AN ARGUS SPECIALIST PUBLICATION

electronics today

INTERNATIONAL OCTOBER 1983 85p

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BIG NEWS ABOUT OUR LATEST ADVANCES IN ROBOTICS SEE INSIDE BACK COVER

DJ90 Stereo Mixer — this is a really versatile new mixer that enables the constructor DJ to produce a professional performance every time. There are two stereo inputs for magnetic cartridges, a stereo auxiliary input and mike input. Other 'plus' features are autopanning for fast or slow slider controls, multi-mixing, ducking, interrupt, input modulation, in short everything . . . the whole works — AND — under £100 complete! Complete kit **£97.50** + VAT

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

SALES COUNTER Collect your order from the factory. Open 9-12/1-4.30 Mon- Fri. Easy parking, no waiting

Digital Delay Line — With its ability to give delay times from 1.6 mSecs to up to 1.6 secs. Many powerful effects including phasing, flangine, A.D.T., chorus; echo &

vibrato are obtained. The basic kit is extended in 400 mS steps up to 1.6 secs. Simply by adding more parts to the PCB. Compare with units costing over £1,000!
Complete kit (400 mS delay)
£130 + VAT
Parts for extra 400 mS delay
£9.50 + VAT

This versatile modular mixer, featured as a constructional article in Practical Electronics can be built up to a maximum of 24 inputs, 4 outputs and an auxiliary channel. Each input channel has Mic and Line inputs, variable gain, bass and treble controls and a parametric middle frequency equalizer. There are send and return jacks, auxiliary, pan and fader controls and output and group switching. The output channels have PPM displays and record and studio outputs. The auxiliary channel also has a PPM display and there is a headphone monitor jack and a built-in talk-back microphone. The mixer modules plug into base units each of which takes up to 6 channels. To eliminate hum, the power supply is in a separate cabinet.

KIT PRICES

Input channel	£19.90	Base unit and wooden front	£27.50
Output channel	£18.50	Pair of mahogany end cheeks	£12.50
Auxiliary channel	£22.50	Power Supply and cabinet	£19.50
Blank Panel	£3.00		

All prices are VAT exclusive

Free Soldering Practise Kit on request with your first kit — useful tips, well illustrated.

TRANSCENDENT POLYSYNTH — A four octave polyphonic synthesiser with outstanding design characteristics and versatility and performance to match.
Complete kit **£230.00** plus VAT (single voice)
Extra voice (up to three more) **£35.60** plus VAT

MPA 200 — is a low price, high power 100W amplifier, its smart styling, professional appearance and performance, make it one of our most popular designs. With adaptable inputs the mixer accepts a variety of sources yet straightforward construction makes it ideal for the first time builder. Complete kit **£49.90 + VAT.**

Chromatheque 5000 — a 5 channel lighting system powerful enough for professional discos yet controllable for home-effects. Sound to light, strobe to music level, random or sequential effects — each channel can handle up to 500W yet minimal wiring is needed with our unique single board design. Complete kit **£49.50** + VAT

ETI VOCODER — 14 channels, each with independent level control, for maximum versatility and intelligibility: Two input amplifiers — for speech/excitation — each with level control and tone control. The Vocoder is a powerful yet flexible machine that is interesting to build and thanks to our easy to follow construction manual, is within the capability of most enthusiasts. Complete kit **£175.00** + VAT

SP2 200 twice the power with two of the reliable, durable and economic amps from the MPA 200; fed by separate power supplies from a common toroidal transformer. Superb finish and quality components throughout — up to (even over) the standard of high prices factory-built units! Complete kit **£64.90** + VAT

Component packs for most kits are available See our great free catalogue, full details of all our range

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INTERNATIONAL OCTOBER 1983 VOL 12 NO 10

Dave Bradshaw: Editor
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Jerry Fowler: Technical Illustrator
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Joanne James: Assistant Ad. Manager
Lynn Collis: Copy Control
Ron Harris B.Sc: Managing Editor
T.J. Connell: Managing Director

PUBLISHED BY:
Argus Specialist Publications Ltd.,
145 Charing Cross Road, London WC2H 0EE.
DISTRIBUTED BY:
Argus Press Sales & Distribution Ltd.,
12-18 Paul Street, London EC2A 4JS
(British Isles)
PRINTED BY:
QB Limited, Colchester.
COVERS PRINTED BY:
Alabaster Passmore.

OVERSEAS EDITIONS and their EDITORS
AUSTRALIA — Roger Harrison
CANADA — Halvor Moorshead
GERMANY — Udo Wittig
HOLLAND — Anton Kriegsman

ABC **Member of the Audit Bureau of Circulation**

☐ Subscription Rates. UK £13.15 including postage. Airmail and other rates upon application to ETI Subscriptions Department, 513 London Road, Thornton Heath, Surrey CR4 6AR.

EDITORIAL AND ADVERTISEMENT OFFICE
145 Charing Cross Road, London WC2H 0EE. Telephone 01-437 1002/3/4/5.
Telex 8811896.

FEATURES

PROJECTS

- Due to lack of space, IC Update and the Readers' Services Page have been held over

INFORMATION

WATFORD ELECTRONICS

33/34 CARDIFF ROAD, WATFORD, HERTS. ENGLAND
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ALL DEVICES FULLY GUARANTEED. SEND CHEQUE, P.O.s, CASH, BANK DRAFT WITH ORDERS, ACCESS/MASTER CHARGE ACCEPTED. GOVERNMENT & EDUCATIONAL ESTABLISHMENTS OFFICIAL ORDERS WELCOME P&P ADD 60p TO ALL CASH ORDERS. OVERSEAS ORDERS POSTAGE AT COST.

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ELECTROLYTIC CAPACITORS: (Values in uF) 500v. 10uf 52; 47 78p; 63V: 0.47, 1.0, 1.5, 2.2, 3.3, 4.7 8p 10 10p; 15, 22 12p; 33 15p; 47 12p; 68 20p; 100 19p; 220 28p; 1000 70p; 2200 99p; 50V: 68 20p, 100 17p; 220 24p; 40V: 6.8 15p; 22 9p; 33 12p; 33C, 47 32p; 1000 48p; 2200 90p; 25V: 1.5, 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: 47, 68, 100 9p; 125 12p, 330 16p; 470 20p; 680 34p; 1000 27p; 1500 31p; 2200 28p, 4700 72p.

TAG-END CAPACITORS: 64V: 2200 139p; 3300 198p; 4700 245p; 50V: 2200 110p; 3300 184p; 40V: 4700 180p; 25V: 2200 90p; 3300 98p; 4000, 4700 98p; 10,000 320p; 15,000 345p; 16V: 22,000 350p.

POLYESTER CAPACITORS: Axial Lead Type
400V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8 11p; 10n, 15n, 18n, 22n 12p; 33n, 47n, 68n 16p; 150n 20p; 220n 30p; 330n 42; 470n 52p; 680n 1uF 68p; 2u2 82p.
100V: 10nF, 12n, 39n, 11p; 150n, 220n 17p; 330n, 470n 30p; 680n 38p; 1uF 48p 42p; 1u5 45p; 2u2 48p; 4u7 58p.
100V: 1nF 17p; 10nF 30p; 15n 40p; 22n 36p; 33n 42p; 47n, 100n 42p.

SIEMENS pcb
Type Miniature poly Capacitors

250V
1nF, 1n5, 2n2, 3n3, 4n7, 6n8,
10n, 15n 7p
18n, 22n, 27n,
33n, 39n, 47n 8p
39n, 56n 12p
82n, 100n 11p

100V
100n, 120n 10p
150n, 180n 12p
220n, 270n 15p
330n, 390n 20p
470n, 560n 26p
680n 30p
1uF 34p 2u2 50p

POLYESTER RADIAL LEAD CAPACITORS: 250V
10n, 15n, 22n, 27n 6p; 33n, 47n, 68n, 100n 7p; 150n, 220n 10p; 330n, 470n 13p; 680n 19p; 1u5 40p; 2u2 48p.

FEED-THROUGH CAPACITORS
1000pF/450V 8p

TANTALUM BEAD CAPACITORS
35V: 0.1uF, 0.22, 0.33 15p 0.47, 0.68, 1.0, 1.5 16p; 2.2, 3.3 18p; 4.7, 6.8 22p 10 28p; 16V: 2.2, 3.3 16p; 4.7, 6.8, 10 18p; 15, 36p; 22 30p; 33, 47 40p; 100 75p; 10V: 15, 22, 26p; 33, 47 35p; 100 65p; 6V: 100 42p.

POTENTIOMETERS: Rotary, Carbon, Track 0.25W Log & Lin values.
500, 1K & 2K (Linear only)
Single Gang 30p
5K 2m Single Gang Log & Lin 30p
5K M Single Gang D/P Switch 78p
5K 2m Double Gang 89p

MYLAR FILM CAPACITORS
100V: 1nF, 2, 4, 4nF, 10 6p; 15nF, 22n, 30n, 40n, 47n 7p; 56n, 100n, 200n 9p; 50V: 470nF 12p.

SLIDER POTENTIOMETERS
0.25W log and linear values 60mm
5K 500K single gang 70p
Graduated Bezels for above 45p

CERAMIC CAPACITORS 50V;
Range 0.5pF to 10nF 4p. 15nF, 22nF 33nF; 47nF 5p. 100nF/300V 7p. 200nF/6V 8p.

PRESET POTENTIOMETERS
0.1W Miniature Vertical or Horizontal, 100R to 4M7 7p
0.25W Larger 100R to 3M3 Horz 12p
0.25W Lathrt 200R to 4M7 Vert 12p

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POLYSTYRENE CAPACITORS:
10pF to 1nF 8p; 1.5nF to 12nF 10p.

SILVER MICA (Values in pF)
2, 3.3, 4.7, 6.8, 8.2, 10, 12, 15, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180pF 15p each 200, 220, 250, 270, 300, 330, 360, 390, 470, 680, 800, 820 21p each 100, 1200, 1800, 2200 30p each 3300, 4700pF 80p

RAM FOR BBC MICRO 4816AP 100ns

MINIATURE TRIMMERS Capacitors 225p
2.6pF, 2.10pF 22p; 2.25pF, 5.65pF 30p; 10.68pf 36p.

RESISTORS

	Carbon	Film	Hi-Stab	5%
	RANGE	Val	1-99	100 +
0.25W	2 2-10M	E24	3p	1p
0.5W	2 2-4M7	E12	3p	1p
1W	2 2-10M	E12	6p	4p
2% Metal Film		E24	6p	4p
1% Metal Film		E24	8p	6p

100+ price applies to Resistors of each type not mixed.

RESISTORS NETWORK S.I.L.
7 Commoned: (8 pins) 100, 680, 1K 2k2, 4K7, 10K 47K 100K 25p
8 Commoned: (9 pins) 150, 180, 270, 330, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K & 100K 26p.

COMPUTER ICs

1702	350	8214	425	TMS4532-3	350
1802CP	650	8216	100	TMS5100	600
2114L 300n	90	8224	110	TMS9927	£14
2114L 200n	95	8225	£11	TMS9928	£20
2147	425	8226	250	TMS9929	£20
2532	300	8228	220	TMS9995	£12
2564	£6	8243	270	ULN2003	75
2708	250	8250	650	UPD7002	425
2716 5V	280	8251A	250	WD1691	£14
2732	295	8253	400	Z80CPU 2.5	285
2764	425	8255	225	Z80ACPU 4M	300
27128-4	£20	8256AC	£36	Z80 CTC	250
27128 250	£25	8257-5	400	Z80A CTC	280
3242	590	8253	395	Z80B	875
4027	100	8271	£40	Z80 DART	495
4116-150n	100	8272	£17	Z80A DART	695
4116-200n	90	8279	410	Z80 DMA	675
4118-250	325	8282	450	Z80A DART	695
4164-200n	400	8283	450	Z80 PIO	260
4334-3 = CMOS		8284	350	Z80A PIO	275
2114-3	325	8285	365	Z80 SIO-1	850
4416-2	475	8287	£17	Z80A SIO	£9
4532-3	100	8288	£10		
4532-4	350	8P8304BN	250		
4816-100ns	225	8T26A	99		
5101-450	230	8T27	150		
6116-150nS	340	8T28A	120		
6116L 120	500	8T31	350		
6117-100n	490	8T95	90		
6167-6	795	8T97N	90		
6502CPU	325	9364AP	650		
6502A	450	9602	220		
6504 250	550	AM26LS31C	125		
6505	600	AM26LS32A	125		
6520PIA	100	AM26LS33A	125		
6522VIA	285	AY-3-1015	300		
6530	£11	AY-5-1013	300		
6532RRIOT	899	AY-5-2376	600		
6545RTC	845	COM8017	275		
6551ACIA	650	COM8116	700		
6592PC	£20	DM8131	275		
6800	220	DS3691N	210		
6802	250	DS88LS120N	255		
6803	850	DS8820	110		
6804	180	DS8830	110		
6805	870	DS8831	125		
6808	520	DS8832	250		
6809	530	E9365	£38		
6810	115	E9366	£38		
6820	110	FD1691	£15		
6821	120	FD1771	£15		
68B21	220	FD1791	£22		
6840	375	FD1795	£26		
6843	£12	FD1799	£28		
6845	650	FD1797	£28		
6847	850	HD26501	75		
6850	110	IM6402	380		
6852	250	INS8060N	1050		
6854	550	INS8154N	£8		
6859	£4	MC1488	55		
68B54	750	MC1489	55		
6875	550	MC14411	675		
68000	£90	MC14412	725		
74C922	400	MC3446	250		
8080A	400	MC3447P	315		
8085A	380	MC3486	225		
8088	£18	MC3487	225		
8118-10	225	MC6846	825		
8123	125	MC6848	625		
8155	360	MK3886-2M	£7		
8156	360	MM5280D	290		
81LS95	80	MM5303	695		
81LS96	80	MM5307	1275		
81LS97	80	MM5387A	475		
81LS98	85	MM58174	700		
8202	£25	MM74C922	420		
8205	225	RO-3-2513L	650		
8212	110	RO-3-2513U	650		
		SFF9364	700		
		SPO256AL2	650		
		TMS2716-3V	725		
		TMS4416-2	475		
		TMS4500	£14		

LINEAR ICs

555Cmos	80	ICL7204	550	MC33040P	120	TL170	50
702	75	ICL7611	99	MC33060P	120	TL430C	90
709C 8 pin	35	ICL7660	248	MC3401	65	TL507	110
710	45	ICL8038CC	300	MC3404	75	TL509	110
741 8 pin	14	ICL8211A	750	MC3405	150	TL061CP	40
747C 14 pin	85	ICM7205A	1150	MC3423	80	TL062CP	60
748C 8 pin	36	ICM7207	475	MC4016	00	TL064CN	98
735 8 pin	165	ICM7215	1050	MF10	350	TL071CP	45
810	156	ICM7216AJ	£22	MFC6040	75	TL072CP	45
9400CJ	350	ICM7216C	£22	MK50398	635	TL074CN	100
AY-1-1320	225	ICM7217A	750	ML924	275	TL081CP	24
AY-1-5050	99	ICM7224	785	MSM5526	820	TL082CP	48
AY-1-5051	160	ICM7240	300	NE515	275	TL083CP	75
AY-1-6720	210	ICM7555	80	NE529	225	TL084CN	90
AY-3-1270	730	ICM7556	150	NE531	140	TL091CP	56
AY-3-1350	350	LA3550	250	NE534	150	UA2240	120
AY-3-8910	420	LA4031P	340	NE543K	225	UA78540	230
Booklet for		LA4032	295	NE544	210	UGN3020T	160
AY-3-8910	200	LA4400	350	NE555	16	ULN2001	80
AY-3-8912	625	LA4422	320	NE556	46	ULN2003	75
AY-5-1230	450	LC7130	340	NE558	140	ULN2004	75
AY-5-1317A	630	LC7120	300	NE560	325	ULN2283	100
AY-5-1350	366	LC7137	395	NE561	398	UPC575	275
CA3011	130	LF347	150	NE562B	410	UPC1025H	375
CA3012	175	LF351	48	NE564	420	UPC1182	320
CA3014	275	LF353	85	NE565A	120	UPC1156H	270
CA3018	85	LF355	85	NE566	155	UPC1366	195
CA3019	80	LF356	85	NE567V	140	XR2206	300
CA3020	210	LF357	110	NE570	410	XR2207	375
CA3023	210	LF398	475	NE571	400	XR2211	575
CA3028A	95	LM10	325	NE5532	145	XR2216	675
CA3035	255	LM301A	24	NE5534A	105	XR2266	360
CA3036	270	LM307	45	OM335	750	ZN414	80
CA3043	275	LM308T	85	RC4136D	80	ZN419E	180
CA3045	385	LM311	55	RC4558	45	ZN423E	130
CA3046	70	LM318N	150	S566B	225	ZN424E	130
CA3048	220	LM319	195	SAB3209	425	ZN425E	345
CA3059	285	LM324A	30	SAB3210	326	ZN426E	300
CA3075	213	LM334Z	90	SAB3271	485	ZN427E	600
CA3080E	70	LM335Z	128	SAB4209	585	ZN428E	410
CA3081	180	LM339	47	SG3402	295	ZN429E	210
CA3086	48	LM348	64	SL490	350	ZN459	325
CA3089E	200	LM349	115	SL6270CD	150	ZN1034E	200
CA3090AQ	375	LM358	60	SN76013	350	ZN1040E	665
CA3123E	185	LM377	175	SN76023ND	240	ZNA234E	850
CA3130	80	LM379	480	SN76131	125		
CA3140	40	LM380	75	SN76227N	95		
CA3160	95	LM381N	145	SN76477	420		
CA3161	180	LM382	115	SN76488	480		
CA3162E	450	LM384	160	SP8629	299		
CA3189	200	LM386	90	TA7204	175		
HA1336W	175	LM387	120	TA7205	80		
HA1388	255	LM389	96	TA7222	150		
ICL7106	680	LM393	45	TA7120	160		
ICL7107	970	LM394	290	TA7310	125		
		LM558	140	TAA621AX1	296		
		LM725CN	325	TAA661A	190		
		LM733	70	TAA700	275		
		LM1458	35	TAA900	395		
		LM1871	325	TAB1042	110		
		LM2917	185	TAD100	159		
		LM3302	75	TBA120S	70		
		LM3900	50	TBA540Q	275		
		LM3909N	85	TBA550Q	330		
		LM3911	200	TBA641BX			
		LM3914	200	or BX11	280		
		LM3915	250	TBA651	190		
		LM3916	250	TBA800	80		
		LM13600	110	TBA810	95		
		LS7220	280	TBA820	80		
		M706B1	125	TBA920Q	200		
		MS1513L	230	TBA950	300		
		MS1515L	320	TBA990Q	350		
		MS1516L	475	TC9109	775		
		MB3712	220	TCA220	350		
		MB3758	440	TCA270Q	350		
		MC1204	250	TCA280A	220		
		MC1301	78	TCA940	175		
		MC1303	96	TCA965	145		
		MC1304P	280	TDA1004	280		
		MC1310P	150	TDA1008	310		
		MC1445	250	TDA1010	198		
		MC145106	695	TDA1022	499		
		MC1455	50	TDA1024	115		
		MC1458	35	TDA1034	350		
		MC1469	300	TDA1490	350		
		MC1494	694	TDA2002	325		
		MC1495	350	TDA2003	198		
		MC1496L	70	TDA2004	485		
		MC1596	228	TDA2006	330		
		MC1648	280	TDA2020	320		
		MC1709G	90	TDA2030	295		
		MC3302	80	TDB0791	420		

DIODES

AA119	15
AA129	20
AAY30	15
BA100	15
BAX	20
BY100	24
BY126	12
BY127	12
CR033	250
OA9	40
OA47	12
OA70	12
OA79	15
OA81	20
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	6
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	15
1N5404	16
1N5406	17
1N5408	19
1S44	8
1S921	9
6A/100V	40
6A/400V	50
6A/600V	60

VARICAPS

BA102	50
BB105B	40
BB106	40
BB109B	45
MVAM2	105

BRIDGE RECTIFIERS

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	45
2A/600V	48
6A/100V	83
6A/400V	96
6A/600V	126
10A/200V	215
10A/600V	296
25A/200V	240
25A/600V	398
BY164	58
VM18 DIL	50

ZENERS

Range: 2V7 to 39V
400mW 8p each
Range: 3V3 to 33V
1.3W 15p each

TRIACS

3A200V	54
3A400V	56
8A100V	60
8A400V	69
8A800V	115
12A100V	78
12A400V	82
12A800V	136
16A100V	103
16A400V	110
16A800V	220
25V500V	220
25A800V	296
12800D	120

75 SERIES

75107/8	96
75110	80
75114/5	150
75121/2	130
75150	125
75154	125
75159	125
75182/4	99
75188/9	56
75322	140
75324	360
75361/3	150
75365	150
75450	65
75451/2	52
75454	70
75491/2	65

SCR THYRISTORS

5A/40V	32
5A400V	42
5A600V	48
8A300V	60
8A600V	90
12A100V	76
12A400V	90
12A800V	188
BT106	150
BT116	150
C106D	36
TIC44	24
TIC45	29
TIC47	36
2N5062	32
2N5064	35
2N4444	130

DIAC

ST2	25

TRANSISTORS

AC126/7	35	BC212L	10	BF 258A	35	MPSA56	30	VK101	90	2N3708/9	10	2SC2078	170
AC141/2	30	BC213	10	BF 258B	45	MPSA70	30	VN10KM	55	2N3713	140	2SC2091	85
AC176	28	BC213L	10	BF 257/8	32	MPSU02	58	VN46AF	78	2N3771	179	2SC2314	86
AC187	37	BC214	10	BF259	35	MPSU05	55	VN66AF	80	2N3772	195	2SC2166	106
AC188	32	BC213L	10	BF 336/7	40	MPSU06	55	VN88AF	94	2N3773	210	2SC2335	225
AC188	32	BC237/8	14	BF594/5	30	MPSU52	65	VN89AF	96	2N3819	22	2SC2547	30
ACY19/21	75	BC258B	30	BFR39/40	23	MPSU55	80	ZTX107/8	11	2N3820	38	2SC2612	225
ACY22/41	75	307B	14	BFR41/79	23	MPSU56	60	ZTX109	12	2N3822/3	45	2SD234	74
AD142	120	BC308	16	BF494/5	30	MPSU56	60	ZTX212	28	2N3866	90p	2SK45	90
AD149	79	BC318	80	BFR41/79	23	OC26	170	ZTX300	13	2N3903/4	15	2SK268	225
AD161	42	BC327	15	BFR80/81	25	OC28	220	ZTX302	16	2N3905/6	15	2SJ83	225
AD162	42	BC337/8	15	BFR98	105	OC35	50	ZTX303	25	2N3906	17	2SJ85	226
AF115/6	80	BC441/61	34	BFX29	28	OC36/41	75	ZTX304	17	2N4264	24	3N128	112
AF168	80	BC477	40	BFX81	45	OC71/72	40	ZTX326	30	2N4286	15	3N140	112
AF124/26	70	BC516/7	40	BFX84	28	OC81/82	60	ZTX451	23	2N4314	78	40315	90
AF139	40	BC547/8	12	BFX85/6	28	OC83/84	40	ZTX500	14	2N4400	18	40316	96
AF178	75	BC549C	14	BFY50/51	23	OC170/71	50	ZTX501/2	15	2N4427	80	40324	100
AF186	70	BC556/7	15	BFY52	23	OC42	50	ZTX503	18	2N4871	55	40326/7	70
AF239	55	BC558/9	15	BFY53	32	OC70	40	ZTX504	25	2N5135/6	20	40347	90
BC107	10	BCY39/40	85	BFY55/6	32	OC75/76	40	ZTX531	125	2N5138	18	40348	120
BC107B	12	BCY45	50	BFY64	35	TIP29A	32	ZTX550	26	2N5172	18	40360	90
BC108	10	BCY58/59	38	BFY81	120	TIP29C	38	2N697	23	2N5179	45	40361/2	70
BC108B	12	BCY70/71	16	BFY90	60	TIP30A	35	2N698	40	2N5180	45	40407/8	75
BC109	10	BCY72	20	BRY39	40	TIP30C	37	2N699	48	2N5190/1	75	40411	285
BC109B	12	BCY78	24	BSX20	20	TIP31A	38	2N706A	18	2N5194	80	40412	90
BC109C	12	BD114	190	BSX26/29	34	TIP31B	39	2N708	15	2N5305/8	30	40467A	130
BC114/5	22	BD121	95	BU105	170	TIP31C	39	2N918	35	2N5457/8	30	40468	85
BC117/8	20	BD124	115	BU205	180	TIP32A	38	2N1131/2	24	2N5459	30	40594	106
BC137/9	40	BD131/32	48	BU206	200	TIP32C	42	2N1302	45	2N5485	36	40603	110
BC142/3	30	BD133	70	BU208	200	TIP33A	65	2N1671B	180	2N5777	45	40673	75
BC147B	9	BD135	45	BUY69C	225	TIP33C	78	2N2160	285	2N5879	180	40871/2	90
BC148B	9	BD136/37	40	E421	250	TIP34A	74	2N2219A	28	2N6027	32		
BC149C	9	BD138/39	40	MD8001	250	TIP34C	88	2N2220A	28	2SA671	250		
BC153/4	27	BD140	40	MJ2955	70	TIP35A	110	2N2221A	25	2SA715	60		
BC157/8	10	BD144/45	198	MJE170	160	TIP35C	128	2N2222A	25	2SC495	70		
BC159	11	BD158	56	MJE180	150	TIP36A	130	2N2368	25	2SC496	70		
BC160	45	BD205/6	110	MJE340	54	TIP36C	140	2N2369A	18	2SC1061	250		
BC167A	10	BD245	45	MJE370	100	TIP41A	50	2N2483/4	27	2SC1096	85		
BC168C	10	BD378	70	MJE371	100	TIP41B	52	2N2646	48	2SC1162	30		
BC169C	10	BD 517	75	MJE520	65	TIP42A	55	2N2904/5	26	2SC1173	125		
BC170	15	BD645	80	MJE521	98	TIP42B	58	2N2906/7	26	2SC1306	100		
BC171/2	11	BD 695A	125	MJE2955	98	TIP120	70	2N2907A	28	2SC1307	150		
BC173	11	BD696A	125	MJE3055	70	TIP121/2	73	2N2926G	10	2SC1449	85		
BC177/8	16	BF115	35	MPF102	40	TIP141/2	105	2N3053	28	2SC1678	140		
BC179	20	BF154/8	25	MPF103	30	TIP147	120	2N3054	58	2SC1679	180		
BC181	20	BF184/5	38	MPF104	30	TIP2955	80	2N3055	48	2SC1923	50		
BC182/3	10	BF194/5	12	MPF105	30	TIP3055	80	2N3252	48	2SC1945	225		
BC184	10	BF198/9	16	MPF106	40	TIS43	32	2N3441/2	140	2SC1963	80		
BC182L	10	BF200	80	MPSA05	25	TIS44/5	45	2N3614/5	180	2SC1957	80		
BC183L	10	BF224A	25	MPSA08	25	TIS88A	50	2N3702/3	10	2SC1969	140		
BC184L	10	BF 224B	29	MPSA12	32	TIS90/91	30	2N3704/5	10	2SC2028	85		
BC188 6/7	25	BF 245	30	MPSA55	30	UC	65	2N3706/7	10	2SC2029	210		
BC12	10												

RF CHOKES Miniature PCB type

1uH, 2u2, 4u7, 10u, 22u, 33u, 47u, 100u, 220u, 330u, 470u 30p
1mH, 1m5, 2m2, 4m7, 10mH 35p
22m, 33m, 43m 60p
100m 75p

TTL74

7400	14	7470	38	74248	120	S475	600
7401	14	7472	24	74249	120	S571	820
7402	14	7473	26	74251	88	S573	950
7403	14	7474	20	74259	150		
7404	14	7475	25	74263	55		
7405	16	7476	25	74273	150		
7406	20	7480	46	74276	120		
7407	20	7481	120	74278	100		
7408	16	7482	65	74279	50		
7409	16	7483	38	74283	50		
7410	16	7484	70	74284	155		
7411	16	7485	80	74285	155		
7412	18	7486	20	74290	105		
7413	18	7489	170	74293	80		
7414	24	7490	20	74297	238		
7416	20	7491	35	74298	100		
7417	20	7492	25	74351	195		
7420	16	7493	25	74365	30		
7421	20	7494	35	74366	30		
7422	20	7495	35	74367	30		
7423	20	7496	35	74368	30		
7425	18	7497	90	74390	75		
7426	18	74100	80	74393	90		
7427	15	74104	50	74490	95		
7428	28	74105	55				
7430	15	74107	20				
7432	22	74109	25				
7433	22	74110	35				
7437	25	74111	55				
7438	22	74112	170				
7440	16	74116	50				
7441	55	74118	55				
7442	32	7419	60				
7443	90	74120	60				
7444	90	74121	25				
7445	56	74122	35				
7446	60	74123	35				
7447	40	74125	35				
7448	45	74126	35				
7450	16	74128	35				
7451	16	74132	30				
7453	16	74136	28				
7454	16	74141	55				
7460	16	74142	175				
		74143	210				
		74144	210				
		74145	50				
		74147	75				
		74148	80				
		74150	50				
		74151	40				
		74153	40				
		74154	150				
		74155	40				
		74156	40				
		74157	30				
		74159	80				
		74160	60				
		74161	48				
		74162	40				
		74163	40				
		74164	40				
		74165	48				
		74166	48				
		74167	150				
		74170	125				
		74172	250				
		74173	60				
		74174	54				
		74175	55				
		74176	40				
		74177	45				
		74178	80				
		74179	80				
		74180	40				
		74181	115				
		74182	60				
		74184	90				
		74185	95				
		74188	250				
		74190	48				
		74191	46				
		74192	46				
		74193	45				
		74194	40				
		74195	40				
		74196	46				
		74197	40				
		74198	80				
		74199	84				
		74221	84				
		74246	120				
		74247	120				

74C

74C244	195
74C245	195
74C373	240
74C374	245
74C922	420
74C923	500

74S

74S00	30
74S10	40
74S11	50
S02	30
S03	30
S04	30
S05	60
S08	60
S20	40
S22	50
S32	70
S37	60
S74	75
S85	295
S86	65
S112	60
S113	90
S114	60
S124	300
S132	110
S133	60
S138	100
S139	115
S140	60
S151	160
S153	182
S157	225
S158	210
S163	300
S174	250
S175	320
S188	140
S189	140
S194	195
S197	400
S201	250
S225	240
S240	300
S241	260
S244	290
S251	170
S257	170
S258	250
S260	70
S262	850
S287	226
S288	210
S289	200
S301	380
S365	250
S373	400
S374	365
S412	380
S470	325
S471	620
S472	1150
S474	400

74LS

LS00	15	LS173	45
LS01	16	LS174	36
LS02	15	LS175	36
LS03	15	LS181	100
LS04	16	LS183	105
LS05	15	LS190	40
LS08	15	LS191	40
LS09	15	LS192	40
LS10	15	LS193	40
LS11	15	LS194	36
LS12	15	LS195	38
LS13	15	LS196	48
LS14	28	LS197	50
LS15	15	LS221	55
LS20	15	LS240	66
LS21	15	LS241	60
LS22	15	LS242	55
LS26	15	LS243	55
LS27	15	LS244	56
LS28	15	LS245	85
LS30	15	LS247	55
LS32	15	LS248	85
LS33	15	LS249	55
LS37	15	LS251	36
LS38	28	LS253	36
LS40	15	LS254	60
LS42	30	LS257	33
LS47	38	LS258	35
LS48	45	LS259	60
LS49	50	LS260	22
LS51	14	LS281	100
LS52	16	LS266	24
LS54	16	LS273	54
LS55	16	LS275	125
LS63	120	LS279	30
LS70	100	LS280	90
LS73	20	LS283	40
LS74	20	LS290	40
LS75	22	LS292	700
LS76	20	LS294	700
LS78	20	LS293	50
LS83	38	LS295	75
LS85	42	LS298	80
LS86	20	LS299	150
LS87	350	LS320	200
LS90	28	LS323	160
LS91	60	LS324	166
LS92	32	LS325	295
LS93	28	LS326	240
LS95	40	LS327	240
LS96	95	LS347	95
LS99	99	LS348	90
LS107	40	LS352	82
LS109	23	LS353	82
LS112	22	LS356	240
LS113	26	LS362	780
LS114	28	LS364	140
LS122	36	LS363	140
LS123	42	LS365	34
LS124	90	LS366	34
LS125	29	LS367	28
LS126	29	LS368	36
LS132	30	LS367	60
LS133	30	LS373	60
LS135	34	LS374	00
LS136	34	LS375	50
LS138	30	LS377	86
LS139	30	LS378	106
LS145	90	LS379	110
LS147	110	LS384	450
LS148	95	LS385	250
LS151	40	LS386	54
LS153	40	LS390	50
LS154	195	LS393	50
LS155	30	LS394	00
LS156	36	LS396	150
LS157	25	LS398	140
LS158	30	399	150
LS160	40	LS445	100
LS161	40	LS447	100
LS162	40	LS465	75
LS163	40	LS490	200
LS164	43	LS540	75
LS165	75	LS541	80
LS166	52	LS624	80
LS168	84	LS640	180
LS169	00	LS641	180
LS170	90	LS645	180
		LS668	128
		LS669	130
		LS670	110
		LS673	50
		LS674	36

SWITCHES

TOGGLE: 2A, 250V

SPST	33p
DPDP	44p

SUB-MIN TOGGLE

SPST on/off	54p
SPDT c/over	60p
SPDT centre off	65p
SPDT biased both ways	105p
DPDT 6 tags	75p
DPDT centre off	85p
DPDT biased both ways	145p
DPDT 3 positions on/on/on	185p
3-pole 2 way	205p

SLIDE 250V:

DPDT 1A	14p
DPDT 1A c/off	15p
DPDT ½A	13p

PUSHBUTTON 6A

with 10mm Button

SPDT latching	99p
DPDT latching	145p
SPDT moment	99p
DPDT moment	145p

Mini Non Locking

Push to Make	15p
Push to Break	25p

DIL SWITCHES

(SPST) 4 way 65p; 6 way 80p; 8 way 85p; 10 way 125p
(SPDT) 4 way 190p

ROTARY SWITCHES
(Adjustable Stop type)

1 pole/2 to 12 way; 2 pole/2 to 6 way; 3 pole/2 to 4 way; 4 pole/2 to 3 way 45p

ROTARY: Mains DP 250V 4 Amp on/off 66p

ROTARY: (Mak-a-switch)
Make a multiway switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers (max. 6 pole/12 way + DP switch). Mechanism only 90p

WAFERS: (make before bread) to fit the above switch mechanism. 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6-/2 ay 65p
Mains DP 4A Switch to fit 45p
Spacers 4p. Screen 6p.

ROCKER: 5A/250V SPST	26p
ROCKER: 10A/250V SPDT	38p
ROCKER: 10A/250V DPDT c/off	95p
ROCKER: 10A/250V DPST with neon	85p

THUMBWHEEL Mini front mounting

Decade Switch Module	220p
B.C.D. Switch Module	278p
Mounting Cheeks (per pair)	75p

VEROBOARD 0.1in

2½ x 3¼	85p	—
2½ x 5	100p	
3¾ x 3¾	100p	
3¾ x 5	115p	
3¾ x 17	390p	
4¾ x 17	495p	
Pkt of 100 pins	55p	
Spot face cutter	150p	
Pin insertion tool	185p	

VA Board	195p
DIP Board	385p
Vero Strip	95p

PROTO DECs

Veroblock	405p
S-Dec	350p
Eurobreadboard	520p
Bimboard 1	575p
Superstrip SS2	1350p

VERO WIRING PEN

+ spool	340p
Spare spool	75p
Combs	6p

DALO ETCH RESIST PEN
Plus spare tip 100p

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

ULTRASONIC TRANSDUCER
40KHz 325 pr

IDC CONNECTORS

	PCB with Pins Strt	Plugs latch Pins Angle	Female Header Plug	Female Card Edge Connect
10 way	90p	99p	05p	120p
16 way	130p	150p	110p	—
20 way	145p	168p	125p	195p
26 way	175p	200p	150p	240p
34 way	205p	236p	160p	320p
40 way	220p	260p	180p	340p
50 way	235p	270p	200p	385p
60 way	—	—	230p	495p

PANEL METERS

FSD
60 x 46 x 35mm
0-50mA
0-100mA
0-500mA
0-1mA
0-5mA
0-10mA
0-50mA
0-100mA
0-500mA
0.aA
0.2A
0.25V
0.50V AC
0.300V AC
"S"
"VU" 490p each

RELAYS
Miniature, enclosed, PCB mount

SINGLE POLE Changeover
RL-91 205 Coil: 12V DC, (10V5 to 19 5V). 10A at 30V DC or 250V AC 195p
DOUBLE POLE Changeover, 6A 30V 0C or 250V AC
RL-100 53 Coil, 6V DC (5V4 to 9V9) 190p
RL6-111 205 Coil, 12V DC (10V7 to 19V5) 195p
RL6-114 740 Coil, 24V DC (22V to 37V) 200p

EURO CONNECTORS

Gold Flashed Contacts	Female Strt. Pins	Socket Angle Pins	Male Strt. Pins	Plug Angle Pins
DIN41617 31 way	170p	—	—	175p
DIN41612 2 x 32 A + B	275p	320p	220p	265p
DIN41612 2 x 32 A + C	295p	340p	240p	300p
DIN41612 3 x 32 A + B + C	360p	385p	280p	395p

AMPHENOL PLUGS

IEEE 24 Way	550
Centronics Parallel 36 Way solder	530
Centronics Parallel 36 Way IDC	495
Centronics 36 Way IDC Female	520p

COPPER CLAD BOARDS

Fibre glass	Single-sided	Double sided	S.R.B.P. S/Speed 9.5" x 8.5"
6" x 6"	100p	125p	110p
6" x 12"	175p	225p	

DILL SOCKETS

	Low Prof	Wire Wrap
8 pin	6p	25p
14 pin	10p	35p
16 pin	10p	42p
18 pin	16p	52p
20 pin	20p	60p
22 pin	22p	65p
24 pin	25p	70p
28 pin	28p	80p
40 pin	30p	90p

EDGE CONNECTORS

	.1	.156
2 x 15 way	—	140p
2 x 18 way	180p	145p
2 x 22 way	180p	200p
2 x 23 way	175p	—
2 x 25 way	225p	220p
2 x 28 way	190p	—
2 x 30 way	245p	—
2 x 36 way	295p	—
2 x 40 way	315p	—
2 x 40 way	315p	—
2 x 75 way	550p	—

DIL PLUG (Header)

	Solder	IDC
14 pin	40p	90p
16 pin	48p	105p
24 pin	86p	178p
28 pin	140p	—
40 pin	250p	255p

RIBBON CABLE

price per foot

	Grey	Color
10 way	15p	28p
16 way	25p	40p
20 way	30p	50p
24 way	40p	65p
34 way	60p	85p
40 way	70p	90p
50 way	100p	135p
64 way	120p	160p

ZIF DIL SOCKETS

24 pin	575p
28 pin	750p
40 pin	875p

CRYSTALS

32.768KHz	100
100KHz	235
200KHz	265
455KH	370
1MHz	275
1.008M	275
1.28MHz	390
1.6MHz	395
1.8NHz	395
1.8432M	200
2.0MHz	225
2.4576M	200
3.278M	150
3.5794M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.80MHz	200
4.19430M	200
4.433619M	100
5.0MHz	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	225
7.0MHz	150
7.168MHz	250
7.7328MHz	250
7.68MHz	200
8.0MHx	150
8.089333M	395
8.86723M	175
9.00MHz	200
10.0MHz	175
10.24MHz	200
10.7MHz	150
12.0MHz	175
12.528M	300
14.31814M	170
16.0MHz	200
18.0MHz	180
18.432M	150
19.968MHz	150
20.0MHz	200
24.0MHz	170
24.930MHz	325
26.69M	150
27.648M	170
27.145M	180
38.6667M	175
48.0MHz	170
100.0MHz	295
116.0MHz	300

BUZZERS

miniature, solid-state 6V, 9V & 12V	70p
PIEZO TRANSDUCERS PB2720	55p

LOUDSPEAKERS

Miniature, 0.3W- 8

2in, 3¼in, 2½in, 3in	80p
2½in 40 . 64 or 80	80p

ETI PROJECTS We stock most of the parts

JUMPER LEADS (Ribbon Cable Assembly)

Length	14 pin	16 pn	24 pin	40 pin
Single ended DIP (Header Plug) Jumper				
24 inches	145p	185p	240p	380p
Double ended DIP (Header Plug) Jumper				
6 inches	185p	205p	300p	485p
12 inches	198p	215p	315p	480p
24 inches	210p	235p	345p	540p
36 inches	290p	370p	480p	525p

IDC Female Deader Socket Jumper Leads 36"

	20 pin	26 pin	34 pin	40 pin
Single ended	160p	200p	260p	300p
Double ended	290p	480p	525p	

ANTEX SOLDERING IRON

C-15W	495p	CS17W	495p
G18W	520p	XS25W	525p

Spare tips, assorted sizes 85p
Spare elements 225p
Iron Stand with sponge 175

SIL SOCKET
0.1" pitch
20 way
65p

'D' CONNECTORS
miniature

	9 way	15 way	25 way	37 way
Male				
Solder lugs	80p	105p	160p	250p
Angle pins	150p	210p	250p	355p
PCB pins	120p	130p	195p	295p
Female				
Solder lugs	105p	160p	200p	335p
Angle pins	165p	215p	290p	440p
PCB pins	150p	180p	240p	420p
COVERS	80p	75p	75p	90p

IDC 25 way 'D' Plug 385p; Socket 450p

ASTEC UHF MODULATORS

Standard 6MHz	325p
Wideband 8MHz	480p

TRANSFORMERS

0-3V; 6-0-6V; 9-0-9V; 12-0-12V; 15-0-15V @ 100mA 98p
Pcb mounting. Miniature, Split Bobbin
3VA: 2x6V-0.25A; 2x9V-0.15A; 2x12V-0.12A; 2x15V-0.1A 200p
6VA: 2x6V-0.5A; 2x9V-0.3A; 2x12V-0.25A; 2x15V-0.2A 295p
Standard Split Bobbin type:
6VA: 2x6V-0.5A; 2x9V-0.4A; 2x12V-0.3A; 2x15V-0.25A 250p
12VA: 2x4.5V-1.3A; 2x5V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A 320p (35p p&p)
24VA: 2x6V-1.5A; 2x9V-1.2A; 2x12V-1A; 2x15V-0.8A; 2x20V-0.6A 365p (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-1A; 2x30V-0.8A 520p (60p p&p)
Specially wound for Multirail computer PSUs
60VA: Outputs +5V/5A; +12V, +25V, −5V, −12V @ 1A 820p (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x25V-2A; 2x30V-1.5A; 2x50V-1A 920p (75p)

P&P charge to be added over and above our normal postal charge

VOLTAGE REGULATORS
1A TO220 Plastic Casing

	+ ve		− ve	
5V	7805	40p	7905	45p
12V	7812	40p	7908	60p
15V	7815	40p	7912	45p
18V	7818	40p	7915	45p
24V	7824	40p	7918	45p
			7924	45p

100mA TO92 Plastic package

5V	78LO5	30p	79LO5	60p
6V	78LO6	30p	—	—
8V	78LO8	30p	—	—
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

ICL7660	248p	TAA550	50p
RC4194	375p	TDA1412	150p
RC4195	160p	78H05 + 5V/5V	550p
LM309K	135p	78H12 +12V/5A	580p
LM317K	320p	78HG + 5V to + 25V	
LM317KP	450p	5A	500p
LM323K	450p	79HG + 2.25V to 24V	
LM337	175p	51	685p
LM723 Var	36p		

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Ideal for making SIL or DIL Sockets

100 pins	75p
500 pins	350p

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3 x 2 x 1"	85p
4 x 2½ x 2"	100p
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4 x 4 x 2"	106p
4 x 4 x 2½"	120p
5 x 4 x 1½"	99p
5 x 4 x 2½"	120p
5 x 2¾ x 1½"	90p
5 x 2¾ x 2½"	130p
6 x 4 x 2"	120p
6 x 4 x 3"	150p
7 x 5 x 3"	180p
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10 x 4 x 3"	240p
10 x 7 x 3"	275p
12 x 5 x 3"	280p
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Jumper Lead Cable Assembly

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The Colour Printer that has broken all price barriers.
A 7 colour graphic printer at the price of a standard Dot matrix printer. Its unique 4 hammer method enables text & high res graphics to be drawn in 7 basic colours or 30 shades. 7 x 8 matrix. Up to 106 char. per line at 50 CPS. Variable line spacing to 1/120". Tractor or Friction feed. Centronix interface standard.
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4001	12	4076	50	4543	70
4002	12	4077	15	4544	150
4006	50	4078	15	4548	40
4007	14	4081	15	4549	375
4008	32	4082	15	4553	245
4009	24	4085	50	4554	180
4010	24	4086	60	4555	35
4011	12	4089	125	4556	35
4012	18	4093	20	4557	320
4013	20	4094	70	4558	120
4014	48	4095	95	4559	395
4015	40	4096	70	4560	180
4016	20	4097	275	4561	104
4017	32	4098	75	4562	485
4018	45	4099	110	4566	165
4019	25	4160	95	4568	250
4020	42	4161	96	4569	175
4021	40	4162	96	4572	36
4022	40	4163	96	4580	460
4023	13	4174	96	4581	25
4024	32	4175	105	4582	99
4025	18	4194	105	4583	90
4026	30	4408	790	4584	40
4027	20	4409	790	4585	70
4028	39	4410	725	4597	330
4029	45	4411	675	4599	29
4030	15	4412	775	40085	90
4031	125	4415	480	40097	45
4032	80	4419	280	40098	42
4033	125	4422	770	40100	215
4034	140	4435	850	40101	130
4035	45	4440	900	40102	140
4036	275	4450	360	40103	175
4037	115	4451	350	40104	96
4038	110	4490	360	40105	106
4039	280	4500	675	40106	36
4040	40	4501	28	40107	60
4041	40	4502	60	40108	198
4020	40	4503	40	40109	100
4043	40	4504	75	40110	198
4044	40	4505	185	40114	240
4045	105	4506	36	40161	194
4046	46	4507	36	40163	50
4047	40	4508	130	40174	45
4048	40	4510	46	40175	50
4049	25	4511	46	40181	220
4050	25	4512	45	40182	80
4051	45	4513	198	40192	75
4052	60	4514	115	40193	95
4053	50	4515	115	40194	70
4054	85	4516	55	40195	75
4055	85	4517	275	40244	198
4056	85	4518	40	40245	198
4057	1915	4519	30	40257	198
4059	435	4520	50	40373	180
4060	45	4521	90	40374	180
4061	1195	4522	125	45106	586
4062	986	4526	60		
4063	85	4527	65		
4066	24	4528	50		
4067	245	4529	150		
4068	14	4530	90		
4069	16	4531	130		
4070	15	4532	50		
4071	15	4534	400		
4072	15	4536	275		
4073	16	4538	80		
		4539	90		

OPTO

LS400C	265
OCP71	120
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BPW21	288
BPX65	270

OPTO ELECTRONICS

LEDs with clips

TIL209	10
TIL211 GRN	14
TIL212 Yel.	14
TIL220 2" Red	12
2" Green, Yellow or Amber	14
0.2" Bi colour Red/Green	65
Green/Yellow	78
0.2" Tri colour Red/Green/Yellow	85
Hi-Brightness Red	58
Flashing red 0.2" red	55
Square LEDs, Red, Green, Yellow	30
Rectangle Stackable LEDs Red, Green or Yellow	18
Triangular LEDs Red	18
Green or yellow	22
LD271 Infra Red	48
SFH205 Detector	118
TIL32 Infra Red	58
TIL78 Detector	60
TIL38	45
TIL100	90
BARGRAPH, Red 10 segments	225

ISOLATORS

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ILQ74	185
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ILCT6 Darlington	135
4N33 Photo Darlington	136

7 Segment Displays

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TIL322 .5" CC	115
DL704 .3" CC	99
DL707 .3" CA	99
FND357 Red	120
FND500	115
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.3" ± Green CA	150
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SD 4478-002	810
Schmitt Receiver	620
Reflective Optical Switch type TIL139	170
Slotted Optical Switch similar to RS Comp.'s	166

COMPUTER CORNER

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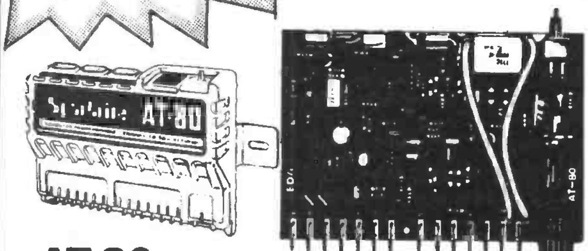

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- Over 250 components to assemble

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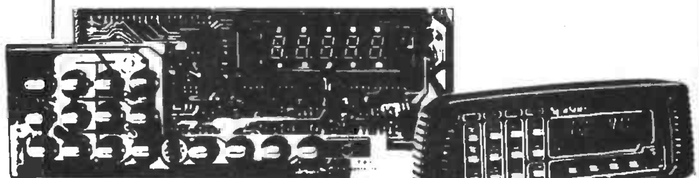


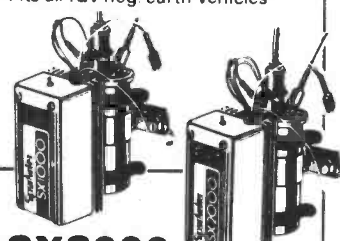
SX1000
Electronic Ignition

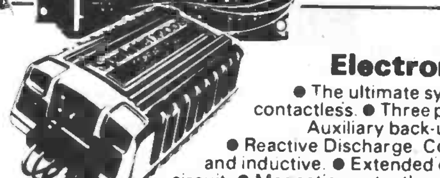
- Inductive Discharge
- Extended coil energy storage circuit
- Contact breaker driven
- Three position changeover switch
- Over 65 components to assemble
- Patented clip-to-coil fitting
- Fits all 12v neg. earth vehicles

TX1002
Electronic Ignition

NEW

● Contactless or contact triggered ● Extended coil energy storage circuit ● Inductive Discharge ● Three position changeover switch ● Distributor triggerhead adaptors included ● Die cast weatherproof case ● Clip-to-coil or remote mounting facility ● Fits majority of 4 & 6 cyl. 12V. neg. earth vehicles ● Over 145 components to assemble.





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Electronic Ignition

- The brandleading system on the market today
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- Combined Inductive and Capacitive Discharge
- Contact breaker driven
- Three position changeover switch
- Over 130 components to assemble
- Patented clip-to-coil fitting
- Fits all 12v neg. earth vehicles

TX2002
Electronic Ignition

● The ultimate system ● Switchable contactless. ● Three position switch with Auxiliary back-up inductive circuit. ● Reactive Discharge. Combined capacitive and inductive. ● Extended coil energy storage circuit. ● Magnetic contactless distributor trigger-head. ● Distributor triggerhead adaptors included. ● Can also be triggered by existing contact breakers. ● Die cast waterproof case with clip-to-coil fitting ● Fits majority of 4 and 6 cylinder 12v neg. earth vehicles. ● Over 150 components to assemble

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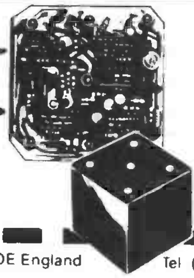

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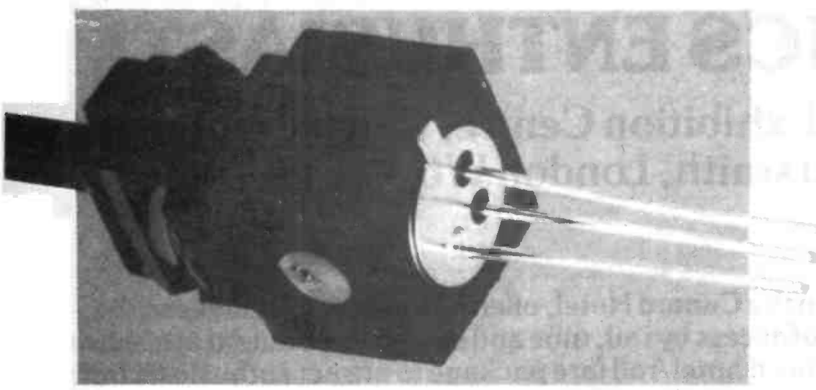
NEXT MONTH

Project Special

As the majority of our readers will be all too aware, the dear old British summer doesn't last that long, and it'll be all too soon before the evenings start to close in, the clocks go back, and thoughts turn back to project work. Well, the November issue of ETI will provide plenty to keep you busy, because in our usual winter effort to lure readers away from the competition (what competition?) we shall be publishing *ten* projects in just the one issue. No silly plastic give-aways from us, we'll just simply deliver where it counts — the contents!

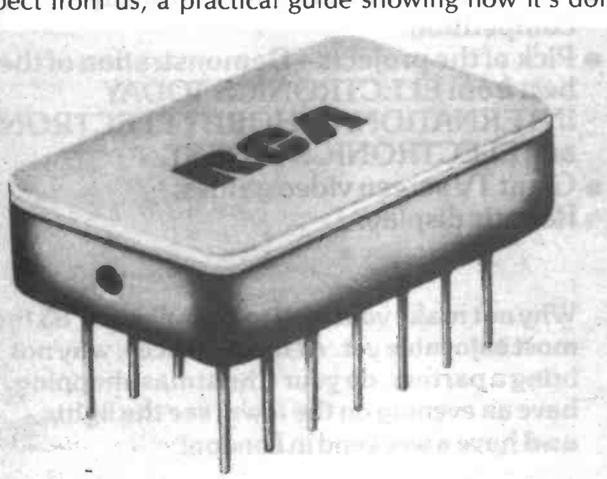
Projects will include a simple design for an active loudspeaker, which, while perhaps not offering the ultimate in audio performance, will certainly be very cost effective and relatively easy to build; a drum synthesiser module so that you can build up a small kit by using several all set to produce different noises; an add-on unit that will help to make many home-made alarms legal; an analogue amplifier/filter module for use with computer ADCs and DACs; and much, much more that we're still working feverishly on!

Add to this the fact that the next issue of ETI will be over 100 pages in size, and it looks as though there's only one possible choice of magazine for you to buy next month.



Optical Fibres

We've heard all about the industrial and communications use of optical fibres — now ETI takes a look at the home use of them, with, as you would expect from us, a practical guide showing how it's done.



Audio Design

John Linsley Hood continues his examination of some of the problems in audio designing with a look at distortion, and this is followed up by some practical designs for moving magnet and moving coil magnet pick-up amplifiers.

ALL THIS AND MORE IN THE NOVEMBER ISSUE OF ETI, ON SALE OCTOBER 7TH. PLACE YOUR ORDER NOW, OR RISK MISSING OUT!

Articles described here are in an advanced state of preparation. However, circumstances may dictate changes to the final contents.

*see next page

HOLIDAY WEEKEND PACKAGE

- ★ Accommodation in a first class hotel with private bath, direct dial telephone, radio and colour television.
- ★ Return 2nd class rail travel from local British Rail station to London.
- ★ Ticket to Breadboard '83.
- ★ Breakfast at the hotel.
- ★ Prices quoted are inclusive of service and VAT.

Please note this offer closes on 1st November 1983.

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Cambs, Hants, Northants, Oxon, Suffolk, Sussex, Wilts	£32.50	£57.50	£57.25	£94.25
Avon, Derbyshire, Dorset, Glos, Gwent, Herefordshire & Worcs, I.O.W., Leics, Lincs, Norfolk, Notts, Somerset, Staffs, Warwickshire, West Midlands	£35.75	£59.75	£59.75	£96.75
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555CMOS	80	ICL7106	790	LM377	170	LM13600	105	NE571	370	TL074	95
556CMOS	150	ICL7611	95	▶LM380	65	MC1496	68	▶RC4136	55	▶TL081	25
709	25	ICL7621	180	▶LM381	120	MC3340	135	▶RC4558	60	TL082	45
▶741	14	ICL7622	180	LM382	120	▶MF10CN	350	SL480	170	TL084	95
748	35	ICL8038	295	LM384	130	ML922	400	SL490	250	TL170	50
9400CJ	350	ICL8211A	200	LM386	65	ML924	195	SL76018	150	UA2240	120
AY-3-1270	720	ICM7224	785	LM387	120	ML925	210	▶SN76477	380	ULN2003	85
AY-3-8910	370	ICM7555	80	LM393	100	ML926	140	SP8629	250	ULN2004	90
AY-3-8912	540	▶LF351	45	LM709	25	ML927	140	TBA120S	70	XR2206	290
CA3046	60	LF353	85	LM711	60	ML928	140	TBA800	75	ZN414	100
▶CA3080	65	LF356	90	LM725	350	ML929	140	TBA810	96	ZN423	135
CA3089	190	LM10	360	LM733	75	MM5387A	465	TBA820	70	ZN424	135
CA3090AQ	375	LM301A	25	LM741	14	NE529	225	TBA950	220	ZN425E	350
CA3130E	85	LM311	70	LM747	60	NE531	160	TDA1008	320	ZN426E	330
▶CA3140E	36	LM318	120	LM1458	40	NE544	205	▶TDA1022	490	ZN427E	650
CA3161E	100	LM324	40	LM2917	200	▶NE555	16	TDA1024	125	ZN428E	480
CA3189	290	LM334Z	100	LM3900	45	▶NE556	45	TL061	40	ZN459	285
▶CA3240E	110	LM335Z	125	▶LM3909	70	NE565	110	TL062	60	ZN1034E	200

TRANSISTORS

				BC517	40	BF337	40	MPSU56	60	ZTX108	8	2N3055	50		
				BC547	7	BFR40	23	TIP29A	30	ZTX109	12	2N3442	120		
				BC548	10	BFR80	23	TIP29B	55	ZTX300	14	▶2N3702	6		
AC125	35	BC149	9	BC549	10	▶BFR81	20	TIP29C	37	ZTX301	16	2N3703	9		
AC126	25	BC157	8	BC558	10	BFX29	25	TIP30A	35	ZTX302	15	▶2N3704	6		
AC127	25	BC158	10	BCY70	18	BFX84	25	TIP30B	50	ZTX304	17	2N3705	9		
▶AC128	20	BC159	8	BCY71	18	BFX85	25	TIP30C	37	ZTX341	30	2N3706	9		
AC176	25	BC160	45	BCY72	18	BFX86	28	TIP31A	35	ZTX500	15	2N3707	10		
AC187	22	BC168C	10	BD115	55	BFX87	25	TIP31C	37	ZTX501	15	2N3708	10		
AC188	22	BC169C	10	BD131	35	BFX88	25	TIP32A	35	ZTX502	15	2N3709	10		
AD142	120	BC170	8	BD132	35	BFY50	23	TIP32C	37	ZTX503	18	2N3772	170		
AD149	80	BC171	10	BD133	50	BFY51	20	TIP33A	50	ZTX504	25	▶2N3773	195		
AD161	40	BC172	8	BD135	40	BFY52	23	TIP33C	75	2N697	20	▶2N3819	18		
AD162	40	BC177	18	BD136	30	BFY53	32	TIP34A	60	2N698	40	2N3820	40		
AF124	60	BC178	18	BD137	30	BFY55	32	TIP34C	85	2N706A	20	2N3823	65		
AF126	50	BC179	18	BD138	30	BFY56	32	TIP35A	105	2N708	20	2N3866	90		
AF139	40	BC182	10	▶BD139	35	BRY39	40	TIP35C	125	2N918	35	2N3903	10		
AF186	70	▶BC182L	8	▶BD140	35	BSX20	20	TIP36A	125	2N1132	22	2N3904	10		
AF239	75	BC183	10	BD204	110	BSX29	35	TIP36C	135	2N1613	30	2N3905	6		
BC107	10	BC183L	10	BD206	110	BSY95A	25	TIP41A	45	2N2218A	45	2N3906	10		
BC107B	12	BC184	10	BD222	85	BU205	160	TIP42A	45	2N2219A	25	2N4037	45		
▶BC108	10	BC184L	7	BF180	35	BU206	180	TIP120	90	2N2221A	25	2N4058	10		
BC108B	12	BC212	10	BF182	35	BU208	170	TIP121	90	2N2222A	20	2N4060	10		
BC108C	12	BC212L	10	BF184	25	MJ2955	99	TIP122	90	2N2368	25	2N4061	10		
▶BC109	10	BC213	10	BF185	25	MJE340	50	TIP141	98	2N2369	16	2N4062	10		
BC109C	12	BC213L	10	BF194	12	MJE520	65	TIP142	98	2N2484	25	2N5457	36		
BC114	18	BC214	10	BF195	12	MJE521	95	TIP147	110	2N2646	45	2N5458	36		
BC115	22	▶BC214L	8	BF196	12	MJE3055	70	TIP2955	60	2N2904	20	2N5459	30		
BC117	18	BC237	8	BF197	12	MPF102	40	TIP3055	55	2N2904A	20	2N5485	36		
BC119	35	BC238	14	BF198	10	MPF104	40	TIS43	40	2N2905	22	2N5777	45		
BC137	40	BC308	12	BF199	18	MPSA05	22	TIS44	45	2N2905A	22	2N6027	30		
BC139	40	BC327	14	BF200	30	MPSA06	25	TIS90	30	2N2906	25	40360	40		
BC140	28	BC328	14	▶BF244B	22	MPSA12	30	TIS91	30	2N2906A	25	40361	50		
BC141	30	BC337	14	BF245	30	MPSA55	30	VN10KM	45	2N2907	25	40362	50		
BC142	25	BC338	14	BF256B	45	MPSA56	30	VN46AF	75	2N2907A	25	40408	70		
BC143	25	BC477	30	BF257	32	MPSU05	55	VN66AF	85	2N2926	9				
BC147	8	BC478	30	BF258	25	MPSU06	55	VN88AF	95	▶2N3053	23				
BC148	8	BC479	30	BF259	35	MPSU55	60	ZTX107	8	2N3054	55				

CABLES

20 metre pack single core connecting cable ten different colours	65p
Speaker cable	10p/m
Standard screened	16p/m
Twin screened	24p/m
2.5A 3 core mains	23p/m
10 way rainbow ribbon	65p/m
20 way rainbow ribbon	120p/m
10 way grey ribbon	38p/m
20 way grey ribbon	80p/m

HARDWARE

PP3 battery clips	8
Red or black crocodile clips	6
Black pointer control knob	15
Pr Ultrasonic transducers	350
▶6V Electronic buzzer	60
▶12V Electronic buzzer	65
▶PB2720 Piezo transducer	75
▶64mm 64 ohm speaker	70
▶64mm 8 ohm speaker	70
20mm panel fuseholder	25

CAPACITORS

Polyester, radial leads. 250v. C280 type: 0.01, 0.015, 0.022, 0.033 - 6p; 0.047, 0.068, 0.1 - 7p; 0.15, 0.22 - 9p; 0.33, 0.47 - 13p; 0.68 - 20p; 1u - 23p.
Electrolytic, radial or axial leads: 0.47/63V, 1/63V, 2.2/63V, 4.7/63V, 10/25V - 7p; 22/25V, 47/25V - 8p; 100/25V - 9p; 220/25V - 14p; 470/25V - 22p; 1000/25V - 30p; 2200/25V - 50p.
Tag end power supply electrolytics: 2200/40V - 110p; 4700/40V - 160p 2200/63V - 140p; 4700/63V - 230p
Polyester, miniature Siemens PCB: 1n, 2n2, 3n3, 4n7, 6n8, 10n, 15n, 7p; 22n, 33n, 47n, 68n, 8p; 100n, 9p; 150n, 11p; 220n, 13p; 330n, 20p; 470n 26p; 680n, 29p; 1u 33p; 2u2, 50p.
Tantalum bead: 0.1, 0.22, 0.33, 0.47, 1.0 @ 35V - 12p. 2.2, 4.7, 10 @ 25V - 20p; 15/16V - 30p; 22/16V - 27p; 33/16V - 45p; 47/6V - 27p; 47/16V - 70p; 68/6V - 40p; 100/10V - 90p.
Cer. disc. 22p-0.01u 50V, 3p each.
Mullard miniature ceramic plate: 1.8pF to 100pF 6p each.
Polystyrene, 5% tol: 10p-1000p, 6p; 1500-4700, 8p; 6800 0.012u, 10p.
Trimmers. Mullard 808 series: 2-10 pF, 22p; 2-22pF, 30p; 5.5-65pF, 35p

REGULATORS

78L05	30	79L05	65
78L12	30	79L12	65
78L15	30	79L15	65
7805	35	7905	40
7812	35	7912	40
7815	35	7915	40
LM309K	130	LM723	35
LM317K	270		
LM317T	120		
LM323K	350		

SPECIAL OFFER! 78P05 10A +5V only 390p each.

POTENTIOMETERS

Rotary. Carbon track Log or Lin 1K - 2M2. Single 32p. Stereo 85p. Single switched 80p. Slide 60mm travel single Log or Lin 5K - 500K 63p each.
Preset submin. hor. 100 ohms -1M 7p each.
Cermet precision multiturn, 0.75W ¾" 100 ohms to 100K - 88p each.

TRIACS

		400V 8A	65
		400V 16A	95
400V 4A	50	BR100	25

DIODES

BY127	12	▶1N4001	3
OA47	10	1N4002	5
OA90	8	1N4006	7
OA91	7	1N4007	7
OA200	8	1N5401	12
OA202	8	1N5404	16
1N914	4	1N5406	17
▶1N4148	3	400mWzen	6

JUMPER LEADS

Length	14pin	16pin	24pin	40pin
Sgle ended DIP(header plug) jumper 24 ins.	145	165	240	380
Dble ended DIP(header plug) jumper 6 ins.	185	205	300	465
12 ins.	195	215	315	490
24 ins.	210	235	345	540
36ins.	230	250	375	595

25 way D Connector jumpers
18ins. long single ended male 495p.
18ins. long single ended f/male 525p.

OPTO

▶3mm red	7	▶5mm red	7
▶3mm green	10	▶5mm green	10
▶3mm yellow	10	▶5mm yellow	10

Clips to suit - 3p each.

Rectangular		TIL32	40
▶red	12	TIL78	40
green	17	▶TIL111	60
yellow	17	ORP12	85
▶TIL38	40	TIL100	90
2N5777	45	Dual colour	60

Seven segment displays:

Com cathode		Com anode	
DL704 0.3"	95	DL707 0.3"	95
▶FND500 0.5"	100	FND507 0.5"	100
TIL313 0.3"	115	TIL312 0.3"	115
TIL322 0.5"	115	TIL321 0.5"	115

LCD: 3½ digit 580p. 4 digit 620p.

BRIDGE RECTIFIERS

1A 50V	20	2A 200V	40
1A 400V	35	2A 400V	45
		6A 100V	80
		6A 400V	95
		VM18 DIL 0.9A 200V	50

COMPUTER CONNECTORS

ZX81 2 x 23 way edge connector wire wrap suitable for ZX81 add-ons 150
SPECTRUM 2 x 28 way edge connector wire-wrap suitable for SPECTRUM add-ons . . 200

RIBBON CABLE

Grey Ribbon cable. Price per metre

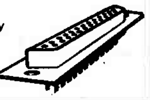
10 way	38	34 way	150
16 way	55	40 way	170
20 way	80	50 way	198
24 way	110	60 way	260

IDC CONNECTORS

	PCB Plug Straight	Socket	Edge Conn.
10 way	90	85	120
16 way	130	110	175
20 way	145	125	195
26 way	175	150	240
34 way	205	170	320
40 way	220	190	340
50 way	235	200	395
60 way	330	230	495

MIN D CONNECTORS

	9 way	15 way	25 way	37 way
Plugs solder lugs	60p	85p	125p	170p
Right angle	120p	180p	240p	350p
Sockets lugs	90p	130p	195p	290p
Right angle	160p	210p	290p	440p
Covers	100p	90p	100p	110p



SOLDERING IRONS

Antex CS 17W Soldering iron	495
2.3 and 4.7mm bits to suit	85
CS 17W or XS 25W element	210
Antex XS 25W	525
3.3 and 4.7mm bits to suit	85
Solder pump desoldering tool	480
Spare nozzle for above	70
10 metres 22swg solder	100

RESISTORS

¼W 5% Carbon film E12 series 4.7 ohm - 10M . . . 1p each.
½W 5% Carbon film E12 series 4.7 ohm to 4M7 . . . 2p each.
¼W 1% metal film E24 series 10 ohm - 1M . . . 6p each.

PCB MATERIALS

Alfac transfer sheets – please state type (e.g. DIL pads etc.)	45
Dalo etch resistant pen	100
Fibre glass board 3.75 x 8"	80
Fibre glass board 8 x 12"	200
Ferric Chloride crystals	100

BOXES

Plastic with lid & screws		Aluminium	
		3 x 2 x 1"	65
		4 x 2¾ x 1½"	95
		4 x 2¼ x 2"	95
3 x 2 x 1"	55	6 x 4 x 2"	120
4½ x 3 x 1½"	88	7 x 5 x 2½"	165
7 x 4 x 2"	160	8 x 6 x 3"	205

CONNECTORS

DIN	Plug	Skt	Jack	Plug	Skt
2 pin	9p	9p	2.5mm	10p	10p
3 pin	12p	10p	3.5mm	9p	9p
5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	12p	13p	4mm	18p	17p

UHF (CB) Connectors:
PL259 Plug 40p. Reducer 14p.
SO239 square chassis skt 38p.
SO239S round chassis skt 40p.
IEC 3 pin 250V/6A.
Plug chassis mounting . . 38p
Socket free hanging . . . 60p
Socket with 2m lead . . 120p

SCRs

▶C106D	30
400V 8A	70
400V 12A	95

VOICE SYNTHESISER!

Now your computer can talk. The GI SP0256 speech processor is able through stored program to synthesize speech. Allophone (extended phoneme) system gives unlimited vocabulary.
Easily interfaced with any digital system; ten TTL compatible signals are used to select the allophones.
SP0256 . 990p. Data: 50p.

VERO

VEROBLOC◀	350
Size 0.1 matrix:	
2.5 x 1	22
2.5 x 3.75	75
2.5 x 5	85
3.75 x 5	95
VQ board	160
Veropins per 100:	
Single sided	50
Double sided	60
Spot face cutter	105
Pin insertion tool	162
Wiring pen and spool	310
Spare spool 75p Combs	6

SWITCHES

Submin toggle:
SPST 55p. SPDT 60p. DPDT 65p.
Miniature toggle:
SPDT 80p. SPDT centre off 90p.
DPDT 90p. DPDT centre off 100p.
Standard toggle:
SPST 35p. DPDT48p
Miniature DPDT slide 12p.
Push to make 14p.
Push to break 22p.
Rotary type adjustable stop.
1P12W, 2P6W, 3P4W all 55p each.
DIL switches:
4SPST 80p 6 SPST 80p. 8SPST 100p.

MICRO

		6116P3	320	6852	240	8228	220
		6502CPU	325	6875	495	8251	250
		6522VIA	295	6880	100	8253	390
		6532	570	81LS95	85	8255	225
		6551 ACIA	650	81LS96	85	8259	390
2114L2	75	6800CPU	220	81LS97	85	MC1488	55
2716	205	6802CPU	250	8080A	250	MC1489	55
2532	290	6809CPU	620	8085AC	340	Z80ACPU	290
2732	290	6810RAM	115	8156	350	Z80APIO	260
2764	540	6821 PIA	110	8212	110	Z80ACTC	260
4116P20	70	6840	360	8216	100	Z80ASIO	900
5101L-1	220	6850	110	8224	120	Z80ADMA	1150

SOCKETS

	Low profile	Wire wrap
8 pin	6p	25p
14 pin	8p	35p
16 pin	9p	42p
18 pin	12p	52p
20 pin	13p	60p
22 pin	16p	70p
24 pin	18p	70p
28 pin	23p	80p
40 pin	25p	98p

Soldercon pins 60P/100

COMPONENT KITS

An ideal opportunity for the beginner or the experienced constructor to obtain a wide range of components at greatly reduced prices. ¼W 5% Resistor kit. Contains 10 of each value from 4.7 ohms to 1M (total of 650 resistors) 530
Ceramic Cap. kit. 5 of each value - 22p to 0.01u (135 caps) . . 370
Polyester Cap. kit. 5 of each value from 0.01 to 1uF (65 caps) . 575
Preset kit. Contains 5 of each value from 100 ohms to 1M (total 65 presets 425
Nut and Bolt kit (total 300 items): 180p

25 6BA ¼" bolts	50 6BA washers	50 6BA nuts
25 6BA ½" bolts	25 4BA ¼" bolts	50 6BA washers
50 6BA nuts	25 6BA ½" bolts.	

CMOS

		4016	20	4034	140	4054	78	4081	12	40193	65	4528	45
		4017	30	4036	249	4055	80	4082	12	4502	60	4529	150
		4018	45	4039	280	4059	430	4085	48	4503	32	4532	60
4000	10	4019	25	4040	40	4060	42	4086	50	4507	35	4534	400
4001	10	4020	42	4041	40	4063	80	4089	125	4508	110	4538	60
4002	12	4021	40	4042	38	4066	22	4093	18	4510	45	4543	50
4006	50	4022	45	4043	40	4067	225	4094	68	4511	40	4549	360
4007	14	4023	16	4044	40	4068	14	4095	65	4512	40	4553	215
4008	36	4024	33	4046	40	4069	13	4097	290	4514	115	4555	35
4009	24	4025	12	4047	35	4070	13	4098	70	4515	115	4556	35
4010	24	4026	75	4048	38	4071	13	4099	70	4516	55	4559	390
4011	10	4027	20	4049	21	4072	13	40106	40	4518	40	4560	140
4012	15	4028	40	4050	21	4073	13	40109	110	4520	50	4584	35
4013	20	4029	45	4051	42	4075	13	40163	60	4521	130	4585	60
4014	45	4030	14	4052	48	4076	45	40173	100	4526	60	4724	140
4015	40	4031	125	4053	48	4077	14	40175	75	4527	50		

LS TTL

		LS20	12	LS75	20	LS123	34	LS160	35	LS197	45	LS353	60
		LS21	12	LS76	17	LS125	24	LS161	35	LS221	50	LS365	28
		LS22	12	LS78	17	LS126	25	LS162	35	LS240	60	LS366	28
LS00	11	LS26	14	LS83	35	LS132	35	LS163	35	LS241	55	LS367	28
LS01	11	LS27	12	LS85	48	LS136	26	LS164	40	LS242	55	LS368	29
LS02	11	LS30	12	LS86	16	LS138	30	LS165	55	LS243	55	LS373	58
LS03	12	LS32	13	LS90	24	LS139	30	LS166	60	LS244	55	LS374	60
LS04	12	LS37	14	LS92	25	LS145	70	LS170	75	LS245	70	LS375	43
LS05	12	LS38	15	LS93	24	LS147	150	LS173	60	LS247	48	LS377	60
LS08	12	LS40	13	LS95	38	LS148	75	LS174	45	LS251	28	LS378	57
LS09	12	LS42	28	LS96	95	LS151	38	LS175	45	LS257	32	LS390	45
LS10	12	LS47	35	LS107	40	LS153	38	LS190	35	LS258	32	LS393	40
LS11	12	LS48	45	LS109	21	LS154	75	LS191	35	LS259	55	LS399	156
LS12	12	LS51	14	LS112	21	LS155	33	LS192	35	LS266	20	LS541	78
LS13	19	LS55	14	LS113	21	LS156	36	LS193	36	LS273	58	LS670	135
LS14	30	LS73	18	LS114	22	LS157	26	LS195	32	LS279	30		
LS15	12	LS74	17	LS122	35	LS158	29	LS196	45	LS283	38		

TTL

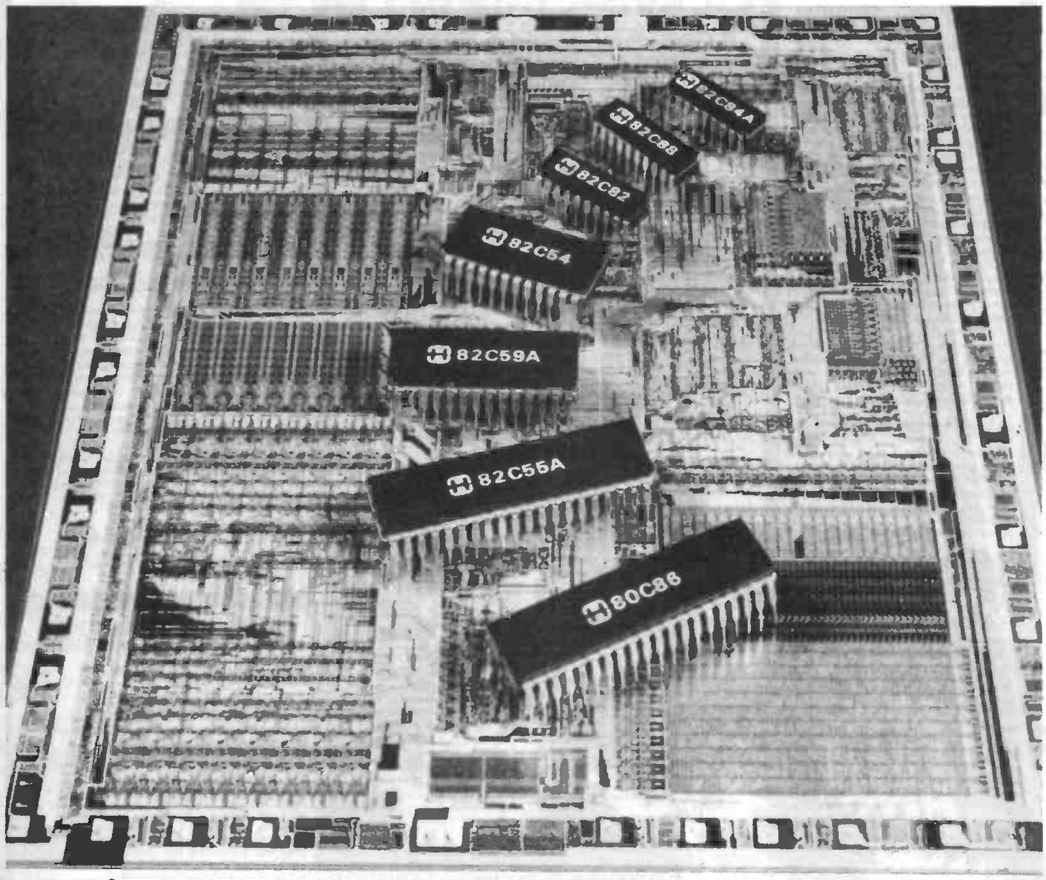
		7413	17	7444	85	7483	30	74122	38	74161	46	74190	40
		7414	23	7446	58	7485	60	74123	38	74162	46	74191	40
		7416	19	7447	36	7486	19	74125	33	74163	46	74192	40
7400	11	7417	19	7448	43	7489	180	74126	33	74164	46	74193	40
7401	11	7420	14	7450	14	7490	19	74132	30	74165	46	74194	40
7402	11	7421	19	7451	14	7491	34	74141	54	74167	150	74195	40
7403	12	7422	19	7453	14	7492	24	74145	48	74170	115	74196	40
7404	12	7427	18	7454	14	7493	24	74147	75	74173	58	74197	40
7405	14	7428	25	7460	14	7494	33	74148	60	74174	53	74198	80
7406	19	7430	13	7472	22	7495	33	74150	48	74175	45	74199	80
7407	19	7432	20	7473	24	7496	38	74153	38	74176	35		
7408	13	7433	20	7474	19	7497	86	74154	47	74177	42		
7409	13	7437	23	7475	26	74100	78	74155	36	74179	75		
7410	13	7438	24	7476	25	74107	22	74156	36	74180	38		
7411	15	7440	14	7480	45	74109	24	74157	28	74181	100		
7412	17	7442	30	7482	65	74121	24	74160	55	74182	55		

The Rapid Guarantee

★ Same day despatch ★ Competitive prices
★ Top quality components ★ In-depth stocks

ORDERING INFO. All components brand new and full specification. All prices exclude VAT. Please add to total order. Please add 50p carriage to all orders under £15 in value. Send cheque/ P.O. or Access/Visa number with order. Our detailed catalogue costs 45p (free with orders over £10). Callers most welcome. Telephone orders welcome with Access or Visa. Official orders accepted from colleges, Schools, etc. . . Callers most welcome, we are open Monday to Friday.

DIGEST



16-Bit CMOS Micro

Harris Semiconductor has announced its 80C86 high performance CMOS 16-bit microprocessor and a family of peripheral devices. Intel Corporation, developer of the industry standard HMOS 8086, will also manufacture the new CMOS devices.

The Harris 80C86 is a completely compatible CMOS alternative for the Intel HMOS 8086. This includes pin-for-pin replacement, TTL level input/output specifications, performance parity at a 5 MHz system frequency and complete software compatibility. The Harris CMOS 80C86 will operate with existing assembly and high level language programs.

The 80C86 features a standby power supply current of 500 microamperes maximum guaranteed over the full operating temperature and voltage ranges. The operating current of 10 mA/MHz maximum is dramatically lower than the HMOS 8086 which operates at 340 mA maximum at 5 MHz. With CMOS, operating power is reduced as the system's frequency is reduced. The static design of the 80C86 and all other members of the family allows system design at lower frequencies (down to DC) to further reduce operating power. For maximum power reduction, the system clock can be stopped with all power requirements falling to the standby level (500 μA for the 80C86, 10 μA for other family members).

The Harris 80C86 is available now with a 5 MHz operating frequency. The 80C86-2, an 8 MHz system frequency compatible version, will be introduced later.

The 80C86 is packaged in the industry standard 40 pin 0.6" centre ceramic and plastic dual-in-line (DIP) packages. Harris/MHS Semiconductor, Harris Systems Ltd, 153 Farnham Road, Slough, Berks, tel 0753 34666.

Mr Kit Fix-It

There's a new service for all our not-so-nimble fingered readers, being offered by WEB Logic Systems Ltd. They will, for a fee (nothing in this life is completely free) build or repair your kit for you.

WEB say that they will also consider repairing any magazine project provided that it's built on a proper PCB, as published with the magazine article. What they suggest doing in either case is ringing them and talking over what's involved, and how much it's likely to cost. Alternatively, if you can't phone, they suggest sending the project in with all the information you have (instruction booklet or full magazine article, etc) and authorisation to debit your credit card by up to so much.

WEB say that they will have a go at — and, more importantly, they have the equipment for — pretty well anything, because they've been offering a similar service to industrial clients for a while now. They expect to be able to turn most jobs around within five days of receipt of the gear.

Further information can be had from WEB Logic Systems Ltd, Gainsborough House, 15 High Street, Harpenden, Herts AL5 2RT, tel 05827 62119.

Breadboard '83

Breadboard '83 will be held on the 25th, 26th, and 27th November at the Cunard International Hotel, Hammersmith. This should make it a lot easier for many people to get to since Hammersmith has good rail and bus connections and the hotel is within a few hundred yards of two NCP car parks.

Breadboard has always had a friendly atmosphere regardless of where it has been held, and moving to the carpeted splendour of the Cunard Hotel should not only preserve this atmosphere but also ensure less wear on the feet!

The dates for the exhibition have been moved nearer to Christmas in response to popular demand . . this way, the exhibitors are happy because the vistors are likely to spend more, and the visitors are better placed to drop hints to their loved ones about what they would like in their Christmas stockings instead of socks, after-shave, or cheap perfume!

At last year's exhibition the lectures proved a popular feature, so much so that at times the lecture room threatened to burst at the seams! This year we will again have a broad range of topics, so check well in advance and make sure you're there early to ensure a place.

Model railway enthusiasts will be interested in our computer controlled layout competition. The rules are very simple, amounting to little more than a restriction on the size of the layout.

Bearing in mind the crowds at last year's Computer Corner, the 'advice'/'hands on' area will be larger so as to be able to cope with all those would-be purchasers of computers.

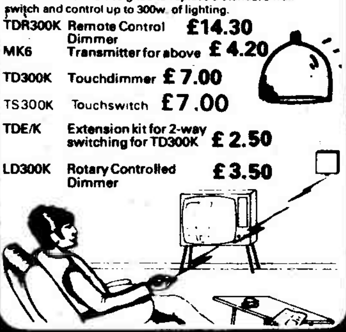
For the benefit of those who live a long way from Hammersmith, we have arranged a special package deal that will include rail travel, first class hotel, breakfast, ticket to Breadboard, and various optional extras (tickets to shows, discount vouchers, etc). You can go to the exhibition while your boy/girl friend, husband/wife or whatever does the Christmas shopping and then meet up afterwards.

Breadboard will continue as an exhibition for the enthusiast (or would-be enthusiast!) in the world of electronics. There will be no three ring circuses, fashion shows or the like, just components, magazines, books, equipment, projects, and all the assorted peripherals in which you the reader (enthusiast?) are interested.

HOME LIGHTING KITS

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

TDR300K	Remote Control Dimmer	£14.30
MK6	Transmitter for above	£ 4.20
TD300K	Touchdimmer	£ 7.00
TS300K	Touchswitch	£ 7.00
TDE/K	Extension kit for 2-way switching for TD300K	£ 2.50
LD300K	Rotary Controlled Dimmer	£ 3.50



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DISCO LIGHTING KITS

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

DLZ1000K
A lower cost version of the above, featuring undirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum. **£8.00**

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

DL3000K
This 3 channel sound to light kit features zero voltage switching, automatic level control and built in mic. No connections to speaker or amp required. No knobs to adjust — simply connect to mains supply and lamps. (1Kw channel) **Only £11.95**

ELECTRONIC LOCK KIT XK101

This KIT contains a purpose designed lock IC, 10-way keyboard, PCBs and all components to construct a Digital Lock, requiring a 4-key sequence to open and providing over 5000 different combinations. The open sequence may be easily changed by means of a pre-wired plug. Size: 7 x 6 x 3 cms. Supply: 5V to 15 V d.c. at 40uA. Ouput: 750mA max. Hundreds of uses for doors and garages, car anti-theft device, electronic equipment, etc. Will drive most relays direct. Full instructions supplied. **ONLY £10.50**

Electric lock mechanism for use with latch locks and above kit £13.50

MINI KITS

MK1 ELECTRONIC THERMOSTAT
Uses LM3911 IC to sense temperature (80°C max) and triac to switch heater (1KW). Mains powered. **£4.00**

MK2 SOLID STATE RELAY
Switches 240V ac motors, lights, heaters from logic/computer circuits. Zero voltage switching, opto-isolated. Supplied without triac **£2.60**

MK4 PROPORTIONAL TEMPERATURE CONTROLLER
Uses "burst fire" technique to maintain temperature to within 0.5°C. Ideal for photography, incubators, wine making, etc. Max. load 3KW (240V ac). Temp. range up to 90°C. **£5.55**

MK5 MAINS TIMER
Mains powered timer enabling a load up to 1KW at 240V ac to be switched on (or off) for a variable time from 20 mins. to 35 hrs. Longer or shorter periods possible with minor component changes. **£5.00**

MK15 DUAL LATCHED SOLID STATE RELAY
Comprises two MK2s with latch circuit enabling the MK12 kit to control two mains loads independently. Two output triacs not supplied. (See remote control kits.) **£4.50**

NEW! MK19 DC CONTROLLED AUDIO AMPLIFIER
May be used with virtually any stereo audio amplifier to control bass, volume, treble and balance remotely either using a wire link or the MK11 infra red receiver. A 1 of 10 decoder with LEDS is also included for remote input selection/display. (See remote control kits.) **£10.70**

COMPONENTS
a wide range in stock including:

LINEAR ICs
555 .17; 556 .40; 741 .15; 748 .35; AD590 3.30; AY-3-1270 7.20; CA3080 .72; CA3130 .75; CA3140 .43; ICL7106 7.00; ICL7107 9.00; ICL7126 8.00; ICL8038 3.10; CMOS555 .79; LF351 .44; LF353 .80; LF356 .90; LM324 .35; LM334Z .90; LM335Z 1.20; LM339 .50; LM348 .63; LM358 .45; LM377 1.45; LM380 .80; LM381 1.15; LM382 1.00; LM386 .75; LM1458 .35; LM1830 1.50; LM2917 1.60; LM3900 .48; LM3909 .60; LM3911 1.20; LM3914 2.10; LM3915 2.20; LM13600 1.10; LS7220 2.75; LS7225 2.60; MF10C 3.30; ML922 4.10; ML924 1.95; ML925 2.10; ML926 1.40; ML927 1.40; ML928 1.40; ML929 1.40; MM74C911 6.50; MM74C915 .96; MM74C922 2.90; MM74C926 4.50; NE566 1.40; NE567 .97; S566B 2.15; S576D 2.15; SAB0600 2.50; SL440 1.75; SL441 1.35; SL480 1.70; SL490 2.40; TBA800 .68; TBA810AS 1.00; TMS1121 8.50; TMS1601 10.00; TDA1024 1.20; TDA2020 2.85; TDA4290 1.98; TL061 .40; TL062 .60; TL064 .98; TL071 .30; TL072 .50; TL074 .95; TL081 .25; TL082 .45; TL084 .95; TL170 .50; TL507C 1.80; UA2240 1.20; ULN2003 .80; ULN2004 .85; ZN414 .98; ZN425 3.40; ZN427 5.70; ZN428 4.10; ZN1034E 1.80

TRIACS
400V Plastic: 1.6A .42; 4A .49; 8A .58; 12A .85; 16A .95; 25A 1.90; Q4006LT .85; MOC3020 1.10; Diac .18

REGULATORS
78L05, 12, 15 .26; 79L05, 12, 15 .60; 7805, 12, 15 .35; 7905 .40; LM317T 1.80; LM338K 4.60; LM723 .40

CMOS
4000 .11; 4001 .11; 4002 .11; 4007 .12; 4011 .11; 4012 .12; 4013 .20; 4015 .39; 4016 .20; 4017 .29; 4019 .24; 4023 .15; 4025 .15; 4026 .72; 4027 .20; 4028 .38; 4040 .39; 4043 .38; 4046 .46; 4049 .21; 4050 .21; 4060 .42; 4069 .13; 4070 .13; 4071 .13; 4077 .16; 4081 .12; 4093 .20; 4501 .24; 4511 .55; 4514 1.15

MEMORIES
2114 .80; 6810 1.25; 2716 2.00; 2732 4.80

MICROS
Z80A cpu 2.65; Z80A ctc 2.80; Z80A pio 2.50; 8035L 5.50

LEDs
Red 9p; Green or Yellow 12p; Flashing Red 49p; Flashing Continuous Red 52p; Tri Colour 5mm Round 50p; Rectangular 55p

DISPLAYS
.3" cc Red 75p; .5" cc ca Red 85p

LCD 3½ DIGIT MULTIMETER

16 ranges including DC voltage (200 mv-1000 v) and AC voltage, DC current (200 mA-10 A) and resistance (0-2 M) + NPN & PNP transistor gain and diode check. Input impedance 10M. Size 155x88x31 mm. Requires PP3 9v battery. Test leads included **ONLY £29.60**

HOME CONTROL CENTRE

This kit enables you to control up to 16 different appliances anywhere in the house from the comfort of your armchair. The transmitter injects coded pulses into the mains which are decoded by receiver modules connected to the same mains supply and used to switch on the appliance addressed. The transmitter also includes a COMPUTER interface so you can programme your favourite micro (e.g. ZX81) to switch lights, heating, electric blanket, make your morning coffee, etc., automatically without rewiring your house. **JUST THINK OF THE POSSIBILITIES.** The kit includes all PCBs and components for one transmitter and two receivers, plus a pre-drilled box for the transmitter.

Order as XK112. £42.00

Additional Receivers XK111 £10.00

"OPEN-SESAME"

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

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REMOTE CONTROL KITS

FOR A DETAILED BOOKLET ON REMOTE CONTROL — send 30p + 6" x 9" S.A.E.

MK6 SIMPLE INFRA RED TRANSMITTER
Supplied with hand-held plastic box. Requires 9V (PP3) battery **£4.20**

MK7 INFRA RED RECEIVER
Mains powered with triac output to switch up to 500W at 240V ac. Range approx. 20 ft. on/off or momentary control. **£9.00**
(RC 500K — special price for MK6/MK7 £12.50)

MK9 4-WAY KEYBOARD
For use with MK 18/MK 12 transmitter receiver where only 4 channels are required **£1.90**

MK10 16-WAY KEYBOARD **£5.40**

MK11 10 channel + 3 analogue o/p receiver
A mains powered LR receiver providing control signals to 10 on/off and 3 analogue circuits. May be used for controlling the volume of an amplifier, brightness of a lamp, etc. **£12.00**

MK12 16-CHANNEL LR RECEIVER
A mains powered LR Receiver providing up to 16 outputs for switching. **£11.95**

MK18 based on the SL490. This kit includes all components to make a coded transmitter. Requires a PP3 battery and keyboard (MK9, MK10 or MK13) size 8 × 2 × 1.3cm Range approx. 60 ft. **£6.20**

MK13 11 way keyboard for use with MK18 and MK11 kits **£4.35**

XK113 MW RADIO KIT

Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5.5 × 2.7 × 2cms. Requires PP3 9V battery. IDEAL FOR BEGINNERS. **£5.00**

3-NOTE DOOR CHIME

Based on the SAB0600 IC the kit is supplied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 × 71 × 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete. AN IDEAL PROJECT FOR BEGINNERS. Order as XK 102. **£5.00**

ALL PRICES EXCLUDE VAT

COMPONENT PACKS

PACK 1 650 Resistors 47 ohm to 10 Mohm — 10 per value £4.00
PACK 2 40 × 16V Electrolytic Capacitors 10μF to 1000μF — 5 per value £3.25
PACK 3 60 Polyester Capacitors 0.01 to 1μF/250V — 5 per value £5.55
PACK 4 45 Sub-miniature Presets 100 ohm to 1 Mohm — 5 per value £2.90
PACK 5 30 Low Profile IC Sockets 8, 14 and 16 — pin — 10 of each £2.40
PACK 6 25 Red LEDs (5mm dia.) £1.25

DVM/ULTRA SENSITIVE THERMOMETER KIT

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

Price £15.50

MICROPROCESSOR CONTROLLED MULTI-PURPOSE TIMER

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

FEATURES INCLUDE:-

* 7mm LED 12 hour display
* Day of week, am/pm and output status indicators
* 4 open collector outputs for driving relays, triacs, etc
* 50/60Hz mains operation
* Battery backup saves stored programmes and continues time keeping during power failures. (Battery not supplied)
* Display blanking during power failure to conserve battery power
* 18 programme time sets
* Powerful 'Everyday' function enabling output to switch every day but use only one time set
* Useful 'sleep' function — turns on output for one hour
* Direct switch control enabling output to be turned on immediately or after a specified time interval
* 20 function keypad for programme entry
* Programme verification at the touch of a button
* Plastic box with attractive screen printed front panel 15 × 10 × 5.5cm

Now only £39.00

(Kit includes all components, PCB, box, assembly and programming instructions)
Order as CT6000

XK114 OPTIONAL RELAY KIT
Kit includes one relay, PCB to accommodate up to four relays, terminal blocks, etc., to fit inside CT6000 box. Provides up to four 3amp 240V AC changeover contacts.

£3.90

Additional relays **£1.65** each.

24 HOUR CLOCK/ APPLIANCE TIMER KIT

Switches any appliance up to 1kW on and off at preset times once per day. Kit contains: AY-5-1230 IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triacs, PCBs and full instructions.

CT1000K Basic Kit £14.90
CT1000K with white box (56 × 131 × 71mm) £17.40
(Ready Built) £22.50

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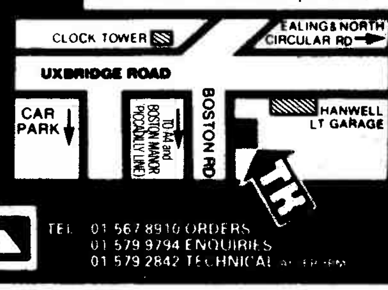

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Multi-Purpose Scope

Brown Boveri claim to have scored a world first with their M2050 Digital Scope Multimeter. Measuring a mere 257 × 169 × 88 mm this (almost) pocket sized instrument combines a 3½ digit, 32 range digital multimeter, a digital oscilloscope featuring a 128 × 64 dot matrix flat screen display, and a transient recorder with two independent 512 × 8 bit memories.

The M2050 will operate for up to eight hours on its internal NiCad batteries and when switched off will retain information stored in the transient recorder memory for up to three months. One set of input range switching serves both the multimeter and the oscilloscope and the two outputs are displayed simultaneously. The multimeter features AC, AC/DC, and DC operation, will operate down to 15 Hz, and has a true RMS option available on the AC and AC/DC ranges. The oscilloscope has comprehensive triggering facilities, a choice of eight timebases ranging from 100 uS/div to 6 minutes/div, and a roll facility which allows slowly changing inputs to be displayed without irritating flicker. The transient recorder has a maximum sampling rate of 500 kHz and features a save facility which prevents accidental overwriting of stored data.

The manufacturers claim that combining three instruments in this way reduces costs by eliminating unnecessary duplication of common circuitry and speeds up measurement by removing the need to connect up several (often incompatible!) instruments. Aside from such obvious advantages as saving space in the lab and enabling the service engineer to make more sophisticated on-the-spot measurements, suggested applications include the measurement and recording of such variables as temperature and pressure in the field.

The instrument is available as described for £975, or with the addition of a hard copy output for £1150, from John Minister Instruments, 137-139 Sandgate Road, Folkestone, Kent CT20 2DE, tel 0303 41598.

Portable Computer

Immediate Business Systems have introduced NOMAD, a portable computer the size of a book yet half the weight and which offers the power of a desktop computer.

Nomad provies up to 256K-bytes of non-volatile bubble memory and has been specifically built for outdoor and harsh environment applications, so it is totally waterproof and shock resistant and can operate within temperature ranges of −30°C to +70°C.

Using Microsoft M-BASIC 80 software, Nomad can be programmed directly on its full alphanumeric keyboard, or can be loaded with software developed on any CP/M-based microcomputer. Nomad has a two-line 80 character display panel, but can also be connected via an inbuilt interface (V24-V28/RS232) to drive a visual display unit or printer. Rechargeable batteries make the Nomad totally portable for in the field computing, and the use of a Z80 microprocessor provides fast processing and conservation of power.

Nomad is ideally suited for all applications where portable data processing is required, including such computer-unfriendly environments as oil exploration, steelworks, coal mines, construction, military, etc. Immediate Business Systems plc, 3 Clarendon Drive, Wymbush, Milton Keynes MK8 8DA, tel 0908 568192.

Computer Drive Amplifier

Following the launch of its first computer-drive New Class A amplifier, the SU-V303, Technics have now introduced two further models, the SU-V505 and the SU-V707. Unfortunately, they forgot to send us any bumf on the SU-V707 so we can only tell you about SU-V505!

The SU-V505 incorporates a number of special features. The Computer Drive New Class A system is designed to eliminate transient crossover distortion: sensors feed information on signal level and transistor temperature to a microprocessor which then calculates the optimum bias. To combat electromagnetically induced distortion, all the high current circuitry is placed in what Technics call a *concentrated power block*, effectively isolated from the rest of the amplifier. Other features claimed for the amplifier include the use of linear feedback (no, we don't know what it is either) as opposed to mere negative feedback and a computer controlled protection system. Output is 2 × 60 W into 4 or 8 ohms, both channels driven, with distortion at no more than 0.004% (still rather worse than our own NDFL amp . .).

Available in either black or silver finish, the SU-V505 sells for £177.95 and is available through Technics' nationwide dealer network. National Panasonic (UK) Ltd, 300-318 Bath Road, Slough, Berkshire, tel Slough 34522.

Superbrush

The Superbrush is a compact tool which will clean and polish a variety of surfaces including, but not limited to, metallic materials. Applications include PCB track cleaning, switch and battery contact cleaning, rust removal, etc.

The brush length is controlled by a knurled cap to give a cleaning action ranging from fine emery cloth to coarse sandpaper. Twist the cap to expose a long brush length for a fine abrasive action, retract the brush until the bristles just protrude for a coarse action.

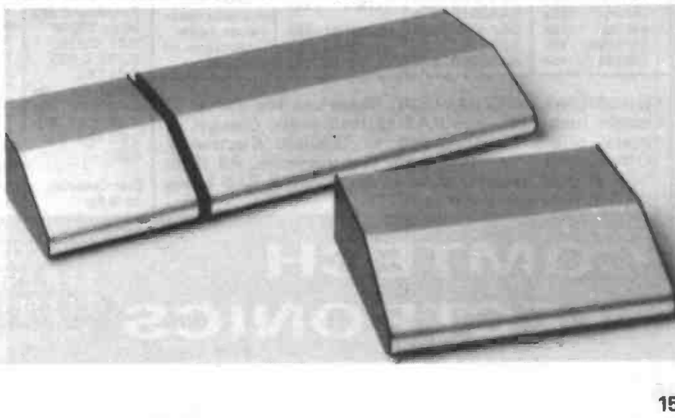
Recommended retail price of the Superbrush is £2.29 and inquiries are welcomed from stores and distributors as well as end users. Eraser International Ltd, Portway Industrial Estate, Andover, Hants. SP10 3LU.

Desk-Top Cases

A new, lightweight case intended primarily for desk-top applications is now available from West Hyde.

Attractively styled with smooth contours, the Empress case is manufactured from 2mm aluminium and has a black and natural anodised finish. It has a sloping top surface at the front which places switches, knobs and meters at an ideal angle. The four sizes available all have a common profile, so that two or more can be placed side by side on a worktop to form attractive 'suites'.

The Empress case comes complete with self-adhesive feet and is available ex-stock from West Hyde Developments Ltd., Unit 9 Park Street Industrial Estate, Aylesbury, Bucks HP20 1ET, tel 0296 20441.



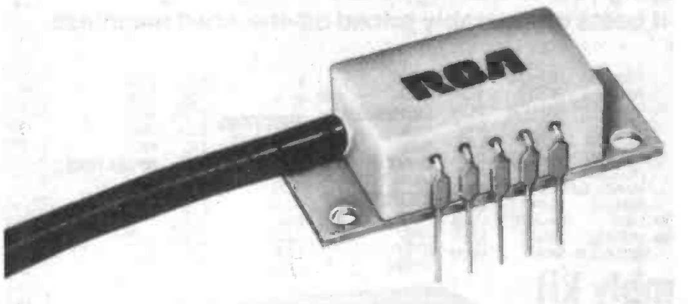
Fibre-Optic Lasers

Two new CW-operated injection laser modules and a new series of long wavelength transimpedance preamplifier photodiode modules have been announced by RCA, designed specifically for fibre-optic communications systems.

The C86041E (pictured below) is a gallium-aluminium-arsenide CW laser module with an output wavelength of 820 nanometers which is well-matched with the wavelength of silicon photodiodes. The C86042E is an indium-gallium-arsenide-phosphide CW laser module with an output wavelength of 1300 nanometers which is well-matched with the wavelength of InGaAs/InP photodiodes. Both types are constructed with a 0.5 meter length of fibre-optic cable internally coupled to the emitting region of the laser chip and are supplied in a special dual-in-line package for simple mounting and good thermal dissipation. The package also contains a photodiode which monitors the laser output, and which may be used in a negative feedback circuit to stabilise the output of the laser. An RTD temperature detector is provided for high duty-cycle pulsed operation at case temperatures up to 70°C.

The C30986E Series are high speed InGaAsP (p-i-n) photodiodes with a hybrid preamplifier supplied in a 14-pin dual-in-line package. A glass window provides optical access to the photodiode and a 50 um graded index fibre pigtail is included. This device provides high responsivity between 900 and 1700 nanometers and is optimised for the detection of 1300 and 1550 nm sources.

Additional information may be obtained from RCA Electro-Optics and Devices, Lincoln Way, Windmill Road, Sunbury-on-Thames, Middx. TW16 7HW, tel 09327 85511.

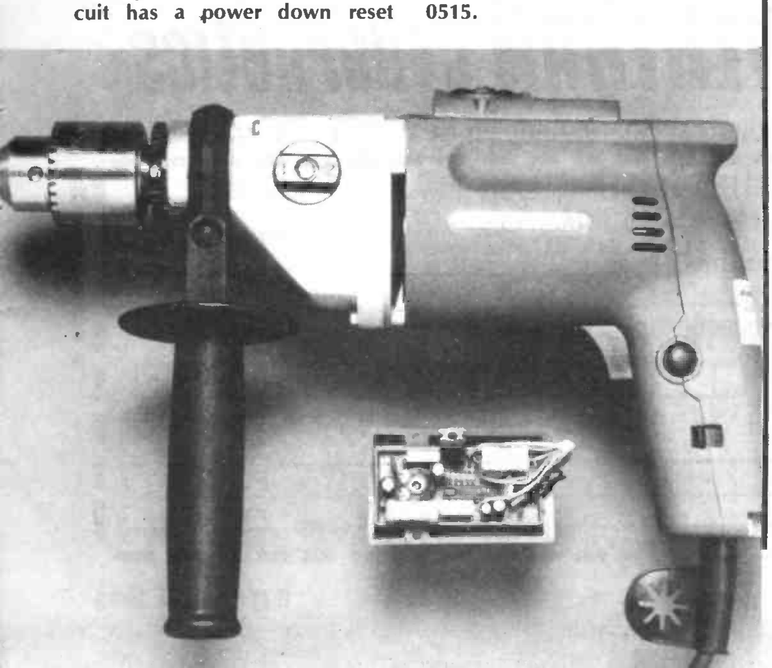


Motor Speed Controller

Ferranti Electronics has recently introduced the ZN411E which, with a minimum of external components, provides precise speed control for electric motors.

Originally designed for use in a professional power drill made by a well known UK power tool manufacturer, the ZN411 will operate from the AC mains or a suitable DC supply and has an on-chip shunt regulator. The circuit has a power down reset facility and a 'soft start' capability whereby the speed builds up smoothly to the set speed. It produces negative triac firing pulses and has a triac retrigger facility. A reversing input on the chip will stop the motor, which then goes through the soft start to reach the speed set for the reverse direction.

The device is available in an 18 lead plastic Dual in Line package. Details from Ferranti Electronics Limited, Fields New Road, Chadderton, Oldham, Lancashire, OL9 8NP, tel 061-624 0515.



New Op-Amps

Burr-Brown International have introduced two new operational amplifiers — a high power hybrid and a low bias current monolithic device with a JFET input.

The OPA501 is rated for continuous 80 W operation and will withstand peaks of at least 200 W without damage. It can deliver 10 amps peak into a 2 ohm load, 4 amps continuously into 5 ohms, and has output current limiting to protect both the amplifier and the load in the event of excessive drive or a fault occurring. Unity gain bandwidth is 1 MHz and the full power bandwidth is typically 16 kHz. Common mode input impedance is 250 M ohms and differential configuration input impedance is 10 M ohm.

The device is housed in an eight pin TO-3 package, the outer can being electrically isolated in order to simplify heat sinking (why aren't more power devices?). The OPA501 is designed to operate on supplies from ± 10 V to ± 36 V, and is very tolerant of supply voltage variations. Suggested applications include servo amplifiers, actuator controls and audio amplifiers.

The OPA100 JFET monolithic operational amplifier has a bias current of less than 0.5 pA at room temperature and less than 1 pA at 75°C but does not sacrifice performance in other areas to achieve this. Maximum offset voltage is 250 uV, offset voltage drift is 5 uV/°C maximum, and input impedance is 10^{12} ohms. All specifications are guaranteed over the temperature range −25°C to +85°C.

Supplied in an eight-pin TO-99 package, the OPA100 uses the standard 741 type pin connections. Suggested applications include current-to-voltage convertors, precision sample and hold amplifiers, and voltage amplification in high impedance circuits using biological probes, pH electrodes, etc. Burr-Brown International Ltd, Cassiobury House, 11-19 Station Road, Watford, Herts WD1 1EA.

Small Memory

WANG Laboratories Inc, has introduced a low-cost high-density dynamic random access memory module. Called SIMM (single in-line memory module) the module more than quadruples the density of the memory that can be positioned within a specified printed circuit board area, using industry-standard mounting practices.

Measuring only .75 × 3.00 inches, the WANG SIMM integrates nine separate 64K DRAMs and related decoupling chip capacitors into 64K bytes of memory with parity (error detection). Suitable for either direct mounting or socketing on a PCB, the module offers the potential for clustering as much as one full megabyte of memory within a three-by-four-inch area of the PCB. WANG say that the SIMM could significantly lessen the need for 256K technology, since it is denser than 256K and is available now. WANG UK, 661 London Road, Isleworth, Middlesex TW7 4EH, tel 01-560 4151.

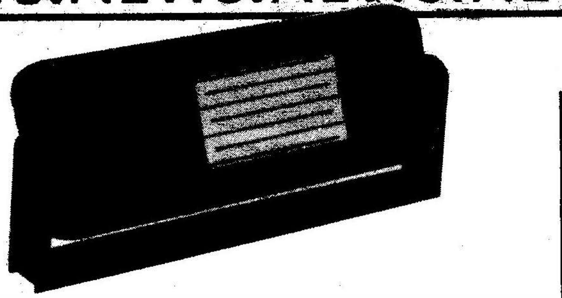
New CCDs From Plessey

Plessey have introduced four new CCD arrays: the MS1002-1 and 2 850 bit registers, and the MS1003-1 and 3 910 bit registers. All these devices are intended for video line storage, an application to which CCDs seem to be well suited.

The MS1002-1 is for analogue storage with interrupted clocks; the MS1002-3 is for delay-line operation with a continuous clock. Both have a video bandwidth of over 5 MHz with a clock frequency of 13.3 MHz, three times the PAL sub-carrier frequency.

The MS1003-1 and 3 are similar, but are intended for use with a 14.3 MHz clock, four times the NTSC colour sub-carrier frequency.

The advent of satellite TV, if it ever does happen, will increase the damand for storage facilities within receivers; as regular readers may recall, the C-MAC system chosen for UK transmissions involves a large degree of time-multiplexing of the TV signal, as opposed to frequency multiplexing which is the predominant form used at the moment. Plessey Semiconductors, Cheney Manor, Swindon, Wilts SM2 1QW, tel 0793 36251.



Competition

Regisbrook of Reading have challenged the electronics world to a test of imagination with an astonishing new device — the problem is that they can't think of any use for it!

The device is a highly effective portable humidity sensor — so sensitive that it will react to the moisture in exhaled breath at a distance of two feet. It is battery powered and pocket sized, with an adjustable mounting bracket and no on/off switch. The unit features a sensing grid of interleaved gold filaments on a ceramic substrate, a robust plastic case, and hermetically sealed electronics for long term stability. It has an integral alarm bleeper which cannot be triggered by short circuiting the gold grid and which stops when the sensing grid is wiped dry.

A grand prize of a magnum of champagne, and ten second prizes of the actual moisture sensors are offered by Regisbrook for the best suggestions (serious or imaginative) of what to do with the things. Ever anxious to be of service (and to assist in the disposal of alcoholic beverages) ETI would like to suggest that a few samples be sent to Conservative Central Office for use in the selection of suitably 'dry' parliamentary candidates. Readers with better suggestions should contact Regisbrook Ltd., Studio House, 215 Kings Road, Reading, Berks.

Improve Your Knowledge Here

Calling all would-be hams! Bradford & Ilkley Community College are running a 1 year course in preparation for the Radio Amateurs Examination. Enrolment starts on 6th September. Those interested should contact P. Nurse, Course Tutor, Bradford & Ilkley Community College, Great Horton Road, Bradford, West Yorkshire BD7 1AY.

For those unable to get to Bradford, Frank Fear is running a similar course at Barr Beacon Comprehensive School, near the M5/M6 junction. Enrolment is on 22nd September and there's even a special 10 week crash course for those with basic electrical knowledge. Further details, telephone Aldridge 52706.

If amateur radio isn't your scene why not try Information Technology? Thames Polytechnic's new four year honours degree course starts in October and includes a year's industrial experience. Details from the Academic Registrar, Thames Polytechnic, Wellington Street, Woolwich, London SE18 6PF.

Salford University are running a series of one and two day courses on various aspects of the CBM/PET microcomputer. The first course starts on 13th September and the complete series will be repeated in three months time. For details, telephone 061-736 5843, extension 248.

Would-be movie directors should take their megaphones and folding chairs down to Piccadilly where JVC are holding two and three day courses in video production. The courses, which cater for both beginners and the more advanced, are repeated twice monthly. Dates, etc from Phil Compton or Mike Whyman at the JVC Video Information Centre, 82 Piccadilly, London W1, or telephone 01-491 3775.

Shorts

● Not one but two catalogues from Ambit! One is aimed at industrial and commercial users and comes free on request; the other is for lesser mortals and costs 80p from your friendly local newsagent. Ambit International, 200 North Service Road, Brentwood, Essex CM14 4SG.

● Concerned Technology, an exhibition of microprocessor based aids for the disabled and those with special needs, begins its twenty-nine stop tour in Hastings on September 8th. Details from Nancy Shawcross or Sue Hardwick on 01-789 4055/6.

● Silicon Valley, eat your heart out! The London borough of Islington is so proud of its local micro-electronics industries that it has made a film about them. "Silicon Green" runs for thirty minutes and is available to schools, business promotions, etc. Contact Jane Smith, 01-226 1234, ext. 268.

● NAHBO, the National Association of Hospital Broadcasting Organisations, is holding its autumn conference at the Ladbroke Mercury Hotel, Watford, on 14th/16th October. Exhibitors and individuals interested in Hospital Radio are welcome. NAHBO, 56 Fleet Road, Benfleet, Essex SS7 5JN.

● Sinclair Research are offering a ZX81, a 16K RAM pack, and a software cassette all for £45. Available for a two month trial period, the 'starter pack' will save you £30 on current prices and is on sale at Boots, John Menzies, and other Sinclair stockists. How long will it be before they start giving away computers with packets of breakfast cereal?

● The Intron IFG 422 is a 0.1 Hz to 2 MHz function generator offering sine, square, triangle, ramp, and pulse waveforms. It has 50 ohm and TTL outputs, is light and compact, and costs £195 from House of Instruments, Clifton Chambers, 62 High Street, Saffron Walden, Essex CB10 1EE, tel 0799 24922.

● Cable Check FC is a bench top go/no-go tester for insulation displacement type ribbon cables. It can test all cable/connector combinations up to 37 ways for both continuity and shorts. Cable Check Systems, Sanderson Centre, Lees Lane, Gosport, Hants, tel 07017 28396.

● The South Coast Hi-Fi Show will be taking its bucket and spade and an awful lot of audio goodies down to Brighton on the 11th, 12th and 13th November. Venue is the Royal Albion Hotel, Old Steine, and details are available from Tim Purcell, 137 Marina, St. Leonards-on-Sea, East Sussex TN38 0BT, tel 0424 715133.

● Market Logic's new Macrobyte printer buffer stores computer data output until the printer is ready for it, allowing the computer to carry on at its own speed. Designed to work with a Centronics interface, the Macrobyte comes in 16 k, 32 k and 64 k versions and prices start at £99.95. Tel 0432-70 456.

● Alcon Instruments claim their new pocket sized direct reading capacitance meter is as good as most bench-mounted bridges. The CP570 has five ranges from 0-50 pF up to 0-0.5 uF, a three inch meter scale, a basic accuracy of ± 3% and costs £51.06 complete with leads and case. Alcon Instruments Ltd, 19 Mulberry Walk, London SW3, tel 01-352 1897.

● Advanced Micro Devices now have available a 256 K EPROM which has an access time of only 170 nS. The Am27256 is organised as 32 K × 8 bits, requires a single 5 V supply, has TTL compatible inputs and outputs and uses the standard 28 pin configuration. Advanced Micro Devices (UK) Ltd, AMD House, Goldsworth Road, Woking, Surrey GU21 1JT, tel 04862 22121.

● For those whose penchant is listening to Stockhausen in the sauna, Fuji have introduced a high temperature cassette tape. The GT-1 will withstand 110°C (230°F) without damage to either shell or tape and is intended for use in cars. Bell & Howell, Alperton House, Bridgewater Road, Wembley, Middlesex HA0 1EG, 01-902 8812.

● Just when you'd got all your accessories colour coordinated, Hanimex go and introduce their LC751. Described as a high fashion calculator, it is superslim and has a glossy black lacquer finish highlighted by gold keys and trim. And when fashions change, you can always use it to work things out on!

● With one snap of their powerful jaws, 3M's new TH212 and TH213 will strip both solid and stranded wires without damage to the conductor. The TH212 covers wires from 0.2 mm to 0.9 mm and the TH213 covers wires from 0.75 to 6 mm, both types adjusting automatically to all wire sizes within their range. 3M UK, 3M House, P.O. Box 1, Bracknell, Berkshire RG12 1JU, tel 0344 26726.

● Roxburgh Suppressors Ltd have introduced two mains filters designed for direct mounting onto printed circuit boards. The PC103 and PC105 are rated at 3 and 5 amps respectively and are full encapsulated. Roxburgh Suppressors Ltd, Eagle Road, Rye, East Sussex, tel 07973 3725.

● An Apple a day has clearly done wonders for the California based computer company. They've just produced the one millionth Apple personal computer and to celebrate are giving an Apple IIe to every school in the state.

electronize

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TYPEWRITER INTERFACE

Daft, isn't it? You can't get a daisy-wheel printer for less than about £400, but you can buy daisy-wheel typewriters containing not just the printer, but a keyboard and some electronics for just over £200. Jon Tyler shows us how you can interface one to your micro.

The Silver Reed EX 42 typewriter is logically divided into two parts. The keyboard is controlled by its own 8049 microcontroller while the printing mechanism is controlled by an 8039 with an EPROM containing the software appropriate to printing the required character set. Information is passed between these devices using a serial interface. It is possible to interface to the machine via an edge connector on the main PCB but if it is to be used as an output device only, a simpler interface may be constructed which operates in parallel with the existing keyboard.

The keyboard is arranged as a 8 × 8 array of keyswitches which are positioned according to the normal QWERTY convention. There are 25 connections made between the keyboard and the electronics, these taking the form of one 10-way and one 15-way ribbon cable connector. The modification to the typewriter is to disconnect these and reconnect them through suitable plug-socket pairs. In the prototype, these connectors were made from a 40-way wire-wrap IC socket cut into suitable lengths.

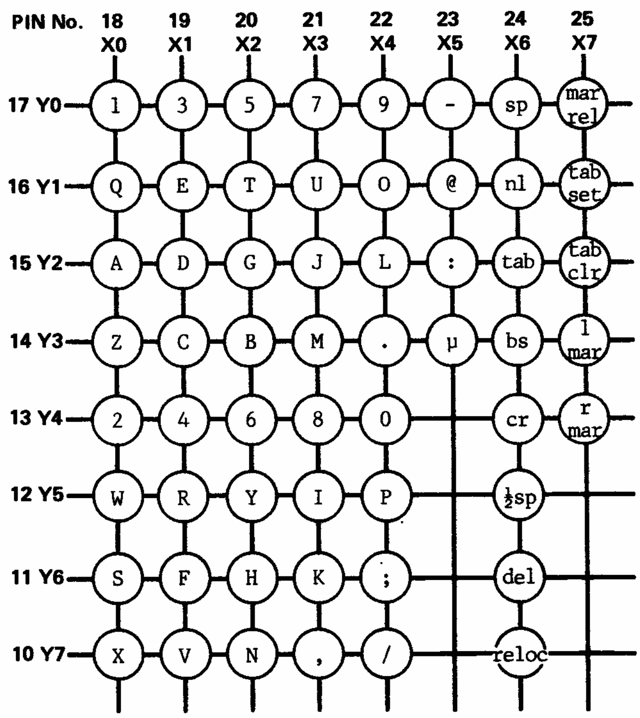

Fig. 1 (above) Keyboard matrix with pin connections.

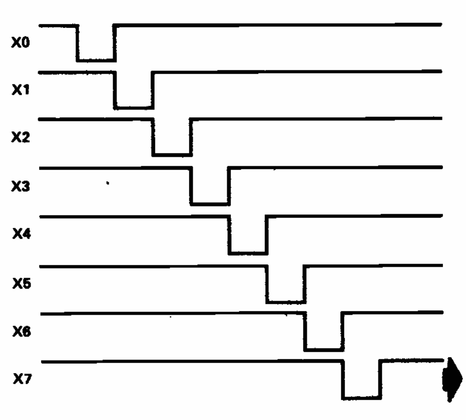

Fig. 2 (right) How the typewriter scans the input multiplex lines to the keyboard.

Construction

The prototype was constructed in a plastic box measuring about 3" by 4.5" by 1.5". A 26-way ribbon cable and matching connector was used to connect to the typewriter and a 12-way connector used to connect to the micro-computer parallel port. The ribbon cable was connected to the typewriter using the home-made adaptors shown in Fig. 5. These were made by cutting a 40-way wire wrap socket into 10 and 15 way lengths which were soldered to strips of Veroboard. The ribbon cable was then soldered to these adaptors, the 26th way being left free and fitted with a solder tag.

The typewriter cover is removed by unscrewing the two grub screws at either end of the platen (roller) using an Allen key. Remove the

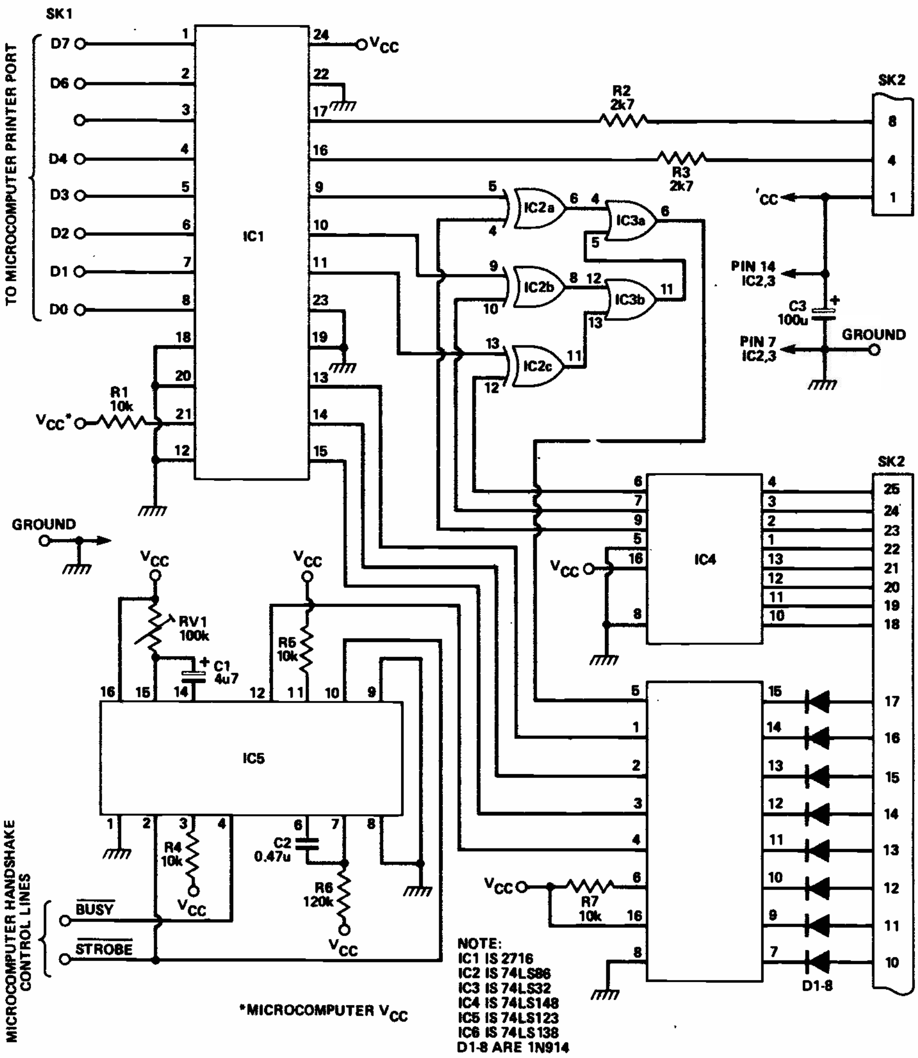

Fig. 3 Circuit diagram for the interface.

HOW IT WORKS

The microcomputer is programmed to put out an 8 bit ASCII coded character via a parallel port. The codes used to denote the X and Y position of the typewriter keys do not correspond to the ASCII codes, and upper and lower case character are selected by pressing the 'shift' key. Each character to be printed by the microcomputer must therefore be translated into the required 3 bit X and 3 bit Y code together with the one bit shift code. This may be achieved either in the microcomputer software (see Fig. 6) or alternatively by programming a suitable EPROM. A listing of the required codes is given in Table 1.

The eight 'X' lines X0 to X7 are scanned by the typewriter as shown in Fig. 2. These lines are connected to IC1 in the interface which encodes the 8 line signal into a 3 bit code. The three outputs A0, A1 and A2 from this priority encoder form the logical inverse of the 3 bit column number which corresponds to the 'X' line currently enabled. These three bits are compared with the least significant 3 bits of the output byte using IC3 and IC4 which perform an exclusive-OR operation. When a match occurs, pin 6 of IC4 goes low and this is used to control the 'Y' outputs.

The pressing of a key is detected in the typewriter by reading in the eight-bit value on the 'Y' lines and comparing this with the previous value. When a key is pressed, the corresponding 'Y' line, which is normally held at '1' by a pull-up resistor, will be made '0' when the appropriate 'X' line is enabled. The typewriter saves the current 'X' (column) code together with the 'Y' (row) code whenever a 'Y' line goes low. To simulate this, a 3 line to 8 line decoder, IC2, is used. The select inputs A, B and C are connected to bits 3,4 and 5 of the output from the microcomputer parallel port.

The shift operation is invoked by pressing the shift key, which is a normally open switch separate from the scanned keys. This switch operates the interrupt line INT to the 8049 microcontroller in the typewriter and is normally held low. In the interface it is connected to bit 6 of the parallel output. There is a similar arrangement to select the 'alternate character set' which is required for 3 of the ASCII codes. This function was assigned to bit 7.

The typewriter manufacturers give a maximum printing speed of nine characters per second. A monostable, IC5, is used to achieve the correct operating speed. IC5 is triggered by an output strobe line which in the prototype was arranged to be active on the positive going edge.

After a valid character has been output from the microcomputer, the strobe line triggers the monostables, and the Q_1 output is used with the output of the exclusive-OR circuit to activate the 3 line to 8 line decoded IC2. The monostable output Q_2 is used as a busy signal by the microcomputer.

BUYLINES

The only difficult item here is the wire-wrap socket. We suggest you experiment with any odd DIL wire-wraps you may have around before splashing out on anything fancy. 26 way ribbon cable is easily obtained by chopping up 30 or 34 way, etc. RV1 is available from Maplin, the 26 way PCB plug and socket from Ambit, the 2716 and other semiconductors are available from several of our advertisers, and the PCB can be obtained from you-know-where (but see page 77).

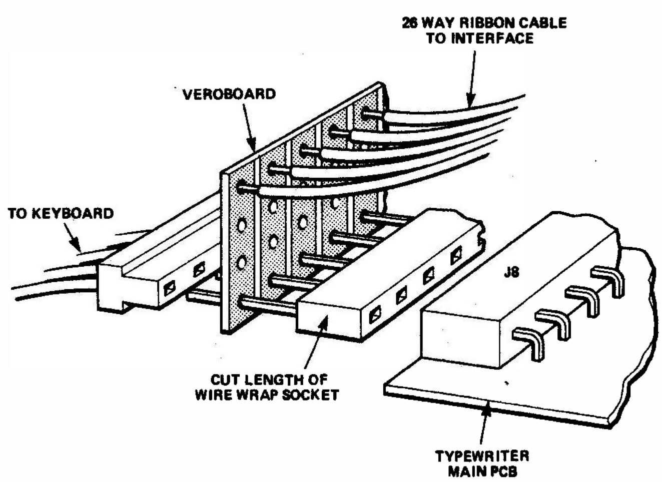

Fig. 4 (left) This shows how the improvised connector is made and how it is fitted into the typewriter.

PARTS LIST

RESISTORS (5% 1/4W)

R1,4,5,7	10k
R2,3	2k7
R6	120k
RV1	100k multi-turn

CAPACITORS (10V working min)

C1	4μ7 tant (see text)
C2	470n polyester
C3	100μ tant

SEMICONDUCTORS

IC1	2716 EPROM
IC2	74LS86
IC3	74LS32
IC4	74LS148
IC5	74LS123
IC6	74LS138
D1-8	1N914 or similar

MISCELLANEOUS

26-way PCB mounting plug and socket (BICC-vero 901-71105D or similar); 40-way wire-wrap socket (see text); PCB; ribbon cable; connector and cable to suit microcomputer used.

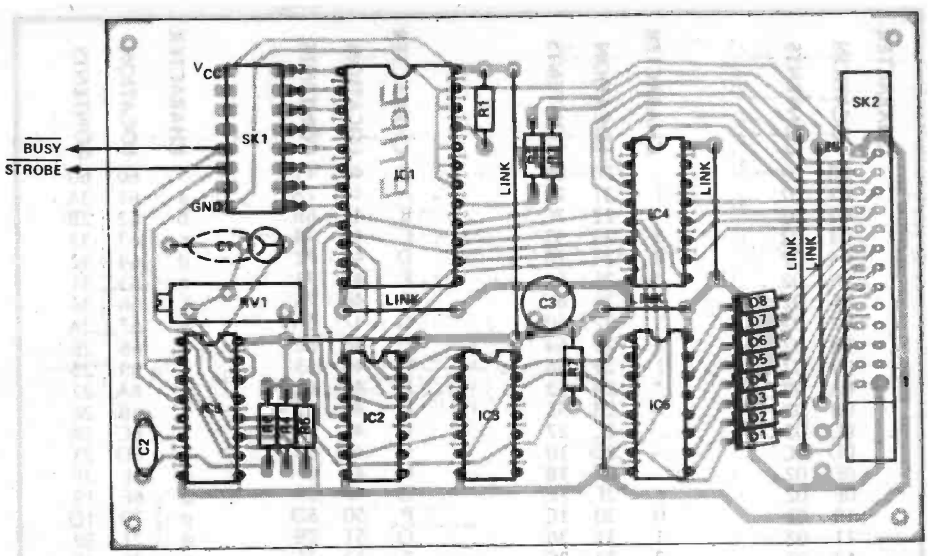

Fig. 5 (above) Overlay diagram of the interface PCB.

Fig. 6 (below) Program to drive the interface, to be used when an EPROM is not used.

```
10 REM PRINTER SIMULATOR ROUTINE
20 DIM D(128)
30 FOR N=1 TO 128
40 READ D(N)
50 NEXT N
60 INPUT "FILENAME ",B£ : REM READ A FILENAME
70 OPEN 1 B£ : ON EOF GOTO 340
80 GET 1 C£
90 FOR P=1 TO LEN(C£) : REM GET EACH CHARACTER
100 A£=MID£(C£,P,1)
110 GOSUB 200
120 IF A£=CHAR£(13) GOTO 140 : REM CHECK FOR CR
130 GOTO 180
140 A£=CHAR£(10) : REM IF SO PUT IN A LF
150 GOSUB 200
160 FOR N=1 TO 125 : REM AND A DELAY
170 NEXT N
180 NEXT P
190 GOTO 80
200 X=D(ASC(A£)+1) : REM SUBROUTINE TO PRINT A CHARACTER
210 OUT(16R7E)=X : REM OUTPUT TO A SUITABLE PORT
220 OUT(16R7F)=0 : REM ISSUE THE STROBE
230 OUT(16R7F)=1
240 Y=IN(16R7F) : REM CHECK FOR BUSY
250 Y=MOD(Y,2)
260 IF Y<>0 GOTO 240
270 RETURN
280 DATA 2,2,2,2,2,2,2,2,2,2,9,2,2,12,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2
290 DATA 8,120,124,83,112,104,108,96,100,88,82,94,39,16,27,31,28,56,60,48
300 DATA 52,40,44,32,36,24,18,30,231,92,220,95,17,122,107,115,114,113,118
310 DATA 106,110,101,98,102,90,99,111,89,93,121,117,126,105,97,119,125
320 DATA 127,109,123,209,8,145,8,80,96,58,43,51,50,49,54,42,46,37,34,38,26
330 DATA 35,47,25,29,57,53,62,41,33,55,61,63,45,59,8,159,8,8,2
340 CLOSE 1
350 STOP
360 END
```

paper pan which is clipped in position under the platen, then unscrew the four screws in the base and remove the top cover by gently raising it at the back and pulling it forward. The keyboard may then be removed from its clips and turned upside down so as to gain access to the ribbon cable connectors. These are then removed from their receptacles on the PCB and the adaptors fitted. The 26th way from the ribbon cable must be taken to ground; a suitable point exists on the typewriter PCB marked 'GND'. The typewriter should then be reassembled and the interface connected to the microcomputer.

The period of the monostable must now be adjusted. Set up the microcompter to send a reasonably long text file and adjust the preset (RV1) to give a printing rate of about nine characters per second. Allowance must be made for the time taken to perform a carriage return and line feed. If this is not done in the microcomputer's standard software (normally by sending an appropriate number of 'null' characters) then CR and/or LF must be detected in the interface program and suitable delays introduced. (See BASIC program, Fig. 4.)

Note that if you decide to use your micro to do the character coding rather than the EPROM (see How It Works and Fig. 6), then the EPROM should be ommitted and what would have been its pins 1 to 8 should be linked to pins 17, 16, 15, 14, 13, 11, 10 and 9 respectively. If you want to retain the option of using an EPROM at a later

CHARACTER	LOCATION	CONTENTS	CHARACTER	LOCATION	CONTENTS	CHARACTER	LOCATION	CONTENTS	CHARACTER	LOCATION	CONTENTS
	00	02		20	08	@	40	11	'	60	60
	01	02	!	21	78	A	41	7A	a	61	3A
	02	02	"	22	7C	B	42	6B	b	62	2B
	03	02	$	23	53	C	43	73	c	63	33
	04	02	£	24	70	D	44	72	d	64	32
	05	02	%	25	68	E	45	71	e	65	31
	06	02	&	26	6C	F	46	76	f	66	36
	07	02	'	27	60	G	47	6A	g	67	2A
	08	02	(	28	64	H	48	6E	h	68	2E
	09	02	)	29	58	I	49	65	i	69	25
	0A	09	*	2A	52	J	4A	62	j	6A	22
	0B	02	+	2B	5E	K	4B	66	k	6B	26
	0C	02	,	2C	27	L	4C	5A	1	6C	1A
	0D	0C	—	2D	10	M	4D	63	m	6D	23
	0E	02	.	2E	1B	N	4E	6F	n	6E	2F
	0F	02	/	2F	1F	O	4F	59	o	6F	19
	10	02	0	30	1C	P	50	5D	p	70	1D
	11	02	1	31	38	Q	51	79	q	71	39
	12	02	2	32	3C	R	52	75	r	72	35
	13	02	3	33	30	S	53	7E	s	73	3E
	14	02	4	34	34	T	54	69	t	74	29
	15	02	5	35	28	U	55	61	u	75	21
	16	02	6	36	2C	V	56	77	v	76	37
	17	02	7	37	20	W	57	7D	w	77	3D
	18	02	8	38	24	X	58	7F	x	78	3F
	19	02	9	39	18	Y	59	6D	y	79	2D
	1A	02	:	3A	12	Z	5A	7B	z	7A	3B
	1B	02	;	3B	1E	[	5B	D1		7B	08
	1C	02		3C	e)		5C	08		7C	9F
	1D	02	=	3D	5C	]	5D	91		7D	08
	1E	02		3E	DB		5E	08		7E	08
	1F	02	?	3F	3F	—	5F	50		7F	02

Table 1 EPROM contents and what they do.

stage, then perhaps the best way of doing this is with a header plug in the IC socket.

Once source of trouble that you may have is with the stability of C1. We've specified a tantalum type, but you may find it necessary to use a polystyrene (we known, we know, they're big and expensive). The exact value of C1 isn't important, but it must not vary too much over time or with temperature and electrolytics are capable of doing just that.

One option you might like to use is to connect two on off toggle switches between the 5 V rail and pins 6 and 8 of the connector SK2. These allow the selection of 15 characters per inch type spacing and of an alternative keyboard to be selected, both independent of the computer output.

This isn't necessarily the end of the story. We're so impressed by the keyboard on the EX42 that we're looking at ways of using it too. Watch this space!

ETI

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AUDIO DESIGN PART 2

As a general classification, one can divide linear ICs into two broad categories: purpose-built or dedicated ICs, aimed at the performance of one specific application; and general purpose ICs, such as the operational amplifier types, which are designed for use as versatile building blocks in a wide range of circuit configurations. The first of these categories contains a host of useful devices, whose numbers increase daily, that are capable of doing a very wide range of jobs, from providing well stabilised, ripple free, power supplies, to complete radio systems or audio amplifiers in a single package.

As a rule, hi-fi circuit designers and their customers tend rather to look askance at such purpose-built ICs in audio applications, since these devices are intended mainly for use in mass-produced consumer hardware, to simplify and reduce the cost of manufacture of competitively priced domestic electronics. A hi-fi specification is not usually either part of the IC designer's brief or of the customer's cost expectation. Nevertheless, some of these dedicated ICs perform extremely well, and have found their way into some of the most prestigious of audio systems. One must, therefore, try not to harbour preconceived opinions about their potential quality, but rather to judge these devices on their individual merits.

So far as the circuitry associated with these dedicated ICs is concerned, although it is great fun to explore their internal construction and to work out schemes for using them in applications their designers had never envisaged, this is rather an exotic field, and full of pitfalls for the unwary. So, in general, it is prudent to stick fairly closely to the circuit applications and component values recommended by the manufacturers in their application data sheets (which one should make sure one gets with the device) since it will probably be difficult to improve greatly upon these recommendations. With general purpose ICs, these constraints upon the method of possible use do not exist, and a very wide range of circuit uses can be envisaged.

Basic IC Amplifier Layouts

Taking the op-amp gain block as a starting point, this will be familiar as a simple, fairly wide bandwidth amplifier unit, having two inputs — one phase-inverting, one non-inverting, an output pin, and two further pins for connection to a +ve and −ve DC voltage supply. Some ICs of this type (in fact, most of the packages which contain just one gain block) also have two further pins which can be used, when connected to an external trimmer potentiometer, to adjust the DC output level of the amplifier when this is used as a DC amplifier stage. Such an op-amp IC will normally be designed to work over supply voltage ranges from ±1.5v to ±15v, or indeed, in a suitable circuit layout, from a single DC supply within the range 3-30 volts.

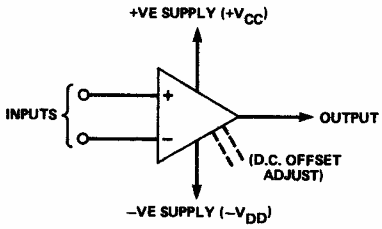


Fig. 1 Conventional circuit drawing of an operational amplifier.

The conventional circuit drawing for such an op-amp is shown in Fig. 1, where, as ever, the + and − symbols on the input leads imply the non-inverting and inverting amplifier characteristics. Although on this drawing I have shown the + and − supply connections to the IC, it is a common practice to take these as read where the ICs are used from a symmetrical or otherwise unremarkable power supply arrangement, and I propose to follow this convention and omit the power supply connecitons, where these are standard, in future drawings.

Most of the popular op-amps of the 741 type are what is known as *internally compensated,* which implies that negative feedback can be used in the circuit by the connection of a suitable network between the output and the inverting input pins, without having to worry about whether the amplifier will then be stable. In some of the earlier op-amp ICs, internal HF compensation was not provided, on the grounds that the necessary worst-case (unity-gain) compensation would lead to a less good HF performance from the IC, at higher than unity-gain conditions, than if the compensation was done by a suitably chosen network of Rs and Cs external to the IC package. However, this situation has been overtaken by progress in IC design, and most of the contemporary IC designs will give a good HF performance without the need to accept an inconvenient external RC network.

Typical values of *open-loop* (ie, before any negative feedback is applied) small signal, low frequency voltage gain are in the range 100,000-200,000, and the rejection of unwanted noise and voltage fluctuations on the voltage supply lines is usually of a similar order. The *common mode rejection ratio* (the ratio between the open loop gain and the 'fault' gain you get when you tie the + and − inputs together and use them as if they were just one input) is usually in this range also, but it is very difficult to organise any circuit layout which will allow gains much higher than 1000 to be achieved. The most common pin configurations for IC op-amps are shown in Fig. 2, and a typical circuit for a small signal AC voltage amplifier is shown in Fig. 3a.

The circuit will give a stage gain determined by the ratio $(R_3 + R_2)/R_2$. For the resistor values shown this is 48, and this circuit will have a frequency response at 1 V out

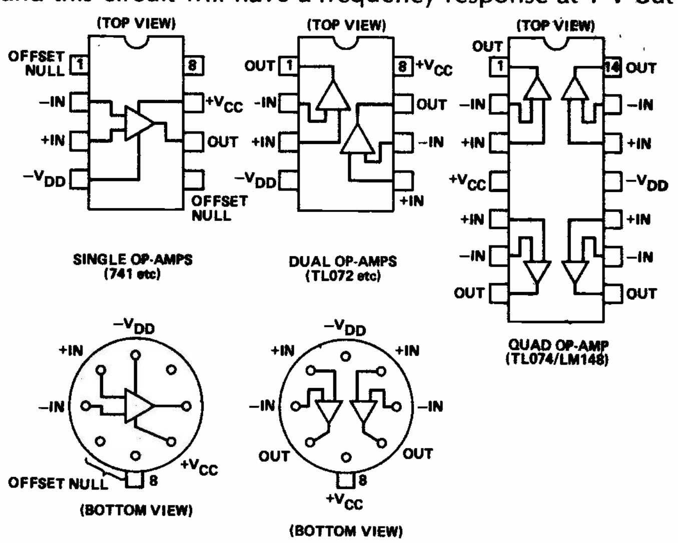


Fig. 2 Common op-amp pin connections.

Problems and ICs often, as we all know, go together. John Linsley Hood takes a look at the two of them in audio.

(RMS) — assuming a ±15 V DC supply — which is substantially flat from 10 Hz to 30 kHz, the LF limit being set by the value chosen for C1 (bigger = lower) and the HF end being determined by the characteristics of the IC itself, as a consequence of its internal HF compensation.

At 1 V RMS and 1 kHz, a typical distortion figure into a 2k ohm load, would be about 0.02% and a S/N ratio (assuming a low source impedance) of about 75dB, when measured over the 10 Hz-30 kHz bandwidth. Substituting one of the newer designs of IC intended for audio use, such as a TL071 or a LF351, would halve the noise, increase the bandwidth to about 300 kHz, and reduce the 1 kHz distortion to some 0.002%. Such is progress!

Such a gain block, particularly when built using a TL071 or a LF351, both of which have high impedance FET inputs and very low noise characteristics, makes a very respectable hi-fi amplifier stage, in any application where a flat gain/frequency response is appropriate. To take advantage of the convenience of a single power supply rail, which facilitates joining IC circuity on to discrete transistor layouts, the circuit of 3a can be rearranged as shown in Fig. 3b without any loss of performance. (To assist in comparing the layout of 3b with that of 3a, I have retained some of the component numbering of 3a in 3b.) Lower supply voltages diminish the available output swing and tend to worsen the THD (total harmonic distortion) at any given output, though this will only become conspicuous as the expected output signal level begins to get near the maximum available due to the DC supply provided.

Both of these op-amp gain stages compare favourably, both in terms of the cost of the components and in terms of performance, with the comparable separate transistor versions, the only major snag being the limit on the possible output voltage swing imposed by the ICs restricted HT supply capability. It is no use, therefore, to try to use an IC of this type if one wants a 100 V P-P signal output.

As shown in Fig. 2, IC op-amps of this type are available in packages which contain up to four separate amplifiers on the same chip, usually with very little sacrifice in performance, and with only minimal signal breakthrough from one to another. In particular, the dual op-amp TL072 and LF353 types have become very popular among audio circuit designers as a means of handling a pair of stereo signal channels in one device.

Frequency Response Shaping

While quite a lot of audio signal handling can be done with stages with linear gain/frequency characteristics, it is very useful to be able to modify this frequency response. I have mentioned above, in the case of Fig. 3a, that the LF response was determined by the value of C1. This is because, in a feedback amplifier, the gain of the stage is really determined by the ratio of the impedances in the two limbs of the feedback network. So long as the impedances of any capacitors (or inductors) in these limbs can be ignored in comparison with the resistive elements, the gain will be independent of frequency. However, if the effects of these *reactive* components are significant within the audio band, this linearity of frequency response will be modified, and this gives the designer considerable scope.

In order to do this kind of design work properly, it is very desirable to be able to work with *complex numbers* (ie, those containing the so-called *imaginary* value **i** or **j**, which is the square-root of −1). Doing the necessary

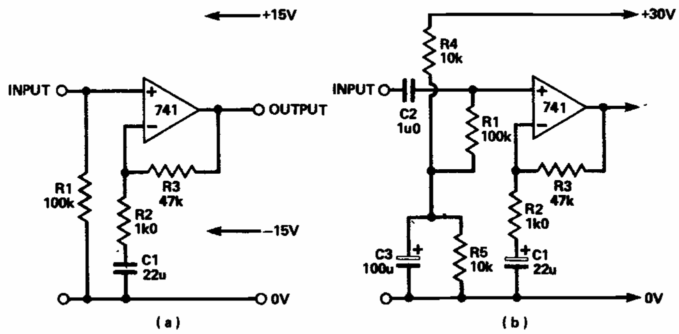


Fig. 3 Simple op-amp circuit. Note that in theory C1 should be unpolarised, in practice an electrolytic is used. (b) is the circuit arrangement for use with a single-rail power supply, in all other respects it is equivalent to (a).

calculations with this type of equation is not really at all difficult, once some simple rules have been memorised, and this allows one to work out quite precisely how a circuit containing capacitors and inductors will operate, and gives both the actual gain and the phase shift. However, it *is* very hard to find text books which give a simple explanation and I propose, later on in this series, to give a non-mathematician's brief guide.

However, for the moment it is sufficient to remember that the −3dB point (the frequency at which the gain is reduced to 71% of its flat response value) occurs in a stage such as that shown in 3a when the impedance of the capacitor C1 (given by $Z_C = 1/(2\pi fC)$) is equal in value to R2. Where the impedance of C1 is either very much less than R2 or very much greater than R2, the stage gain

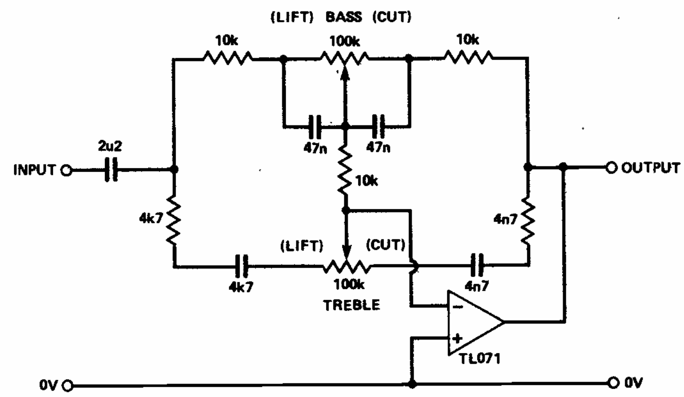


Fig. 4 'Baxandall' type tone-control circuit.

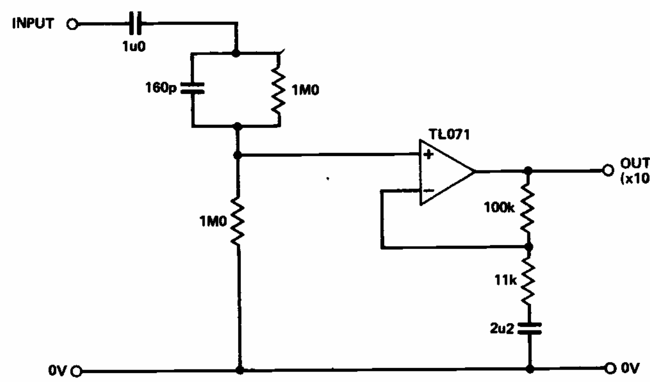


Fig. 5 Compensated ceramic pick-up input amplifier.

calculations can be simplified to (R3 + R2)/R2 or (R3 + Z_C)/Z_C. If one draws a graph and smoothly joins these three points, one will get a near-correct idea of the true way the circuit will behave.

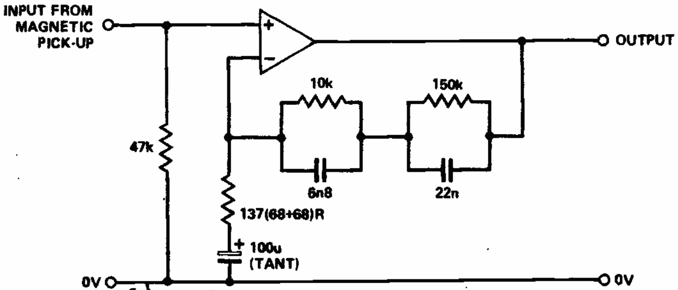


Fig. 6 Conventional RIAA-equalised magnetic pick-up amplifier stage (gain = 100 at 1 kHz).

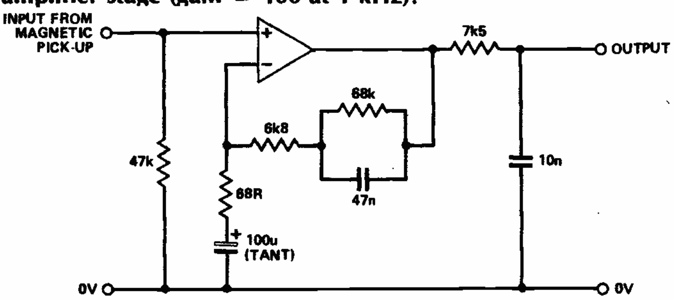


Fig. 7 Improved RIAA-equalised magnetic pick-up amplifier (stage gain = 100 at 1 kHz).

Thus the circuit varies its response according to frequency, and this is entirely due to the presence of the reactive components (more usually capacitors than inductors). Very many practical and useful designs are made possible: some examples are Fig. 4, which is a tone control circuit, and, as explained in the captions, Figs. 5, 6 and 7 which are pick-up amplifiers that accord with the RIAA specifications as shown in Fig. 9. The circuit arrangement shown in Fig. 7, in which the necessary double-step correction of the curve shown in Fig. 9, is done in two stages, is more accurate, particularly in respect of the sonically important transient performance, than the simpler, more commonly used arrangement of Fig. 6. The ceramic cartridge equalisation has a different requirement, since this is an amplitude — rather than velocity — sensitive device, and requires the type of replay curve shown in Fig. 10. Otherwise, when it is used with an adequately high input impedance to give a flat LF response, the reproduced sound is rather lacking in treble.

Combining bass cut and treble cut stages allows one to make local lift and local cut response circuits, such as those shown in Figs. 11a and 11b and whose performance is illustrated in Figs. 12a and 12b. Figs. 11a and b are really both the same circuit, but with the 'shelf' frequencies moved sideways.

I have illustrated all these later circuits using op-amps

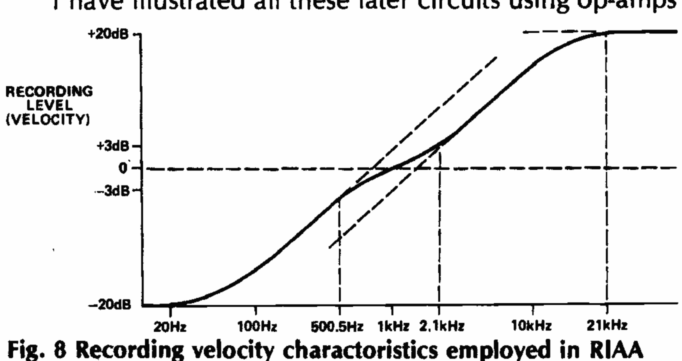


Fig. 8 Recording velocity charactoristics employed in RIAA pre-emphasis convention for 33 and 45 RPM discs.

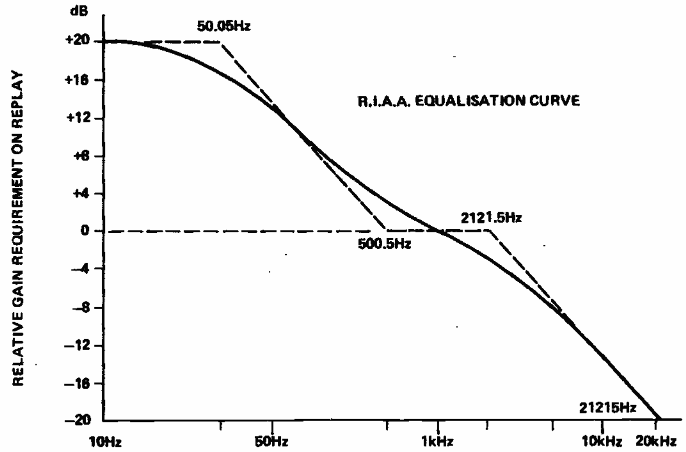


Fig. 9 Required replay curve for magnetic (velocity sensitive) pick-up cartridges.

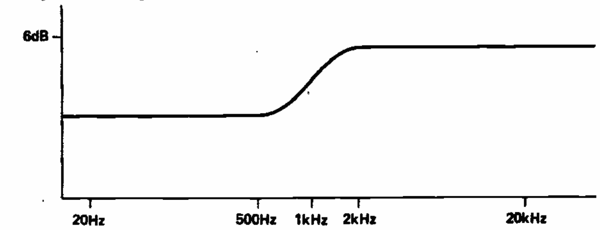


Fig. 10 Required replay curve for flat frequency-response output from ceramic (displacement sensitive) pick-up cartridges.

(a TL071 will work satisfactorily in all these). Let me confess that this was at least partly for convenience — it's much simpler (and easier to follow) if one can just show an amplifier as a triangle with three leads going to it. However, this also makes the point that circuit design (and circuit lay-out in the PCB) with op-amps is very much easier than with the equivalent discrete components (this is provided, of course, that the devices you are using have adequate performance in terms of output capability, distortion, noise, etc). But I still have the feeling that, for 'ultimate-fi', circuits using discrete components alone can be superior, if only because one can get the equivalent results with far fewer components (remember that a typical op-amp can contain the equivalent of 39 separate resistors, transistors, diodes, and capacitors, each with its own imperfections, all of them contributing to an accumulated total imperfection). Instinctively, I feel that the less one handles a hi-fi signal the better the end result.

Steeper cut circuits using two or more RC elements

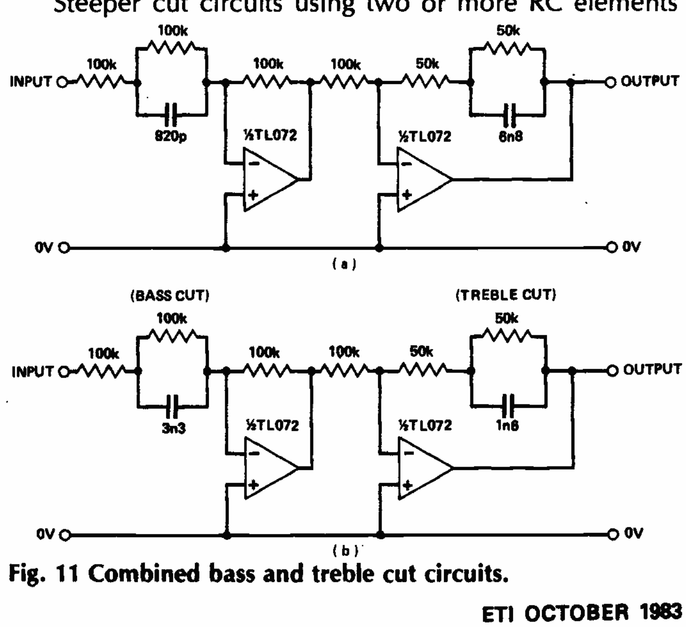


Fig. 11 Combined bass and treble cut circuits.

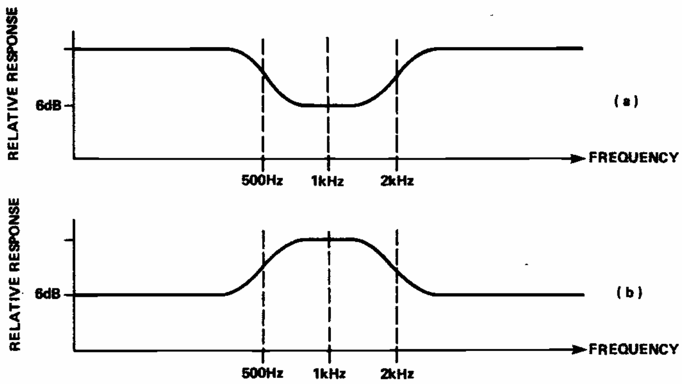


Fig. 12 Response curves for the two circuits in Fig. 11.

can be built, and if these RC groups are included in the feedback network we are now building active filters. These are great fun, but working out just what is going to happen requires rather more tricky maths, and a few useful dodges. Again, this is a topic I will defer until later. So, while I certainly use ICs in my own designs, and I accept that I will do so even more in the future as they get better and more versatile, nevertheless I do not see them displacing the circuits built up with separate transistors and resistors yet awhile. On the other hand, if one is making something like a car radio to which hi-fi standards are not really appropriate, or an FM tuner where the discrete component circuitry would be very cumbersome, *not* to use ICs would be truly ostrich-like behaviour.

Noise And Distortion — And Other Problems!

So far, I have largely pretended that we are living in an ideal world, where everything is as good as we would wish. Unfortunately, this isn't true, and the extent to which we will be successful in the field of audio design — as in any other — will depend on our ability to recognise the possible existence of defects, and to shape our designs, both on paper and as hardware, to avoid them. The problem, of course, is that it just isn't possible to optimise everything simultaneously, so what one ends up with must be a working compromise in which one has tried to assess what are the most important problems likely to affect one's listening pleasure, and to make sure that these are adequately dealt with.

This is, incidentally, one of the areas in which the DIY designer has a great advantage over the person who simply goes along to his hi-fi shop and hands over a wodge of pound notes for the latest black and chrome creation. This is because the commercial hi-fi is built to provide a good specification/price ratio, which will get a good review in the buyers' guides and ensure healthy sales. Unfortunately, no one really knows what makes hi-fi equipment, such as amplifiers, tuners and recorders, sound well; so, in the absence of any firm knowledge, a series of specifications relating to bandwidth, signal-to-noise ratio, power output, distortion and channel separation, have arisen — and these are the specs for which the commercial manufacturers seek to get good values. Whether the final thing sounds well cannot be so easily specified, but there are some areas, and I will look at these later, where something which measures less well does indeed sound better. So, if one is doing ones own thing one can design for sound rather than specifications.

Noise

If, in this term one includes all unwanted intrusions into the signal output, this consists of five main categories. These are: thermal noise, defective component noise, radio breakthrough, impulse noise, and hum (from the AC mains power supply). There are also some other kinds of device noise with transistors (and ICs) which relate to the device operating conditions, and I have lumped these with thermal noise. I will leave this until last.

Hum: in any normal domestic environment, there is a possibility of the local (in the UK, 50 Hz) AC mains field intruding into the circuitry, even when this is battery operated. The only answer, in this case, is full screening of the lot, and care in the layout of connecting wires. Diecast metal boxes, such as those made by Eddystone and ITT, provide ideal housings for low-level and high-gain circuitry. Where one is powering equipment from the mains anyway, these problems multiply. Here one must make sure that one does not earth the equipment separately in more than one place (the all too familiar *earth loop* problem), one must make sure that the mains transformer has an adequately low external AC magnetic field, and that it is sited as faraway as possible from low signal level areas. Also, one needs to remember that the currents flowing in the transformer secondary, rectifier, and reservoir capacitor loop have very high peak values and will produce quite significant voltages across even small wiring resistances. Take care, therefore, to take off the DC supply from across the reservoir capacitor, including your 0V return! A further important point to watch is that there is no incipient instability in the circuitry of any amplifier, in that this will make it very prone to a hard rasping hum sound — similar to that given by two different earthing points on the mains DC supply.

Impulse noise: this has a lot in common with radio breakthrough, and is that annoying problem of clicks and bangs when other mains operated equipment in the same locality, lamps, fridges, central heating equipment, and so on, is switched on and off. This can be caused, partly, by the same things as radio breakthrough (see below), but is particularly exaggerated by incipient instability and unnecessarily wide gain bandwidth. If one had a moving coil head amp feeding the PU input, and if the head amp had a 10 MHz bandwidth, one would expect impulse noise problems. Thorough screening will also help here.

Radio breakthrough: for those who suffer from it, this is one of the most infuriating of problems — worse even than noisy neighbours. There is, unfortunately, no universal answer. In general, the problem arises because the various connecting leads act as aerials feeding signals into the amplifier, which are then rectified by slightly less than perfect plug-socket connections, transistors or IC semiconductors, or even by poor soldered joints. Decoupling those earth returns which are not directly connected to the chassis, via a non-inductive (eg, ceramic disc) capacitor will help, as will the connection of judicious 100 to 1000 pF ceramic capacitors between input transistor emitters and bases. Also, putting a few ferrite beads on likely live-side input leads can help. Alas, the trick which works in one case may be useless in another, so this requires a lot of experimentation, and not a little luck.

Defective component noise: in my early days as an electronics enthusiast, resistors which crackled, capacitors which spluttered, sizzled, and hissed, and valves which rang like a bell when one tapped them, were just part of life — and one tried, by replacement, to end up eventually with a good set, until yet another component 'went noisy'. Happily, things have changed for the better, and nowadays defective components are relatively rare, at least at normal signal levels, where an electrolytic capacitor installed with reversed polarity is likely to be the major noise culprit.

However, at low signal levels, such as at the phono input to an audio amp, this isn't so reliably the case, and while proper selection of components for the application will help, for very low level use there is no real substitute for individual testing to guarantee good performance. Remember also that most electronic components don't like heat, so if one has had to spend a lot of time with the soldering iron bit close to the component in question — perhaps in taking it out of a PCB and in reinstalling it — it may not be as good afterwards as it was to begin with.

Thermal noise: this is the result of the random motions of electrons — the basic carrying elements — as a consequence of their being excited by heat. This noise component increases with absolute temperature (°K = 273 + °C), and with the amount of resistance in the circuit. The formula for calculating this is

$$V = \sqrt{4k.T.dF.R}$$

where V is the mean AC output voltage, k is Boltzmanns constant (1.38×10^{-23}), T is the absolute temperature (° Kelvin), dF is the measurement bandwidth and R is the circuit resistance. It follows from this, immediately, that the larger the amount of resistance in the circuit (other things being equal) the worse the noise. A graph showing this relationship is given in Fig. 13.

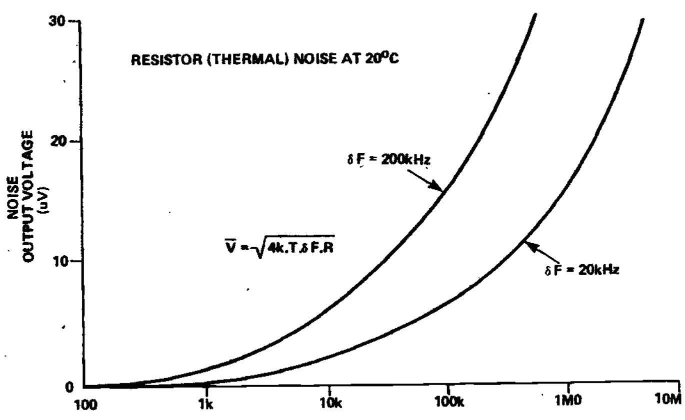


Fig. 13 Resistor thermal noise at 20°C.

Other sources of noise, related to circuit resistance, occur in junciton and other transistors. These are those due to what is known as *base spreading resistance* (which decreases as the chip size and dopant concentration increase), and shot noise, which is a statistical problem and decreases, within limits, as the ratio of the total emitter current to the fundamental electronic current lumps, the electrons, increases. There is also *modulation* or *l/f* noise, which is proportional to the current and inversely proportional to frequency: this is very much depedent on the device used. Finally, there is reverse leakage noise, which worsens as the collector (or drain in the case of an FET) voltage increases.

To summarise this, the lowest noise in a transistor stage will be given by an optimally chosen device (in respect to type and performance), operated at the collector current which is best suited to its base and emitter circuit resistance and its chip size, at the lowest sensible temperature and operating voltage, and the lowest input impedance. Since all of the noise sources are bandwidth dependent, those which arise before a bandwidth limiting filter, such as an RIAA equalising stage, are less obstrusive than those which occur after this — other things being equal. Also, those noise sources which are inductive in character, such as a magnetic pick-up on the input to a preamplifier, have an impedance which increases with frequency, and will therefore give a worse noise level — since the ear sensitivity increases with frequency up to a few kHz — than a simple calculation based on its DC resistance would suggest.

ETI

MACHINE CODE PROGRAMMING

Machine code programming has two uses: firstly, as a way of getting your (normally BASIC-loving) microcomputer to go faster; and secondly, it's the only way to get a 'naked' microprocessor to do what you want. This latter use is what will primarily interest ETI readers. However, it's pretty difficult to learn on a bare micro, so in this short series, Bob Bennett will be showing us how it's done on a home computer, with some comments on using a microprocessor in the raw.

The best way to learn to programme using machine code is to have a go, after all, that was how you learned to programme in BASIC. But then, BASIC does bear some resemblance to everyday English, and machine code looks like . . . well . . . code, so how is it done? To answer that you need to have an insight into what is happening inside the computer — not a lot, just enough to make machine code programming clearer. In this magazine, starting in August of 1982, Owen Bishop wrote an excellent series on designing micro systems, and explained how all the pieces are put together to make a computer. I'll start with a short recap of some of the points relevant to machine code programming.

Deep In The Heart (of Texas?)

At the heart of any computer is a processor, and in most home computers it is a single chip. The Jupiter, Lynx, Spectrum and many others use a Z80 type, whilst the processor in the BBC, Vic 20, Apple, etc, is a type 6502. Each processor has its own instruction set, which is a repertoire of instructions the processor will obey, and each processor has a register set, most of which can be used directly by the programmer. It is by the judicious use of the instruction set that the programmer manipulates the data in the registers to execute, in a controlled sequence, the various effects which constitute the desired aim of the overall programme.

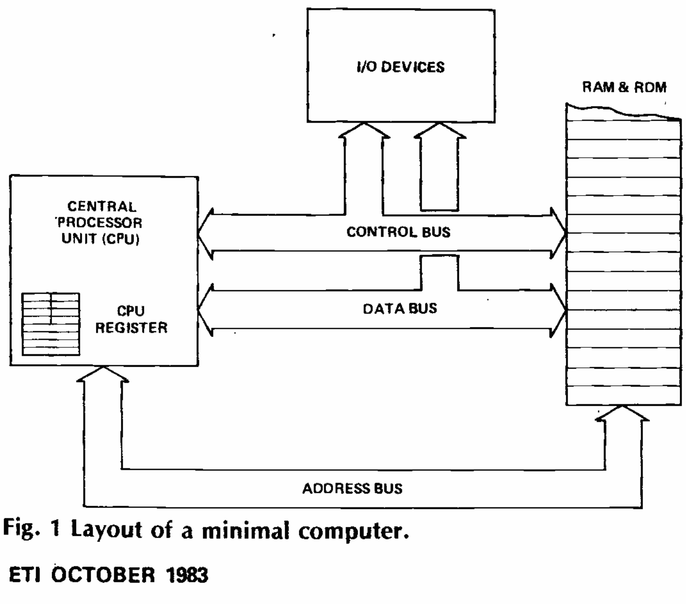


Fig. 1 Layout of a minimal computer.

CPUs differ quite a lot in both the sizes of their instruction repertoirs and in the number of registers that they contain. We'll be looking at registers in a moment.

The two more common types of memory used in home computers are random access memory (RAM), and read only memory (ROM). Fundamentally they appear the same in general makeup, inasmuch as they both have a number of locations (called addresses) where data can be placed, but in ROM that data is sealed in and cannot be altered, hence read only. It is in the ROM where the designer has put the routines to control all the effects I mentioned earlier, such goodies as PRINT, PLOT, SCROLL, etc, in fact everything your computer can do. RAM is where the machine code programmer (that's you!) places the instructions (program) which the processor hopefully will obey. The designation random is a bit of a misnomer: there is nothing random in the way the memory is accessed, at least, not (we hope) in a computer!

Bits And Pieces

So what's the connection between RAM, ROM, registers and the processor? The answer is a bus. Not the number 8 to the office, but another name for a connecting wire, or, as is more usual in a computer, a group of wires (or tracks on a PCB). These wires carry information in the form of electrical signals, and it is the level of the voltages present on the bus which conveys the meaning of the signals. An acceptable high level can be taken to mean a 1, and an acceptable low level can signify a 0, which leads us to use binary notation on computing (convenient isn't it?).

If there are n wires making up a bus, then the total information on the bus can be represented as 2^n. Most home computers have eight-bit registers (where bit is a contraction of Binary digIT), so the highest number this register can hold is 2^8-1 which is 255 if all the bits are 1s. These eight bits are known as a byte.

255 is not a very high number to play around with so it

is arranged that registers can be used in pairs, but only in certain combinations. This combination broadens our horizons somewhat because we can now use numbers up to 2^{16} which is equal to 65,536 decimal. The normal way to present data is one byte at a time, so our data bus usually has only eight wires. However, because we need a lot of memory, we use 16 wires on the address bus which allows up to 65,536 addresses, or locations to be used. This is known as 16K or 16 Kilobytes because it gets tedious writing

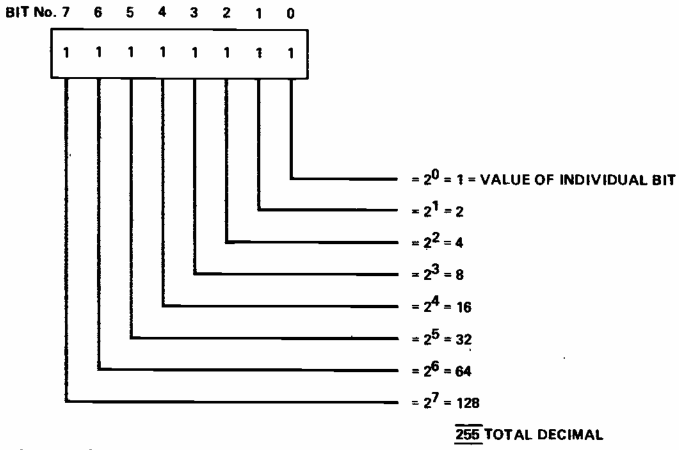


Fig. 2 The make-up of an eight-bit register.

out complicated binary numbers in decimal all the time. A K is 2^{10}, and this is equal to 1024 — it's the nearest convenient binary number to 1000, but note that a capital K is used to distinguish it from the decimal k (=1000). We just have to hope that the context is such that any numbers are obviously not absolute temperatures (ie in degrees Kelvin or K)!

When you see advertisements extolling the virtues of home computers you will probably notice something along the lines of "16K ROM and 16K RAM". You will know that the ROM is for the routines that the designers have built into the machine. The start of the ROM area is usually (but not always!) address 0, so in the example given, it will extend up to address 16 × 1024 −1, ie 16383 (the −1 is because we've started counting at 0 rather than 1 as is usual outside computers — think of a street with 16 houses, if the first is numbered 0, the last will be number 15).

Unfortunately, this doesn't leave the RAM entirely free for the user to place all his or her programs, data, etc, because the computer needs some space to use for its own internal housekeeping (it stores what are known as the systems variables). It is very important not to over-write or **corrupt** the areas that the computer needs for this purpose — doing so is a very effective way of bringing your micro to its knees (or whatever the micro equivalent of a knee is). However, even in the most modest of systems, there will be more than enough space left for a decent machine code program.

Do You Do Voodoo?

If you are a student of the occult you may have come across the word hex before (I believe it has something to do with casting a spell), but in computing circles it is a word that machine code buffs drop all over the place. Actually it is short for hexadecimal, where hexa is from the Greek pertaining to six, and decimal of course is all about tens, so putting them both together means we are counting using the base 16. Some people may believe that this is the Martian base for counting because they have sixteen fingers! Starting at zero (written as O) we count up to 9 and then we go from A to F where A = 10 decimal and F = 15 decimal.

Note that we would write down 10 decimal as OA hex (or OAH), and 15 decimal is OF hex (or OFH): you must get used to the idea of writing hexadecimal numbers as two characters; for example, F on its own is meaningless whereas OF equals 15 decimal, and FO equals 240 decimal. FF hex equals 255 decimal which, if you remember, is the maximum that a register can hold, and also the number that eight bits would represent if they were all 1s which in turn represents one byte (see how it all fits in?), so two hex characters equal one byte. All this means that it is possible to write a machine code program in either binary, decimal or hexadecimal and still get the same result, but I think that you can discount using binary because it's far too cumber-

CONVERSIONS

CONVERSION OF HEXADECIMAL TO DECIMAL

A single hexadecimal register holds up to 256, and, as we do when counting in tens, we split this into a 16^1 figure and a 16^0 figure (as in tens and units). A register pair would hold figures for 16^3, 16^2, 16^1 and 16^0.

hex	16^3	16^2	16^1	16^0
0	0	0	0	0
1	4096	256	16	1
2	8192	512	32	2
3	12288	768	48	3
4	16384	1024	64	4
5	20480	1280	80	5
6	24576	1536	96	6
7	28672	1792	112	7
8	32768	2048	128	8
9	36864	2304	144	9
A	40960	2560	160	10
B	45056	2716	176	11
C	49152	3072	192	12
D	53248	3328	208	13
E	57344	3584	224	14
F	61440	3840	240	15

Using the table: decimal 15 in a register pair = 000F whereas 240 decimal in a single register would = F0.
A0B0 hex = 40960 + 176 = 41136 decimal
FEDC hex = 61440 + 3854 + 208 + 12 = 65514

CONVERSION OF DECIMAL TO BINARY OR HEXADECIMAL

Conversion can be achieved in two ways, successive division or by spotting powers of two. Let's look at an example:
To convert 365 into binary by successive division goes as follows:

365 divided by 2 is 182 remainder 1
182 divided by 2 is 91 remainder 0
91 divided by 2 is 45 remainder 1
45 divided by 2 is 22 remainder 1
22 divided by 2 is 11 remainder 0
11 divided by 2 is 5 remainder 1
5 divided by 2 is 2 remainder 1
2 divided by 2 is 1 remainder 0
1 divided by 2 is 0 remainder 1

all successive divisions by 2 will yield the result 0 and the remainder 0.
The very first remainded we obtained the value of 2^0, the next is 2^1, the next is 2^2, etc
So the binary for 365 is 0001 0110 1101 and the hex is 01 6D.
Spotting the powers of two would work as follows:
365 is over 256 (2^8) but under 512 (2^9) so the binary bit corresponding to 2^8 is 1
365 − 256 = 109
109 is less than 128, so the bit for 2^7 is 0
109 is greated than 64 so the bit for 2^6 is 1
109 − 64 = 45
45 is greater than 32 so the bit for 2^5 is 1
45 − 32 = 13
13 is less than 16, so the bit for 2^4 is 0
13 is greater than 8 so the bit for 2^3 is 1
13 − 8 = 5
5 is greater than 4 so the bit for 2^2 is 1
5 − 4 = 1
1 is less than 2 so the bit for 2^1 is 0
1 is equal to 1 so the bit for 2^0
We follow this through in the same way as before.

some (although a knowledge of the binary system is essential for some applications as you will see).

To sum up so far: a machine code program is written to (or placed in) addresses in RAM one byte at a time, some bytes representing instructions, and some representing data. Registers, either singly or in pairs, are used to manipulate the instructions and data, and the processor sorts out all that little lot. According to the information in the programme, different routines in ROM are called into use to give different effects. This is a very simplified explanation, but essentially correct, and although I have only been talking about typical home computers, very much the same sort of process happens in larger computers, only on a much grander scale.

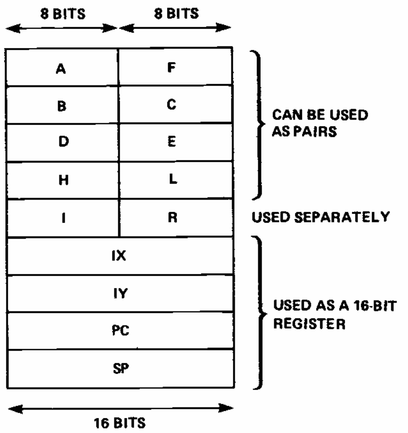


Fig. 3 The Z80 register set. Note that there is also an alternate set of registers A,B,C,D,E,F,H, L, usually referred to as A',B', etc.

I mentioned earlier that I would discuss registers in greater detail, so here we go. Using the Z80 set as a model (Fig. 3), the A register is historically called the accumulator because it was used to accumulate the results of computations. It is still a hard worked register, and there are certain operations that can only be carried out using the A register, but more of that later. The F register is the flags register alias the status register. This is so important to machine code programming that it warrants a section to itself. The B,C,D,E,H, and L registers are general purpose registers which are not found in a lot of CPUs.

When an input device requires the attention of the CPU it sends out a signal called an interrupt. What happens then depends on the CPU type, but usually an indicator signals the fact that an interrupt has occurred, and then the interrupt routine is entered. The Z80 has a rather unique way of dealing with an interrupt, however. Once an interrupt has been acknolwedged, the decive puts the low byte of an address onto the data bus. The high part of the address is in the I register, the two parts forming the address of a routine to handle the interrupt.

The R register is a simple counter (0 to 255) which is used to periodicaly refresh memory cells in RAM in order not to lose the contents. When a GOSUB is used in BASIC the computer uses a portion of RAM as a stack to store the address of the next instruction to be executed after meeting a RETURN. The stack is also used when pushing and popping (more later) to keep tabs on the addresses. It seems quite logical therefore to have a stack pointer to hold the address of the last item to be put onto the stack, this is the SP pair. The last registers in this set are the two used as a program counter (PC), the PC holds the address of the current instruction.

I have saved the two sets of register pairs IX and IY until now because not many CPUs have these sets. They are used for indexed addressing which, very simply, is this, using IX as an example. The IX pair are made to hold the address of a table, where information relating to your program has been stored, this is known as the base address. When required the IX pair will meet instructions pertaining to their role in the program. These instructions are in two parts, the first part is a number, which is added to, or subtracted from the base address. This will point to an address in the table. The second part is an instruction relating to what will happen at that address, and this may, or may not influence what happens next in your program.

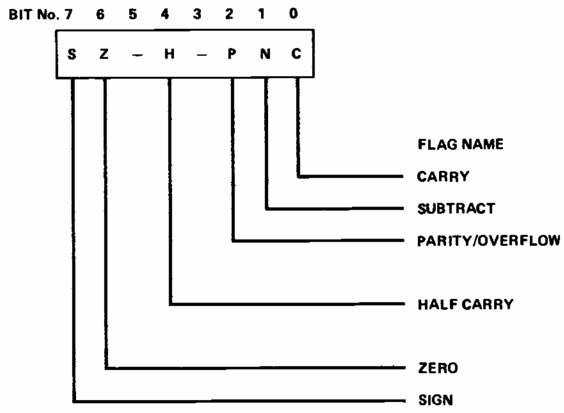


Fig. 4 The flags available in register F.

A Bit Of Flag Waving

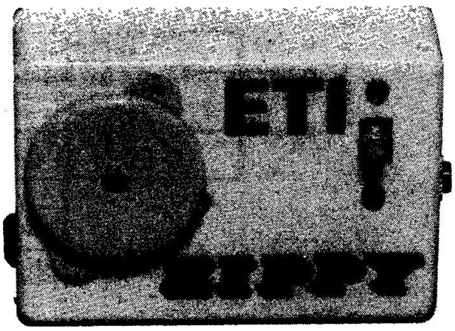
As well as the general purpose registers, each processor will have a **flag,** or **status register.** These are constructed in exactly the same way as any other register, but the bits are used as indicators, or **flags,** to signal whether or not certain conditions have been met. The convention is that when a bit is set it is 1, and when reset, it is 0; when the condition has been met the flag is set, and reset otherwise.

Every micro I know of has a zero flag of some sort — one that is set when the contents of a particular register are zero. As an example, let's look at what is involved in the execution of a FOR-NEXT loop; something like this will be taking place: load a register with n (the loop count); do the task contained in the loop; decrement the count (n = n – l); test the flag to see if the register is zero. If it is not, then go back and do the task again; if it is, go on to the next task. Note that both conditions of the flag can apply, and we program the computer to do one thing if the flag is set, another if it isn't.

The more usual flags are **zero, parity/overflow, sign, carry, half-carry, substract,** and others may be **interrupt, decimal** and **break.** Whatever flags your processor uses, get to know them along with the instruction set. Any good computer handbook should give the instruction set, and any good library will have a computer section with a good selection of books on micros.

Other registers will include the **stack pointer** (SP), which may be a pair or a single register, which is used as a pointer to the stack area of memory. **Index registers** may come singly or in pairs, and are usually designated X and Y singly, and prefixed with I in pairs. As their name implies, these are used for indexing along tables of data. If you remember, a program is stored in a number of addresses, so a **program counter** (PC) is used as a pointer to these addresses. One last register: dynamic RAM will need refreshing (electrically) every now and again so that information isn't lost, so there is a **refresh register** (they think of everything). This list isn't exhaustive and don't worry if it isn't all completely clear what's going on. However, I hope that your appetite is whetted enough to probe further into your computer. **ETI**

SUPPLY PROTECTOR



Does that flickering of the house lights all too often indicate that your ZX has just had its memory corrupted? Here's a very simple remedy, designed by Phil Walker.

Designed primarily with the ZX81 home computer in mind but applicable to many others, this project aims to protect the program that you've just spent three hours correcting from short term mains failure or accidental supply disconnection. The sort of thing we mean is the temporary (or worse) dimming of the lights caused by lightning strikes on the grid lines or load switching at a sub-station. These effects usually only last a few tenths of a second but can cause your computer to forget itself and delete your program — resulting in instant frustration!

The solution is embodied in this project. What is needed is that the computer should be rapidly switched over to a standby battery. This need only be able to supply the current drawn for a few minutes until the normal supply is restored. The ETI Zippy does this and also sounds an alarm to tell you that something is wrong

The Circuit

The main part of the circuit consists of B1, D1 and IC1. B1 is a Nickel- Cadmium rechargeable battery with a capacity of 110 mAh at a voltage of around 8.4 volts. This means that when fully charged it should be able to supply a ZX81 for at least 6 minutes — longer if you do not have many extras plugged in. This will even give you time to save your program on tape (provided you have a battery powered tape recorder). D1 effects the switch-over from normal supply to Zippy's internal battery while IC1 recharges the battery while the mains is available. The rest of the circuit provides the audible warning signal from the piezo-electric sounder when the normal supply voltage drops too low.

It is probably a good idea to charge the battery periodically so that you don't get caught out.

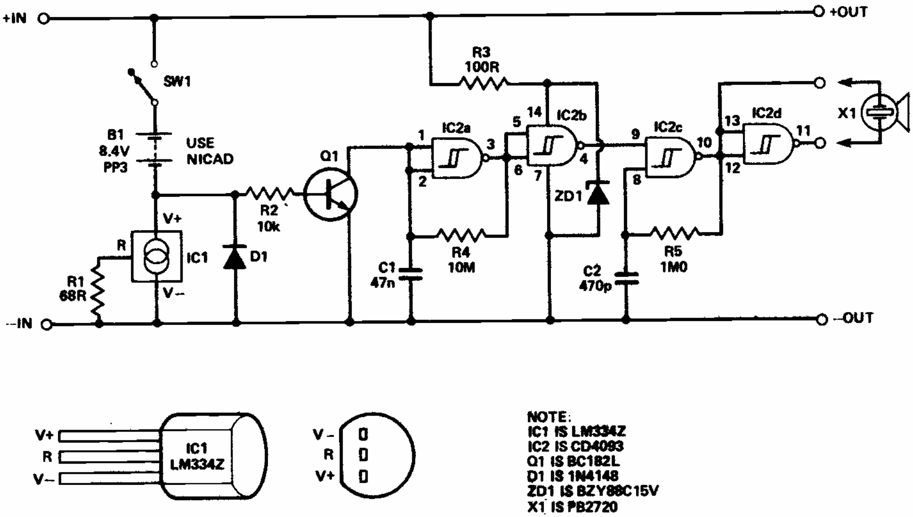


Fig. 1 Circuit diagram of Zippy

HOW IT WORKS

B1 is the main energy store with a capacity of 110 mAh and a terminal voltage of 8.4 volts. IC1 is a constant current device whose operating current is set at about 0.6 mA by R1. This level of current can be sent through the battery constantly with little degradation of performance and will keep it ready for use.

D1 blocks current flow from the power pack to the battery but will allow current to flow from the battery on to the supply lines if the power pack voltage drops below about 7.7 volts. This ensures that the supply lines never drop below this level. The internal regulator in a ZX81 needs about 6.5 to 7 volts minimum at its input pin to keep it working correctly.

While the input voltage from the power pack is more than a volt or so greater than the battery voltage, Q1 will be turned on by current flowing through R3. This will keep C1 discharged. This will cause the outputs of IC2a and IC2c to stay high and IC2b and IC2d to stay low.

If the input voltage falls below this level, Q1 will turn off and allow C1 to be changed via R4 until it reaches the switching threshold of IC2a. The output of IC2a will now go low and C1 will be discharged via R4 until it reaches the lower switching threshold of IC2a whereupon IC2a output will go high again to repeat the cycle. While IC2a output is low the output of IC2b will be high. This enables a similar oscillator configured around IC2c. The frequency of IC2a oscillator is of the order of 2 Hz while that of IC2c is around 2 kHz; the resulting output from IC2c is bursts of 2 kHz which when applied to the piezo sounder make a slow bleep-bleep noise. IC2d is used to invert the output from IC2c and increase the signal voltage applied to the sounder.

Construction

The project can be built into a small plastic box of the type made by Bicc-Vero (see Buylines). It is a tight fit in the one specificed so some care must be taken when siting the switch and input socket. The PCB is designed to fit along one side of the box with the battery along the other. Don't forget to cut the corners off the PCB where marked.

Assembly of the PCB is straightforward but care should be taken when fitting the diodes,

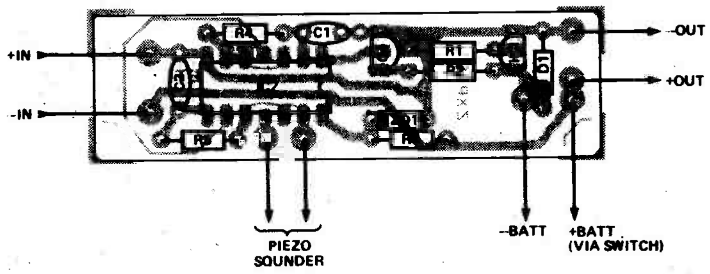


Fig. 2 Component overlay for the PCB

transistor and ICs that they are the right way round. Connect all the lead-out wires except those to the sounder before assembling the complete unit.

In our unit, the sounder was glued to the outside of the case and the wires taken inside through a small hole. Holes should also be cut for the switch, input socket and output wire. Make sure everything will fit before deciding where these holes will be.

For a ZX81, the input connector is a 3.5mm jack socket and the output wire is terminated in a matching plug (after assembly), but for your system these can be as required. Beware . . . not all power supplies have the centre conductor positive, so check this before wiring up.

When everything is ready, put the PCB, switch and input socket in the case, thread the output lead out through the hole provided for it (you did cut one, didn't you?) fit a grommet if you want it to look nice, and wire up the sounder and other components as neatly as possible. Do not have the battery connected while you do this, as it has a very low impedance and can discharge with some violence. The PCB can be fastened in with a bit of sticky tape if you want but it cannot move about much in the limited space available. **ETI**

PARTS LIST

RESISTORS (¼ W 5% carbon film)	
R1	68R
R2	10k
R3	100R
R4	10M
R5	1M
CAPACITORS (disc or plate ceramic etc.)	
C1	47nF
C2	470pF
SEMICONDUCTORS	
IC1	LM334Z
IC2	CD4093
D1	1N4001 (Germanium or Schottky of 1A+ rating may improve performance)
ZD1	BZY88C15V (or similar 15V zener)
Q1	BC182L
MISCELLANEOUS	
X1	PB2720 piezo sounder
B1	8.4 V 110 mAh PP3 size Ni-Cd
SW1	min. on/off slide switch
Box	Vero general purpose 202-21024B

3.5 mm jack plug & socket or as required; PP3 battery connector; PCB; small grommet, wire etc.

BUYLINES

There should be no problems in obtaining any of the components.

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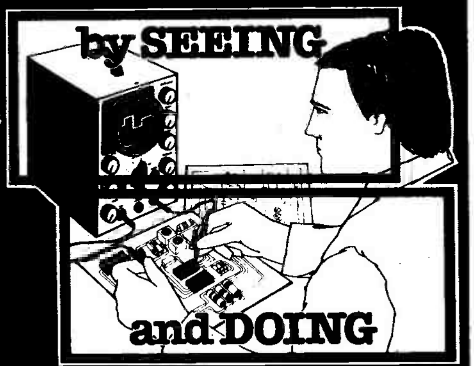

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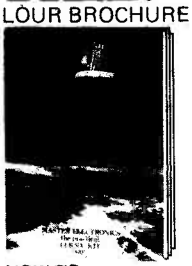

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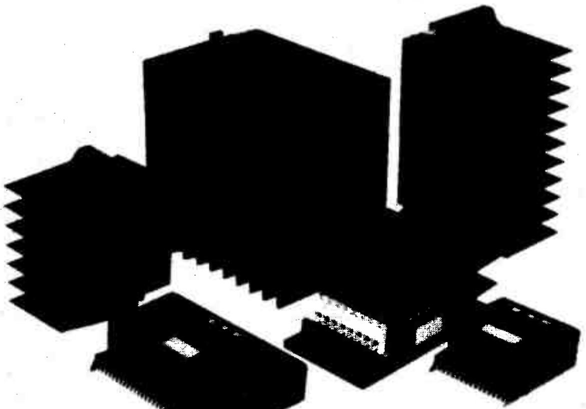
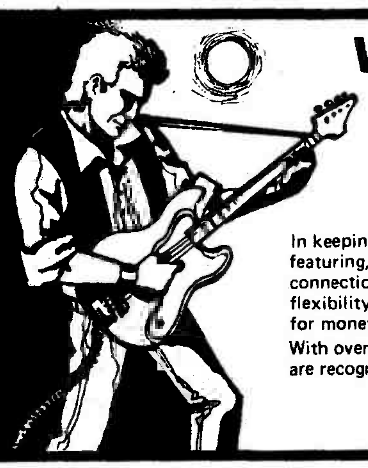


Over the last few years we have received feedback via the general public and industry that our products are from Taiwan, Singapore, Japan, etc... ILP are one of the few 'All British' electronics Companies manufacturing their own products in the United Kingdom. We have proved that we can compete in the world market during the past 12 years and currently export in excess of 60% of our production to over twenty different countries – including USA, Australia and Hong Kong. At the same time we are able to invest in research and development for the future, assuring security for the personnel, directly and indirectly, employed within the UK. We feel very proud of all this and hope you can reap some of our success.

I.L.Potts – Chairman



WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.

With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.

BIPOLAR MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

Protection: Full load line. Slew Rate: 15v/μs. Risetime: 5μs. S/N ratio: 100db.
Frequency response (–3dB) 15Hz – 50KHz. Input sensitivity: 500mV rms.
Input Impedance: 100K Ω . Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

Mounting Boards

For ease of construction we recommend the **B6** for modules HY6–HY13 £1.05 (inc. VAT) and the **B66** for modules HY66–HY78 £1.29 (inc. VAT).

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0,005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/μs. Rise time: 3μs. S/N ratio: 100db
Frequency response (–3dB): 15Hz – 100KHz. Input sensitivity: 500mV rms
Input impedence: 100K Ω Damping factor: 100Hz >400.

'NEW to ILP' In Car Entertainments

C15

Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

Robust construction.

£9.14 (inc. VAT)

Mounts anywhere in car.

Automatic switch on.

Output power maximum 22w peak into 4Ω
Frequency response (–3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω
Size 95 x 48 x 50mm, Weight 256 gms.

C1515

Stereo version of C15.

£17.19 (inc. VAT)

Size 95 x 40 x 80. Weight 410 gms.

POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

Model Number	For Use With	Price inc. VAT
PSU 21X	1 or 2 HY30	£11.93
PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.83
PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

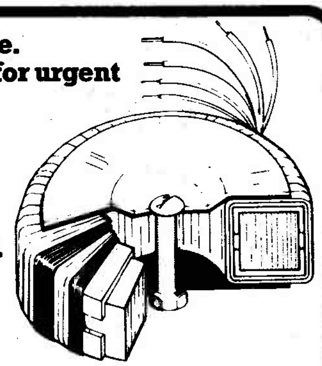
Please note: X in part no. indicates primary voltage. Please insert "0" in place of X for **110V**, "1" in place of X for **220V**, and "2" in place of X for **240V**.

TOROIDALS

***Gold service available. 21 days manufacture for urgent deliveries.**

***Orders despatched within 7 days of receipt for single or small quantity orders.**

***5 year no quibble guarantee.**



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

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

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
15 VA	0x010	6+6	1.25	
62 x 34mm	0x011	9+9	0.83	
0.35Kg	0x012	12+12	0.63	**£5.12**
Regulation	0x013	15+15	0.50	+ p&p £0.78
19%	0x014	18+18	0.42	+ VAT £0.89
	0x015	22+22	0.34	TOTAL £6.79
	0x016	25+25	0.30	
	0x017	30+30	0.25	
30 VA	1x010	6+6	2.50	
70 x 30mm	1x011	9+9	1.66	**£5.49**
0.45Kg	1x012	12+12	1.25	+ p&p £1.10
Regulation	1x013	15+15	1.00	+ VAT £0.99
18%	1x014	18+18	0.83	TOTAL £7.58
	1x015	22+22	0.68	
	1x016	25+25	0.60	
	1x017	30+30	0.50	
50 VA	2x010	6+6	4.16	
80 x 35mm	2x011	9+9	2.77	
0.9Kg	2x012	12+12	2.08	
Regulation	2x013	15+15	1.66	**£6.13**
13%	2x014	18+18	1.38	+ p&p £1.35
	2x015	22+22	1.13	+ VAT £1.12
	2x016	25+25	1.00	TOTAL £8.60
	2x017	30+30	0.83	
	2x028	110	0.45	
	2x029	220	0.22	
	2x030	240	0.20	
80 VA	3x010	6+6	6.64	
90 x 30mm	3x011	9+9	4.44	
1Kg	3x012	12+12	3.33	**£6.66**
Regulation	3x013	15+15	2.66	+ p&p £1.72
12%	3x014	18+18	2.22	+ VAT £1.26
	3x015	22+22	1.81	TOTAL £9.64
	3x016	25+25	1.60	
	3x017	30+30	1.33	
	3x028	110	0.72	
	3x029	220	0.36	
	3x030	240	0.33	
120 VA	4x010	6+6	10.00	
90 x 40mm	4x011	9+9	6.66	
1.2Kg	4x012	12+12	5.00	
Regulation	4x013	15+15	4.00	**£7.42**
11%	4x014	18+18	3.33	+ p&p £1.72
	4x015	22+22	2.72	+ VAT £1.37
	4x016	25+25	2.40	TOTAL £10.51
	4x017	30+30	2.00	
	4x018	35+35	1.71	
	4x028	110	1.09	
	4x029	220	0.54	
	4x030	240	0.50	
160 VA	5x011	9+9	8.89	
110 x 40mm	5x012	12+12	6.66	
1.8Kg	5x013	15+15	5.33	
Regulation	5x014	18+18	4.44	**£8.43**
8%	5x015	22+22	3.63	+ p&p £1.72
	5x016	25+25	3.20	+ VAT £1.52
	5x017	30+30	2.66	TOTAL £11.67
	5x018	35+35	2.28	
	5x026	40+40	2.00	
	5x028	110	1.45	
	5x029	220	0.72	
	5x030	240	0.66	
225 VA	6x012	12+12	9.38	
110 x 45mm	6x013	15+15	7.50	
2.2Kg	6x014	18+18	6.25	
Regulation	6x015	22+22	5.11	**£9.81**
7%	6x016	25+25	4.50	+ p&p £2.05
	6x017	30+30	3.75	+ VAT £1.78
	6x018	35+35	3.21	TOTAL £13.64
	6x026	40+40	2.81	
	6x025	45+45	2.50	
	6x033	50+50	2.25	
	6x028	110	2.04	
	6x029	220	1.02	
	6x030	240	0.93	
300 VA	7x013	15+15	10.00	
110 x 50mm	7x014	18+18	8.33	
2.6Kg	7x015	22+22	6.82	
Regulation	7x016	25+25	6.00	**£10.88**
6%	7x017	30+30	5.00	+ p&p £2.05
	7x018	35+35	4.28	+ VAT £1.94
	7x026	40+40	3.75	TOTAL £14.87
	7x025	45+45	3.33	
	7x033	50+50	3.00	
	7x028	110	2.72	
	7x029	220	1.36	
	7x030	240	1.25	
500 VA	8x016	25+25	10.00	
140 x 60mm	8x017	30+30	8.33	
4Kg	8x018	35+35	7.14	**£14.38**
Regulation	8x026	40+40	6.25	+ p&p £2.40
4%	8x025	45+45	5.55	+ VAT £2.52
	8x033	50+50	5.00	TOTAL £19.30
	8x042	55+55	4.54	
	8x028	110	4.54	
	8x029	220	2.27	
	8x030	240	2.08	
625 VA	9x017	30+30	10.41	
140 x 75mm	9x018	35+35	8.92	
5Kg	9x026	40+40	7.81	**£17.12**
Regulation	9x025	45+45	6.94	+ p&p £2.55
4%	9x033	50+50	6.25	+ VAT £2.95
	9x042	55+55	5.68	TOTAL £22.62
	9x028	110	5.68	
	9x029	220	2.84	
	9x030	240	2.60	

(encased in ABS plastic)

ALSO AVAILABLE
Sizes up to and including 5KVA are manufactured to order.

The benefits of ILP toroidal transformers
ILP toroidal transformers are only half the weight and height of their laminated equivalents, and are available with 110V, 220V or 240V primaries coded as follows:

For 110V primary insert "0" in place of "X" in type number.
For 220V primary (Europe) insert "1" in place of "X" in type number.
For 240V primary (UK) insert "2" in place of "X" in type number.

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

Also available at Electrovalue, Maplin

NEW PRODUCTS

HYBRID REGULATOR MODULES

The HR314 and HR614 regulated power supplies provide a constant 13.8 volt d.c. output at up to 3 Amp or 6 Amp respectively. The modules are encapsulated to an integral heatsink and are fully short circuit protected making them suitable for home or bench running of CB, car stereos or any 12 volt d.c. equipment required for many hobby or professional applications.

HR314 £10.23 inc. VAT
HR614 £18.51 inc. VAT

TECHNICAL SPECIFICATIONS

MODULE	HR314	HR614
Output Voltage	+13.8v ±5%	+13.8v ±5%
Output Current	Up to 3A	Up to 6A
Current limit (nominal)	3.5A approx	7A approx
Maximum Input Voltage	+30v	+30v
Minimum Input Voltage	+16v	+16v
Maximum Input Voltage for nominal output current	+20v	+20v
Maximum output current at 30v input	1.8A approx	3.5A approx
Output ripple (100Hz) · See Note 1	‹10mV rms	‹10mV rms
Size in mm.	76 x 68 x 40 high	120 x 78 x 40 high

POWER SUPPLY UNITS: comprising toroidal transformer plus 90 x 50 x 55 mm high printed circuit board containing smoothing and rectification

PSU31X Suitable for running one HR314 at full rated current. £13.17 inc. VAT
PSU56X Suitable for running one HR614 at full rated current. £19.13 inc. VAT

For 110v operation insert 0 in place of X – brown primary leads.
220v (Europe) operation insert 1 in place of X – pink primary leads.
240v (UK) operation insert 2 in place of X – orange primary leads.

For mail order please make your crossed cheques or postal orders payable to ILP Electronics Ltd. Barclaycard/Access welcome. Trade orders standard terms.

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ILP ELECTRONICS LTD.

(a division of ILP Electronics Ltd)

CURVING ELECTRONS

Magnetic fields can be mind-bending when you try to understand what's going on. They can also bend the paths of poor little innocent electrons, too. John Dance shows us a practical import of this phenomenon.

Discovered as long ago as 28th October, 1879 by Edwin Hall of the John Hopkins University, Baltimore, the Hall effect found few applications until high quality semi-conductor materials became available since it is so small that it is difficult to detect in metals. Hall found that if a magnetic field is applied to a current carrying conductor at right angles to the direction of the current flow, a potential difference appears across the material in a direction which is at right angles to both the direction of the current flow and to that of the magnetic field.

In Fig. 1(a), the potential applied between the two electrodes causes an electric current to flow through the material. If this material is homogeneous and no magnetic field is present, the current flow through it is of uniform density. In the case of the P-type semiconductor material shown, current is effectively carried by the majority hole carriers which behave as positive charges, and these move in the same direction as the conventional current flow in the external wires.

If a magnetic field is now applied so that its direction is into the paper, Fleming's left-hand motor rule indicates that the moving holes will experience a force towards the left and will tend to curve in this direction, as shown in Fig. 1(b). As holes cannot flow out of the left-hand face of the block of P-type material, some positive charges will accumulate there. Similarly, negative charges will accumulate on the right-hand face of the block of material since no holes can flow into this face.

The electric field created by these charges tends to repel the holes from the positively charged left-hand face towards the negatively charged right-hand face. The field increases until the positive charges are again moving uniformly across the block of semiconductor material as shown in Fig. 1(c). Any tendency on the part of the positive charges to move to the left will increase the electric field, causing the charges to move directly across the block of material so that the balance is accurately restored. A pair of Hall electrodes placed in the position shown in Fig. 1(c) can be used to detect the Hall voltage produced in this way.

In the case of N-type semiconductor materials in which the majority carriers are electrons, the flow is in the opposite direction to that of the conventional current in the external wires. The left-hand rule again shows that the charge carrier movement is towards the left, but in this case the negative charge carriers build up a negative charge on the left-hand side and a positive charge on the right-hand side. Thus we can use the Hall effect to distinguish between N and P-type materials by detecting the polarity of the Hall effect voltage produced.

In most metals one obtains a Hall effect voltage with the same polarity as in an N-type semiconductor material, since conduction is by means of electrons. However, the Hall voltage is much smaller than in semiconductor materials and a few metals, such as zinc, produce a Hall voltage of the opposite polarity; in such metals the interaction of the moving electrons with fixed positive ions results in the current being effectively carried by holes. Intrinsic (pure) semiconductor materials show a small Hall effect; although the numbers of electrons and holes per unit volume are approximately equal, the electrons are more mobile, and the overall behaviour is normally like that of an N-type material.

The Hall effect in semiconductor materials produces a much larger Hall voltage than in metals because the number of charge carriers per unit volume is far smaller. The Hall voltage, V_H, is given by the equation:

$$V_H = \frac{BI}{Net}$$

where B is the magnetic flux density
I is the current flowing through the specimen
N is the number of charge carriers per unit volume
e is the charge of an electron (1.6×10^{-19} coulombs)
t is the thickness of the specimen.

If one considers a piece of copper of thickness 1 mm carry-

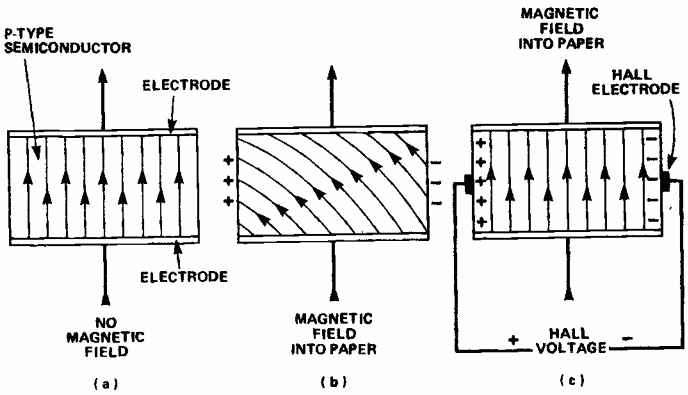

Fig. 1 (a), (b) and (c) The Hall effect illustrated by hole flow.

ing a current of 1A in a magnetic field of 1 Tesla (10,000 Gauss), V_H works out as a mere 62.5 nV, since N is about 10^{29} electrons per m^3 for copper. It is extremely difficult to measure 60 nV in such a circuit. In silicon, however, N may be 10,000 times smaller, so under the same conditions one obtains a V_H value of 625 μV which is a much more reasonable voltage for measurement. Hall first detected the effect using a thin gold foil.

The Hall effect has been widely used in materials science research where it enables information to be obtained about the charge carriers. When indium antimonide semiconductor Hall cells became available, they were used for the measurement of magnetic fields, but indium arsenide produces a Hall cell with about one-tenth of the temperature coefficient of indium antimonide, although its Hall output voltage is lower. Hall cells can be used as multiplying devices, for example in wattmeters, where a voltage is used to generate a proportional current through a Hall cell using a series resistor, while the load current passes through coils which generate the magnetic field in which the Hall cell is placed. Thus the output is proportional to the product of the voltage and current.

Other important applications of discrete Hall devices include their use in brushless DC motors in which the conventional brush and commutator system is replaced by Hall effect devices and suitable amplifiers. The use of such brushless motors avoids the inconvenience of brush replacement and improves reliability, but the elimination of sparking at the brushes is perhaps the most important advantage where low electrical noise is important (such as in high quality tape recording equipment).

Hitachi developed a Hall effect tape replay head in 1977 which is stated to have a high signal-to-noise ratio and excellent transient response (since it is non-inductive). A thin film of indium antimonide is employed, the output being determined only by the magnetic flux present so that a constant response is obtained at the lower frequencies — even down to zero frequency.

Monolithic Hall Devices

Silicon Hall effect devices have the great advantage that other circuitry can be integrated on the same silicon chip using normal IC production processes. Unfortunately the Hall voltage from silicon cells is about a hundred times smaller than that of Hall devices made from indium arsenide, but the temperature stability of silicon devices is far better and the small output levels can be amplified by on-chip components. Typical Hall voltage outputs from silicon cells are in the millivolt to tens of mV region, depending on the operating conditions.

Although most Hall effect devices are used in switching circuits, there are plenty of applications for linear

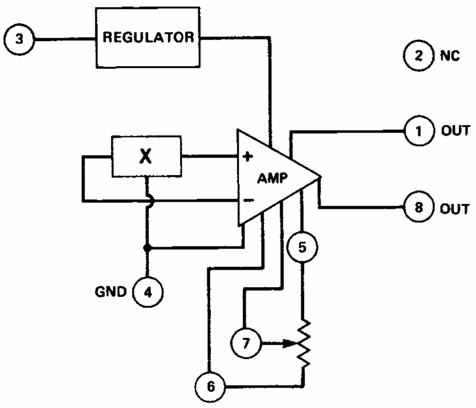

Fig. 2 Block diagram of a monolithic linear Hall effect device.

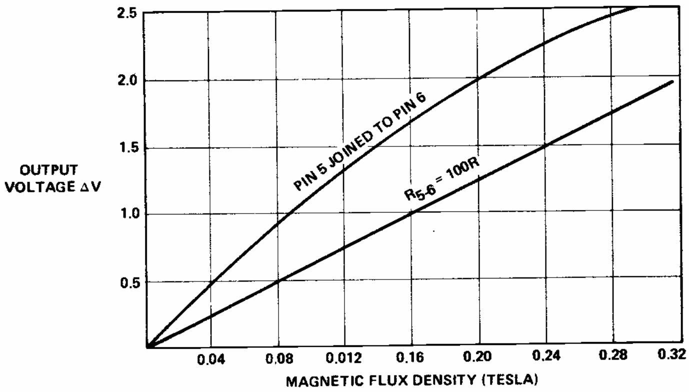

Fig. 3 Output voltage versus magnetic flux density for a UGN-3501M.

Hall devices. The basic internal circuit of the Sprague UGN-3501M linear device is shown in Fig. 2; it can be seen that the small output from the Hall cell itself is amplified by an op-amp. Offset output nulling facilities are included in this eight-pin DIL device, but not in the UGN-3501T which has only 3 connections. The UGN-3501T operates on from 8 to 12 V and the UGN-3501M from 8 to 16 V power supplies. The output voltage from a UGN-3501M device at various values of magnetic flux density with a 12 V supply, a 10 k load and two different values of resistor between pins 5 and 6 are shown in Fig. 3. The frequency response of these devices extends to about 25 kHz (−3dB). The sensitivity of the UGN-3501T is roughly twice that of the UGN-3501M.

Fig. 4(a) shows an application of the UGN-3501T as a ferrous metal detector and Fig. 4(b) is the circuit used. The pole of the magnet is fixed in contact with the Hall device and the output falls by 20 mV peak as the 25 mm steel ball rolls above the sensing device. This signal is amplified by a 741 device and drives the 2N8512 to conduction so that 0.5 A passes through the load. The low frequency response may be controlled by changing the value of the 22 μF coupling capacitor and high frequency attenuation may be introduced by using a small capacitor to shunt the feedback resistor of the 741.

By attaching the opposite pole of the magnet to the

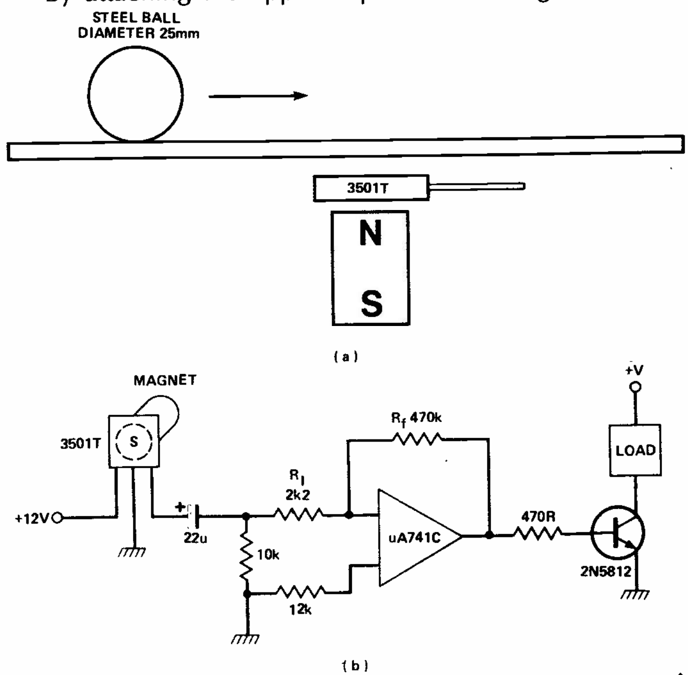

Fig. 4 (a) and (b) A ferrous metal detector using the UGN-3501T.

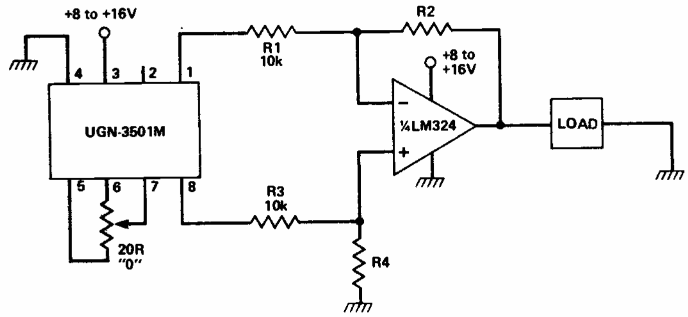

Fig. 5 A Hall effect switch using the UGN-3501M.

Hall device, it can be made to sense the *absence* of ferromagnetic material rather than its *presence*.

Fig. 5 shows the use of a LM324 operational amplifier to supply a voltage gain and to transform the differential output of a UGN-3501M into a single-ended output so that the circuit can drive a load which has one side earthed. The LM324 can be operated from a single power supply provided that the output does not swing below 0V. The connections shown are suitable for the detection of the field from a south pole, but if that from a north pole is to be detected, pins 1 and 8 should be reversed.

Another application for linear devices is in fluxmeters, but calibration will be required. A typical UGN-3501M provides a differential output of about 1.4 mV in a 0.1 T field. The response is quite linear to 0.1 T, but the useful linear range can be extended to 0.3 T if a resistor of about 47 R is placed between pins 5 and 6 (see Fig. 2).

Linear devices can also be employed in current measurement applications. The device may be placed in the gap of a toroid and the current passed through a coil on the toroid. This may be used for overload detection in electric motors, current limiting, etc.

Siemens have recently introduced a KSY 10 linear Hall effect position sensor in which a gallium arsenide (GaAs) substrate is employed. This device is unique in that it is manufactured by an ion implantation planar technique which produces a doped layer only 0.3 μm in thickness; the use of this thin layer enables a sensitivity of 200 ± 30 V/AT to be obtained with a temperature coefficient of only about $\pm 5 \times 10^{-4}$ per degree K. For example, it will provide a Hall output of about 200 mV with a 5 mA control current in a field of flux density 0.2 T. The sensitivity can be selected in the range 30 to 300 V/AT by choosing the appropriate ion doping level during manufacture. The two Hall voltage output connections and the two control current connections are interchangeable, since the active sub-regions are symmetrical.

The output from the KSY 10 device is proportional to the effective magnetic field and to the control current passing through the device. The sensor is only 1 mm deep, so it can easily be positioned in the magnet yoke of current converters for current measurements. The active area itself is a mere 0.2 mm by 0.2 mm and lies 0.35 mm behind the front of its mini-plastic case. The device is very suitable for determining the position or speed of toothed gears or of rack and pinion mechanisms. The wide band gap of the gallium arsenide material used enables this device to be used at temperatures of up to 150°C, so applications in the engine compartment of motor vehicles are envisaged and it may also be used in brushless DC motors.

It is interesting to note that Yoshito Takehana's Group of the Electronic Devices Development Division of the Sony Corporation of Tokyo has developed a very sensitive silicon Hall effect sensor inside a special transistor. The output terminals of this magnetic sensor are in the reverse biased depletion layer; a magnetic field perpendicular to the flow of the charge carriers between the base and collector terminals will produce an output of about 85 V/cm at a flux density of 0.1 T. If such a linear device is successfully developed to the production stage, a much wider field of application may be opened to Hall effect sensor devices at some future date.

Switching Devices

Switching or digital Hall effect monolithic devices are especially easy to use and are finding many applications in keyboards, in vehicle circuits, in toys and in any applications where movement must be converted into an electrical digital type of signal.

The basic circuit of a typical Hall effect switching device is shown in Fig. 6. An on-chip regulator is usually incorporated in the device, since this is necessary to produce a constantly repeatable performance, especially in automobile applications where the supply voltage can vary over a wide range. The regulator supplies a constant current through the Hall cell (shown by a X in Fig. 6) and the two connections which supply the Hall output voltage feed the inverting and non-inverting inputs of a comparator device which in turn drives a Schmitt trigger circuit and an output stage.

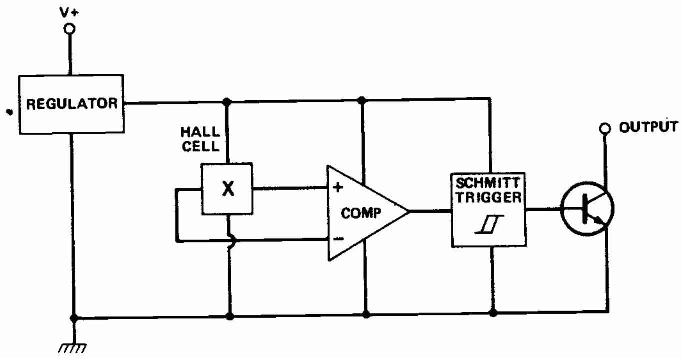

Fig. 6 Block diagram of a monolithic switching Hall effect device.

When the magnetic flux density in the Hall cell changes, the Hall voltage from this cell will change so that the comparator will switch the state of the Schmitt trigger circuit. A suitable amount of hysteresis is built into the circuit so that if a small increase in the magnetic flux density causes the output to switch into its other state, an appreciably larger decrease in the flux density will be required to cause the circuit to switch back to its former state. This prevents repeated rapid switching between the two states for very small changes in the flux density.

The Sprague UGN-3019T device (formerly coded ULN-3006T), is an economical product very suitable in most applications for the experimenter. This is encapsulated in the T-type package shown in Fig. 7, the Hall element itself being at the centre of one face of the device as indicated. As Hall effect devices are used in conjunction with a magnetic field, it is obviously important that the package used should allow the device to be easily orientated with respect to the field and to be easily mounted. The type of package shown is, in the opinion of the writer, usually more convenient for magnetic field sensing than the dual-in-line packages sometimes used for Hall Effect sensors. The UGN-3201M (formerly designated ULN-3006M) is very similar to the UGN-3019T, but is mounted in an 8-pin dual-in-line package.

The UGN-3019T may be used in the basic circuit of Fig. 8. In the absence of any magnetic field, the internal output transistor is cut off and passes only a very small col-

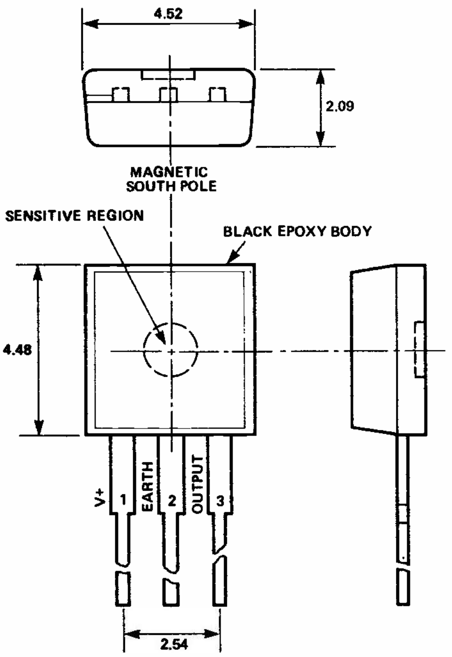

Fig. 7 The UGN-3019T — "T" type package.

lector current (typically, 1 μA, maximum 20 μA). The output voltage is therefore 'high' and has a value which is almost equal to the positive supply voltage; this supply voltage may have any value from +5 V to +16 V with an absolute maximum of +20 V (above which the device may be damaged).

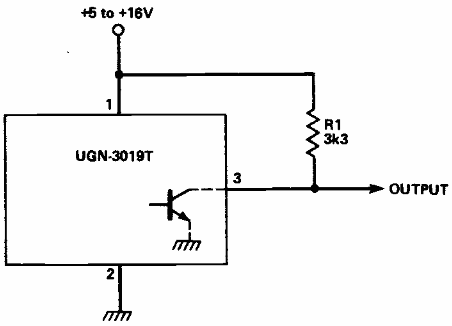

Fig. 8 A Hall effect switch using the UGN-3019T.

If a magnetic field of adequate flux density and of the correct polarity is now applied perpendicular to the face of the device, the internal Hall cell provides a voltage to the comparator of Fig. 6 which switches the Schmitt trigger so that the output transistor in the device conducts. The output falls to its low state with a typical value of +0.15 V and a maximum value of +0.4 V. The UGN-3019T can sink a current to its output of up to 15 mA, so the load resistor R1 of Fig. 8 must be chosen so that not more than 15 mA will flow into pin 3 with the particular value of positive supply voltage used.

The writer found that a UGN-3019T would switch to its low voltage output state when a small bar magnet was brought within about 3 mm of the centre of the body of the device. Owing to the built-in hysteresis in the internal circuit of the device, it did not revert back to the 'high' output state until the bar magnet was withdrawn to a distance of over 10 mm. The hysteresis characteristics of the ULN-3019T are shown in Fig. 9. A typical device switches to the 'low' output state at a field of 0.05 T and all devices are certain to switch at a field of 0.075 T at the centre of their face. A typical device reverts to the 'high'

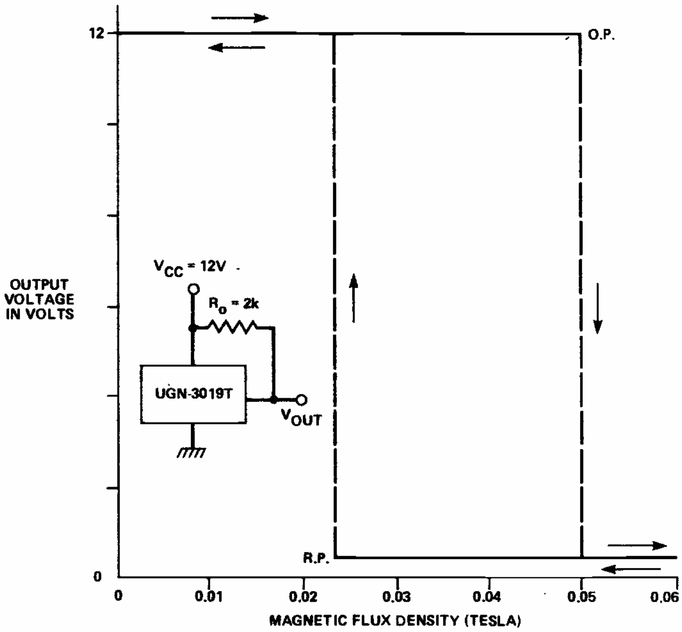

Fig. 9 Output voltage versus magnetic flux density for a UGN-3019T.

output at 0.0225 T and all devices at a value not less than 0.01 T. The device is unaffected by small stray magnetic fields from any transformers, relays, etc. which may be near to it.

UGN-3019T circuits are unaffected by the application of a field of the opposite polarity to that required to switch the output to the low voltage state. If the field is too weak to cause switching to the low output state, an improvement in the sensitivity can be obtained by placing a piece of iron or other ferromagnetic material on the far side of the device from the magnet as close to the device as possible. A greater increase in sensitivity can be obtained if the device is placed between two magnets with opposite poles on each side of the device. It is important that the magnet should be moved on a line directly towards the centre of the device, since a displacement of about 3 mm from the centre line can more than double the required flux density.

The UGN-3019T requires a supply current of about 7 mA (maximum 9 mA) with a 5 V supply and about 12 mA (maximum 16 mA) with a 12 V supply. A particular advantage of Hall effect switching devices over mechanical contact switching is their high speed of operation, the rise and fall times being measured in nanoseconds with operating speeds of up to about 100kHz. The output pulses are 'clean' without the 'bouncing' which is characteristic of mechanical contacts. Monolithic Hall effect devices are comparable in price to reed switches.

Using Hall Switches

An important use of Hall effect switching devices is for the detection and measurement of rotation. Many types of mechanical system arrangement are possible. In the 'slide by' mode one or more small magnets are mounted on a spinning disc and these magnets pass close to the face of a Hall effect IC. Each time a magnet passes the device, the circuit switches first to its low output voltage state and then back to the high output voltage state as the magnet moves away from the device.

An alternative system is the 'vane switch' technique, in which soft iron vanes attached to the rotating metal disc pass between the magnet and the Hall device. Each time a vane passes through this gap, the magnetic flux no longer

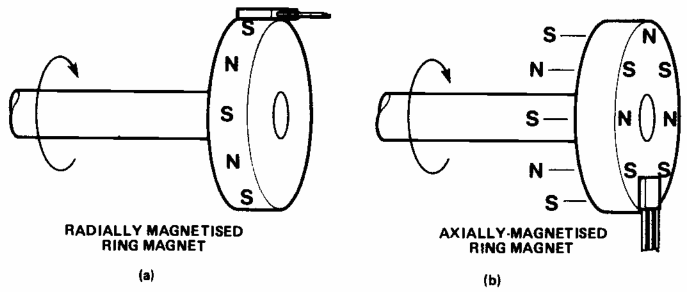

Fig. 10 (a) and (b) Ring magnet revolution indicators.

reaches the Hall device owing to the shielding effect of the iron in the vane, and the Hall circuit switches back to its high output voltage state.

Fig. 10(a) shows a system for detecting rotation which uses a radially-magnetised ring magnet. Suitable inexpensive ring magnets for use with either type of system are readily available. Up to eight pulses per revolution per 10 mm diameter of the magnet disc are possible, so 80 pulses per revolution can be obtained from a 100 mm diameter disc. These two arrangements have been designed for the UGN-3030T device; this is similar to the other devices discussed except that switching to the low voltage state occurs at a typical flux density of 0.016 T (maximum 0.025 T) and return to the high voltage state at 0.011 T (minimum −0.025 T). The power supply current required is only about half that needed for the UGN-3019T. It should be noted that to ensure switching of the UGN-3030T back to the high voltage state, a field of the opposite polarity is required of flux density −0.025 T; this is provided by the use of alternate polarity magnetic poles in the ring magnets of Figs. 10(a) and 10(b).

Rotational systems as described above have a very wide range of use in engines and machinery. One that many readers will have first-hand experience of is in car ignition circuits, where the contact breakers are replaced. This leads to the ignition timing being a once-and-for-all setting, as there is no wear, and this can only help improve fuel economy and lower exhaust pollution.

The same sort of sensor head can be used for measuring rotational speeds and counting the number of revolutions. In this case possibly the best course to take with the electronics is to have a pulse-generating circuit after the Hall effect device, so that the pulses can either be counted or fed to an analogue meter (to get a rate of revolution indication).

When fitted to a vehicle wheel such a system could have a further important use, namely in an anti-skid braking system. In this the electronics would detect when the wheel was not turning while the car was still moving. The system would then momentarily reduce the brake

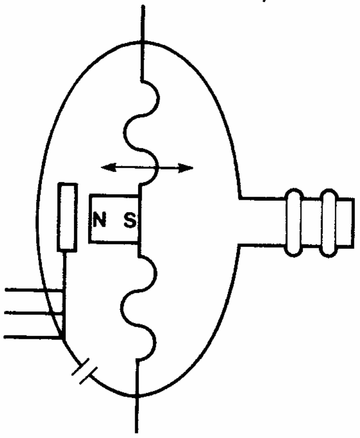

Fig. 11 A Hall effect pressure switch.

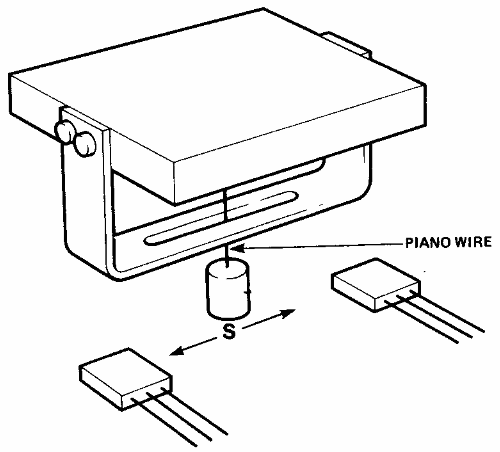

Fig. 12 An acceleration sensing system.

force to the wheel so that it would turn again and control would be restored, after which full braking force would be restored. This has the effect of pumping the brakes — but be warned, it's not eary to construct such a system, and we strongly recommend not trying!

Hall effect devices can be used to detect linear motion; Fig. 11 shows a simple pressure switch. Coupled with a push-button, this sort of arrangement is common in keyboard switches. A similar application is as an acceleration detector, and Fig. 13 shows how this can be done. In this, acceleration forwards or backwards causes the magnet to move nearer to one of the two Hall devices. Conversely, the tilt sensor in Fig. 13 works by detecting when the magnet moves away from directly above the Hall device.

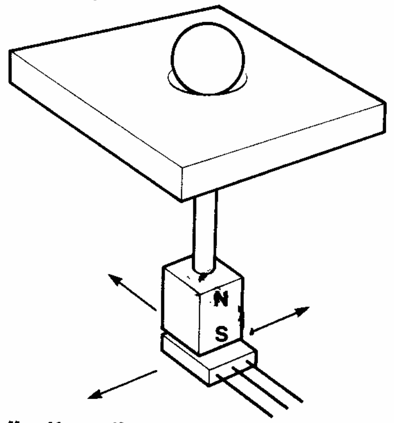

Fig. 13 A Hall effect tilt sensor.

As transducers go, Hall Effect devices can give a relatively large switching capability, being capable of sinking ample current to interface directly with TTL. Fig. 14 shows a suitable circuit for interfacing to CMOS devices.

Fig. 15 shows a handy buffer circuit that can be used to drive larger loads, such as a 12 V relay coil. In Fig. 14, when the magnetic field is strong enough, the output from the Hall device will be low and the transistor will be off. Hall devices can drive reed relays directly provided that they do not pass too much current, and provided that a transient suppressing diode is connected across the coil to prevent the back-EMF from destroying the Hall device (the diode cathode should go to the positive terminal of the relay coil).

If a Hall device such as the UGN-3030T is required to control a triac such as the RCA 40669 which can handle up to 8 A RMS, a transistor amplifier stage is required between the Hall device and the triac as shown in Fig. 16. When the Hall device conducts, a current of 9 mA flows from the base of the PNP 2N5811 transistor which in turn

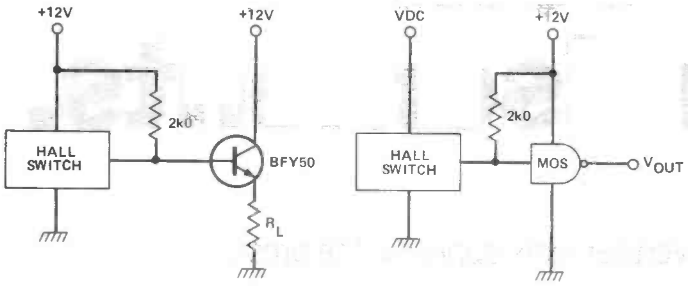

Fig. 14 (left) Driving CMOS from a Hall effect device.
Fig. 15 (right) A current amplifier for the Hall device.

supplies 80 mA to the triac gate to turn on the load current. It should be noted that the Hall device is connected to one side of the mains supply; this could be avoided by the use of an opto-coupling device between the Hall IC and the triac circuit.

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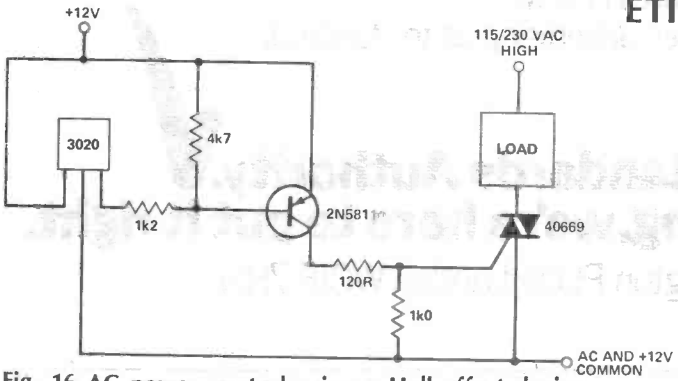

Fig. 16 AC power control using a Hall effect device.

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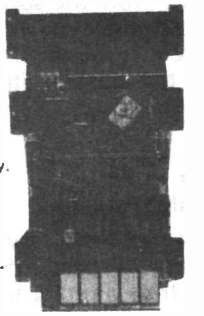

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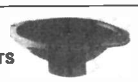

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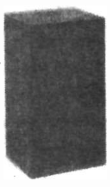

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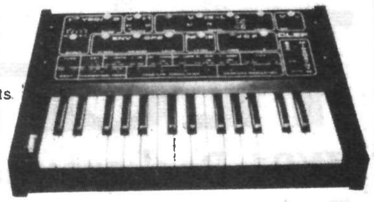

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TECH TIPS

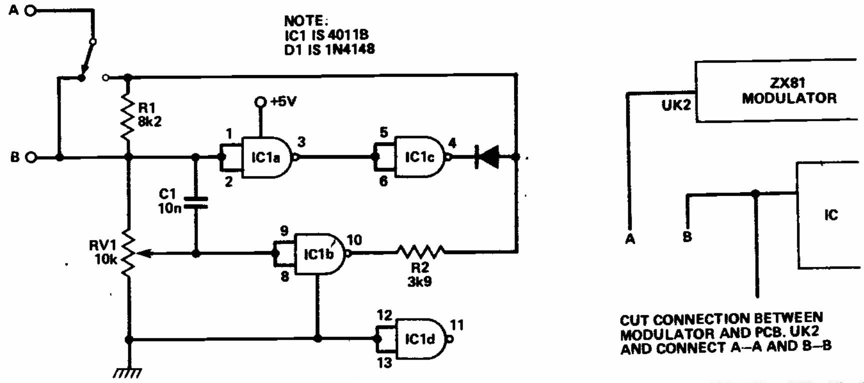
ZX81 Background Reverse

F.W. Picken,
Stoke on Trent

This simple circuit uses readily available (and cheap!) components to provide white symbols on a dark background. It can be put together on a small piece of circuit board which could then be housed inside the case of the computer and held in position by double-sided tape or Araldite.

The change-over switch, used for switching from black symbols on white and vice-versa, can be mounted on the side of the case, a push-on push-off type probably being the most suitable due to ease of mounting. The power requirement is very low, and can be taken from the ZX81 supply line.

Action of the circuit is very simple: IC1a and c carry the negative-going sync pulse and nothing else, thus ensuring that this is not inverted. The remainder of the video signal is inverted by IC1b. The value of RV1 needs careful setting to obtain the best results.



Sophisticated 5V Supply

A.J.J. Gilchrist,
Paris

This supply will deliver up to 6A at +5V. It has an active overvoltage clamp on the output. Current is limited at around 6A and has foldback short-circuit protection.

Starting on the line side, S1 is a transient suppressor which helps protect the supply against high voltage transients (studies have shown spikes of 5kV to be common on the domestic mains!), and C1, R1 cut down on switch arcing when the supply is switched off. R2 is a bleed resistor which is useful if the suply is not permanently connected as it prevents the output staying high after the unit is switched off.

Q2 is the pass resistor, it is switched on by R3 when more than 100mA is being drawn from the supply. Q1 and Q3 provide the current limiting. When current through R7 is 6A the voltage on the base/emitter junction of Q3 is given by:

$$V = V_{out} - \frac{R5*(V_{out} + R7*6)}{(R5 + R6)}$$

$= 0.58V$ for the values shown.

Thus Q3 begins to conduct, switching Q1 on, which increases the base voltage of Q2, thus limiting the current.

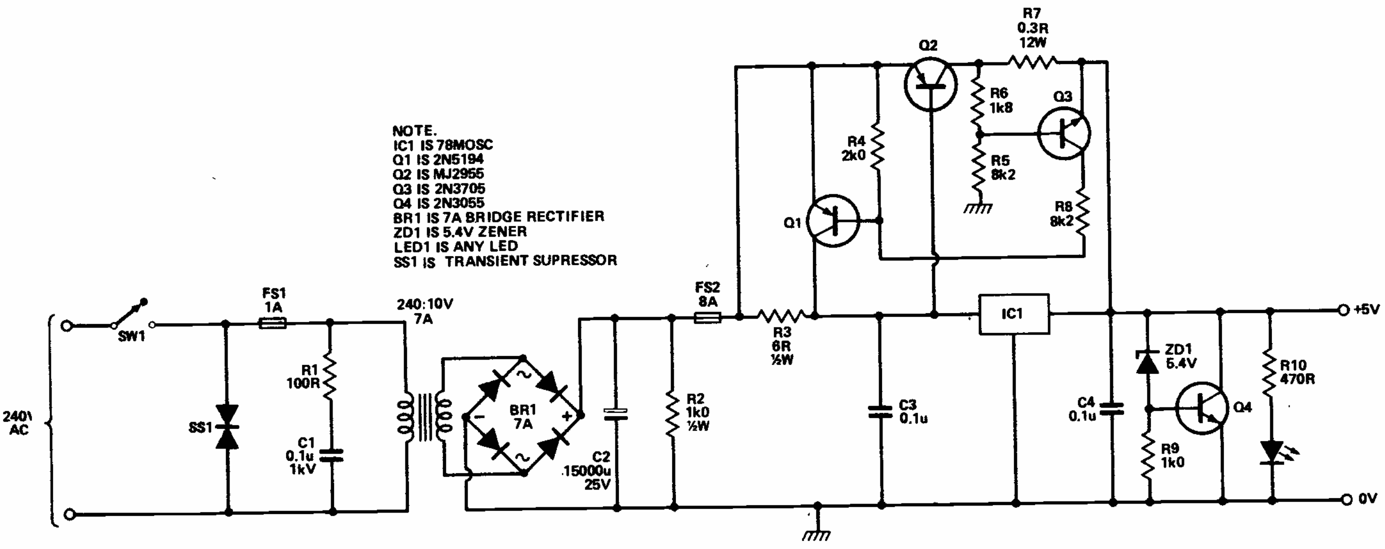
This arrangement also provides foldback limiting. If we consider the output shorted, the voltage at the base of Q3 will be about 0.6V; thus the voltage at the collector of Q2 is approximately given by:

$$V = 0.6(R6 + R5)/R5$$
$$= 0.7V$$

thus the current supplied will be i = 2.3A. The foldback current may be changed by altering R5, R6 and R7. I have set this high to ensure the supply starts up under heavy loads.

ZI, R9 and Q4 provide an active overvoltage clamp. When the output voltage rises above the zener drop plus the switch-on voltage for Q4, Q4 conducts. This circuit is capable of sinking 15A indefinitely (with a proper heat sink) with a much higher peak current. This ensures that the fuse blows before the protection circuit. This active clamp is necessary because one of the most common types of failure in power supplies is the pass transistor failing with the collector/emitter junction shorted.

Note that Q1, Q2 and Q3 should all be mounted on heat sinks, and Q1 must be capable of passing the maximum output current of the 78M05 (500mA).

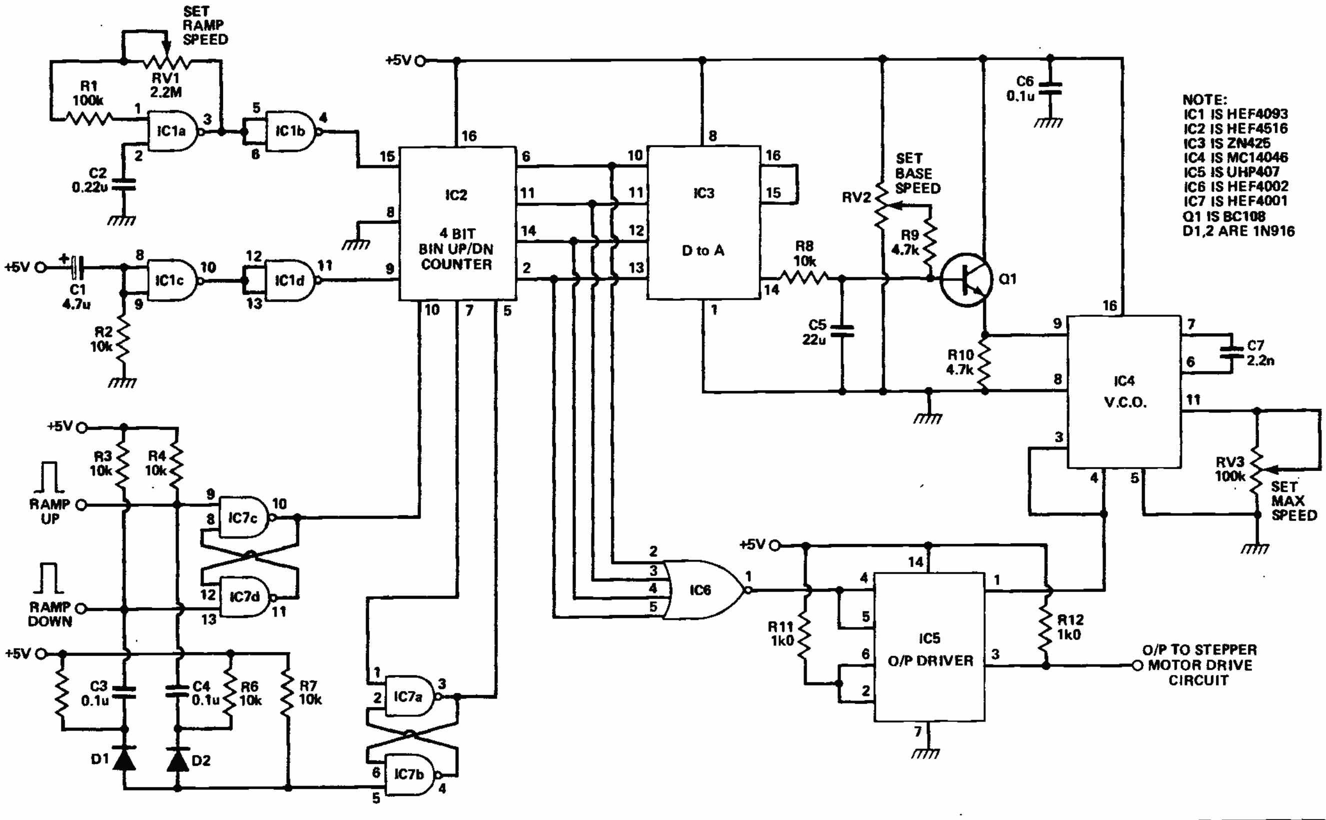


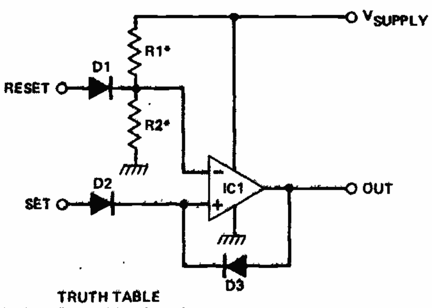
Ramped Pulse Generator For Stepper Motors

Clive Pantrey
Farnborough

A circuit that I needed for use with an experimental robot arm was one which would ramp up or down the pulse repetition rate of pulses delivered to a stepper motor drive circuit. With the motor stopped, the command 'ramp up' should start the motor at its base speed (ie the speed at which the motor will start and stop under load, without loss of synchronisation), ramp up to maximum speed (the top speed available without loss of synchronisation) and run for as long as required. The command 'ramp down' should make the motor slow down to base speed and then stop.

The figure shows the circuit that was eventually produced. IC1a/b provide clock pulses (Ramp Speed) to a four-bit binary up/down counter, IC2. On receipt of a ramp up command IC7c/d sets count up and IC7a/b enables the counter. Unless a ramp down command is received the counter will reach its maximum count (Max Speed) and hold at this until the ramp down command is received; this will set count down and enable the counter, which will count down to zero (Base Speed), and hold again until the next ramp up command. The counter output drives a D-to-A IC3 whose ramping output controls the VCO, IC4. The lower frequency of the VCO, (Base Speed) is set by the bias adjustment of Q1. Upper frequency (Max Speed) is set by the 100k pot at pin 11 of IC4. IC5 provides open collector drive for the output pulse train and also the on/off gate, controlled by IC6, when the counter is at zero. IC1c/d provides a set zero pulse to IC2, to ensure that the output, at pin 3 of IC5, is at base speed and off each time the generator is switched on.





TRUTH TABLE

SET	RESET	OUT
0	0	NC
0	1	0
1	0	1
1	1	1

NC = NO CHANGE

*SEE TEXT

NOTE:
IC1 IS ANY OP-AMP
D1-3 ARE 1N4148

Analogue Set-Reset Latch

T. P. West, Lancaster

Although CMOS gates are commonly used to provide analogue amplifiers, the operational amplifier is often overlooked for use in digital applications. Often, a circuit design calls for a set-reset latch within an analogue circuit: this normally requires digital circuitry to be included in the design. By the use of this circuit, spare op-amps in a package may be utilised to provide the set-reset function. The op-amp used may be of any type with the low and high voltages at the output being only a function of the op-amp's internal output drive circuitry. The resistors R1 and R2 should be chosen so that $R2 = 2.4R1$ and $R2 < V_{supply}/0.05$. Although the circuit is shown for a single supply rail, it will work on a dual supply but produces a low of around the negative supply voltage. All changes in state occur on the low-to-high transition. **ETI**

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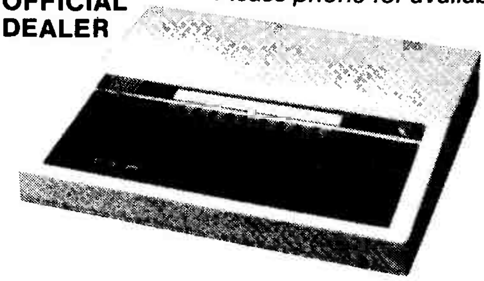

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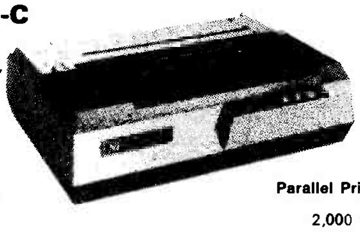

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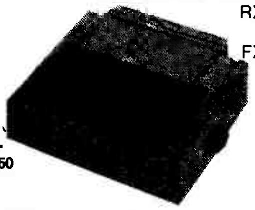

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Z80 CONTROLLER COMPUTER

The UK is now full of MARVINs just sitting there rusting, or worse, complaining about the pain in their diodes all down one side. Peter Grigson and David Harris tell us about the software needed to make them all spring into life.

The following is split into two sections; the first is a general introduction on machine code programming the Z80. Without writing an entire book, we can't really tell you all about it, so what we've aimed at doing is to give you a flavour of what's involved. There are quite a large number of books on the Z80 in particular, and on microprocessors in general, and we would suggest getting hold of one of these. Alternatively, elsewhere in this magazine is the start of a series on maching code programming.

The second section will move on to a brief description of the operating system for MARVIN that is pre-programmed into his EPROM.

Writing Z80 Programs

The nice thing about machine code programs is that they run the computer very fast and need a comparatively small amount of memory to achieve what can be a fairly sophisticated task. In general, machine code programming is much more appropriate to control functions because it enables you to tell the computer exactly how you want a particular task to be carried out.

Every silver lining has a cloud, and the cloud over using machine code is that a program consists of nothing but numbers, as has already been pointed out on page 35. However, common practice is to substitute mnemonics for the code when doing the writing, and convert the instructions into machine code using either a special program (an assembler) or a table and a great deal of hard work. Such is life . . . For the sake of clarity, we will use mnemonics for the remainder of this article.

Getting Into The Z80

Internally, the Z80 CPU has seven eight-bit registers, A (the accumulator) and B,C,D,E,H,L. There are three pseudo-16-bit registers, made by pairing B and C, D and E and H and L. There are also the two 16-bit index registers, IX and IY. Each register can only be used with certain commands and it will pay you to make yourself familiar with the rules. All registers can be loaded directly with a number, and the mnemonic for this will be **LD (reg), (number)**, where (reg) is the register to be loaded and (number) is the binary (or hexadecimal) number to be stored; for example, **LD A, 23** stores 23 (hex) in the register A; **LD HL, 1234** stores 1234 in the HL pair as a 16-bit number.

Remember that the above is written in mnemonic code, and that unless you have another micro to do the work for you, you will have to translate this into machine code before MARVIN will be able to understand what it means. Also worth noting is that the two instructions **LD A** and **LD HL** will have different machine code equivalents, not just the same instruction with a different register address to be loaded.

Contents of registers can also be transferred. Any eight-bit register can be loaded with the contents of another. For example, **LD B,D** copies the contents of D into B. Sixteen-bit registers can only be copied by two operations on their component registers; to transfer HL to BC **LD B,H** then **LD C,L**.

You will very often need to operate with more numbers than the available registers can hold and so numbers must be transferred between RAM and the CPU registers. The accumulator or any 16-bit pair can be stored at a specific address. For example, the instruction **LD (8234), A** stores contents of A in RAM at address 8234. The instruction **LD (8234), HL** involves storing 16 bits so L goes into memory at 8234 and H at 8235.

Any of the other eight-bit registers can be stored at the location pointed to by the contents of HL: **LD HL,8349** then **LD (HL),E** puts the contents of E at 8349.

0000-07FF	MARVIN operating system
0800-OFFF	User program. The operating system hands over to the routine at 0800 after reset and so this should contain the first instruction of your program.
8000-83FF	RAM. The first 32 bytes from 8000 to 801F are used by the operating system and the stack extends down from 83FF. The rest is freely available.

Fig. 1 Memory map of MARVIN.

OUT (n),A	Output accummulator contents to port n. $0 \leqslant n < 10$.
OUT (C),r	r is any of A,B,C,D,E,H,L. The contents of C register define the port. $0 \leqslant C < 10$.
IN A,(n)	Load accummulator with data on port n. $0 \leqslant n < 10$.
IN r,(C)	r is any of A,B,C,D,E,H,L. The contents of C register define the port. $0 \leqslant C < 10$. Load register r with the data on port C.

Fig. 2 The Z80's Input/Output instructions. Note that it is recommended that output is channeled through the operating system if you wish to operate on individual bits.

Another useful source of temporary storage is the stack. This is a 'pile' of 16-bit numbers in RAM onto which more can be added by the instruction **PUSH: PUSH HL** puts the contents of HL onto the top of the stack. The number on top can be retrieved by the instruction **POP,** eg **POP DE** removes the number from the top of the stack and puts it in DE. A special CPU register, SP, is used to point to the stack and is updated by each **PUSH** and **POP.**

Only simple arithmetic and logic instructions can be carried out. Any eight-bit number or register can be added to, subtracted from, ANDed with, XORed with, ORed with the accumulator and the result is stored in the accumulator, eg **ADD A,27** ; **SUB A,C** ; **AND A,E** ; **OR A,H** ; **XOR A,255.**

As far as 16-bit registers are concerned, any of them can be added to or subtracted from HL,IX,IY with the result being stored in HL,IX,IY. For example, **ADD HL,DE** adds the contents of HL to the contents of DE and stores the result in HL.

The order in which the code is carried out can be controlled by use of **JP** (equivalent to the BASIC GOTO) and **CALL** (equivalent to GOSUB). When using an assembler, various points in the code can be identified with labels by writing the label at the beginning of the line with no preceding gap and following it by a colon. This tells the assembler to assign the value of the program counter at that point to the label so that when the label is used in conjunction with **JP** instructions, the appropriate 16-bit address is assembled. Labels can also be used in conjunction with other instructions that require 16-bit addresses, for example, **LD A, (LABEL).** The instruction **JR** is used for local jumps within 128 bytes and assembles to a relative displacement instruction. **RET** is used to return from a **CALL**ed routine.

Decision making in machine code is carried out by the use of flags. These are set according to the result of each logical or arithmetic operation. The most useful flag is called Z (the zero flag) and is set if the result of an operation is zero. It is also set if A equals B in compare instructions, eg **CP A,B.** There are several other flags indicating other conditions and you should refer to a book to find out what these are, and when they are set.

The flags are used in conjunction with **JP, CALL, JR, RET** which can be made conditional on the state of a particular flag.For example, after executing the instructions **CP A,3** then **JP Z,FINISH** the processor will only have gone to FINISH if A was equal to 3.

The most useful instructions on MARVIN however are those involved with I/O. There are several to choose from, and Fig. 2 shows them . Note that it is best to avoid using the output instructions directly but to use the operating system output routines which will also correctly set the port masks (see below).

In order to follow the example program in Fig. 3 you will need to know one or two more things. An instruction called **LDIR** is used which shifts blocks of memory around. It takes a number of bytes from memory starting at the location defined by the contents of HL and copies them to memory commencing at the location defined by the contents of DE; the number of bytes it copies depends on the contents of BC.

DEFB is not a true Z80 instruction but one to the assembler. It is followed by a series

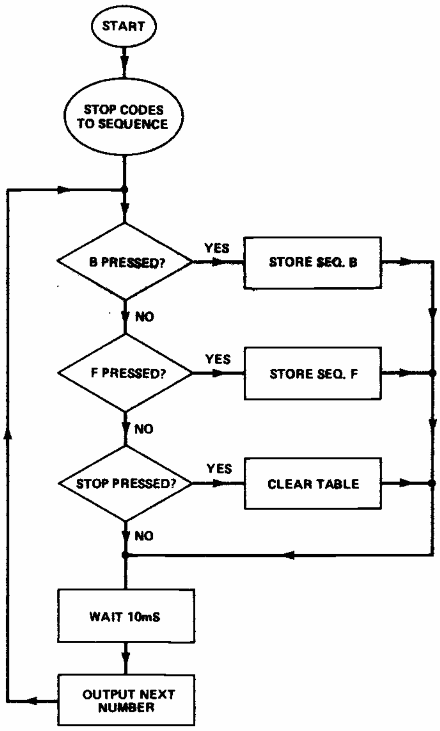


Fig. 3 An example program to drive a stepper motor. The two operating system routines used are 5, which reads the keyboard and returns a number at location 801BH, and 7, which outputs successive numbers in a sequence each time it is called. IX is the beginning of the table; IX+0 is the table; IX+1 is the position in the table of the first one to be output; IX+2 is the first byte in the sequence, etc.

```
        ORG   800H        Set start of prog. to 800H in memory
        JR    STOP        Stop motor at beginning
NKEY:   DEFB  0F7,4       Instruct processor to execute op. sys. routine 4
        LD    A,(801BH)   Number of key returned to 801B — transfer to A
        CP    A,0BH       Compare content of A with 0BH
        JR    Z,BAK       If comparison true go to routine at BAK
        CP    A,0F        Compare with 0FH
        JR    Z,FWD       If true go to FWD
        CP    A,00        Compage with 00H
        JR    Z,STOP      If true, go to STOP
NEXT:   LD    BC,990      Start of 10 mS pause; for 10 mS put 990 in BC
        DEFB  0F7,5       Call op. sys. routine which waits 100+ 10BC mS
        LD    IX,8020H    Set pointer to beginning of table
        LD    C,1         Sequence to be output from port 1
        DEFB  0F7,7       Call op. sys. routine to output next byte
        JR    NKEY        Return to start
BAK:    LD    DE,8020H    Start of sequence table in RAM
        LD    HL,BTAB     Point HL to table in ROM
        LD    BC,6        6 bytes to be copied
        LDIR              Copy the backward sequence to RAM
        JR    NEXT        Goto NEXT
FWD:    LD    DE,8020H    Start of sequence in RAM
        LD    HL,FTAB     Point HL to table in ROM
        LD    BC,6        6 bytes to be copied
        LDIR              Copy the forward sequence to RAM
        JR    NEXT        Go to next
STOP:   LD    HL,8020H    Fill RAM sequence with 0s
        LD    DE,8021H
        LD    BC,6
        LD    (HL)0
        LDIR
        JR    NEXT
FTAB:   DEFB  4,0,10,6,9,2
BTAB:   DEFB  4,0,2,9,6,10
        END
```

of eight-bit numbers which the assembler places directly in memory. This can be used in MARVIN programs to assemble the special instructions for calling the operating system routines which consist of two bytes: F7 (hex) followed by the number of the routine, eg **DEFB F7,03.**

An example of a typical MARVIN program is shown in Fig. 3. This program turns a motor forwards if key F is pressed, backwards if key B is pressed and stops it if key 0 is pressed. It uses several of the operating system routines described below.

A stepper motor is connected to output port 1 using power transistors so that to turn it forwards the sequence

10, 6 ,9, 2

must be sent, one number every 10 mS. In order to turn it backwards the reverse sequence must be sent. The motor stops if nothing is sent.

The Operating System

The operating system has two tasks: it controls the system, and this involves such chores as dealing with start-up initialisation, dealing with interrupts, communicating with other systems, etc; the other task is to provide various useful routines for controlling MARVIN's peripherals.

When power is applied or the reset switch is pressed, the operating system first clears all ports and sets the interrupt vectors to the beginning of the user program. It also sets the stack pointer to the top of RAM (83FF). It then tests to see if the user EPROM socket contains a RAM IC or an EPROM. If it detects the latter then control is transferred to the program in the EPROM at 0800H. If it detects a RAM then it enters a routine which can receive data from a microcomputer and place it in the RAM. In order to be suitable for connection your micro must have an eight-bit user output port and either a separate user input port or a single handshake input line; Z80 PIO and, 6522 VIA are suitable. This facility is extremely useful for testing prototype programmes without having to blow an EPROM each time.

Interrupts

In order to define MARVIN's response to interrupts, the user program should place eight vectors in RAM to define the start of routines to deal with interrupts on each channel. Interrupts can then be enabled by an EI instruction and the appropriate routine will be called (with all registers and flags preserved) on receipt of an interrupt.

User-available routines include the following:

Output Port Control Since the Z80 only provides for alteration of all eight output bits of a port at once, if the user wishes to change a bit or bits without affecting any others a note must be kept of how each bit has previously been set. The operating systems deals with this by storing masks of each output port in RAM and, if the user ensures ports are written to via the operating system routines, then the masks will be constantly updated. Routines are provided for the setting/resetting of individual bits as well as whole ports.

Outputting a sequence Certain devices such as stepper motors require a sequence of bytes to be output in order to operate. The operating system provides a routine which will output consecutive bytes of a sequence each time it is called.

Timing If a real time clock is not available then the operating system is capable of generating pauses of between 100 μS and 0.65 secs to the nearests 10 μS and also between 0.1 and 25 seconds to the nearest 0.1 seconds.

Peripheral Control Routines are provided to : 1. read a keyboard of up to 64 keys consisting of simple switches connected between an input and output port ; 2. display alphanumeric data on a 7 segment display connected to an output port ; 3. detect the last code sent by the MARVIN remote control ; 4. send allophones to the MARVIN speech board ; 5. output a frequency burst of between 40 Hz and 10 kHz.

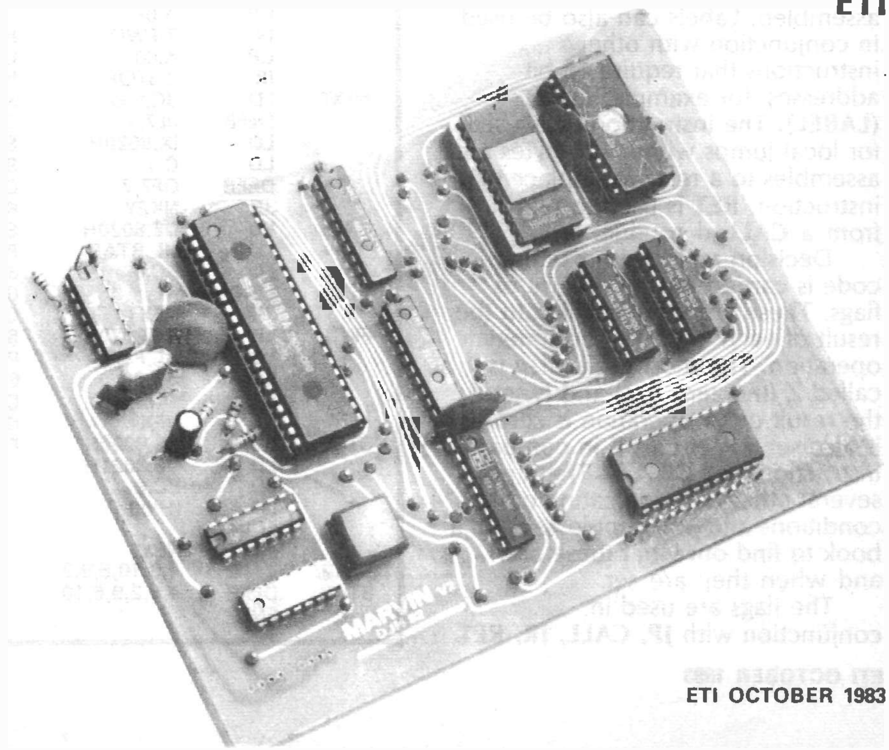
The other peripherals avaiable (D/A, A/D, light dimmer) are accessed simply by writing to or reading the relevant port.

All the routines are accessed by 2 byte routines of the form : F7, nn where nn is the number of the routine in question.

Full details of exactly how to use all the routines are supplied with the operating system EPROM.

Readers who have been puzzled by the naming of MARVIN, or who have found little sense in the humour adopted in this project series (and throughout much of the rest of the magazine) are referred to 'The Hitch Hiker's Guide To The Galaxy' et seq., copies of which should be on sale from all leading component suppliers in the Alpha Centauri district.

ETI



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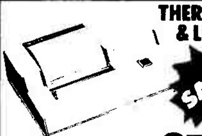

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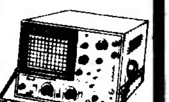

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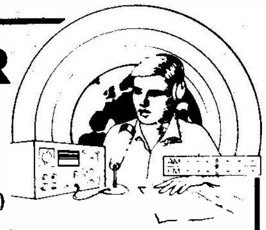

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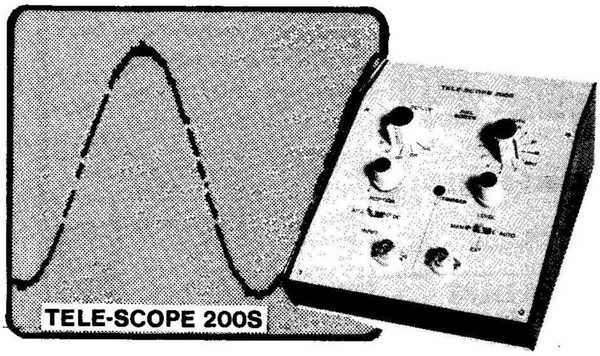

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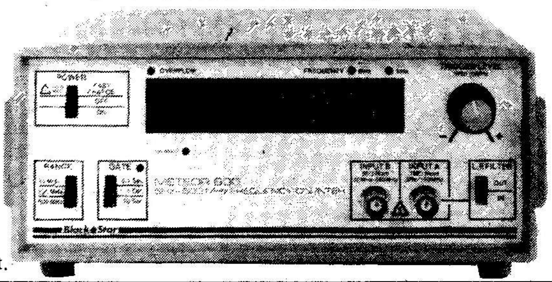

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DON'T SNEEZE!

There are places on this earth where a sneeze can be very expensive indeed — and where spotlessness will be only just clean enough. Stephen McClelland elucidates.

An anecdote, popular in the silicon chip industry, relates how, in the recent past, a certain chip company found its production going haywire. The devices it made suddenly became duds because of contamination of the otherwise ultra-clean process areas, but no one knew where the trouble lay. At length, after a massive investigation during which the factory was almost taken apart, the Company discovered to its considerable embarrassment that the person responsible for cleaning the operators' overalls had changed the washing powder. Contaminant had migrated from the freshly washed overalls into the process line, and so to the chips themselves.

Although an extreme case, the tale serves to illustrate how careful chip manufacturers have to be to ensure their production environment is flawless and the paranoia that descends when it isn't. Setting up these facilities, the cleanest places on the planet, is prodigiously expensive — upwards of £300 per square foot.

Such facilities are now becoming necessary because the complexity demanded of silicon chips takes them into the VLSI (Very Large Scale Integration) domain. These chips have features, therefore, which are unprecedentedly small — about 1 micro metre (or 0.04 thousandths of an inch) in most cases. As a result even the most minute particles of dust are capable of settling on the silicon circuit during its sensitive process stages and causing havoc.

Indeed there is evidence to suggest that even the maximum pure air conditions presently achieved might not be clean enough for future chips under some conditions. But even to get to this state (dubbed Class 100 by the US because it contains a bare 100 particles per cubic foot in the critical size range) requires enormous efforts. Class 100 requires a clean-up factor of more than 100,000 times on atmospheric air (containing about 10 million particles per cubic foot).

Such clean rooms are generally maintained at positive atmospheric pressure (to prevent outside air-borne dirt from being driven in) with a wide host of complicated access doors and passages. In the cleanest facilities, floors and ceilings are both perforated to allow the filtered air to be pumped through them downwards in parallel vertical lines. The laminar flow creates a minimum of turbulence which might otherwise re-distribute the particles already present.

In addition, these areas need a formidable battery of support services. The water used to wash the silicon chips themselves must approach absolute purity — and the inadequacy of most conventional distillation techniques means that the water is usually the most expensive chemical the plant has to purchase. The gases used to process the silicon can also present a hazard — either because they are toxic, or flammable, or both. This is one reason why even small semi-conductor houses in California — especially those located near the San Andreas fault — maintain elaborate fire fighting teams.

But getting a clean room 'clean' is only half the story — keeping it so is rather more difficult and research throws an interesting light on the most significant source of dirt — people themselves.

A NASA study conducted by James Useller turned up some surprising conclusions. He found that one of the most destructive things you can do in a Class 100 environment is simply to write on an ordinary sheet of paper with an ordinary ballpoint pen — this alone can generate particles up to 20 micrometres in size. Stamping on the floor (whether due to a fit of pique or just through lack of exercise the study neglects to say) is almost as bad. Even workers properly clad — in astronaut-like boots, trousers, smocks and hats — can generate or redistribute particulate matter by merely moving about irregularly.

Normal breath, in fact, should produce no increase of atmospheric dirt but the best advice one can give to smokers is that they shouldn't breathe at all — NASA detected significant numbers of particles 20 minutes after the subjects had finished smoking. Personal hygiene is encouraged. Anti-social habits like scratching yourself (which releases dead skin cells) are not. Sneezing is singled out as being a big offender — it can push the particle count up by as much as 20 times. Even an overtly social act like pulling out a handkerchief to suppress it can spray the same amount of contamination into the air.

An equally insidious source of contamination is the purely chemical kind as the story at the beginning shows. Sodium ions (whether from sweat, chemicals or soap powder) can be lethal to many types of devices particularly the MOS (Metal-Oxide-Silicon) varieties. Some engineers have even suggested that MOS chip factories should never be built near sea coasts because of possible salt contamination.

Silicon chip companies are aware that the contamination risk will eventually become so strong even with conventional clean rooms that chip making will have to be taken — quite literally — out of human hands. IBM has already gone some way towards making an automatic production line that is enclosed completely in its own clean environment. Other companies are deterred by the enormous amount of investment required to overcome the tricky problems of silicon water handling. Ironically, micro-electronics, of all industries, might be very difficult to automate fully. **ETI**

ZX 80 TAPE MOD

When we published the article on modifying the ZX81 tape output to get reliable cassette operation, a plaintive cry went up: "What about my ZX80?". Ian Ridout to the rescue.

The predecessor to the ZX81, the ZX80, is still a popular machine especially if fitted with the replacement Sinclair ROM. However, like the ZX81, it suffers from unreliable SAVEing onto cassette tape and LOADing from tape.

A previous article in this magazine (February 1983) gave details of how to improve the reliability of SAVEing programs onto tape for the ZX81. This article gives details of the simple modifications required to allow the ZX80 to enjoy the same SAVEing reliability onto tape. The modification costs less than £1 to do and takes only a few hours.

If you have experienced difficulty with SAVEing programs onto tape with your ZX80, observe the following recommendations before implementing this modification:

- Make sure that the EAR socket on the ZX80 is connected to the EARPHONE socket on the cassette and likewise that the MIC socket goes to either the MICROPHONE or AUX socket on the cassette (we don't want to insult your intelligence, but you'd be surprised how often . . .);
- Remove all traces of the brown magnetic tape material from the heads in the cassette player by using cotton buds dampened (not dripping wet) in white or surgical spirit;
- Use computer tapes or the higher quality audio tapes;
- When SAVEing and LOADing, keep the cassette player as far as possible from the television because the television line-scan and frame-scan signals will be picked up by the cassette player;
- On playing back from tape (ie LOADing) keep the volume as high as possible without the television picture breaking up. If the picture begins to break up, this indicates that the input level is overloading the computer circuitry and the playback volume on the cassette should be slightly reduced. Having found the correct level, rewind the tape to the beginning and try to LOAD the program into the ZX80 again.

If these recommendations still fail to give you reliable SAVEing and LOADing then this article could well help you. The problem is probably due to the low signal level coming out of the MIC socket when SAVEing.

The tape system in the ZX80 is very similar to that in the ZX81, the major difference being the component numbering! As before, one IC output is for both the TV modulator and the tape out socket, via a simple filter with a peak at 3.4 kHz and a roll-off of 6dB per octave on either side of the peak. Like the ZX81 filter, the loss is −66dB *at the pass frequencies*, which leads to only 2 mV of signal at the tape output.

Circuitry Modification

The reasons behind choosing a FET for this modification were discussed in the previous article, so I won't repeat them here. The new circuit differs slightly from that used on the ZX81 to take account of the different PCB layout.

The DC biasing conditions of the FET are such that the source voltage should be between 1 volt and 3.5 volts and this is achieved by making the source resistance about 4k and the drain current about 0.5 milliamps.

C13 (47nF) and R34 (1k0) are retained in their original positions but C14 (47pF) is moved and R35 has to be changed in value only if a manual record-level tape recorder is used. For use with an automatic record-level machine R35 (1M0) is retained but one end has to be desoldered from the printed circuit

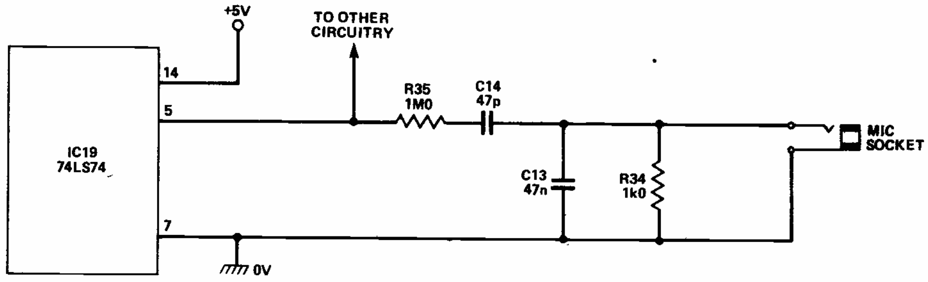

Fig. 1 Original tape-recording circuit.

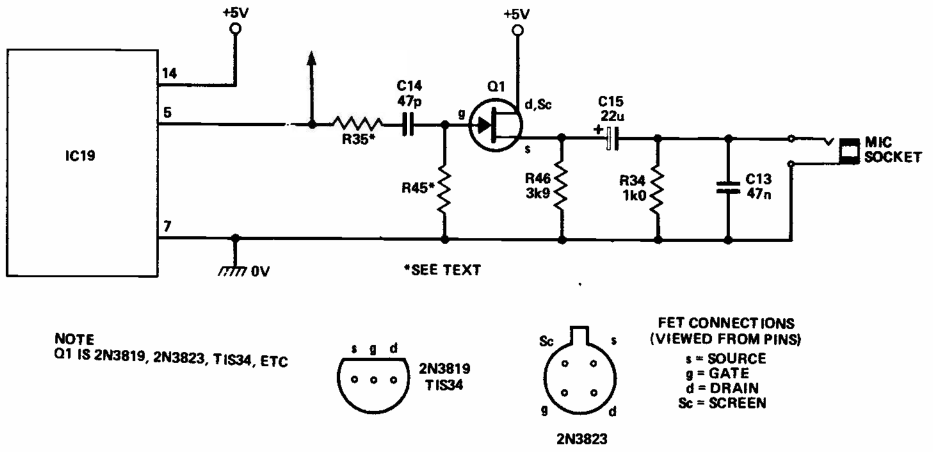

Fig. 2 New circuit; note the difference between this and the circuit published in February.

board. See Table 1 for the values of both R35 and the gate bias resistor that I have called R45.

Most machines used for storing programs on tape are of the automatic record level type. If, with the resistor values shown for R45 (39K), the recording sounds distorted on playback through the cassette loudspeaker, R45 should be reduced in value to 6k2 or 8k2. The sum of the values of R35 and R45 should be within the range 900k to 1M1 to preserve the filter characteristics.

Doing The Modifications

Remove the five white and two black plastic studs holding the bottom half of the case to the top half and to the keyboard. These are removed by first pushing the centre plastic pins through the outer part of the studs and then pulling the complete stud out of the case.

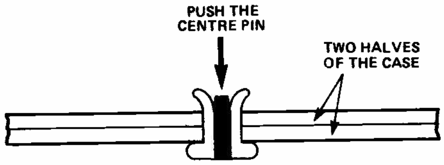

Fig. 3 How to get inside the ZX80.

Now remove the three plastic clips holding the PCB to the back half of the case by carefully squeezing them and pushing them through the PCB.

For use with manual record-level machines, remove R35 (1M0) and insert one end of the new R35 (820k) into the left hand end of the position vacated by the old R35. For use with automatic record-level machines, desolder only the right-hand end of R35 (1M0). The rest of these instructions apply irrespective of the type of cassette machine to be used.

Carefully remove C14 (47pF) and resolder it in series with R35 so that its right-hand end is soldered into the PCB hole from which the right-hand end of R35 was removed. The left-hand end of C14 should be soldered to the free end of R35 and trimmed off as short as possible.

Solder R45 (See Table 1 for value) in the position shown in Fig. 5. Solder the negative end of C15 (22µF, 16 volt) as shown keeping the lead short and leave its positive end unconnected for the moment.

If the metal cased 2N3823 is used, solder the drain and screen leads together and then cut one of them off. Solder the drain lead to the +5 volt PCB line shown. Connect the FET gate lead to the junction between C14 and R45. One end of a 3k9 resistor (R46) is soldered to the 0V lead shown and its other end connected to the positive end of C15 and the source of the FET. It is important to check the connections to the FET and to make sure they are not touching each other.

Put the PCB and the back of the case together again, securing them as before, with the three push-through plastic studs inserted from the back.

At this point test the modification by plugging in the television (tuned to channel 36) and the computer power. When the normal computer television picture appears, plug in the two cassette leads to the computer and the cassette, write a two or three line program and SAVE it. LOAD it into your ZX80 observing the suggestions earlier in this article.

Fault Finding

The FET gate should be at 0 volts, the drain should be at +5 volts and the source at about 2 volts (1V to 3.5V). If not, check the connectins and the layout.

SAVE a short program on to the cassette and listen to it through the cassette loudspeaker. If it sounds distorted, reduce the value of R45 as mentioned earlier.

See the February '83 issue of this magazine for a fuller fault finding guide.

PARTS LIST

This is a list of the *new* components required:

RESISTORS (¼ w 5%)	
R35	**see Table 1.**
R45	**see Table 1.**
R46	**3k9**
CAPACITOR	
C15	**22µF, 16 v axial electrolytic.**
SEMICONDUCTOR	
Q1	**2N3819, TIS34 or 2N3823**

TABLE 1

	R35	R45
Manual Recorders	820K	220K
Auto-level Recorders	1M	39K*

*See text

Table 1 Values of R35 and R45

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ETI

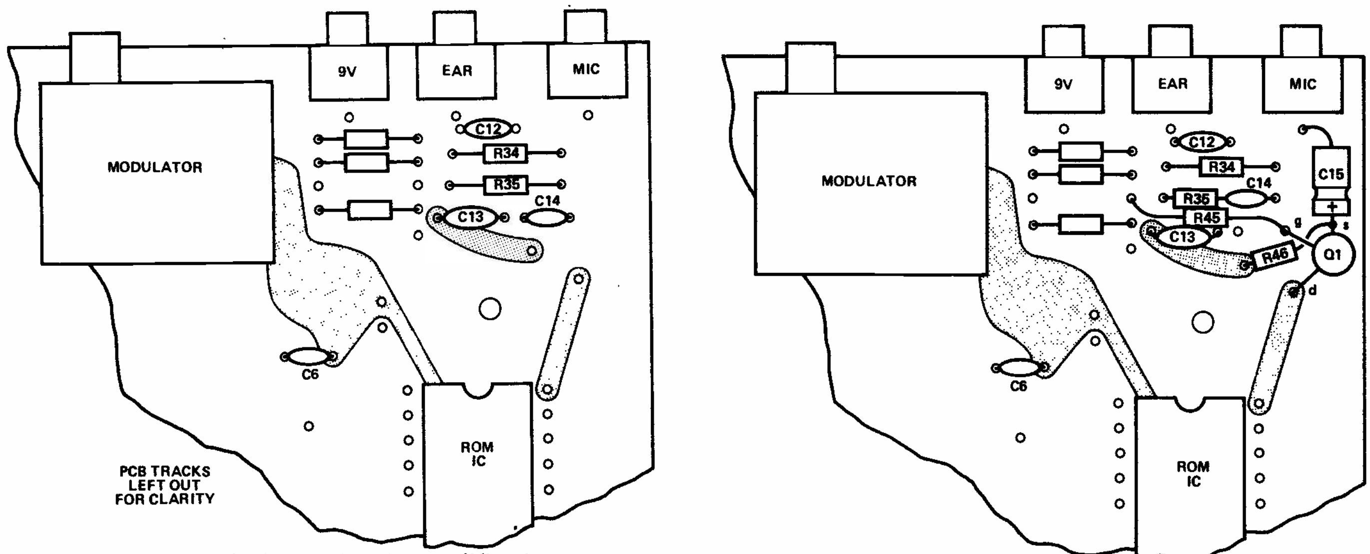

Fig. 4 Before (left) and after (right) the modification.

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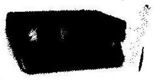

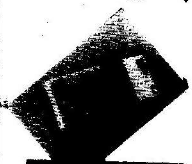

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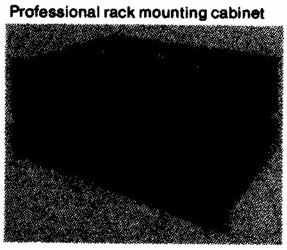

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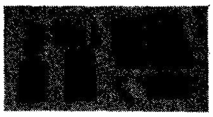

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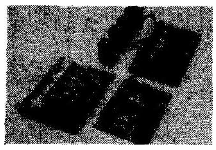

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CAR ALARM

Alarmed at the prospect of your car taking a walk? Ian Forster shows you how to protect it, or your house, a little better. Development by Phil Walker.

This multi-purpose alarm unit can be used in a car, or, if desired, in the home with the addition of a 12V power supply. The basic version provides for a fairly simple alarm that can be triggered either by a negative-going or a positive-going pulse.

If the source of the alarm is removed, the unit will reset itself, as is required by law (and one's neighbours!). There is a delay of approximately 16 seconds before sounding a piezo alarm, which could be used as a warning, and the main car horn will be sounded after about 24 seconds.

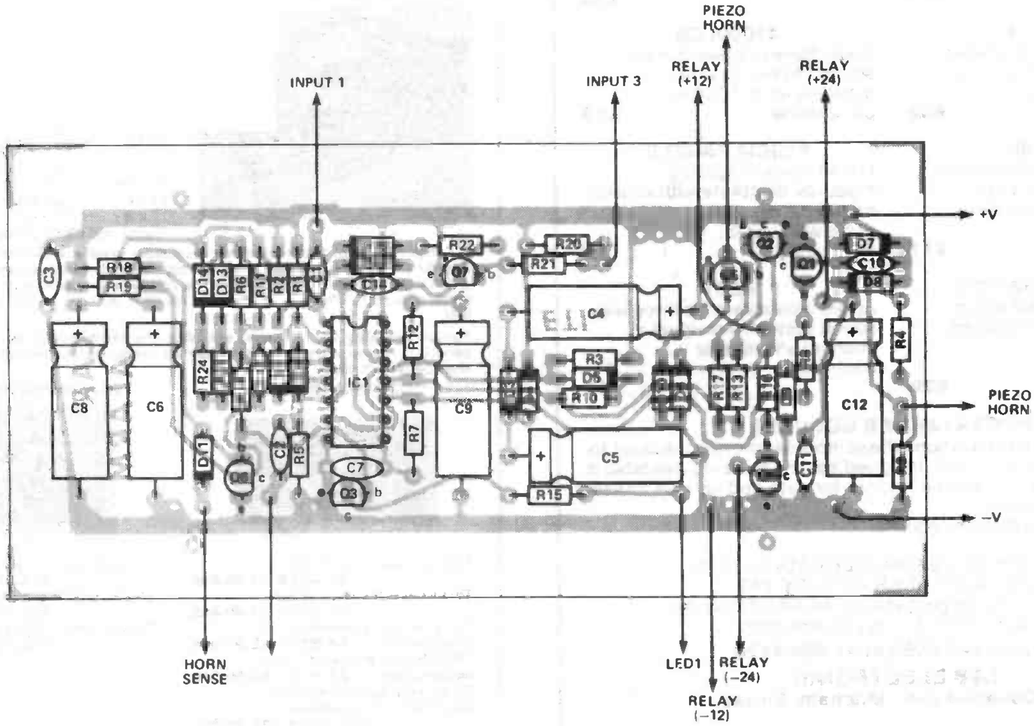
There seems to be a good

RESISTORS (all ¼ W 5%)	
R1, 2, 5	**56K**
R3	**560K**
R4, 8	**10k**
R6	**470k**
R7	**100k**
R9	**1k0**
R10, 12	**270k**
R11	**820k**
R13	**18k**
R14	**33k**
R15	**680R**
R16, 17, 18, 19, 20, 21	***18k***
R22	***100k***
R23, 24	***2k7***
CAPACITORS	
C1, 2, 3	**100n ceramic or polyester**
C4, 6, 8, 9	**33µ 16V axial electrolytic**
C5	**100µ 16V axial electrolytic**
C7	**100n or 1µ unpolarised (see text)**
C10, 11	***100n ceramic or polyester, 24V min***
C12	***100µ axial electrolytic, 24 min***
C13, 14	***100n ceramic or polyester***
SEMICONDUCTORS	
IC1	**4093BE**
Q1, 2	**BC212**
Q3	**BC182, TIP31, BD131**
Q4, 6	***BC182, TIP31, BD131***
Q5, 7	***BC212***
D1-6	**1N4148**
D7-10, 12-15	***1N4148***
D11	***OA91***
LED1	**single LED**
MISCELLANEOUS	
RLA1	**12V *(or 24V, see text)* relay, NO contacts**

Piezo tweeter or *piezo horn (see text), normally open push-button switch,* PCB, wire, etc.

NOTE: Items in italics are for the extension options.

Fig. 1 Circuit diagram: the basic circuit is shown in black and the optional sections in blue.



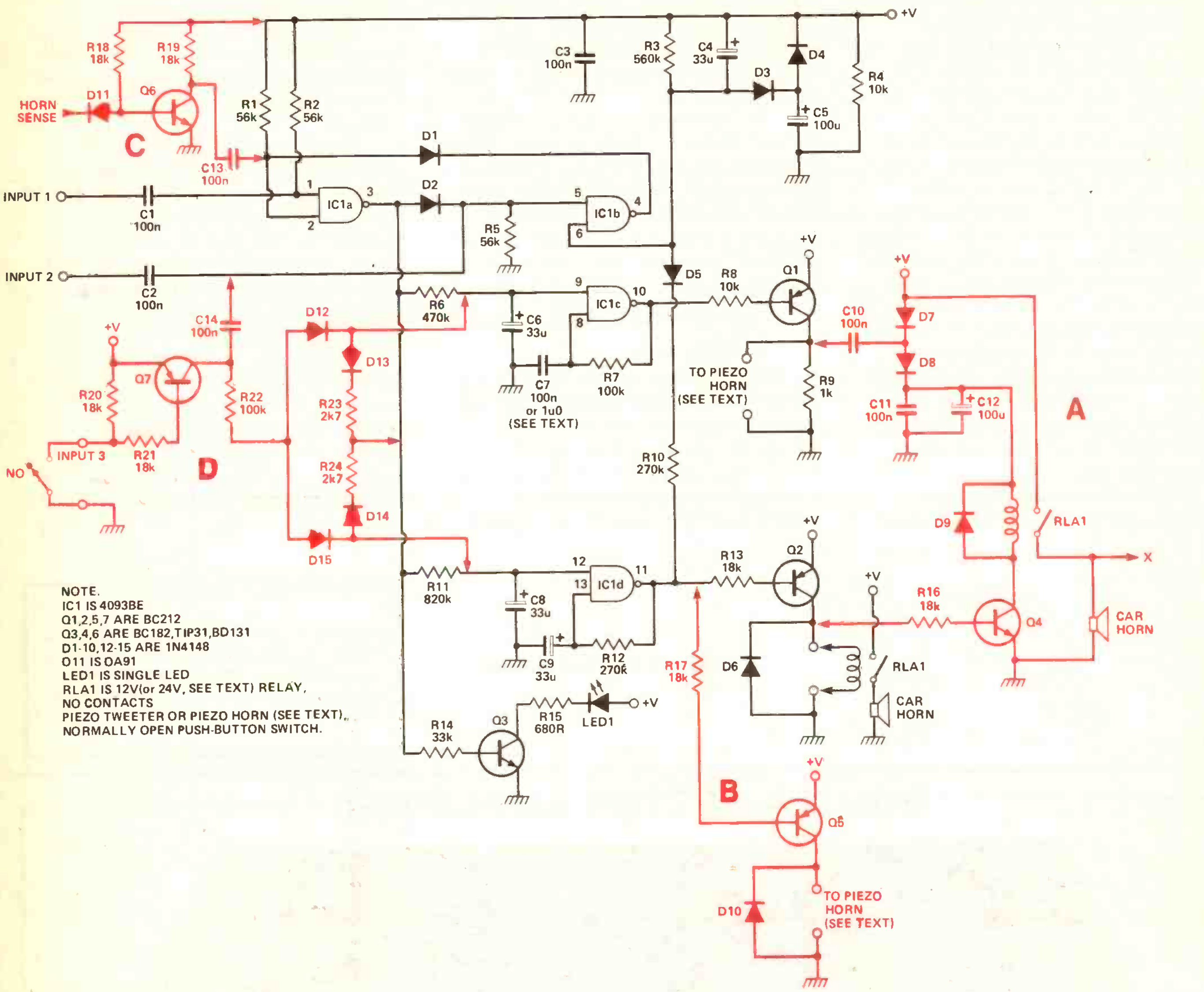


Fig. 2 Component overlay for the PCB.

HOW IT WORKS

The basic circuit is that of a latch, built round IC1a and IC1b, and two drivers for the audible alarms, built round IC1c and Q1, and IC1d and Q2. However, it's not quite that simple . . .

On switch-on, C4 and C5 share current via D3 pulling one of the jnputs of IC1b low, which disables the latch until C5 is charged and C4 discharged via R3: this prevents the circuit being immediately activated at switch-on. If any troubles develop in this respect, it may well be because the values of C4 and C5 are not correct, electrolytics having very wide tolerances. On switch-off, C5 is discharged via D4 and R4.

A negative-going pulse at INPUT1 or a positive-going pulse at INPUT2 will trigger the latch, causing the output of IC1a to go high. C6 charges via R6 and C8 via R11, and LED1 is lit via R14, Q3, R15.

When C6 reaches a sufficient voltage, IC1c will start to oscillate at a frequency determined by C7/R7. For use with a piezo tweeter as a horn, C7 should be 100n which will give an oscillation frequency of 3 kHz. This can be fed to a piezo tweeter via R8 and Q1, to make a very unpleasant sound in a would-be thief's ear! R9 is needed to discharge the tweeter because there is no DC path through these beasties, and it would otherwise just sit at around + V.

Similarly, when C8 reaches a sufficient voltage, IC1d will begin to oscillate at about 1.5Hz, and this will turn the car horn on and off via R13, Q2 and RLA1. D6 protects Q2 against back-EMF from the coil of RLA1. The output of IC1d is also used to pump down C4 (via D5 and R10) so that the latch will be reset after a period, but will retrigger almost immediately if the input conditions persist.

Circuit A allows a 24V relay to be used instead of a 12V one. C7 should be changed to 1u0 to lower the oscillation frequency of IC1d to 300 Hz. C10, D7, D8 and C11 and C12 form a fairly straightforward voltage doubler to provide the 24V necessary. Q4 is needed to invert the output from Q2 and pull down rather than up.

Note that in either case, you connect the relay contacts to suit your car — we have shown how to connect them when your car switches on the positive line to sound the horn, but some (eg Minis) switch the negative side, the positive side of the horn being permanently connected to the 12V supply.

Circuit B can be used to substitute a self-oscillating piezo-horn for the piezo tweeter — this could be useful if you use a 24V relay with circuit A.

Circuit C passes a small current through the car horn; if the connection to the horn is interrupted, the alarm will be triggered.

Circuit D is the fast-acting circuit; when the normally open external contact is closed, Q7 is turned on, and this charges C6 and C8 via R22, and D12 and D15, as well as latching the alarm in the usual way through C14. D13 and 14 and R23 and 24 are necessary to reset this circuit.

supply of 24V relays around at bargain prices, mainly because they're a lot less convenient for most circuits than 12V types. For this reason, the circuit can be adapted to drive a 24V type, as shown in circuit A (shown in blue on the main circuit diagram). This circuit has the disadvantage that you cannot use the piezo tweeter, and circuit B shows how to connect a self-oscillating piezo horn instead.

A common thieves' tactic is to cut the lead to the horn before attempting to break into the car itself. This can be foiled by circuit C, which will trigger the alarm if this is done — note that once the horn lead is cut, there is no way that it can be used, so just the warning siren will go off.

Finally, there may be some items that you may want to protect with a fast-acting alarm, and circuit D provides for this: all that is needed is a set of normally open contacts that can be arranged so as to close.

The method you use to trigger the car depends on how your car is wired up. Most cars have courtesy light switches mounted in the door pillars, and these could be used. Another possibility is to use mercury switches to detect any motion or disturbance.

Construction And Setting Up

Construction of the PCB should present no problems, provided the usual precautions are followed. Things being what they are, it would also be best to make up your mind which options you want before building, though at a pinch bits and bobs can be added later.

As mentioned in How It Works, should there be any problems with the circuit arming at switch-on, then C4 and C5 are the most likely culprits.

If you use circuit A with a particularly current-thirsty relay, then it may be possible that R9, C10 and C12 will need revising (R9 should be reduced in value, C10 and C12 should be increased); Q1 may possibly need upgrading to a high gain medium power type and/or heatsinking, as might Q4.

Otherwise, your biggest headache will be the triggering switches. Unfortunately, we can't advise you generally on this because everybody's car or home will vary; but let us say that careful though put into this aspect will not be wasted. **ETI**

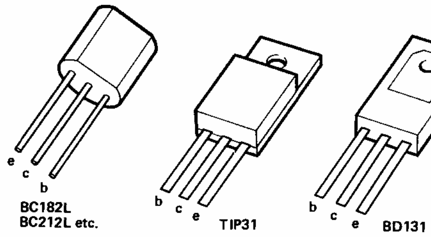


Fig. 3 Transistor pinouts.

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Nothing here should present any problems. A self-oscillating piezo-alarm is available from Maplin and the PCB is, as ever, available through our very own PCB service.

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HOW PERMANENT IS PERMANENT?

With the silicon revolution in full swing, everybody from private individuals to the governments of nations are dependent on the use of magnetism for the storage of information. Is our faith in the technique misplaced? Vivian Capel investigates.

Some years ago it was reported that the BBC were considering whether or not to dispose of their vast library of sound recordings on disc after dubbing them on to tape. The decision was against, because although there would be considerable savings in space, magnetic recordings were deemed to be too ephemeral to trurst as the medium for preserving so many historic and unrepeatable sounds.

This decision would seem to be justified by the fact that on more than one occasion broadcasts have had to be cancelled because the tape had been inadvertently wiped. Imagine if this had happened to an historic only copy! Most users of magnetic storage for sound, video and computer programs will know that this is all too easily done!

Video recordings in particular would seem to be vulnerable. Each picture field with all its colour information and light and shade detail is stored in a single microthin magnetic diagonal line, much narrower than a human hair, across the width of the tape which itself is a thin plastic film. Compared to that a cine film seems positively robust.

As most readers are aware, erasure of a magnetic recording is usually done with a magnetic field. In modern equipment, this is nearly always an alternating field applied either from an erasing head or from a special erasing unit. In some older cheap reel-to-reel recorders erasure was achieved by bringing a permanent magnet into contact with the tape.

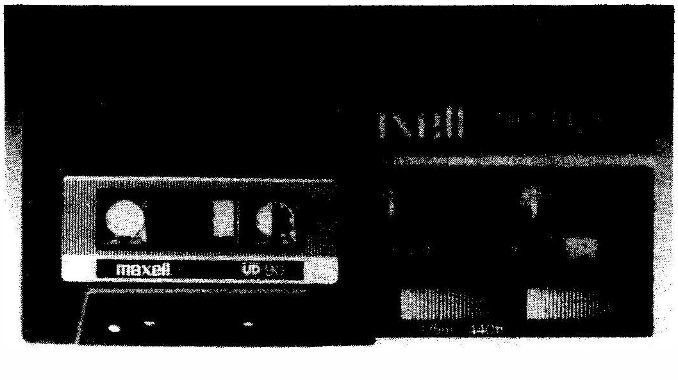
Quite fascinating stories have circulated which tell of a credit-card company that was almost put out of business when a workman walked through its computer centre with a magnet in his toolbox, thus erasing all the magnetically stored data. An even more interesting one concerns the Inland Revenue records that were wiped clean by a nearby airport radar! Hope springs eternal . . .

Another way that the magnetization of a tape can be destroyed is by heat. Apart from the effect of heat on the plastic substrate, above a certain temperature (known as the Curie point), a magnetic material will lose its ability to hold magnetization. This phenomenon is made use of in some brands of thermostatic soldering iron. Here, a disc made of magnetic material is placed in the bit of the iron. In the barrel of the iron is a small magnet, which, because it is attracted to the material in the bit, holds a contact shut. When the iron comes to the required temperature, which is also the Curie point of the bit, this attraction ceases, opening the contact and cutting off the heating current.

Now before everyone dashes out to dispose of their video recorders and floppy disc drives so as to get the best price before the rush starts, let us take a closer look at the process of demagnetisation. A fully magnetised tape, like any other magnetised material, needs a certain minimum field strength applied to its surface to impress or remove magnetism. This field strength is known as the **coercivity** of the material. To understand how this works, you could think of a thug trying to get you to do something you didn't want to do — for example, hand over your money. If the thug applies enough coercing force, you must give way. However, your capacity to resist will depend on how strong you are. It's just the same with magnetic materials — some are much harder to magnetise (and to demagnetise) than others.

For audio cassettes a figure for coercivity of around 300 to 400 (ie 2.4 to 3.2 x 10^4 A/m to our SI readers) oersteds is common, video tapes are usually somewhat higher. This means that a magnetic field of that order would be required to demagnetise a fully magnetised (or **saturated**) tape. Of course, tapes are not recorded into saturation otherwise the recorded signal would suffer distortion, so a normally recorded tape would be completely erased by a lesser field that that of the specified coercivity. Even so, it would take a field of at least 100 oersteds to do any damage to the recording.

So what sort of fields do we find around domestic equipment? External fields depend on the current flowing in the apparatus and the number of turns if a transformer, motor winding or other inductive component is involved. It also depends on the efficiency of the internal magnetic path. For example, a toroidal mains transformer is more efficient in containing the field through its core than a laminated type. Thus there is very little field **external** to a toroidal transformer. Equipment screening **is** another factor.



Magnetic tape — too ephemeral for the BBC.

A power drill running under full load will take a heavy current and the internal magnetic path is not particularly efficient taking in, as it must do, the rotating motor amature. So we can expect a sizeable external field. Surprisingly, the field at the casing of a domestic power drill under load has been measured at around 10 oersteds. This is well below that which could affect a recorded tape. House wiring and flexible mains leads also generate fields, but even when carrying a heavy current these are not great. The reason is that cable is reasonably straight and so constitutes only a single turn compared with the hundreds of turns of a transformer or motor windings. Further more, both live and neutral are contained within the same cable, and as these are carrying equal and opposite currents, there is a high degree of cancellation of the produced field. (For maximum cancellation the conductors would need to be tightly twisted.) So there is not much to worry about from these.

Permanent magnets are fairly common in domestic equipment — a few examples are in loudspeakers, tin openers, magnetic door catches, magnetic switches for burglar alarms, etc. Some of these produce fields of 1,000 oersteds and more, and could constitute a real hazard. Any such device coming into direct contact with a recorded tape or disc would certainly wipe that portion of the recording clean.

One factor which saves endangered recordings is that magnetic field is very strongly dependent on distance. For a single magnetic pole, the magnetic field would be proportional to the inverse square of the separating distance. However, magnetic poles come in opposite pairs, and this has the effect of making the field fall off even more quickly — the further you get away from the one pole, the more the field from the other pole tends to cancel out the field altogether.

This has the consequence that the casing around a video cassette, for example, will be sufficiently thick to protect it from contact with most small magnets — but it's still probably not a good idea to have a magnetic catch on the door of the cupboard in which you keep your tapes, just in case!

The situation is somewhat different with a floppy disc. This is contained in a protective packing similar to an ordinary record sleeve except that the disc is played inside the cover through a slot. The sleeve is there mainly to protect against finger marks and other minor handling hazards. It is not very thick, about 0.5 mm, so any magnet that was brought into contact with it would almost certainly wipe part of the information on the disc. Therefore, some care is needed in handling and storing these.

Then what about those stories of chain-reactions, with whole shelves of tapes being wiped out by a single stray field? It is possible for such a reaction to take place along the length of a single tape if the recording is of very low level. This was demonstrated some years ago by a team who were developing a method of recording very high frequency square waves with zero bias. The recorded signals were of very low amplitude but at one stage the recording level was accidentally increased to ten times that of normal. It was found that the previous 1,000 feet or so of recording had been wiped out by the excessive flux form the recording head at that one point travelling backward. To verify that this in fact was the cause, the conditions were repeated and other possible factors eliminated. The result was the same: erasure of the entire reel.

This however, does not happen under normal circumstances. In fact, it is a common practice to erase part of a tape by re-recording it, while the remainder stays unaffected. Audio tape enthusiasts having open reel machines often eliminate clicks and bumps in amateur productions by judicious use of a permanent magnet, and post-recorded fades can be made by sweeping a magnet over the particular length of tape while gradually raising or lowering it.

So with normal recordings the tape affected is only that portion which comes in close proximity to the magnetic field. As for several tapes being wiped by chain reaction, this is just a myth. The only way a number of tapes could be affected would be if there were a pervading field of such intensity as to exceed the tape coercivity at the surface of the tapes themselves.

There are stories in circulation about flash bulbs being triggered off by radar installations, and demolition teams that won't use electrical detonators nearby; and indeed, directly in front of a radar dish a magnetic field of several thousand oersted can exist. This would certainly be enough to wipe any magnetic tape clean, but any person in the vicinity would already be experiencing a few problems on their own account! In any case, airports and other users of radar don't like bodies getting in the way, so the antennae are usually mounted well away from people.

However, the question of whether or not a strong electromagnetic radiation field could cause erasure is worth exploring. 3M, the tape manufacturers conducted some experiments to determine this in America. The object was to discover the effect of microwave energy. Reels of recorded tape were actually placed in a microwave oven and the power applied until the reels and the tape began to melt and burn. Those parts of the tape that were not physically damaged were examined and the recording was found to be unaffected. The tape had not demagnetised.

A further experiment was tried using radar. Reels of recorded tape were placed directly in front of a radar dish having a range of 250 miles, Two lots of tape were used, one placed at a distance of 18 feet, and the other much closer at 16 inches. These were scanned by the radar beam for 16 minutes, then removed and examined. It might be anticipated that the nearer tapes would have suffered from the magnetic field, but in fact both lots were unaffected. There was no physical damage, and the recorded signal level was the same as before.

So, radar can be eliminated as a hazard for magnetic recordings, but there is another potential danger for tapes that are transported by air travellers, and also by air freight. Firstly, baggage, or packages that are sent through the post which for some reason may give rise to some suspicion, may be examined by means of X-rays. In other experiments by 3M, recorded tapes were exposed to X-rays of much higher level that those normally used for parcel examination. Again there was no ill effect and the

Floppy discs — the most vulnerable to demagnetisation.

recordings were intact, with no loss of signal level.

Secondly, at most air terminals, passengers are required to pass through a weapons detector with their hand luggage. These devices are magnetically operated, so what effect could they have on a recording? The majority are passive, that is they do not produce a magnetic field of their own but measure changes in the earth's magnetic field caused by ferrous objects. These pose no threat at all to recordings.

Other detectors are active. These produce a magnetic field in a doorway or other region through which the passenger must pass. Any metal object distorts the field, and the change is detected by instruments. Usually the field employed is quite low, in the region of 20 oersteds, which is insufficient to affect a magnetic recording. There are some detectors, though, that go up to 100 oersteds. Although below the coercivity of fully saturated tapes, they do constitute a hazard. While in most cases no damage may result, if there is reason to suspect that a high intensity field is in use it may be safer to advise the staff that you have recorded tapes, and request a visual examination instead.

Could, under normal circumstances, the temperature ever go sufficiently high to affect recordings? Certainly it's common experience that the temperature inside a car with its windows closed can soar to the unbearable — particularly in countries blessed with warmer climates than Britain. However, for iron oxide the Curie point is around 850°F (450°C) and physical damage to the tape substrate or case (or to the recorded itself) would occur long before this temperature was reached.

The Curie point for chromium dioxide is 250°F (120°C) which, although still above boiling point and hence unlikely to be attained in a domestic environment, can still cause problems. This is because as the temperature rises towards the Curie point (remember that physical phenomena are governed by the absolute temperature, and although 50°C looks a long way from 120°C, the equivalents 323°K and 393°K look a lot closer) magnetic materials become much more susceptible to small magneitc fields. This principle was at one time used in the copying of videotapes: heat was used to transfer the magnetic pattern from the master tape to an intermedaite medium and from that to the copies.

So one possible effect of excessive heat is print-through, ie signals from one layer of tape getting superimposed on an adjacent one to give pre- or post echo. This can and does happen at normal temperatures when thin (long playing) tapes are spooled up without playing, for long periods. High temperatures can therefore increase this risk. Print-through is also more likely in the presences of an external field which would be insufficient to erase the tape.

To sum up, there is not very much danger to magnetic tapes in most domestic environments apart from print through, provided the common sense precautions are taken. Obviously, if you allow a combination of hazard factors to occur together, the risk to the recording is increased commensurately.

I would add on a personal note that audio recordings made by me some 30 years ago have survived various hazards and sound as good today as they did on the day they were made.

ETI

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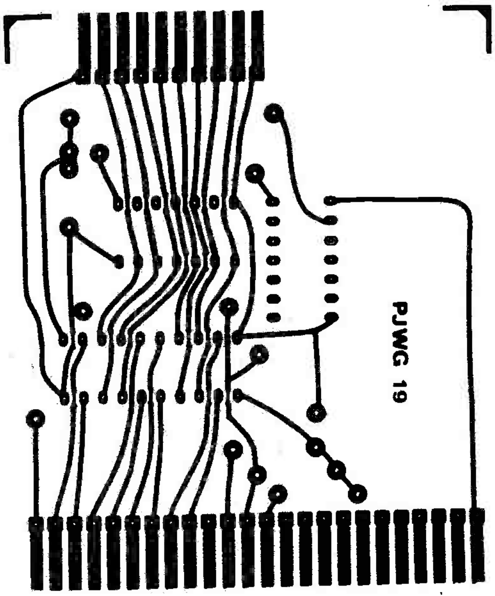

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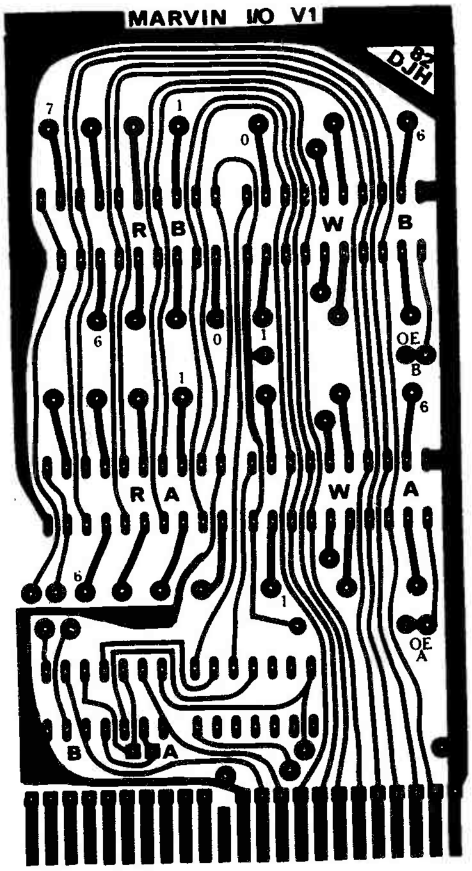

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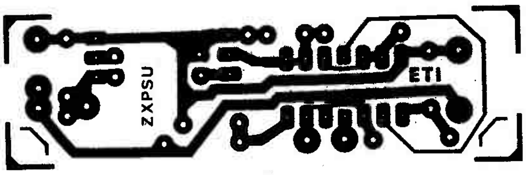

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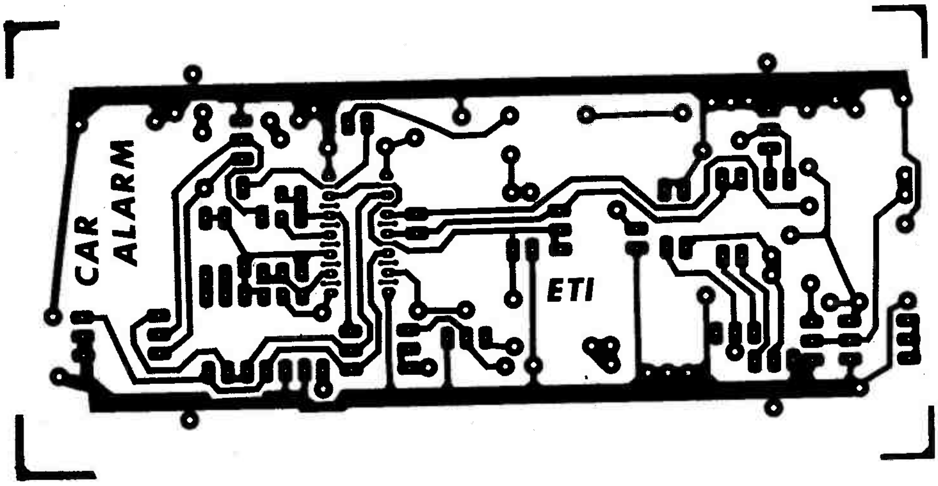

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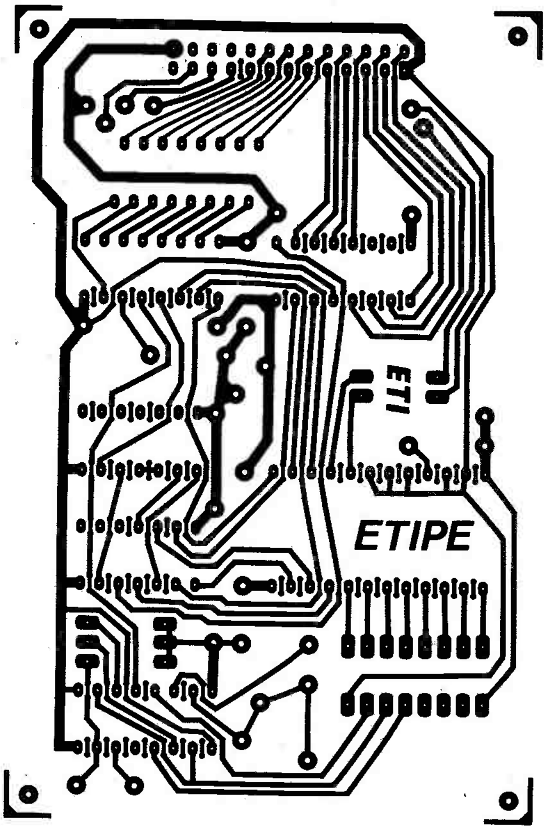

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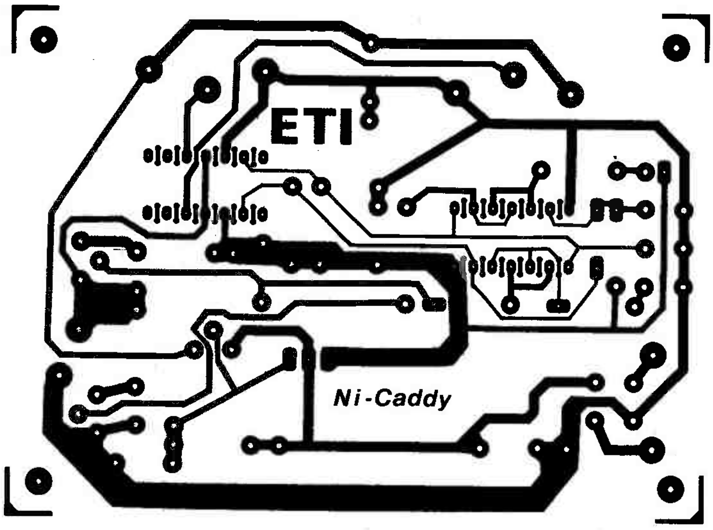

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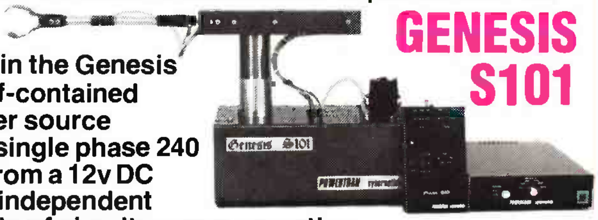

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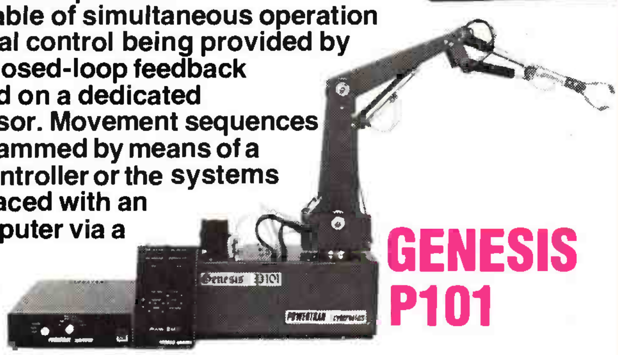

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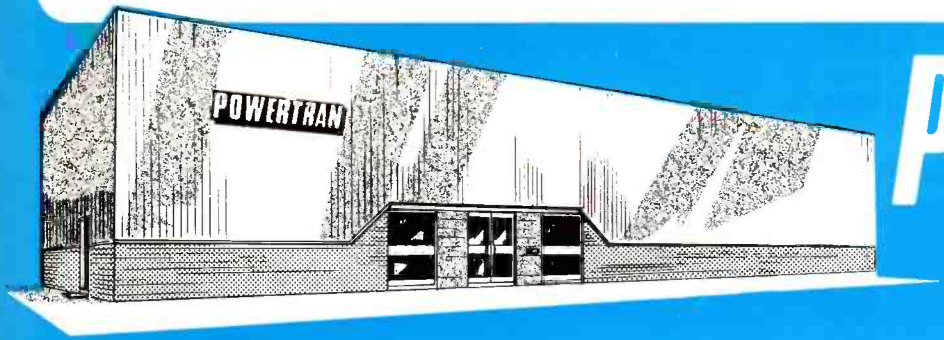

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