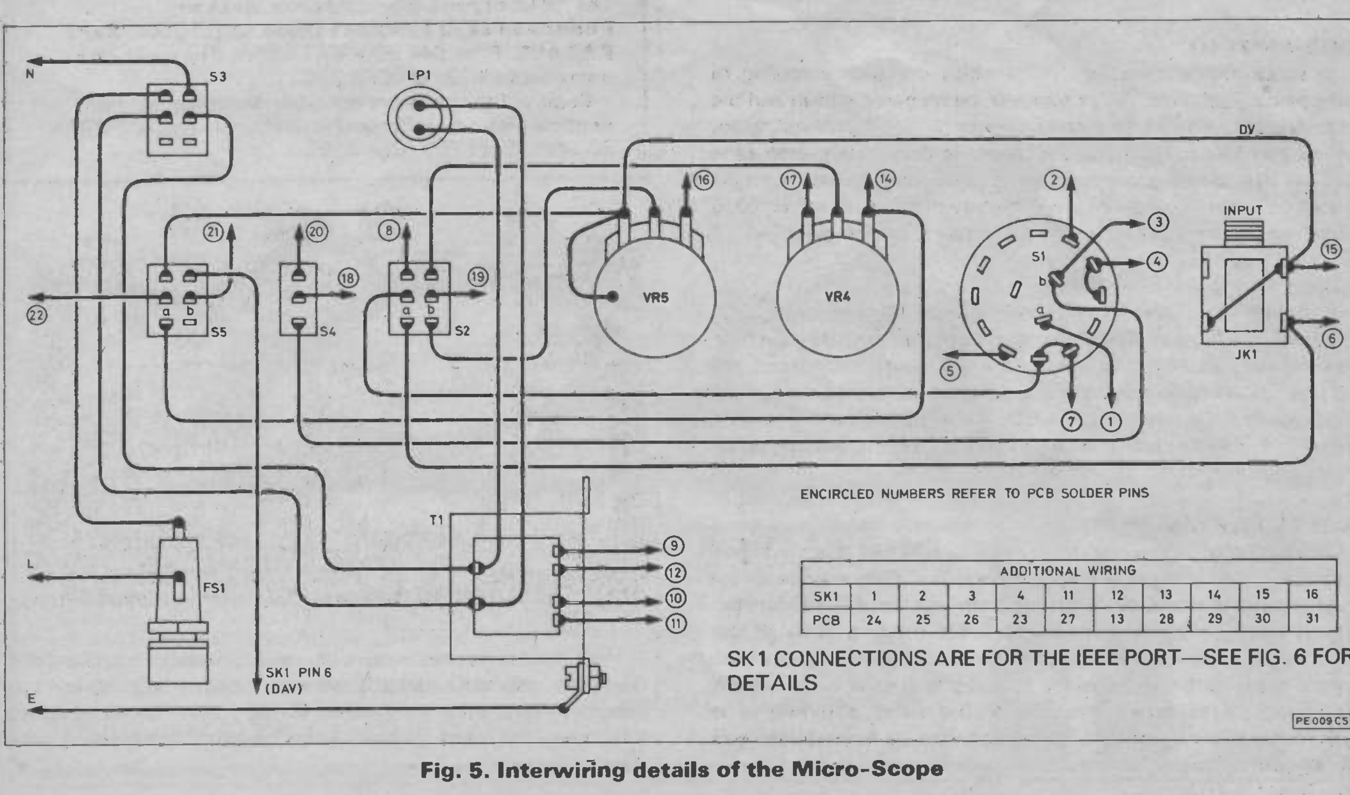
PEAK TO PEAK

The program routine finds the maximum and minimum levels the numbers reach, the difference between the two is stored and represents the peak to peak voltage value. Upon completion the program drops back to BASIC which then finally calculates and displays the voltage and frequency values in the top screen line. The keyboard will then be checked for a keypress and if none is found it will jump back to the first machine code routine for the next sampling block. Although BASIC is comparatively slower than machine code for the factor displays, leaving this routine in BASIC gives flexibility if anyone wants to put extra parameters into the program.

ACQUISITION RATE

Without any synchronisation or rate correction, the program acquires and displays data as fast as it can. The acquisition time is basically around 59 microseconds, so the 256 memory locations can be filled in about 15ms. The number of times that a full block is read and displayed is about four times per second. At any time while the main program is running any of the keys may be pressed, and during its drop back into BASIC the computer will assess which key has been pressed, and what action to take. Pressing any key except those stated in the menu options at the start will cause the program to request new information, whereupon synchronisation and rate factors can be changed. The rate at which data is acquired can be slowed down in steps of 10 microseconds over a range of 255 progressions. This is done by varying the length of a holding loop in the sampling program, the holding factor being set from BASIC. The maximum delay obtainable between each sample is about 2·5ms. This enables slow speed waveforms to be sampled and effectively compressed. The frequency counter corrects for this holding displacement. Note that the precise delay may vary depending on the memory location of the holding loop as page boundaries may affect it.

The point at which signal sampling takes place can also be set from BASIC at the same time that the rate is set. Normally acquisition occurs at the first available point in the frequency cycle, but by setting sync, the start of acquisition can be delayed until the signal slope has reached a point above the set level. This provides for a more stable signal display.



ADDITIONAL WIRING										
SK1	1	2	3	4	11	12	13	14	15	16
PCB	24	25	26	23	27	13	28	29	30	31

SK1 CONNECTIONS ARE FOR THE IEEE PORT—SEE FIG. 6 FOR DETAILS

Fig. 5. Interwiring details of the Micro-Scope

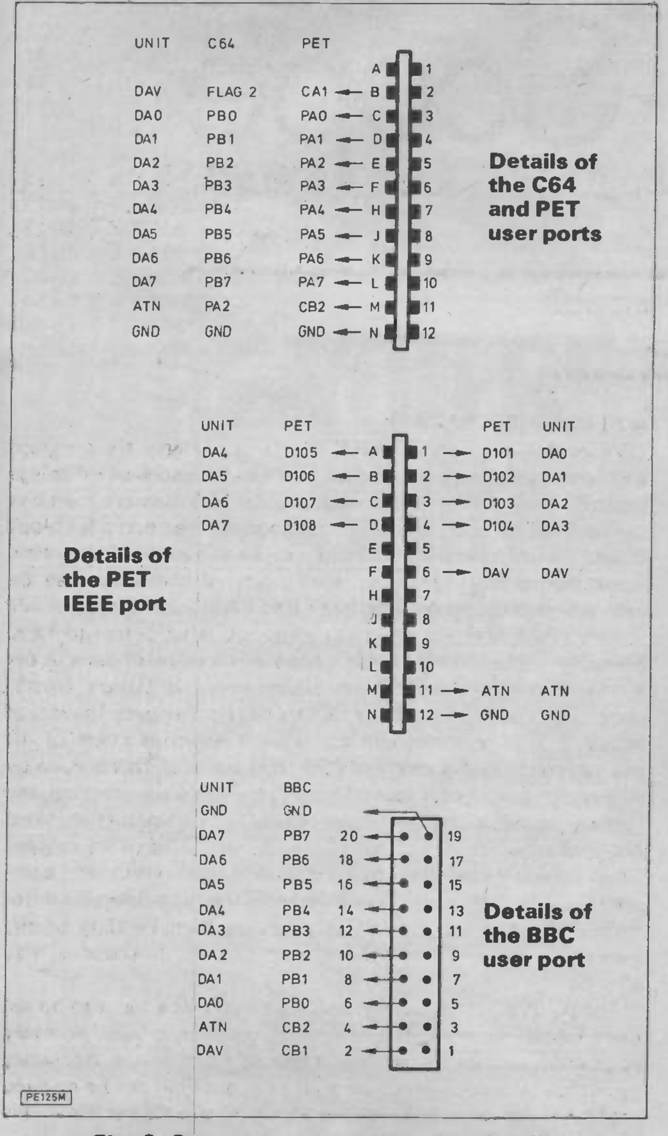


Fig. 6. Computer port connection details

ONE-SHOT (+)

In scope mode, pressing "+" enables one-shot sampling to take place. Each time "+" is pressed the memory is filled and the screen displayed and held indefinitely until "+" is pressed again, or another key to return to the menu. In conjunction with sync setting this allows the computer to wait for a particular signal transient, capture and display it for examination. If no signal is acquired the program will wait indefinitely after pressing "+".

PRINTER (P)

A paper read-out to a printer can also be achieved simply by pressing "P" when in the one-shot mode. Any data displayed on the screen will be printed out as a permanent record of the display, including frequency, voltage, sync and rate factors. If the control unit is connected to the IEEE line in addition to the printer, the switch S5 must be turned off to take IC2 off the bus before the printer will respond.

VOLTS BAR GRAPH (V)

Whilst in the scope mode, if "V" is pressed the mode will change to the voltage bar graph display. This allows either a.c. or d.c. voltage levels to be displayed both graphically and numerically in steps of 10mV from 0V to 2,540mV (see photo H last month). At 2,550mV and above the screen flashes to indicate an out of range condition. From the volts mode, pressing "S" returns the program to scope mode with the same parameters as previously set. Any other key pressed enables fresh parameters to be set.

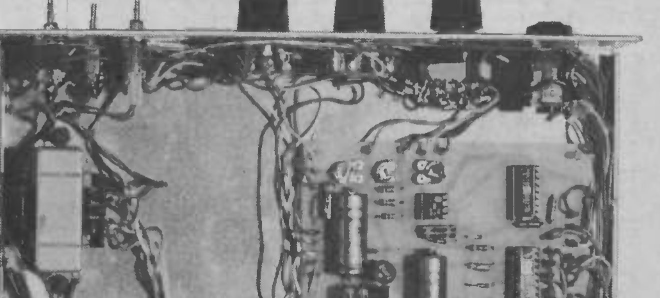
HIGH RATE (!)

The final option comes from pressing "!" to put the program into non-interruptable scope mode in which only data acquisition and display are performed without frequency and voltage calculation. The result is a faster display rate, of about nine full screen blocks per second, but as the program does not drop back to basic, once set it cannot be interrupted without turning off the computer and the program reloaded. Therefore, sync and rate factors should be set immediately prior to the high speed mode.

For those wishing to convert the data statements for other computers, the following variables are used. Not all computers may require all equivalent registers to be set.

BA, RV and VE = Symbols for Bar Graph, Reverse Screen and Vertical Line respectively.
BN and BQ = 208 and 240 respectively if data register flag does not equal zero on receipt of DAV. They are 240 and 208 respectively if register flag equals zero at DAV. (208 is "BNE" in 6502 and 6510 machine code, and 240 is "BEQ".) DN and UP set the respective bit that toggles the ATN line. DR = Data Direction Register to be set for all Data lines to be used as inputs.
ML and MH = Low and High bytes respectively of Top of Memory pointers.
PI = Data Port output location.
RG = Interrupt Control Register that detects DAV.
SC = First Screen RAM location.
SE = Bit that is set upon receipt of DAV.
V1 = Data Port register that sends ATN.
Z0 and Z1 = Zero Page temporary storage locations, need to be consecutive.

Constructors' Note
The full kit of parts is available from **Becker-Phonosonics, 8 Finucane Drive, Orpington, Kent BR5 4ED.** Price £44.50 + VAT + P&P. The p.c.b. on its own costs £3.33. ☎ 0689 37821.
Copies of the software are available on request from *Practical Electronics* (Poole office). Please send SAE 230 × 300mm. (State PET, C64 or BBC).



The Pet also requires location 59467 to have Bit 0 set for DAV detection (this automatically occurs in line 1340). Within the program listing other information for BBC users is also given as this computer does a few things slightly differently to the Commodores. ★

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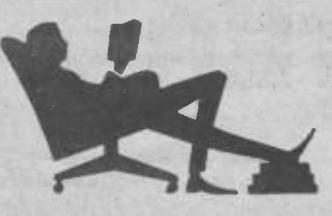

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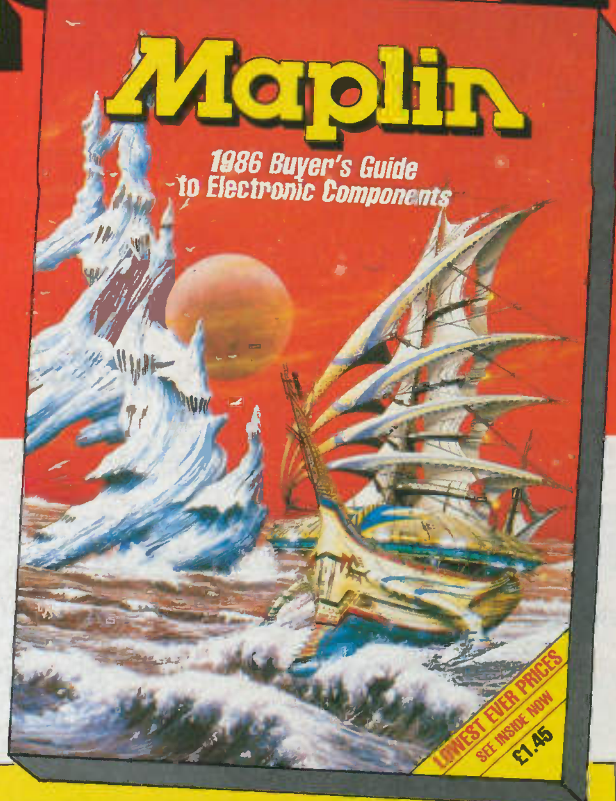

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