AN ARGUS SPECIALIST PUBLICATION

electronics today

INTERNATIONAL

AUGUST 1987 £1.30

CAR SPECIAL

AUTO ELECTRONICS – THE STATE OF THE ART

BUMPER BUNDLE OF CAR PROJECTS TO BUILD

AUDIO.... COMPUTING.... MUSIC.... RADIO.... ROBOTICS...

electronics today INTERNATIONAL AUGUST 1987 VOL 16 No. 8

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FEATURES

PROJECTS

REGULARS

01-208 1177 TECHNOMATIC LTD 01-208 1177

BBC Micro Computer System

BBC Master Series
AMB15 BBC MASTER includes free bundled software .... £395 (a)
AMB12 BBC MASTER Econet computer .... £315 (a)
AMC06 Turbo (65C102) Expansion Module .... £99 (b)
ADF14 Rom Cartridge .... £13 (d)
ADF10 Econet Module .... £41 (c)
ADJ22 Ref. Manual Part I .... £14 (c)
ADJ23 Ref. Manual Part II .... £14 (c)
ADJ24 Advanced Ref Manual . £19.50 (c)
ACORN ADD-ON PRODUCTS
Universal 2nd Processor .... £75 (b)
TORCH ZEP 100 .... £229 (a)
Muliform Z80 2nd Processor .... £289 (b)
Acorn Teletext Adaptor .... £75 (b)
Acorn IEEE Interface .... £265 (a)
BBC Master Compact
SYSTEM 1
128K, Single 640K Drive & bundled software .... £385 (a)
SYSTEM 2
System 1 with a 12" Med Res RGB Monitor .... £469 (a)
SYSTEM 3
System 1 with a 14" Med Res RGB Monitor .... £599 (a)

Second Drive Kit .... £99 (c)
UPGRADE KITS
1770 DFS Upgrade for Model B £43.50 (d)
Basic II ROM .... £22.50 (d)
1.2 OS ROM .... £15 (d)
DNFS ROM .... £17.50 (d)
ADFS Rom (for B with 1770 DFS & B Plus) .... £26 (d)

ECONET ACCESSORIES
Econet Starter kit .... £85 (d)
Econet Socket Set .... £29 (c)
Econet Bridge .... £174 (b)
File Server Level II .... £75 (d)
Printer Server Rom .... £41 (d)
10 Station Lead set .... £26 (c)
Adv. Econet User Guide .... £10 (d)

COMMUNICATIONS ROMS
Termulator .... £25 (d)
Communicator .... £49 (d)
Commstar .... £28 (d)
DATABEEB .... £24 (d)
BBC FIRMWARE & SOFTWARE
Database Management Systems. Word Processors, Languages, Spreadsheets, Utilities
For full details on the wide range of above packages please write to us.

EPSON
LX800NLQ (80 col) .... £229 (a)
EX800 .... £409 (a)
LQ800 (80 col) .... £439 (a)
LQ1000 (136 col) .... £589 (a)
JX80 4 colour .... £229 (a)
FX800 .... £329 (a)
FX100 .... £449 (a)
TAXAN KP815 (80 col) NLQ .. £269 (a)
TAXAN KP915 (156 col) .... £369 (a)
NATIONAL PANASONIC
KXP1081 (80 col) .... £169 (a)
NATIONAL PANASONIC
KXP 3131 .... £249 (a)
STAR NL10 (IBM Interface) £209 (a)
JUKI 6100 Daisy Wheel .... £319 (a)
BROTHER HR20 .... £349 (a)
INTEGREX Multicolour .... £549 (a)
HITACHI 672 A3 Plotter .... £479 (a)

Paper:
2000 Sheets Fanfold:
9.5" x 11" .... £13 (b)
14.5" x 11" .... £18.50 (b)
Labels: (per 1000)
3.5" x 17/16" Single row .... £5.25 (d)
27/16" x 17/16" Triple row .... £5.00 (d)

ACCESSORIES

EPSON
FX plus sheet feeder .... £129.00 (b)
LX80 Sheet feeder .... £49.00 (b)
Paper Roll Holder .... £17.00 (d)
Interfaces: 8143 RS232 .... £28.00 (c)
8132 Apple II .... £60.00 (c)
8165 IEEE + cable .... £65.00 (c)
8177P NLQ (FX80+/FX100+) . £99 (d)
Serial & Parallel interfaces with larger buffers available.
Ribbons: RX/FX 100/100+ .... £5.00 (d)
RX/FX 80/80+ .... £10.00 (d)
LX80 .... £4.50 (d)
Spare pens for H180 .... ££8.25/set (d)
FX80 Tractor Attachment (c)

RS232 Interface + 2K Buffer .... £63 (c)
Ribbon KP810/910/815/915 .... £6.00 (d)
JUKI:
RS232 Interface .... £65 (c)
Spare Daisy Wheel .... £14.00 (d)
Ribbon .... £12.00 (d)
Sheet Feeder .... £182 (a)
Tractor Feed Attachment .... £149 (a)

Sheet Feeder .... £239 (a)
Tractor Feeder .... £118 (a)
Ribbons Carbon or Nylon .... £3.00 (d)
Red Correction Ribbon .... £2.00 (d)
BBC Printer Lead:
Parallel (1.2m) .... £6.00 (d)
Serial (1.2m) .... £7.00 (d)
Printer Leads can be supplied to any length.

DISC DRIVES

These are fully cased and wired drives with slim line high quality mechanisms. Drives supplied with cables manuals and formatting disc suitable for the BBC computer. All 80 track drives are supplied with 40/80 track switching as standard. All drives can operate in single or dual density format. All floppy drives carry a two year warranty.

PD800P (2 × 400K/2 × 640K 40/80T DS) with built in monitor stand .... £249 (a)
PD800 (2 × 400K/2 × 640K 40/80T DS) .... £229 (a)
TD800 (as PD800 but without psu) .... £199 (a)
TS400 1 × 400K/1 × 640K 40/80T DS .... £114 (b)
PS400 with psu 1 × 400K/1 × 640K 40/80T DS .... £129 (b)
3.5" DRIVES
1 × 400K/1 × 640K 80T DS
TS35 1 .... £75 (b)
PS35 1 with psu .... £119 (b)
2 × 400K/1 × 640K 80T DS
TD35 2 .... £135 (b)
PD35 2 with psu .... £187 (b)

3M FLOPPY DISCS

High quality discs that offer a reliable error free performance for life. Each disc is individually tested and guaranteed for life. Ten discs are supplied in a sturdy cardboard box.

5¼" DISCS		3½" DISCS
40T SS DD £10.00 (d)	40T DS DD £12.00 (d)	80T SS DD £20.00 (d)
80T SS DD £14.50 (d)	80T DS DD £15.50 (d)	80T DS DD £25.00 (d)

DISC ACCESSORIES

FLOPPICLENE Disc Head Cleaning Kit with 20 disposable cleaning discs ensures continued optimum performance of the drives .... 3½" £16 (d), 5¼" £14.50 (d)
Single Disc Cable .... £6 (d)
10 Disc Library Case .... £1.80 (c)
40 Disc Lockable Box .... £8.50 (c)
Dual Disc Cable .... £8.50 (d)
30 Disc Case .... £6 (c)
100 Disc Lockable Box .... £13 (c)

MONITORS

All 14" monitors now available in plastic or metal cases, please specify.

MICROVITEC: 14" RGB
1431 Std Res .... £179 (a)
1451 med Res .... £225 (a)
1441 Hi Res .... £365 (a)
14" RGB with PAL & Audio
1431 AP Std Res .... £199 (a)
1451 AP Med Res .... £259 (a)
Swivel Base for Plastic 14" Microvitecs .... £20 (c)
20" RGB with PAL & Audio
2030CS Std Res .... £380 (a)
2040CS Hi Res .... £685 (a)
TAXAN SUPERVISION 620 12" High Resolution .... £279 (a)
TAXAN SUPERVISION 625 with amber/green option, BBC & IBM . £329 (a)
MITSUBISHI XC1404 14" RGB Med Res IBM & BBC Compatible .. £219 (a)

TAXAN KX 117 Hi Res 12" Etched Green Screen .... £85 (a)
TAXAN KX 118 Hi Res 12" Long Persistence (P39) .... £95 (a)
TAXAN KX 119 Hi Res 12" Etched Amber Screen .... £95 (a)
PHILIPS BM7502 12" Hi res Green Screen .... £75 (a)
PHILIPS BM7522 12" Hi Res Amber Screen .... £75 (a)

Swivel Base for Taxan Monochrome fitted with Digital Clock .... £21 (c)

MODEMS

— All modems listed below are BT approved

MIRACLE 3000.
MIRACLE WS2000 V21/23 Manual .... £92 (b)
MIRACLE WS4000 V21/23. (Hayes Compatible, Intelligent, Auto Dial/Auto Answer) .. £135 (b)
MIRACLE WS3000 V21/V23 As SW4000 and with BELL standards and battery pack up for memory .... £265 (b)
MIRACLE WS3000 V22 As WS3000 V21/V23 but with 1200 baud full duplex .... £445 (b)
MIRACLE WS3000 V22 bis As V22 and 2400 baud full duples .... £585 (b)
The price of WS4000 & WS3000 Modems includes a Commstar II ROM and BBC Data Cable.
BBC DATA CABLE for WS3000/4000 .. £7 (d)

'DATATALK Comms Package' if purchased with any of the above modems' .... £70 (c)
PACE Nightingale Modem V21/V23 Manual .... £75 (b)

SPECIAL OFFER

2764-25 .... £2.50
27128-25 .... £2.75
6264LP-15 .... £2.80

ATTENTION

All prices in this double page advertisement are subject to change without notice.

ALL PRICES EXCLUDE VAT
Please add carriage 50p unless indicated as follows:
(a) £8 (b) £2.50 (c) £1.50 (d) £1.00

Serial Test Cable
Serial Cable switchable at both ends allowing pin options to be re-routed or linked at either end using a 10 way switch making it possible to produce almost any cable configuration on site.
Available as M/M or M/F .... £24.75 (d)

Serial Mini Patch Box
Allows an easy method to reconfigure pin functions without rewiring the cable assy.
Jumpers can be used and reused. .... £22 (d)

Serial Mini Test
Monitors RS232C and CCITT V24 Transmissions, indicating status with dual colour LEDs on 7 most significant lines.
Connects in Line. .... £22.50 (d)

GANG OF EIGHT INTELLIGENT FAST EPROM COPIER

Copies up to eight eproms at a time and accepts all single rail eproms up to 27256. Can reduce programming time by 80% by using manufacturer's suggested algorithms. Fixed Vpp of 21 & 25 volts and variable Vpp factory set at 12.5 volts. LCD display with alpha moving message. £395(b).

SOFTY II

This low cost intelligent eprom programmer can program 2716, 2516, 2532, 2732, and with an adaptor, 2564 and 2764. Displays 512 byte page on TV — has a serial and parallel I/O routines. Can be used as an emulator, cassette interface.
Softy II .... £195(b)
Adaptor for 2764/2564. £25.00(c)

UV ERASERS

All erasers with built in safety switch and mains indicator.
UV1B erases up to 6 eproms at a time .... £47(c)
UV1T as above but with a timer .... £59(c)
UV140 erases up to 14 eproms at a time. £88 (b)
UV141 as above but with a timer .... £88 (b)

CONNECTOR SYSTEMS

I.D. CONNECTORS

(Speedblock Type)

No of ways	Header Plug	Recep-tacle	Edge Conn.
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No of Ways

	9	15	25	37
MALE:				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	-
FEMALE:				
St Pin	100	140	210	380
Ang pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	-
St Hood	90	95	100	120
Screw	130	150	175	-
Lock				

TEXTOOL ZIF SOCKETS

28-pin £9.00 | 24-pin £7.50 | 40-pin £12

EDGE CONNECTORS

	0.1"	0.156"
2 x 6-way (commodore)	—	300p
2 x 10-way	150p	—
2 x 12-way (vic 20)	—	350p
2 x 18-way	—	140p
2 x 23-way (ZX81)	175p	220p
2 x 25-way	225p	220p
2 x 28-way (Spectrum)	200p	—
2 x 36-way	250p	—
1 x 43-way	260p	—
2 x 22-way	190p	—
2 x 43-way	395p	—
1 x 77-way	400p	500p
2 x 50-way(S100conn)	600p	—

EURO CONNECTORS

DIN 41612	Plug	Socket
2 × 32 way St Pin	230p	275p
2 × 32 way Ang Pin	275p	320p
3 × 32 way St Pin	260p	300p
3 × 32 way Ang Pin	375p	400p
IDC Skt A + B		400p
IDC Skt A + C		400p

For 2 × 32 way please specify spacing (A + B, A + C).

MISC CONNS

21 pin Scart Connector 200p
8 pin Video Connector 200p

AMPHENOL CONNECTORS

	Solder	ZDC
36 way plug	500p	475p
36 way skt	550p	500p
24 way plug IEEE	475p	475p
24 way skt IEEE	500p	500p

PCB Mtg Skt Ang Pin
24 way 700p 36way 750p

GENDER CHANGERS

25 way D type
Male to Male £10
Male to Female £10
Female to Female £10

RS 232 JUMPERS

(25 way D)
24" Single end Male £5.00
24" Single end Female £5.25
24" Female Female £10.00
24" Male Male £9.50
24" Male Female £9.50

4-way 90p 6-way 105p
8-way 120p 10-way 140p

RIBBON

(grey/metre)

10-way	40p	34-way	160p
16-way	60p	40-way	180p
20-way	85p	50-way	200p
26-way	120p	64-way	280p

DIL HEADERS

	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
18 pin	60p	-
20 pin	75p	-
24 pin	100p	150p
28 pin	160p	200p
40 pin	200p	225p

TECHNOLINE VIEWDATA SYSTEM

Using 'Prestel' type protocols for information and orders phone 01-450 9764. 24 hour service, 7 days a week.

74 SERIES

7400	30p
7401	30p
7402	30p
7403	30p
7404	36p
7405	30p
7406	40p
7407	40p
7408	30p
7409	30p
7410	30p
7411	30p
7412	30p
7413	50p
7414	70p
7416	36p
7417	40p
7420	30p
7421	60p
7422	36p
7423	36p
7425	40p
7426	40p
7427	40p
7428	43p
7430	30p
7432	36p
7433	30p
7437	30p
7438	40p
7439	40p
7440	40p
7441	90p
7442A	70p
7443A	100p
7444	110p
7445	70p
7446A	100p
7447A	100p
7448	120p
7450	36p
7451	35p
7453	38p
7454	38p
7460	55p
7470	50p
7472	55p
7473	55p
7474	50p
7475	60p
7476	45p
7480	65p
7481	180p
7483A	105p
7484A	125p
7485	110p
7486	42p
7489	210p
7490A	55p
7491	70p
7492A	70p
7493A	55p
7494	110p
7495A	60p
7496	80p
7497	290p
74100	190p
74107	50p
74109	75p
74110	75p
74111	55p
74116	170p
74118	110p
74119	170p
74120	100p
74121	55p
74122	70p
74123	80p
74125	65p
74126	55p
74128	55p
74132	75p
74136	70p
74141	90p
74142	250p
74143	270p
74144	270p
74145	110p
74147	170p
74148	140p
74150	175p
74151A	70p
74153	80p
74154	140p
74155	80p
74156	100p
74157	80p
74159	225p
74160	110p
74161	80p
74162	110p
74163	110p
74164	120p
74165	110p
74166	140p
74167	400p
74170	200p
74172	420p
74173	140p
74174	110p
74175	105p
74176	100p
74178	150p
74179	150p
74180	100p
74181	340p
74182	140p
74184	180p
74185A	180p
74190	130p
74191	130p
74192	110p
74193	115p
74194	110p
74195	80p
74196	130p
74197	110p
74198	220p
74199	220p
74221	110p
74251	100p
74259	150p
74265	380p
74273	200p
74276	140p
74278	170p
74279	90p
74283	105p
74285	320p
74290	90p
74293	90p
74298	180p
74351	200p
74365A	80p
74366A	80p
7436A	80p
74367A	80p
74368A	70p
74376	160p
74390	110p
74393	112p
74490	140p

74LS SERIES

74LS00	24p
74LS01	24p
74LS02	24p
74LS03	24p
74LS04	24p
74LS05	24p
74LS08	24p
74LS09	24p
74LS10	24p
74LS11	24p
74LS12	24p
74LS13	34p
74LS14	50p
74LS15	24p
74LS20	24p
74LS21	24p
74LS22	24p
74LS24	50p
74LS26	24p
74LS27	24p
74LS28	24p
74LS30	24p
74LS32	24p
74LS33	24p
74LS37	24p
74LS38	24p
74LS40	24p
74LS42	50p
74LS43	150p
74LS47	80p
74LS48	90p
74LS49	100p
74LS51	24p
74LS54	24p
74LS55	24p
74LS73A	30p
74LS74A	35p
74LS75	45p
74LS76A	36p
74LS83A	70p
74LS85	75p
74LS86	35p
74LS90	48p
74LS91	90p
74LS92	55p
74LS93	54p
74LS95B	75p
74LS96	90p
74LS107	40p
74LS109	40p
74LS112	45p
74LS113	45p
74LS114	45p
74LS122	70p
74LS123	80p
74LS124/	629/140p
74LS125	50p
74LS126	50p
74LS132	65p
74LS133	50p
74LS136	45p
74LS138	55p
74LS139	55p
74LS145	95p
74LS147	175p
74LS148	140p
74LS151	65p
74LS152	200p
74LS163	65p
74LS154	160p
74LS155	65p
74LS156	65p
74LS157	50p
74LS158	65p
74LS160A	75p
74LS161A	75p
74LS162A	75p
74LS163A	75p
74LS164	75p
74LS165A	110p
74LS166A	150p
74LS168	130p
74LS169	100p
74LS170	140p
74LS173A	100p
74LS174	75p
74LS175	75p
74LS181	200p
74LS183	180p
74LS190	75p
74LS191	75p
74LS192	80p
74LS193	80p
74LS194A	75p
74LS195A	75p
74LS196	80p
74LS197	80p
74LS221	90p
74LS240	80p
74LS241	80p
74LS242	90p
74LS243	90p
74LS 244	70p
74LS 245	90p
74LS247	110p
74LS248	110p
74LS249	110p
74LS251	75p
74LS253	75p
74LS256	90p
74LS257A	70p
74LS258A	70p
74LS259	120p
74LS260	75p
74LS261	120p
74LS266	60p
74LS273	125p
74LS279	70p
74LS280	190p
74LS283	80p
74LS290	80p
74LS 292	£14
74LS293	80p
74LS295	140p
74LS 297	£14
74LS298	100p
74LS299	220p
74LS321	370p
74LS323	300p
74LS324	320p
74LS348	200p
74LS352	120p
74LS353	120p
74LS356	210p
74LS363	180p
74LS364	180p
74LS365	50p
74LS366	50p
74LS367	50p
74LS368A	50p
74LS 373	70p
74LS 374	70p
74LS375	75p
74LS377	130p
74LS378	95p
74LS379	130p
74LS381	450p
74LS385	325p
74LS390	60p
74LS393	100p
74LS395A	100p
74LS399	140p
74LS445	180p
74LS465	120p
74LS467	120p
74LS490	150p
74LS540	100p
74LS541	100p
74LS608	700p
74LS 610	£25
74LS 612	£25
74LS624	350p
74LS626	225p
74LS628	225p
74LS629	125p
74LS640	200p
74LS640-1	300p
74LS641	150p
74LS642-1	300p
74LS643	250p
74LS643-1	300p
74LS644	350p
74LS645	200p
74LS645-1	400p
74LS668	90p
74LS669	90p
74LS670	170p
74LS682	250p
74LS684	350p
74LS687	350p
74LS688	350p
74LS 783	£16

74S SERIES

74S00	50p
74S02	50p
74S04	50p
74S05	50p
74S08	60p
74S10	50p
74S11	75p
74S20	50p
74S22	50p
74S30	50p
74S32	60p
74S37	60p
74S38	80p
74S40	50p
74S51	45p
74S64	45p
74S74	70p
74S 85	550p
74S86	100p
74S112	150p
74S113	120p
74S114	120p
74S124	300p
74S132	100p
74S133	60p
74S138	180p
74S138	180p
74S139	180p
74S140	100p
74S151	150p
74S153	150p
74S157	200p
74S158	200p
74S163	300p
74S169	550p
74S174	300p
74S175	320p
74S188	180p
74S189	180p
74S194	300p
74S195	300p
74S196	350p
74S200	450p
74S201	320p
74S225	520p
74S240	400p
74S241	400p
74S 244	400p
74S251	250p
74S257	250p
74S258	250p
74S260	100p
74S261	300p
74S283	270p
74S287	225p
74S288	200p
74S289	225p
74S 299	450p
74S373	400p
74S374	400p
74S387	225p

4000 SERIES

4000	20p
4001	24p
4002	25p
4006	70p
4007	25p
4008	60p
4009	45p
4010	60p
4011	24p
4012	25p
4013	36p
4014	60p
4015	70p
4016	36p
4017	55p
4018	60p
4019	60p
4020	80p
4021	60p
4022	70p
4023	30p
4024	48p
4025	24p
4026	90p
4027	40p
4028	60p
4029	75p
4030	35p
4031	125p
4032	100p
4033	125p
4034	250p
4035	70p
4036	70p
4037	110p
4038	100p
4039	250p
4040	60p
4041	55p
4042	50p
4043	60p
4044	60p
4045	100p
4046	60p
4047	60p
4048	55p
4049	36p
4050	35p
4051	65p
4052	60p
4053	60p
4504	60p
4055	80p
4056	85p
4059	400p
4060	70p
4063	85p
4066	40p
4067	230p
4068	25p
4069	24p
4070	24p
4071	24p
4072	24p
4073	24p
4075	24p
4076	65p
4077	25p
4078	25p
4081	24p
4082	25p
4085	60p
4086	75p
4089	120p
4093	35p
4094	90p
4095	90p
4096	90p
4097	270p
4098	75p
4099	90p
4501	38p
4502	55p
4503	38p
4504	95p
4505	360p
4506	90p
4507/4030	35p
4508	120p
4510	55p
4511	55p
4512	55p
4513	150p
4514	110p
4515	110p
4516	55p
4517	220p
4518	48p
4519	32p
4520	60p
4521	115p
4522	80p
4526	70p
4527	80p
4528	65p
4529	100p
4531	75p
4532	65p
4534	380p
4536	250p
4538	75p
4539	75p
4541	90p
4543	70p
4551	100p
4553	240p
4555	36p
4556	50p
4557	240p
4560	140p
4566	140p
4568	240p
4569	170p
4572	45p
4583	90p
4584	48p
4585	60p
4724	150p
14411	750p
14412	750p
14416	300p
14419	260p
14490	420p
14495	450p
14500	650p
14599	200p
22100	350p
22101	700p
22102	700p
40014/4584	
40106	48p
40085	120p
40097	36p
40098	40p
40100	150p
40101	125p
40102	130p
40103	200p
40104	120p
40105	150p
40106	48p
40107	55p
40108	320p
40109	20p
40110	225p
40114	225p
40147	280p
40163	100p
40173	120p
40174	100p
40175	100p
40192	100p
40244	150p
40245	150p
40257	180p
40373	180p
40374	180p
80C95	75p
80C97	75p
80C98	75p

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ADC0808	1180p
AM7910DC	£25
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AY-3-1350	450p
AY-3-8910	450p
AY-3-8912	500p
CA3019A	100p
CA3028A	110p
CA3046	70p
CA3059	325p
CA3080	80p
CA3080E	70p
CA3086	90p
CA3089E	210p
CA3090AQ	375p
CA3130E	90p
CA3130T	130p
CA3140E	48p
CA3140T	100p
CA3160E	90p
CA3161E	200p
CA3162E	600p
CA3189E	270p
CA3240E	180p
CA3280G	270p
D7002	£8
DAC1408-8	300p
DAC0800	300p
DAC0808	300p
DG308	300p
HA1366	180p
ICL7106	675p
ICL7611	95p
ICL7650	400p
ICL7660	250p
ICL8038	400p
ICM7555	90p
ICM7556	140p
LC7120	300p
LC7130	300p
LC7137	350p
LF347	120p
LF351	80p
LF353	80p
LF355	90p
LF356N	110p
LF357	100p
LM10C	450p
LM301A	30p
LM307	45p
LM308CN	75p
LM310	225p
LM311	60p
LM318	150p
LM319	180p
LM324	45p
LM334Z	115p
LM335Z	130p
LM336	180p
LM339	40p
LM348	80p
LM358P	90p
LM377	300p
LM380N-8	150p
LM380	150p
LM381N	300p
LM382	200p
LM383	325
LM384	220
LM386N-1	100p
LM387	270p
LM391	180p
LM392N	110p
LM393	380p
LM394CH	400p
LM709	35p
LM710	48p
LM711	100p
LM723	60p
LM725CN	400p
LM733	68p
LM741	22p
LM747	70p
LM748	30p
LM1011	480p
LM1014	180p
LM1801	300p
LM1830	280p
LM1871	300p
LM1872	300p
LM1886	580p
LM1889	480p
LM2917	300p
LM3302	90p
LM3900	60p
LM3909	100p
LM3911	180p
LM3914	380p
LM3915	340p
LM3916	340p
LM13600	180p
M51513L	230p
M51516L	480p
MB3712	200p
MC1310P	180p
MC1413	75p
MC1458	48p
MC1495L	300p
MC1496	70p
MC3340P	200p
MC3401	70p
MC3403	68p
MF10CN	400p
MK50240	900p
ML920	600p
ML922	400p
MM8221A	300p
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NE544	180p
NE555	22p
NE556	60p
NE564	400p
NE565	120p
NE566	150p
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NE570	400p
NE571	300p
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SL490	300p
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SN76489	400p
SN76495	400p
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TA7130	140p
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TA7205	90p
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TBA820M	75p
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TDA1022	400p
TDA1024	110p
TDA1170S	300p
TDA2002	325p
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TDA2006	320p
TDA2020	320p
TDA2030	280p
TDA2593	500p
TDA3810	750p
TDA7000	380p
TEA1002	700p
TL081CP	40p
TL082	60p
TL084	90p
TL071	40p
TL072	70p
TL074	110p
TL081	38p
TL082	58p
TL083	75p
TL084	100p
TL094	200p
UA759	320p
UA2240	150p
UCN5801A	600p
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ULN2804	180p
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XR2206	400p
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XR2211	575p
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ZN409	180p
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ZN419P	175p
ZN423E	130p
ZN424E	130p
ZN425E8	350p
ZN426E	300p
ZN427E	600p
ZN428E	450p
ZN429E8	225p
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ZN1040E	680p
ZNA134H	£23
ZNA234E	850p

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6V		7806	50p	7906	50p
18V		7808	50p	7908	50p
12V		7812	45p	7912	50p
15V		7815	50p	7915	50p
18V		7818	50p	7918	50p
24V		7824	50p	7924	50p
5V	100mA	78L05	30p	79L05	45p
8V	100mA	78L08	30p		
12V	100mA	78L12	30p	79L12	50p
15V	100mA	78L15	30p	79L15	50p

OTHER REGULATORS

Fixed Regulators		
LM309K	1A 5V	140p
LM323K	3A 5V	250p
78H05KC	5A 5V	575p
78H12	5A 12V	750p
Variable Regulators		
LM305AH		250p
LM317T	TO-220	120p
LM317K	TO3	240p
LM337T	3A+VAR	225p
LM350T	5A+VAR	400p
LM396K	10A+VAR	£15
LM723N		50p
78HGKC	5A+VAR	650
79HGKC	5A+VAR	675p
78GUIC	1A+VAR	225p
79GUIC	1A+VAR	250p
Switching Regulators		
ICL7660		250p
SG3524		300p
TL494		300p
TL497		225p
78S40		250p

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2650A	1050p
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8502A	450p
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6800	250p
6802	300p
6809	650p
6809E	£8
68B09	£10
68B09E	£12
68000-LB	£36
8035	350p
8039	420p
80C39	700p
8080A	750p
8085A	300p
8087-5	£120
8087-8	£160
80C85A	900p
8086	£22
8088	1750p
8741	£12
8748	£12
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TMS9995	£18
V20-8	£10
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Z80CMOS	750p
8279	480p
8282	300p
8284	480p
8287	380p
8288D	650p
8755A	£16
TMS9901	£14
TMS9901	500p
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Z80CTC	250p
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Z80DART	650p
Z80ADART	700p
Z80DMA	700p
Z80ADMA	750p
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Z80BP10	800p
Z80BCTC	500p
Z80DART	900p
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3242	800p
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6522	350p
6522A	550p
6532	480p
6551	550p
6821	180p
68B21	300p
6829	£12.50
6840	375p
68840	800p
6850	180p
68B50	300p
6852	250p
6854	650p
68B54	800p
6875	500p
8154	850p
8155	380p
8156	380p
8205	225p
8212	200p
8216	160p
8224	300p
8226	425p
8228	550p
8243	280p
8250	£12
8251A	325p
8253C-5	350p
8255AC-5	320p
8256	£18
8257C-5	400p
8259C-5	400p
8275	£28

EPROMs

2516+5v	350p
2516-35	550p
2532	450p
2532-30	550p
2564	£11
2708	400p
2716+5v	350p
2716-35	550p
2732	450p
2732A-2	800p
2732A-35	£7
2764-25	200p
27C64-25	£6
27128-25	250p
TMS2716	500p

CRT CONTROLLER

CRT5027	£18
CRT5037	£12
CRT6545	£9
EF9364	£9
EF9365	£25
EF9366	£25
EF9367	£36
MC6845	650p
MC6845SP	650p
MC6847	650p
EF 9369	£12
SFF96364	£8
TMS9928	£10

INTERFACE ICs

AD558CJ	775p
AD561J	£20

AD7581	£18
ADC0808	1180p
AM25S10	380p
AM25LS2521	350p
AM25LS2538	350p
AM26LS31	120p
AM26LS32	120p
D7002	£8
DAC80-CB1-V	£28
DM8131	800p
DP8304	350p
DS3691	350p
DS8830	140p
DS8831	150p
DS8832	180p
DS8833	225p
DS8836	150p
DS8838	225p
MC1488	60p
MC1489	60p
MC3446	250p
MC3459	450p
MC3470	475p
MC3480	880p
MC3418L	880p
MC3486	250p
MC3487	250p
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MC4044	550p
	£16
MC14411	750p
MC14412	750p
ULN2003	75p
ULN2004A	75p
ULN2068	280p
ULN2802	180p
ULN2803	180p
ULN2804	180p
75107	90p
75108	90p
75109	120p
75110	90p
75112	160p
75113	120p
75114	140p
75115	140p
75121	140p
75122	140p
75150P	120p
75154	120p
75159	220p
75160	500p
75161	650p
75162	750p
75172	400p
75182	150p
75188	60p
75189	60p
75365	150p
75450	50p
75451	50p
75452	50p
75453	70p
75454	70p
75480	150p
75491	65p
75492	65p
8T26	120p
8T28	120p
8T95	120p
8T96	120p
8T97	120p
8T98	120p

81LS95	140p
81LS96	140p
81LS97	140p
81LS98	140p
88LS120	450p
9602	300p
9636A	160p
9637AP	160p
9638	180p
ZN425E8	350p
ZN426E8	350p
ZN427E	600p
ZN428E8	450p
ZN429E	210p
ZN447E	950p

MEMORIES

2101	400p
2107B	500p
2111A-35	400p
2114	150p
2114-3L	250p
2147	400p
4116-15	200p
41256-15	300p
4164-15	150p
4416-15	300p
4532-20	250p
5101	370p
5514	450p
5516	400p
5517	400p
6116LP-3	400p
6264-15	700p
6264LP-15	340p
6810	260p
74S189	225p
74S201	350p
74S289	225p
93415	600p
93425	600p

ROMS/PROMs

28L22	400p
24S10	250p
18S030	200p
18SA030	200p
74S188	180p
74S287	225p
74S288	180p
74S387	225p
82S23	150p
82S123	150p

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	£10
6843	£8
8272	£12
D765A	£13
FD1771	£20
FD1791	£20
FD1793	£20
FD1797	£22
WD1770	£24
WD2793	£27
WD2797	£27
WD1691	£15
WD2143	£12

CHARACTER GENERATORS

R03-32513	
UC	850p
LC	850p

KEYBOARD ENCODERS

AY 5 2376	1180p
74C922	600p
74C923	600p

BAUD RATE GENERATORS

MC14411	750p
COM8116	650p
4702B	750p

UARTs

AY-3-1015P	300p
AY-5-1013P	300p
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6MHz UHF	375p
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CRYSTALS

32.768 KHz	100p
1.00MHz	270p
Freq in MHz	
1.8432	225p
2.00	225p
2.45760	200p
2.5	280p
3.12MHz	175p
10.00MHz	175p
3.276	150p
3.5795	100p
4.00	140p
4.194	150p
4.43	100p
4.608	250p
4.9152	200p
5.000	150p
6.00	140p
17.734	200p
7.00	150p
7.168	175p
8.00	150p
8.867	175p
10.50	250p
10.70	150p
11.00	300p
12.00	150p
14.00	175p
14.318	160p
14.756	250p
15.00	200p
16.00	200p
18.00	170p
18.432	150p
19.969	150p
20.00	175p
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8 pin	25p	22 pin	50p
14 pin	30p	24 pin	55p
16 pin	35p	28 pin	65p
18 pin	40p	40 pin	90p
20 pin	45p		

LOW PROFILE SOCKETS BY TEXAS

8 pin	10p	22 pin	22p
14 pin	10p	24 pin	24p
16 pin	11p	28 pin	26p
18 pin	16p	40 pin	30p
20 pin	18p		

WIRE WRAP SOCKETS BY TEXAS

8 pin	30p	22 pin	75p
14 pin	30p	24 pin	75p
16 pin	42p	28 pin	100p
18 pin	50p	40 pin	130p
20 pin	66p		

OPTO-ELECTRONICS

BPX34	300p	MAN4640	200p
BPW21	300p	MAN6610	200p
FND357	100p	NSB5881	570p
MAN74/DL704	100p	TIL311	650p
MAN71/DL707	100p	ORP12	120p
		CQY 21	300p
		MAN8910 0.8"	120p
TIL32	90p	TIL78	90p
TIL31A	120p	TIL81	120p
TIL100	120p	SFH305	100p

DRIVER

9368	350p
9374	350p

COUNTERS

74C925	650p
74C926	650p
74C928	650p
ZN1040	670p

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MOC3020	150p	TIL116	70p
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		6N137	350p

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TIL212 Green	18p
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• **There were fewer business failures in the electrical engineering industry in 1986 than in 1985, according to a survey by business information company Dun and Bradstreet Ltd. The total fell from 539 to 480, a drop of 10.9%. Company liquidations fell by 11.1% to 449 whilst bankruptcies among firms, partnerships and individuals fell by 8.8% to 31. However, the survey points out that these figures are still far higher than those for other sectors of British industry. In electrical engineering the failure rate represents 4.5% of the number of registered companies while the national business failure rate is 1.4%.**

• J.A. Crewe sells a small but varied range of electronic and mechanical components, tools and assemblies. Among the new and used items listed in the current catalogue are power rheostats, electric motors, disc drives and miniature wire-ended bulbs. For a free copy contact J.A. Crewe & Co, Dawn Edge, Spinney Lane, Aspley Guise, Milton Keynes MK17 8JT. Tel: (0908) 583 252.

• *The Ferranti Super E-Line transistor handbook contains full and abbreviated data on the company's range of plastic encapsulated transistors. Medium power, high voltage and Darlington types are amongst those listed and the handbook includes application notes on typical circuits. Copies are available free-of-charge from Ferranti Electronics Ltd, Gem Mill, Fields New Road, Chadderton, Oldham OL9 8NP. Tel: 01-624 0515.*

• Precision Monolithics Incorporated manufactures ICs for use in many applications including amplifiers, converters, analogue signal processing and switching, signal measurement and much more. The range is described in a new applications handbook which provides detailed information and is indexed in several ways to make it easy to use. Copies are available free of charge from RR Electronics Ltd, St. Martins Way, Cambridge Road, Bedford MK42 0LF. Tel: (0234) 47211.

• **RDM sells test equipment from Fluke, Kent, Hitachi, Robin and many other manufacturers. The range includes oscilloscopes, multimeters, chart recorders, wattmeters and insulation testers plus a number of more unusual instruments for measuring quantities such as temperature, pressure, pH, salt content and so on. It's all described in an 8-page catalogue available from RDM Test Equipment Company, Unit 74, The Maltings, Swanstead Abbotts, near Ware, Hertfordshire SG12 8HG. Tel: (0920) 871 231.**

Portable Workstation Takes Off

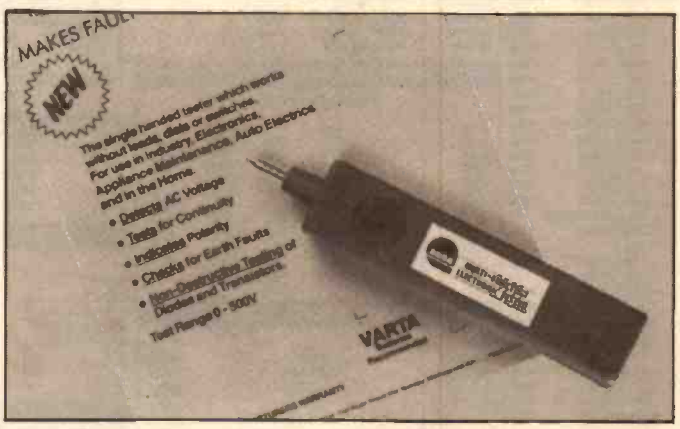
The FLT-101 workstation from Flight Electronics combines power supply, signal generator, metering and a large breadboard in a portable, benchtop unit.

According to Flight, the FLT-101 costs less than the equivalent individual items of test equipment and is ideal for use in design and development work or as an individual workstation in electronics training establishments.

The breadboard has 1680 tie points and accepts most standard components. The power supply provides 5V/1A and ±15V/0.3A DC outputs and is fully regulated and protected while the function generator offers sine, square and triangle wave outputs from 1Hz to 100kHz.

Other features include a voltmeter covering the range 0-30V, a 100μ A ammeter, a loudspeaker and various switches and potentiometers.

The FLT-101 costs £200 plus VAT from Flight Electronics Ltd, Ascupart Street, Southampton SO1 1LU. Tel: (0703) 227 721.



A Plug For The Lead-Less Tester

The neon screwdriver has been brought firmly into the microchip era with the launch of the Amba Multi-Function Tester.

This single-handed probe detects mains live voltages and also acts as a continuity tester.

It is housed in a slim rectangular case and features an insulation-piercing probe tip, a red indicator LED and a small metal touch panel. It runs from a 9V battery but has no on/off switch — it only operates when someone completes the external circuit by touching the metal panel.

For mains testing it is used in exactly the same way as a neon screwdriver. The person using it completes the circuit to earth simply by holding the tester and the LED lights up when the probe is touched against a live terminal.

In continuity testing the user touches some part of the circuit under test with their other hand, so completing a circuit through the tester. This removes the need for a probe lead. The LED will light when there is a connection between the user's hand and the tip of the probe.

The Amba Multi-function Tester has a recommended retail price of £12.60 and comes with a two-year guarantee. It is being distributed by The Goport Company Limited, York House, Empire Way, Wembley, Middlesex HA9 0QH. Tel: 01-903 2065.

Imports Hit Electronics Sales

Sales of consumer electronics products in this country rose sharply between 1983 and 1985 but the profit margins of British manufacturers fell substantially over the same period.

The disparity came about because of increased competition from Japanese and other foreign manufacturers according to a recent report from ICC Business Ratios.

This conclusion will confirm the fears of many people who believe that money from tax cuts and cheaper credit has been spent largely on imported goods.

The report shows that sales of consumer electronics goods in this country rose by 13.9% in 1983/84 (compared with 1982/83 figures) and by 18.8% in 1984/85. At the same time average industry profit margins fell from 4.3% to 2.8%. Figures for return on capital also fell over the period from 18% to 10.5%.

The only manufacturing company which did particularly well was Amstrad. ICC suggest this is because Amstrad has many of its products manufactured in the Far East and relies on established rather than emerging technologies.

The report, entitled The Consumer Electronics Industry, is available from ICC Business Ratios, 28-42 Banner Street, London EC1Y 8QE. Tel: 01-253 3906.

Technology Centre Loses Funding

The Technical Change Centre is to close following withdrawal of its remaining research council funding.

The Centre provides advice on technology to industrial users and also seeks to keep government and the general public informed on the likely impact of changes in technology.

A committee set up by the Economic and Social Research Council and the Science and Engineering Research Council reviewed the Centre's operations early in 1985. Its report called for some restructuring but recommended that funding be continued for a period of five years.

In spite of this the SERC withdrew its core funding in April last year. A recent decision by the E&SRC to withdraw its funding has removed the Centre's other major source of income. Efforts to attract funding from other sources have failed and the Directors now say they have no option but to close the Centre down.

ATE Takes On Complex Chips

A new research programme at London's Imperial College will look into the problem of testing electronic circuit boards which include complex ICs.

The programme reflects concern that advances in IC design will soon produce circuit boards which cannot be handled by existing automatic test equipment.

Known as FLAIR (Fault Location Algorithms — a programme of Integrated Research) the project will receive backing from Factron Schlumberger, a major manufacturer of automatic test equipment (ATE). The company will provide an ATE system plus a 32-bit workstation and will loan Imperial College one of its staff, Dr. Bill Rae.

According to Dr. Rae, design tools such as CAD have enabled engineers to design advanced ICs which often cannot be tested when they are in circuit. He suggests we are fast approaching a situation where functional ATE will be able to detect faults but not locate them.

FLAIR will investigate a number of approaches including the use of real-time interaction between the ATE and the circuit under test. At present ATE systems generally use pre-determined inputs which remain unchanged throughout the test. The programme will also look into the use of probability theory whereby actual and predicted failure patterns could be compared.

It is hoped that the results of the research will be useful both in the development of future generations of ATE and in the production of CAD tools which can check new designs for testability.

Factron Schlumberger, Ferndown Industrial Estate, Wimborne, Dorset BH21 7PP. Tel: (0202) 893 535.

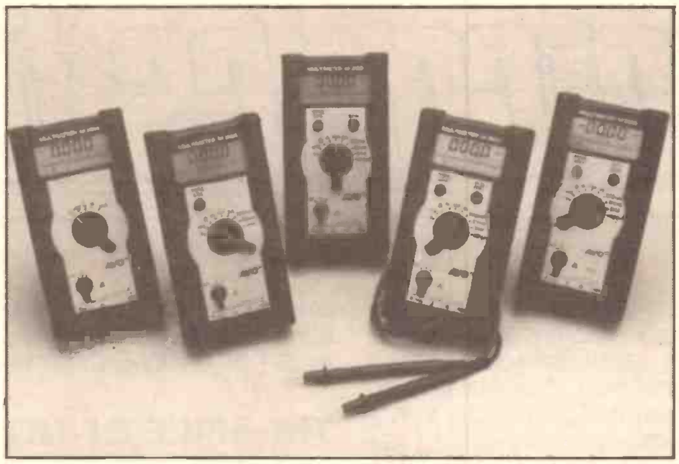
Sparking Off Muscle Growth

It may soon be possible for anyone to have a fit, muscular body without having to do any exercise, according to a recent report.

Fitness-freaks could watch television while a sequence of electrical signals triggered their muscles to produce exercise.

The technique is known as neuro-muscular stimulation and involves passing tiny electrical impulses through the skin to underlying muscles. Stroke victims and others who have suffered a loss of mobility are already being treated in this way.

The report (no. 737) is produced by International Resource Development, 6 Prowitt Street, Norwalk, Connecticutt 06855, USA.



German 'AVOs' have Analogue Display

Thorn-EMI are marketing a range of digital multimeters which feature a high-resolution analogue display and an unusually rugged case design.

Manufactured by Metrawatt GmbH of West Germany, they will be sold under the well-known AVO brand name following a recent agreement on marketing and development.

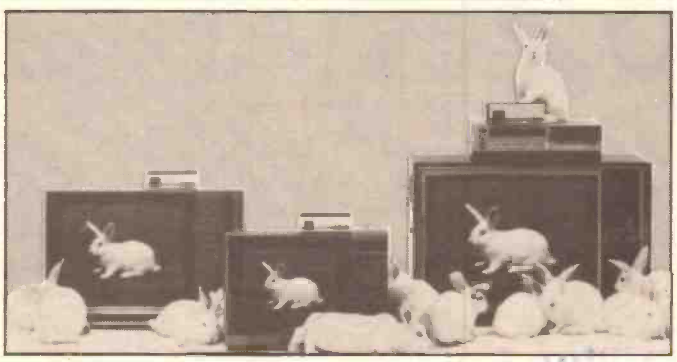
The meters combine a 10.5mm high 3¾ digit display with a 70-division analogue scale traversed by a moving pointer. Thorn-EMI says the resolution available is far higher than on other analogue/digital meters.

The case design features two side 'buffers' made from an impact-absorbing material which provides a high degree of protection should the meter be dropped or otherwise mishandled.

The five models in the range all offer voltage measurement up to 1000V AC and DC, resistance measurement from 300R to 30M FSD and at least one AC/DC current range rated at 10A but capable of handling 20A for short periods. Range selection is generally automatic but there is an additional switch-selected 300mV AC/DC range and all models incorporate a diode test function.

Prices range from £89 to £210 plus VAT and a list of dealers is available on request.

Thorn-EMI Instruments Ltd, Archcliffe Road, Dover, Kent CT17 9EN. Tel: (0304) 202 620.



American Rabbits Invade Britain

The VCR Rabbit is presumably so-named because it 'breeds' TV signals but the term rabbit-like might also be applied to the way in which the machines themselves have been multiplying.

The manufacturer claims to have sold 600,000 of them in America since the product was launched a year ago and the Rabbit is now set to over-run this country too.

The Rabbit takes the signal from a video cassette recorder and multiplies it for use by up to five television sets around the house. The only cabling required is a single, 0.7mm thick wire between units and if the VCR has a remote control facility the Rabbit will allow it to be operated from any of the five TV positions.

The system uses a transmitter which connects directly to the VCR and one adjacent TV set while the remaining TVs are connected to receiver units which are 'chained' along the wire. The UHF signal from the VCR is converted to a low-frequency signal for transmission along the wire and then converted back to a UHF signal at each receiver unit.

Further details from S.A.R. Chipstone, 27 Northolt Road, Harrow, Middlesex HA2 0LS. Tel: 01-864 7512.

• Philips Test & Measurement has published a short brochure on the IEEE 488 instrument communications standard. The brochure explains the rationale behind IEEE 488 and lists all the Philips test equipment products currently available with this capability. Copies can be obtained free-of-charge from The Sales Promotion Department, Enquiry Handling Section, Pye Unicam Ltd, York Street, Cambridge CB1 2PX. Tel: (0223) 358 866.

• Micrologic have copies of a new 5-page guide to advanced logic devices from Monolithic Memories Incorporated. The range includes numerical processing, FIFO and memory support ICs and the guide includes a set of tables which compare the performance of MMI products with those from rival manufacturers. The guide is available free of charge from Micrologic Ltd, The Cornerstone, The Broadway, Woking, Surrey GU21 5EZ. Tel: (04862) 29551.

• Bulgin's complete range of electrical and electromechanical components is described in a new 272-page illustrated catalogue. It includes all necessary technical data and is laid out in an easy reference format. Aimed at design engineers and buyers it is available from The Marketing Department, A.F. Bulgin & Company PLC, Bypass Road, Barking, Essex IG11 0AZ. Tel: 01-594 5588.

• The popular Analyser II software package from Number One Systems is now available for use with Research Machines Nimbus microcomputers. Reviewed in the March 1987 issue of ETI (in its BBC micro version), the package allows the user to build up a circuit on screen and then analyse it for gain, phase, group delay and impedance characteristics over a wide range of frequencies. For details and price contact Number One Systems Ltd, 9A Crown Street, St. Ives, Huntingdon, Cambridgeshire PE17 4EB. Tel: (0480) 61778.

• How many electric motors would you expect to find in the average motor car? Five? Six? Seven or more? According to a recent report by market research company Frost and Sullivan Ltd, the number of electric motors used in cars is expected to rise considerably in the near future from its present figure of 'only 16' per vehicle. Sixteen! And that is the figure for an average car which is unlikely to include automatic windows or anything fancy like that. If you can list sixteen electric motors on an average car you're doing a lot better than the ETI staff did!

NEXT MONTH

AN ARGUS SPECIALIST PUBLICATION

electronics today INTERNATIONAL

EEK! IT'S EEG

Tense? Nervous? Brain not working? Forget the aspirin, what you need is an ETI brainwave monitor. Starting next month, the ultimate electronic health project. Aquaint yourself with alpha. Battle with beta. Get along with gamma. Defy delta. ETI is committed to making this a better world to live in and the best method is to get everyone to plug their head into an ETI brain-drain machine — totally safe but the ultimate experience. Tune in next month for your dose.

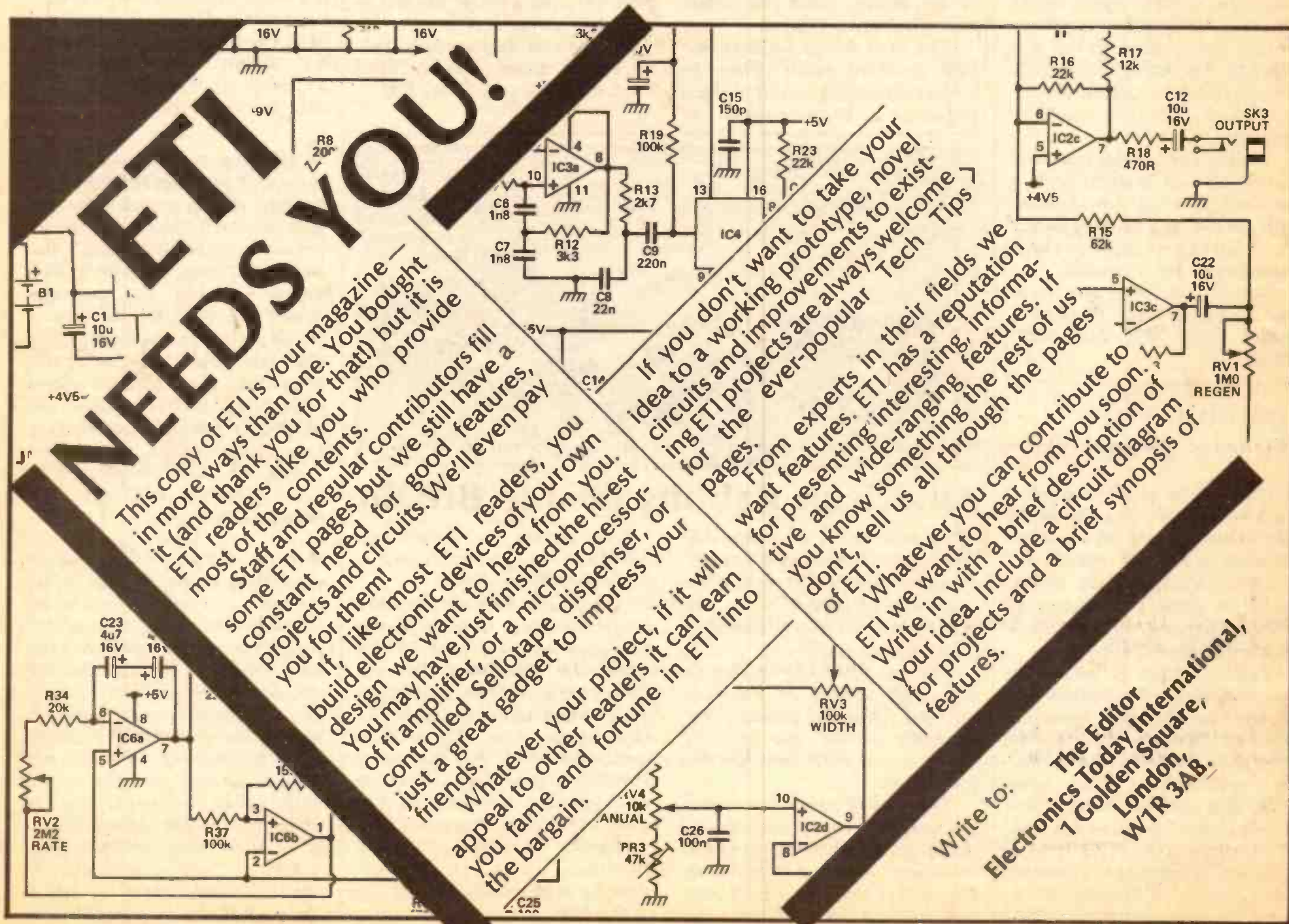
Summer's nearly over (what do you mean you haven't noticed it start yet?) so it's time to think about those long cold winter's nights when the thermostat goes on the blink and the boiler will only heat the water to 12°C. Fit an ETI Boiler Controller now while there's still time.

THE SPICE OF LIFE...

...is variety (and also an excellent pub not far from here...) Next month ETI has more variety than you could possibly want. The only mag with a digital sound sampler for the Amstrad CPC micros, a PA system you can carry with one finger and all the latest on 3D television plus the usual mind-gripping news and views, Hardware Design Concepts, Circuit Theory, Tech Tips and all that matters to the electronics enthusiast.

THE SEPTEMBER ETI — OUT 7th AUGUST

All the articles listed are in an advanced state of preparation but circumstances beyond our control may prevent publication.



ETI NEEDS YOU!

This copy of ETI is your magazine — in more ways than one. You bought it (and thank you for that!) but it is ETI readers like you who provide most of the contents. Staff and regular contributors fill some ETI pages but we still have a constant need for good features, projects and circuits. We'll even pay you for them!

If, like most ETI readers, you build electronic devices of your own design we want to hear from you. You may have just finished the hi-est of fi amplifier, or a microprocessor-controlled Sellotape dispenser, or just a great gadget to impress your friends.

Whatever your project, if it will appeal to other readers it can earn you fame and fortune in ETI into the bargain.

If you don't want to take your idea to a working prototype, novel circuits and improvements to existing ETI projects are always welcome for the ever-popular Tech Tips pages.

From experts in their fields we want features. ETI has a reputation for presenting interesting, informative and wide-ranging features. If you know something the rest of us don't, tell us all through the pages of ETI.

Whatever you can contribute to ETI we want to hear from you soon. Write in with a brief description of your idea. Include a circuit diagram for projects and a brief synopsis of features.

Write to: The Editor, Electronics Today International, 1 Golden Square, London, W1R 3AB.

High-Res Graphics From Micro Concepts

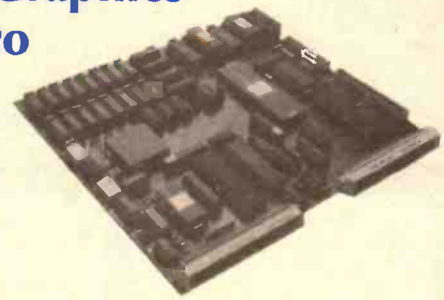


Image-10 is a new 16-32bit single-board computer from Micro Concepts, the company which produced the 6909-based microcomputer featured in ETI last year.

The new design uses a 68010 microprocessor with a 82786 graphics co-processor to provide high speed with high resolution. The board has extensive I/O facilities and supports several popular software formats.

Prices start from £1295 and further details can be obtained from Micro Concepts, 2 St. Stephens Road, Cheltenham, Gloucestershire GL51 5AA. Tel: (0242) 510 525.

• Siemens publish booklets on many aspects of their research, development and manufacturing activities. Among the latest batch to arrive are one on surface mounting components and technology and another which looks in detail at several different types of components including gate-turn-off thyristors. The booklets are well illustrated and include notes on applications, case histories, interviews with leading figures in the company's R & D operation plus simple, clear explanations of new technologies and circuit techniques. Much of the material would be ideal for educational use. For copies of Siemens Components booklets contact Siemens Ltd, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex TW16 7HS. Tel: (09327) 85691.

Superconductivity Research Hots Up

Scientists at Plessey's Caswell Research & Technology centre claim to have achieved superconductivity at just below –185°C, the highest temperature yet reported by a British laboratory.

They are confident the process can be repeated at even higher temperatures, allowing superconductivity to be achieved using conventional freezing agents such as liquid nitrogen. This would open up the way for a whole range of practical applications including zero-loss power distribution cables, frictionless magnetic bearings and lower power, higher speed logic circuits.

The benefits of superconductivity have been known for many years. Electrical conductors lose all their resistance below a certain temperature with the result that electrical energy can be transferred without losses. A current made to circulate in a loop of superconducting material will continue indefinitely without a power source to drive it.

Unfortunately, superconductivity has hitherto been achieved only at very low temperatures indeed, and the cost of maintaining such an environment far outweighs the benefits.

Plessey claims to have overcome these problems through the use of a ferroelectric ceramic material. Ceramics act as electrical insulators at normal temperatures, but recent research showed they could also act as superconductors.

With over 30 years experience of ceramic materials research to draw on, Plessey set up the Caswell programme early this year and began formulating a new ferroelectric crystal two months ago. Tests on the new material led to the announcement of a breakthrough on May 14th.

Plessey is continuing its research work in an effort to achieve superconductivity at temperatures nearer to normal atmospheric conditions. Potential applications include the distribution of electrical energy over long distances without loss, removing the need for high-voltage cables and pylons. In mechanics it could be used in magnetic levitation systems, opening up the prospect of friction-free bearings. It could also revolutionise such fields as telecommunications, radar and computing.

DIARY: DIARY: DIARY: DIARY: DIARY: DIARY: DIARY: DIARY:

Amstrad Computer Show — July 10-12th
Alexandra Palace, London. Dominated by software, etc, for the PC1512 IBM-clone but there should be plenty to interest owners of other Amstrad machines. Contact Database Exhibitions on 061-456 8835.

Radio Frequency Techniques — July 19-24th
University of Bradford. Vacation school. Contact the IEE at the address below.

Satellite Communications System — July 26-31st
University of Surrey. Vacation school. Contact the IEE at the address below.

Television By Numbers — September 11th
The IBA, London. Seminar on digital television techniques. Covers the subject from first principles for the benefit of managers, analogue engineers and others unfamiliar with the technology. Contact the BKSTS at the address below.

Designing For Electromagnetic Compatibility — September 13-18th
University of Sussex. Vacation school. Contact the IEE at the address below.

7th International Display Research Conference — September 15-17th
The IEE, London. See July '87 ETI or contact the Institute of Physics on 01-235 6111.

Eurodisplay '87 — September 15-17th
The IEE, London. Conference covering all aspects of electronic display research. Contact the Institute of Physics.

Electronics In Engineering Design — September 15-18th
NEC, Birmingham. Exhibition and conference on mechanical/electronic systems interfacing. Contact Cahners at the address below.

Design Engineering Show — September 15-18th
NEC, Birmingham. See July '87 ETI or contact Cahners at the address below.

IDEX '87 — September 21-23rd
Metropole Exhibition Halls, Brighton. See April '87 ETI or contact Nutwood Exhibitions on (04848) 25891.

Semiconductor International — September 29-October 1st
NEC, Birmingham. See July '87 ETI or contact Cahners at the address below.

Internepcon — October 6-8th
Metropole Convention Centre, Brighton. See July '87 ETI or contact Cahners at the address below.

Digital Audio Post Production — October 11th
BAFTA, London. Training seminar organised by the BKSTS. Contact them at the address below.

Automotive Electronics — October 12-15th
The IEE, London. See July '87 ETI or contact the IEE.

Computer Graphics Exhibition and Conference — October 13-15th
Wembley Conference Centre, London. For details contact Online on 01-868 4466.

Conference For Young Engineers — October 16-18th
Strand Palace Hotel, London. See July '87 ETI or contact the IEE at the address below.

International Video & Communications Exhibitions — October 18-21st
Metropole Exhibition Centre, Brighton. See July '87 ETI or contact Peter Peregrinus Ltd at the IEE address below.

Radar '87 — October 19-21st
Kensington & Chelsea Town Hall, London. See July '87 ETI or contact the IEE at the address below.

Testmex '87 — October 20-22nd
Business Design Centre, London. See July '87 ETI or contact Network Events at the address below.

Interact '87 — November 17-19th
Kensington Exhibition Centre, London. See June '87 ETI or contact Network Events at the address below.

Addresses:
British Kinematograph Sound and Television Society, 547-549 Victoria House, Vernon Place, London WC1B 4DJ. Tel: 01-242 8400.

Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham TW1 3SZ. Tel: 01-891 5051.

Institution of Electrical Engineers, Savoy Place, London WC2 0BL. Tel: 01-240 1871.

Network Events Ltd, Printers Mews, Market Hill, Buckingham MK18 1JX. Tel: (0280) 815 226.

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BD132	0.60
BD135	0.34
BD136	0.35
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BFX85	0.40
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TIP31A	0.48
TIP31B	0.56
TIP31C	0.54
TIP32A	0.42
TIP32C	0.42
TIP33A	1.00
TIP41A	0.63
TIP42A	0.55
TIP3055	0.76
TIP2955	0.76
ZTX300	0.17
ZTX500	0.17
2N3053	0.60
2N3054	1.60
2N3707	0.12
2N3703	0.12
2N3705	0.12
2N3771	1.40
2N3904	0.15
2N3906	0.15

DIODES

IN4001	0.05
IN4002	0.05
IN4003	0.06
IN4004	0.06
IN4007	0.08
IN4148	0.06
IN4448	0.06

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14 pin DIL	0.12
16 pin DIL	0.13
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40 pin DIL	0.30

OPTO ISOLATORS

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3021 Triac driver	1.50

LEDs

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Red	0.18
Yellow	0.18
Green	0.18
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Red	0.35

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TIC225D 8 Amp 400V	0.90

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4V7	0.10
10V	0.10
12V	0.10
BZX55C 500m W	
24V	0.10
BZX85C 1.3 Watt	
4V7	0.20
10V	0.20
12V	0.20
24V	0.20

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47uF	25V	0.10
100uF	25V	0.12
470uF	25V	0.28
1000uF	25V	0.36
220uF	25V	0.15
Tantalum		
0.1uF	35V	0.10
0.22uF	35V	0.10
0.47uF	35V	0.10
1uF	35V	0.10
2.2uF	35V	0.15
4.7uF	35V	0.20
Ceramic		
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470pF	500V	0.06
1000pF	100V	0.06
2200pF	100V	0.06
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120K 150K 180K 220K
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560K 680K 820K 1M

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Miniature horizontal or verticle Values: 100R 220R 470R 1Kq 2K2 4K7 10Kq 22Kq 47Qk 100Kq 220Kq 470Kq 1Mq 0.19

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NE555	0.30	ZN414	0.90
NE556	0.65	ZN416	1.60
LM301	0.28	LM308	0.70
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READ/WRITE

Crossed Line

A slight error crept into the excellent article on 'The Telephone System' in the June issue.

The out of service resistor in a master socket is not to hold a call. It is in series with the bell capacitor so that when all phones are unplugged the terminal still presents an AC (but not DC) path to line testing equipment at the exchange. A full disconnection therefore indicates a line fault. When a phone is plugged in, it's bell simply shunts the resistor.

D. B. Lyall
Cheltenham, Gloucestershire.

Keith Brindley says the UK phone system is the best in the world — rubbish!

The UK system is the worst in the world and the most costly. If you want a box changing it will cost £25 and to put in a phone costs £100. Then there's standing charges on top of that plus the £3.10 a month for the set. Phone boxes are years out of date and always vandalised by the public fed up trying to get through.

The US system is the best. The UK system is rubbish and 50 years out of date.

H. Hollins
Leeds, Yorkshire.

To be fair, Keith Brindley only suggested the UK system itself is the world beater and cited its non-failure during the recent engineer's strike as proof. The prices charged by BT and their organisation he is as vocal about as the next man, as regular readers of his Open Channel column will know.

Phone box vandalism is rarely due to disgruntled BT customers but a fact of today's life (both here and in the US). It is to counteract this very fact that BT is currently (and controversially) replacing the 'out of date', but extremely popular, red boxes with new high tech booths.

Our thanks to D. B. Lyall and all the others who wrote in to put us right on the out of service resistor.

Out Classed

The May Issue of ETI has just passed across my desk and I found two articles of particular and peculiar interest.

The first was Andrew Armstrong's article 'The Truth About Hi-Fi' which examined many popular items of misinformation put about by those who 'know' about hi-fi. Regrettably they usually know very little but will readily jump on this week's fad.

The second article was Ian Pitt's review of the Sage Audio power amplifier modules. Not only did he insist on going into all the nebulous arguments which Andrew Armstrong had shown to be fallacial, he even had the gall to include some very obviously impossible statements.

He says, for instance, that the modules feature a class A output stage. He then claims an efficiency of 70% — not only clever but impossible. A class A output stage has a maximum efficiency of 50% and this assumes 100% efficient output devices and no other current required for driver circuitry, etc.

With a claimed power output of up to 150W RMS, the total dissipation within the amplifier would be a little under 780W and a transformer of at least 1kVA per channel would be required. This makes a mockery of Ian Pitt's argument for using a 500VA transformer in preference to a 225VA unit.

No wonder the general public is taken in by all the rubbish printed about hi-fi when even ETI technical authors believe all they read in manufacturers handouts!

J. Howes
Salisbury.

Ian Pitt replies: Sage claims to have developed a high-efficiency 'dynamic' class A system for use in the Superamp and SuperMOS modules. Given more space and a chance to see the circuit diagrams it would have been worth exploring this claim in some detail. As it was, I could only pass on the claims and then review the modules as I found them.

The modules exhibit the sort of efficiency normally associated with class B designs. This may be because they use some stunning new variant of the class A system or because they use good old-fashioned class B, but I have no means of knowing. I can only report what I found, which is that the modules work perfectly well with a 225VA transformer.

As for Mr. Howes' opening remarks, I'm glad he liked 'The Truth About Hi-Fi' article but I wasn't aware Andrew had *'shown'* any arguments to be fallacious. What he did was to express his opinion that some arguments were fallacious. I would agree with much that he said but I would also differ on some points.

How Much RIAA?

Armed with the knowledge ETI has given me I design and build hi-fi preamps. They usually outperform commercial equipment.

So, while I thank you for Wilfred Harms' interesting article on RIAA networks, pragmatism demands a simple question: forgive my evil suspicion but is it possible the record companies only use the same kind of two resistor/two capacitor networks (which Mr. Harms wishes to modify) for the RIAA pre-emphasis in the first place.

I'd love to know whether this striving for accuracy is worth the bother.

R. Leach
Hurst Hill, West Midlands.

Far be it from us to spread malicious rumours but we wouldn't be surprised if some of the smaller record companies cut a few corners in this department. However, the likes of Deutsche Gramaphon are hardly likely to skimp on the EQ so if you listen to this kind of material it will be worth it.

Timely Advice

I am glad to see you welcome letters on any topic 'past, present or future' (Read/Write, June 1987).

Well, after completing the time machine project from the January 2196 issue it has developed a fault while testing and has stranded me here (and now).

Unfortunately I did not bring the circuit diagram but I think the problem lies in the Bramble-weeny Bozon warp vortex control circuit, possibly in the superconducting coils of the vortex bottle.

I can only describe the noise it makes on starting as the sound of a C5 (the basis of all personal transport in the 22nd century) embedding itself in the underside of a juggernaut. I do hope you can help.

Per Isstak
Dundee, Scotland.

No problem, this one. We were sent the circuit details by the ETI photocopy service from 2196 via the (working) prototype. We have forwarded all the details you need by C5-mail. However, I'm afraid our calculations show this will take around 209½ years to get to Dundee.

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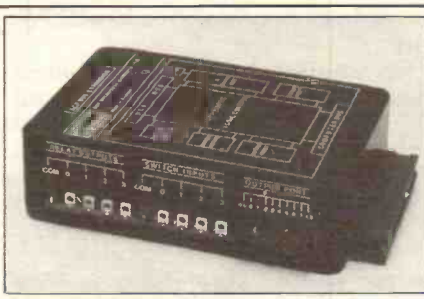


INTERSPEC £29.95

The Interspec unit plugs directly onto the expansion edge connector of the Spectrum to provide a full range of interfacing facilities.

The unit is housed in a plastic case approximately 4½x3x1in which contains the top quality double sided PCB and interface connections.

- **8-bit input port**
- **8-bit output port**
- **four switch sensor inputs**
- **four relay-switched 12V 1A outputs**
- **eight channel multiplexed analogue to digital converter**
- **15-way expansion bus**

All sections of the interface are I/O port mapped and designed for maximum compatibility with existing Spectrum peripherals. Power is supplied through the Spectrum edge connector.

The expansion bus provides all the data and address/control signals for the addition of further DCP modules or home-built devices. Connection is by multi-way PCB connector and all the information required for adding further devices is given.

INTERBEEB £49.95

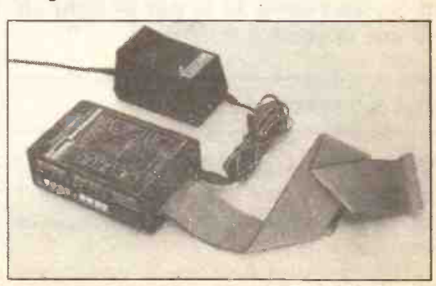
The Interbeeb unit connects to the BBC micro's 1MHz bus expansion connector and is supplied complete with its own power supply unit.

The interface unit is housed in a plastic case approx 4½x3x1in which contains the top quality double sided PCB and interface connectors.

- **8-bit input port**
- **8-bit output port**
- **four switch sensor inputs**
- **four relay-switched 12V 1A outputs**
- **eight channel multiplexed analogue to digital converter**
- **precision 2.5V reference**
- **external power supply**
- **15-way expansion bus**

All sections of the interface are memory mapped in the 1MHz expansion map for maximum ease of use and compatibility with existing peripherals.

The expansion bus provides all the data and address/control signals for the addition of further DCP modules or home-built devices. All the information required for using additional devices is included.



THE ELECTRONIC CAR

Keith Brindley has found that electronics is beginning to stretch to more than just the cassette/radio in the modern car.

On the surface modern automobiles have changed little since Ford's Model-T. Granted, modern cars cost a bit more and come in a greater range of colours but they do the same job and arguably are only marginally better than the original mass-produced car.

Yet a great deal is happening to the modern motor car that is hidden away under the bonnet. After what was probably a slow start, car makers at the turn of the decade realised that electronic systems and computer (particularly microcomputer) controls were going to have an enormous impact on the automobile market. Indeed, over the last ten years cars have seen more changes (most of them barely detectable to the customer) than they had experienced in the previous 70 years of their existence.

To be fair to the car manufacturers there were reasons why electronics and computers weren't adopted into motor vehicles they way they have been adopted into the home (in the form of home computers, hi-fis, videos etc). The main reason is the very fact that the car carries with it its own extremely hostile environment. Temperatures and humidities in and around a car vary over an enormous range — far more than the average turn-of-the-decade electronic circuit could cope with. Winter temperatures can be well below freezing and summer cockpit temperatures rise into the 50s and 60s (Celsius) even in our 'temperate' climate. Given this and the vibration, acceleration, and deceleration common in all cars, manufacturers were faced with the probability of an unreliable product which would give too much trouble.

Electronics reliability started with Large Scale Integration (LSI). Since the turn of this decade, LSI has really taken off. For the motor car makers LSI heralded the beginnings of a new age in cars, allowing them to offer the customer a number of changes which previously weren't possible. Some of these changes have been the result of governmental regulations on safety and pollution. On the other hand, some changes were customer initiated, brought about by rising fuel costs, extra demands for comfort and the quest for greater reliability.

It's not just the *addition* of electronics which has brought about this new age of motor cars. Associated transducers have been developed specifically for use in cars, allowing the control system to sense necessary inputs through sensors and control necessary functions with the help of actuators.

We can break down electronics systems in the car into two main areas, engine control and safety, and these are the areas we'll cover here. Additionally a fair amount of electronics is appearing inside the cockpit in instrumentation display and comfort control systems but to do justice to such systems would require more space than we can afford here.

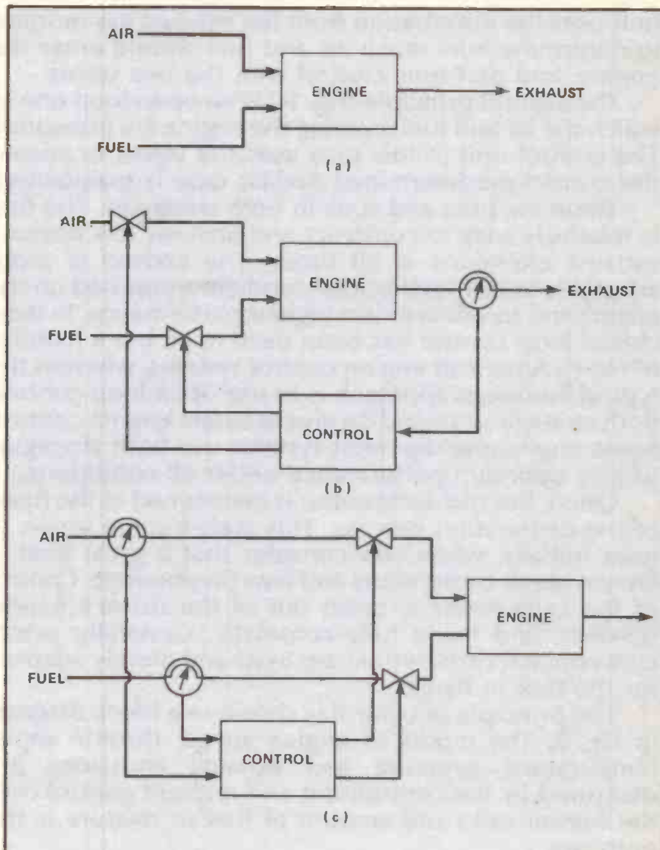


Fig. 1 Carburation control strategies (a) No control. (b) Closed loop control. (c) Open loop control.

Engine Control

Most readers will know all too well the principles of the spark-ignited, internal combustion, four-stroke engine. It only remains for us to see how modern electronics has invaded the carburation and ignition processes.

Carburation and ignition are pretty simple processes in terms of electronics but the overall engine performance relies totally upon them. If the right quantity and strength of the fuel/air mixture is not present in the right cylinder at the right time and if the spark generated by the ignition system is not produced at the right spark plug at the right time, *for every load condition imposed on the engine,* then the engine will not perform to its maximum capabilities. As we'll see soon, one system relies upon the other to a very large extent.

Manufacturers' first problem is to make carburation and ignition systems more precise. To do this, a number of different engine management systems have evolved. Some of these systems maintain carburation and ignition as physically separate (though interdependent) systems. Others combine the two in a complete system.

Carburation

One of two control strategies is used in all electronic carburation systems. The basic non-electronic carburation principle is shown in Fig. 1a, where air and fuel are inputs to the engine and exhaust gasses are the output. The first control strategy (Fig. 1b) is a closed loop in which the exhaust gas is monitored to ensure the correct fuel/air ratio is maintained, so indicating that the engine is using fuel to its maximum capabilities. A control unit uses the information from the exhaust gas monitor to determine how much air and fuel should enter the engine, and performs control with the two valves.

The second principle (Fig. 1c) is an open loop one in which the air and fuel entering the engine are measured. The control unit in this case uses the valves to ensure the correct predetermined fuel/air ratio is maintained.

There are pros and cons in both strategies. The first is relatively easy to construct and ensures low noxious exhaust emissions at all times. The second is more adaptable to suit varying load conditions imposed on the engine and so will maintain highest performance. To date, closed loop control has been used in all but a handful of North American engine control systems, whereas the typical European approach is to use open loop control. Both strategies can and do give accurate engine control. Some engine management systems use both strategies to give optimum performance under all conditions.

Often, the 'old' carburettor is maintained as the heart of the carburation process. This makes some sense, at least initially, when you consider that a great deal is known about carburettors and how they operate. Control of the carburettor is taken out of the driver's hands, however, and made fully automatic. Generally, pretty conventional carburettors are used and merely adapted for the task in hand.

The principle of control is shown in a block diagram in Fig. 2. The inputs of engine speed, throttle angle, temperature, pressure and exhaust emissions are measured by the control unit and relevant control over the fuel/air ratio and amount of fuel/air mixture is the outcome.

By measuring temperature (both ambient and engine), the control unit can decide whether the engine is being cold-started and operate the choke valve giving fuel enrichment when required. By measuring outside pressure the control unit can take into account altitude variations, adjusting fuel/air ratio and quantity to suit. A measurement of exhaust emissions allows the control unit to maintain exactly the right proportions of fuel and air to ensure all the fuel is being used and no waste chemicals are being exhausted into the atmosphere. So, a closed loop control of this type ensures reasonable economy of fuel *and* helps to meet stringent exhaust emission regulations.

Transducers

Varieties of electronic carburettors differ only in the actuators used to control choke and throttle valve position. Typically, the actuators will be servomotors,

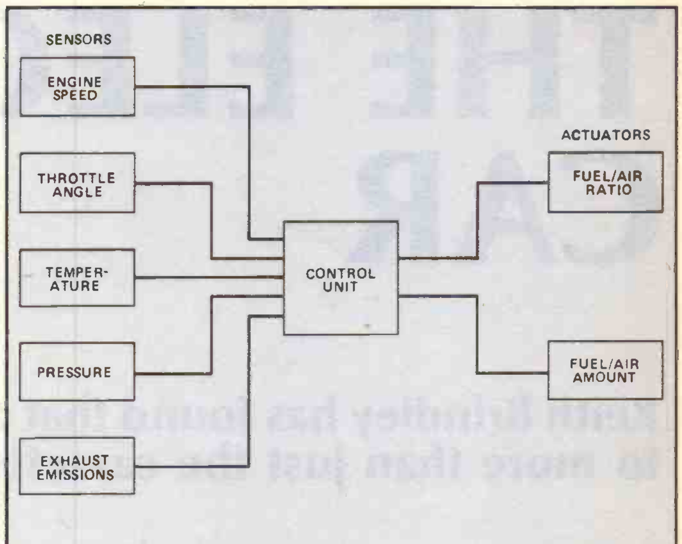


Fig. 2 Electronic carburettor control principles.

turning their central spindles through 0° to 90° in response to control signals. Such devices offer accurate control and high speed so rapid variations of each carburettor valve setting can be made — useful when kick-down acceleration is required because the fuel/air mixture can be enriched momentarily to aid acceleration. Other types of actuators used in an electronic carburettor include torque motors, electropneumatic actuators, stepper motors, and so forth.

Sensors in the system of Fig. 2 are used for measuring ambient temperature and engine temperature (both simple thermistor or thermocouple devices), the driver's depression of the accelerator pedal (rotary potentiometer mounted on the pedal itself), engine speed and exhaust gas. Engine speed is usually monitored by sensing the rotational speed of the crankshaft with a simple coil arrangement in which a voltage is induced each time a tooth of the flywheel passes the sensor. Sometimes, however, engine speed can be measured optically or with a Hall effect sensor again detecting crankshaft speed or by simply counting the number of ignition sparks over a period of time or using numerous other methods.

The Hall effect approach is probably the most suitable for a number of reasons. No interfacing circuits are required between the sensor and the control unit, a digital (squarewave) output is obtained (unlike inductive/reluctive and tachometrical methods), sensor performance is not degraded by dirt or corrosion (unlike optical methods) and reliability is good.

Exhaust gas is typically monitored using a sensor capable of detecting residual carbon monoxides, nitrogen oxide, or unburnt hydrocarbons in the exhaust emissions. The main principle behind the use of exhaust gas sensors is that a weak fuel/air mixture (too much air in the fuel/air mixture) will cause nitrogen oxide to occur in the exhaust emissions (Fig. 3). Apart from unwanted gas, engine power is reduced. On the other hand, if a strong fuel/air mixture (too much fuel) is supplied to the engine then although engine power is a maximum and emissions of nitrogen oxide are reduced, carbon monoxide and hydrocarbons will be present in the exhaust gases.

Complete combustion of petrol and air occurs when the fuel/air ratio is approximately 15:1. At this ratio the mixture is said to have an excess air factor, sometimes called the equivalance ratio or λ, of one, where:

$$\lambda = \frac{\text{actual quantity of air}}{\text{theoretical air quantity}}$$

That is, when $\lambda = 1$, combustion is theoretically complete and few hydrocarbons are emitted in the exhaust. When λ is less than one the fuel/air mixture is too rich, creating carbon monoxide and hydrocarbon emissions. When λ is greater than one the mixture is too weak, reducing engine power and emissions of nitrogen oxide are quite high. Because of this oxygen sensors used to measure exhaust emissions are often called 'lambda sensors'.

The two main types of lambda sensors are the zirconia oxide type, and the titanium oxide type. Functions of both types are similar — any oxygen present in the exhaust emissions are diffused into the porous material, allowing a voltage to be generated across two electrodes which changes sharply at the λ = 1 point. Generally, lambda sensors are available in a small package (Fig. 4) which bolts directly into the exhaust pipe.

Control process is quite simple: reduce the amount of air entering the engine until the point where levels of carbon monoxide and hydrocarbons just start to increase rapidly. At this point the fuel is being used most efficiently. To allow for changing engine load conditions altering the fuel/air requirements, it is necessary for the control systems to constantly monitor the exhaust gas levels in a cycle, increasing the amount of air intake until carbon monoxide disappears then backing off until it is just sensed again.

Burning Ambition

In America and Japan lambda sensors have been used since 1976 in closed loop control systems of this sort to reduce unwanted engine emissions. They run the engine exactly at the λ = 1 point, then use a catalytic converter in the exhaust system to further reduce noxious unwanted wastes. As yet, the UK has no regulations requiring such low emissions and as the cost of catalytic converters is high this technique has not found favour in UK vehicles. Economy seems to be the European market's primary concern.

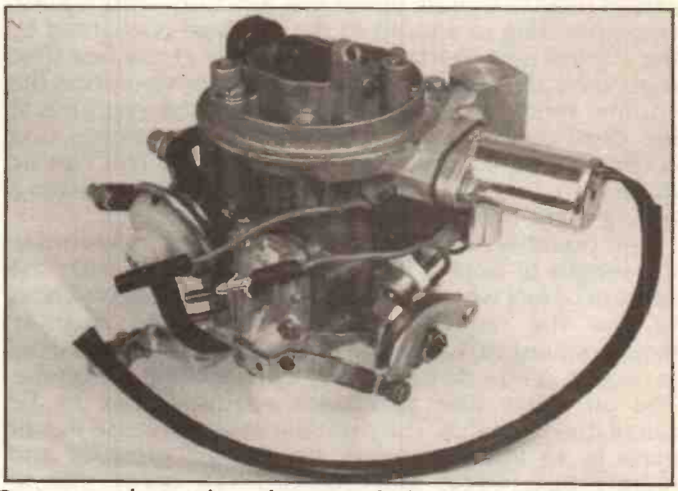
However, considerable interest has been shown recently in Europe about the fact that nitrogen oxide emissions fall off as the excess air factor increases well above one (as the fuel/air mixture gets very weak). Lambda sensors have been used in this way to produce the 'lean-burn' engines now available. These run the engine at an excess air factor up to 1.5 as long as the engine's full power is not required (when coasting on an open road). Whenever power is needed the control unit automatically adjusts the excess air factor.

EFI

Electronic carburation allows reasonably accurate control of fuel/air mixture ratio and amount. One of its few disadvantages is that the fuel/air mixture is still sucked into the cylinder from the carburretor via the inlet manifold. It's a bit of a sloppy method, when you think about it, which can't ensure that all of the fuel/air mixture produced by the carburretor for a particular cylinder actually gets into that cylinder. Some may remain in the inlet manifold until the *next* cylinder inlet valve opens. This can be overcome by having a separate carburettor for each cylinder but that's a bit of a Heath Robinson arrangement and is costly so most car manufacturers have gone to electronic fuel injection (EFI) systems to get round the problem.

In the best EFI systems (using 'multi-point injection') separate fuel injectors place a precisely measured quantity of fuel into individual cylinders, at precisely the right moment — an instant before the inlet valve for that cylinder opens. In systems with slightly lower specifications, fewer injectors may be used (as few as one per engine simply replacing the carburettor — single point injection) and timing of the injection may not be so precisely controlled. Nevertheless, any type of EFI system represents a great advance in the engine carburation process and more and more cars will be fitted with EFI as time goes by. Their higher accuracy in terms of control over fuel/air ratios mean that exhaust emissions can be kept to low levels without sacrificing engine performance.

A typical EFI system is shown in Fig. 5. It is classed as a multi-point system (because it has one injector per cylinder) and a control unit turns each injector on at the required time, for the length of time necessary to inject the required amount of fuel. Fuel pressure is maintained at a constant level with the use of a pressure regulator.



Prototype electronic carburettor designed by Weber for Fiat,

It would be perfectly possible to use the closed loop control strategy of Fig. 1b with a lambda sensor to measure exhaust emissions and maintain the optimum fuel/air mixture (indeed, some systems do). EFI systems often use the other engine control strategy (Fig. 1c), in which fuel and air quantities are measured to ensure the correct fuel/air mixture. A few of the more modern EFI systems even use both strategies with the microprocessor determining which strategy to follow at any particular time. The main reason for this approach is that closed loop control is more of an analogue approach and doesn't easily take into account such engine operations as cold-starting (when a rich mixture is required for a considerable period), warm-starting (when a quick burst of rich mixture is required) and heavy load conditions. An open loop control strategy, on the other hand, lends itself to microprocessor-based control methods which can easily cater for both usual and unusual load options.

Apart from sensors to detect engine speed,

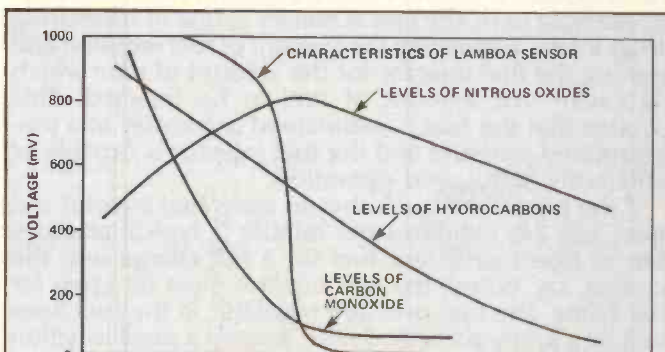


Fig. 3 Output voltage characteristics of a typical lambda sensor showing levels of nitrous oxides, carbon monoxide and hydrocarbons dependent on the excess air factor used in an engine.

accelerator pedal position, engine temperature and air temperature (all present in the closed loop strategy), sensors are also required to measure engine position and quantity of air. However, no measurement of fuel quantity is incorporated. This is because the quantity of fuel entering a cylinder is determined automatically by the length of time a fuel injector is open as the fuel in the feed lines is maintained at a constant pressure.

A knowledge of engine position is necessary so that fuel is injected from a fuel injector at the precise moment the inlet valve of the corresponding cylinder opens. In effect, the same sensor which measures engine speed can be used to double up for this function — each pulse corresponding to a tooth in the flywheel is counted by the control unit so that the count value at any one time represents the engine position. Once per revolution the counter must be zeroed, usually when the engine is at top dead centre on cylinder one, so the control unit counter is constantly being re-referenced. This can be done with a second, identical, sensor detecting when a timing mark on the flywheel passes it by.

Air quantity measurement is necessary to determine the length of time a fuel injector is opened from the amount of fuel which must be injected into each cylinder to give the required fuel/air mixture. Air quantity measurement isn't a simple process. Most sensors used in cars up to now do it indirectly by measuring air volume. The air mass (the parameter required) has to be calculated from this. The problem arises because the air mass is so interdependent on the air pressure and temperature. Great innaccuracies can occur due to altitude and weather variations unless fairly complex compensation techniques are used with temperature and barometric pressure sensors.

Hot-wire anemometers, on the other hand, are capable of measuring air mass directly with fairly simple interfacing circuits and recently types have been developed for use as air intake sensors in motor cars (Fig. 6). In such a sensor, a platinum wire is heated and accurately maintained at a constant temperature using a bridge arrangement circuit. As air passes through the sensor to the cylinders, heat is taken from the hot-wire and the extra current required to maintain the wire's temperature is a direct indication of the mass of air which has passed through. No errors can be introduced due to variations of air pressure. Temperature variations are compensated for with a second wire as changes in air temperature affect both wires to the same degree.

Part of the fuel/air metering process in an EFI system, as we've already seen, is to accurately inject the required amount of fuel through a fuel injector into the combustion chamber. If the fuel is at a constant pressure, as in the example here, the task is merely (!) one of measuring the air intake, calculating the amount of fuel required and opening the fuel injector for the amount of time which will cause that amount of fuel to be injected. This requires that the fuel is maintained accurately at a predetermined pressure and the fuel injector is capable of sufficiently high-speed operation.

If the pressure is such that an open fuel injector will inject, say, 240 millilitres per minute (a typical amount) then to inject sufficient fuel for a full charge into the cylinder, say, 0.01ml, the fuel injector must be open for only 2.5ms. The fuel pressure regulator in the fuel lines must be a pretty accurate device, as even a small variation in pressure means a corresponding variation of the amount of fuel getting to the cylinder. Fuel injectors are typically solenoid operated valves (Fig. 7), specially constructed to give fast and constant opening and closing lag times.

Some previous EFI systems, although digital, are not microprocessor-controlled. Instead, integrating/differentiating circuits determine the required opening times of the fuel injectors *directly* from the minimum important characteristic variables of engine speed, engine temperature, air mass, and accelerator pedal position. Although producing perfectly adequate EFI systems in current motor cars, this method is not adaptable to meet future requirements.

For each injection of fuel to a cylinder in a microprocessor-controlled digital EFI system, on the other hand, the control unit simply looks up, in a ROM-based table, what length of time the fuel injector must be open for to provide the correct amount of fuel. So-called 'programmed fuel injection' systems, seen more and more on the latest models are simply microprocessor-controlled systems of this sort. Microprocessor-control has important bearings on the future of EFI systems because it means the system can be altered to suit different requirements simply by changing the ROM

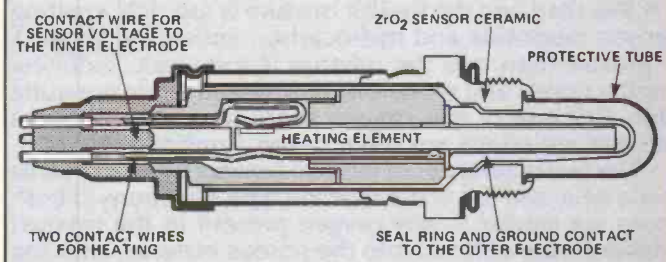


Fig. 4 Construction of a typical lambda sensor (Bosch).

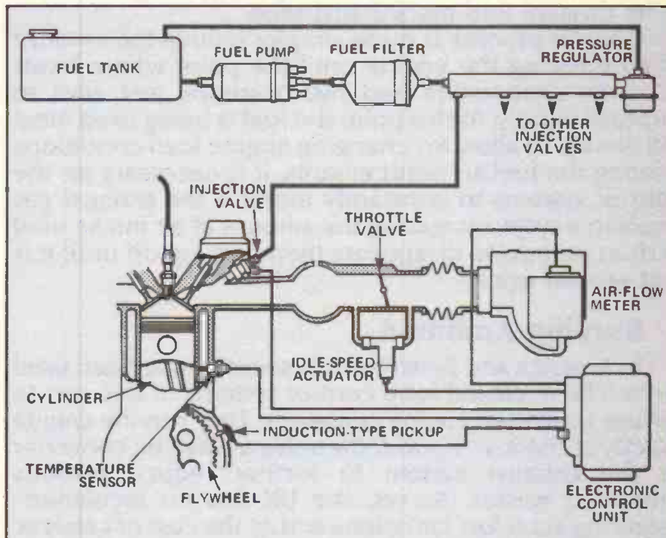


Fig. 5 Typical multi-point electronic fuel injection system.

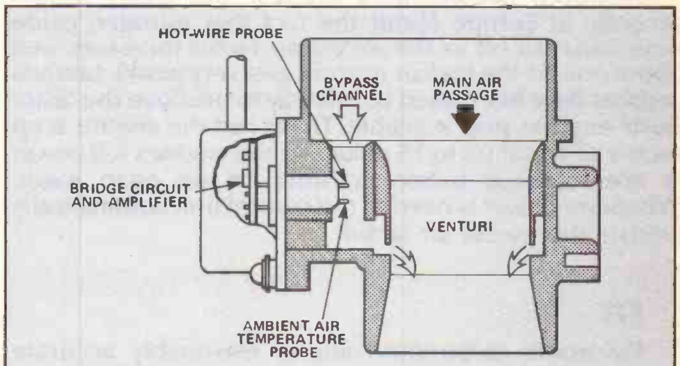


Fig. 6 Construction of a hot-wire air mass sensor.

look-up table. In other words, changing the chip changes the car's performance!

That's an interesting thought. Taken to its logical conclusion it means manufacturers in the future will produce a *single* engine (or at best only three sizes of single engines, say, 1200, 1600, 2000cc) whose exact performance (power, economy, exhaust emissions, etc) relies totally on a single ROM chip. It may even be possible to switch in different chips to alter engine performance depending on your driving mood. (I feel like a burn-up down the motorway today, I think I'll switch in the GT-ROM!) Will manufacturers ever again be able to convince us that the GXYZ Turbo is, in fact, worth two or three thousand pounds over the Popular model?

Ignition Control

Like carburation, motor car ignition timing has seen a number of significant advances in recent years from the basic Kettering system (battery contacts, coil, distributor, spark plugs) invented back in 1908, to microprocessor-controlled fully automatic systems able to adjust engine performance to suit all load conditions and meet any exhaust emission regulations.

The first stage in improving the Kettering system is to eliminate the major cause of inaccuracies — the contact breaker points. Systems which do this still maintain the distributor, however, in much the same way that automatic carburettor carburation systems maintain the carb. Looking at it another way, although the major cause of ignition timing innaccuracies has been removed, the *other* mechanical parts of the distributor (the centrifugal advances, the vacuum advance, and the rotor arm switching mechanism) are then the limiting factors in

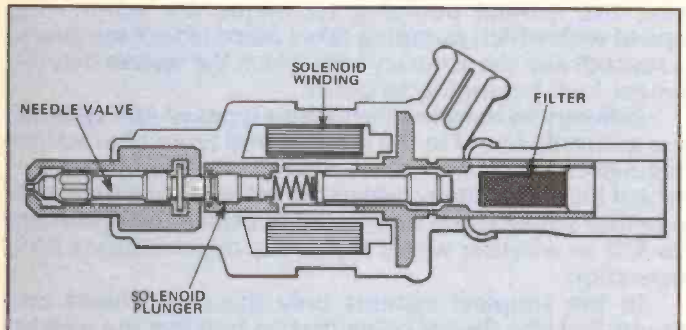


Fig. 7 Construction of a solenoid actuated fuel injection valve.

ignition performance.

Newer and higher performance ignition systems eliminate the distributor entirely, using electronic means to create the high voltage pulses required and distribute them to individual spark plugs. Like carburation control, ignition control systems may be closed or open loop.

Figure 8 shows the basis of a completely electronic closed loop ignition system. Sensors are used to monitor engine temperature and inlet manifold air pressure, engine speed and position and engine knock. The control unit adjusts spark timing to suit varying engine load conditions and requirements using an ignition timing curve stored in a ROM-based look-up table, much as the EFI system stores fuel injection times. The distributor's role is taken over by the use of an ignition coil, performing both distribution and coil functions. Coil shown is a double-ended type, and has diodes fitted either internally or externally to determine which plugs are to be fired. Alternatively, two double-ended coils are sometimes used in electronic distribution ignition systems without diodes.

Use of a transducer (typically, a piezo-electric accelerometer — Fig. 9) to sense engine knock is worth a quick mention here. Generally it is best to run an engine as advanced as possible, but not so advanced as to cause knocking. Knocking means the fuel combustion is starting too soon and the power developed by the 'burn' is acting against the piston coming up in the compresion stroke. Apart from wasting power, it does the engine no good. Sensing the occurrence of knock allows the control unit to run the engine so that ignition timing is as advanced as possible — any slight knock detected causes the control unit to retard the ignition timing preventing further knock.

Engines run on this 'knock limit' using electronic distribution offer greater economy than is possible with mechanical distributors simply because of accuracy. Fig. 10 illustrates a possible ideal engine advance with speed, which can be seen to vary considerably over the full range of speeds. An electronic distribution system can follow accurately the advance curve whatever the engine speed.

A mechanical distribution system, on the other hand (and by this I mean a conventional distributor, whether or not electronic circuit breakers are used) just cannot cater for the rapid variations in engine advance which are needed, and engine knock can only be avoided by retarding the ignition timing sufficiently so that knock cannot occur under any operating circumstances. Obviously, there are conditions when the ignition is too retarded in the mechanical distribution system and so power is lost, fuel economy is poor and unwanted exhaust emissions occur.

Operation of the closed loop knock sensing system is pretty straightforward. Under usual circumstances the ignition timing is derived from ROM-based tables of timing and temperature correction factors. However, when unusual engine load conditions cause knock to occur the control unit retards the ignition in, say 5° steps, until no further knocking is sensed. Then the ignition timing is progressively advanced again, say, by 1° per 25 ignition sparks until the memory mapped tables are again followed or, until knock re-occurs.

Separate fuel management and ignition management systems like these without doubt give great advances in overall engine control — lowering fuel consumption, giving maximum power and lowering noxious exhaust emissions. Nevertheless, two separate control systems of this sort of complexity means there is inevitable component redundancy. Similar temperatures sensors, similar engine speed sensors and similar control units are used in both.

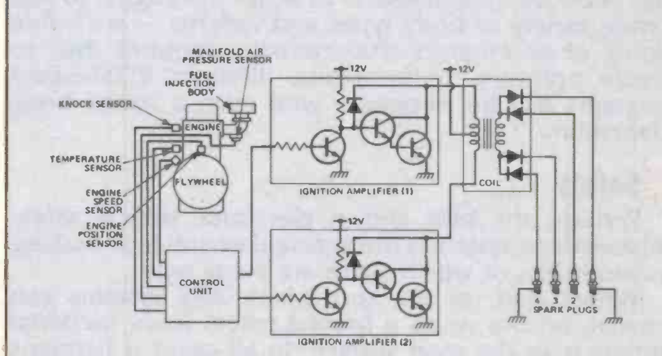


Fig. 8 Completely electronic distributorless ignition system, comprising a double-ended coil with two primary windings which takes the place of a mechanical distributor. This particular system is used on the Escort RS 1600i and XR4i.

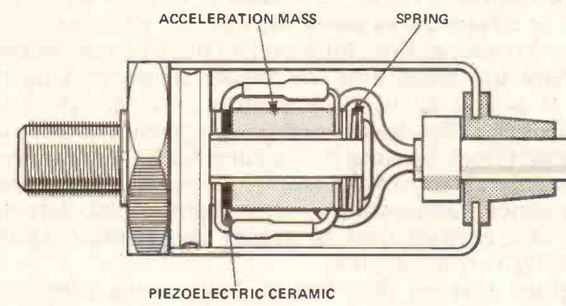


Fig. 9 Construction of a knock sensor.

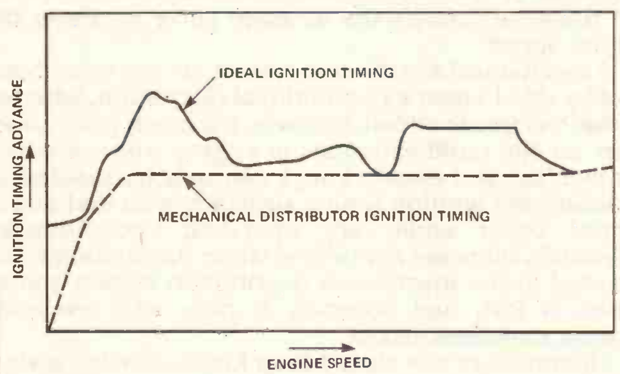


Fig. 10 The ideal ignition timing curve as a function of engine speed and timing advance, compared with the curve obtained using a mechanical distributor.

Nowadays, some pretty complex engine control systems (known as 'total engine management systems' — TEMS) are being developed which perform the functions of both previous systems using a single control unit, saving the cost of duplicated parts. Looking further ahead, it's feasible that systems will eventually combine engine control together with safety, instrumentation display and comfort systems into a single automotive electronic system with all parts controlled by one control unit.

Whatever the way forward, it's pretty apparent that programmable systems will become the norm because they allow the manufacturer to adapt the engine to suit a wide variety of body types and weights — such fine tuning of an engine's characteristics requires that, to ensure optimum performance, different ROM-based programs will be necessary with even a minor body adaptation.

Safety

Perhaps the best known electronic vehicle safety improvement system is the anti-skid or anti-lock braking system (ABS), of which there are many types.

Wheel skid, of the sort which ABS systems can prevent, occurs when a braked wheel loses frictional contact with the road surface. In all cases it happens because the driver has applied too much pressure onto the brake pedal considering the road surface condition. The result is a locked wheel which is skidding along the road surface. Vehicle stopping distance is greatly increased because the maximum amount of wheel/surface friction is not available. To regain complete control of the vehicle in such a case, the driver needs to release the brake pedal until the wheel is turning once more and then re-apply brake pressure.

Maximum braking efficiency occurs just before the wheel actually loses frictional contact with the road surface, so ideally, the driver needs to apply just enough brake pressure to reach that condition, but not enough for frictional contact to be lost. You'd probably think that maximum braking efficiency would occur when the wheel is not slipping at all, but in fact maximum coefficient of friction occurs when the wheel is slipping by about 25-30%, so the shortest stopping distances will be reached with wheel slip of this amount.

Needless to say, obtaining maximum braking efficiency is not an easy task, particularly for an inexperienced driver. Some experienced drivers get pretty close to maximum braking efficiency by applying sufficient brake pressure to just cause wheel lock, then as rapidly as possible, release and press the brake pedal in a fast pumping action to 'step back' from skidding. This 'cadence' braking ensures good braking efficiency and it's the basic principle of all electronic ABS methods.

ABS operation is fairly straightforward. Sensors detect wheel rotary motions and this is generally the same for each wheel. If one sensor (Fig. 11) detects a rapidly reducing motion or even a stationary wheel while the other wheels continue with the same motions, then that wheel is locking up and beginning to skid. Some form of controlled pressure regulating device in the braking system is operated which reduces the brake fluid pressure, reducing the braking effect and counteracting the tendency for the wheel to lock.

Once the sensors detect the wheel is again in motion the pressure regulating device returns full brake fluid pressure and the cycle continues — brake-release, brake-release, etc. The advantages of an automatic ABS system over the manual pumping technique are simply the speed with which pumping takes place (about ten times a second) and the accuracy with which the system detects wheel lock beginning to occur.

Differences between the various types of ABS systems are generally found in the number and types of pressure regulators used, how many wheels are monitored for wheel lock, how many brakes are actuated at a time and whether wheel slip is monitored to obtain the optimum 25-30% or whether wheel slip of any degree causes ABS operation.

In the simplest systems only the rear wheels are controlled (the theory being that on braking, the weight is shifted forward giving the rear wheels lower grip). Both rear wheels are monitored by a single sensor mounted on the rear axle and the control unit uses the sensor signal to detect rapidly reducing rear wheel motion (with only one sensor the system cannot compare wheel motions of different wheels!). A dual-circuit hydraulic system (one circuit for the front, one for rear wheels) means the control unit can reduce the brake pressure to the rear wheels without affecting the front brake pressure, once rear wheel lock is detected.

In the most complex systems (Fig. 12), each wheel motion is monitored by the control unit and a four-line hydraulic system ensures each brake pressure is individually controlled. The control unit calculates individual wheel slip from wheel motion signals from each sensor so that once the optimum 25-30% is passed on braking, the corresponding brake pressure is reduced to maintain optimum slip at each individual wheel.

Brake fluid pressure regulators in any ABS system are of two main types — a centralised actuator or individual actuators at the wheel brake assembly. In the former, brake pressure in the pipes to each brake is varied, so that different pipes may have different fluid pressures within. In the latter, all brake pipes have the same pressure, but the brake assembly at each wheel modulates the pressure acting on the brake pads.

Belt Up, You Bag Of Wind

Even anti-skid braking systems can't prevent all accidents. But if the brakes can't stop the car safely, electronics can still help in making cars safer for occupants in an accident. The most notable systems to have been developed in this area are the airbag and the seat-belt tightener. Both of these use a sensor to measure the deceleration which the car undergoes. If deceleration is greater than a predetermined limit, such as the car would experience in an accident, then actuators are used to tighten the seat-belt, preventing the occupant from being catapulted forward and maybe hitting the dashboard and/or rapidly pump up a rubber balloon-type bag in front of the occupant, breaking the momentum.

Suspension

ABS systems and even safety features like seat-belt tighteners and airbags are almost old-hat now when it comes to car electronics systems. One new type of vehicle safety system which is still in an early stage of development is electronic suspension. The Lotus 'active suspension system' currently causing a great deal of chin-wagging is an example of things to come in this field. The idea is to counteract the apparent weight transfer which occurs as a car corners, brakes or accelerates and which causes the car to experience body roll or pitching. This is done by adjusting the suspension units at each wheel to maintain the wheels' positions in relation to the car body.

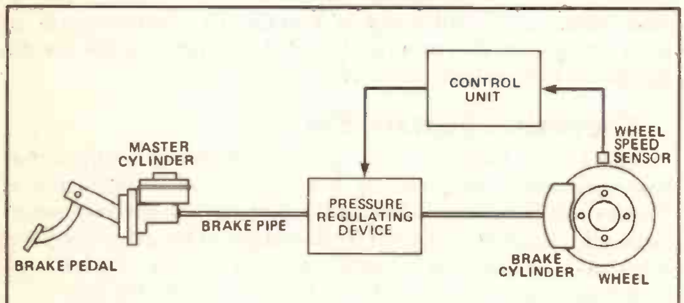


Fig. 11 The basis of all anti-lock braking systems.

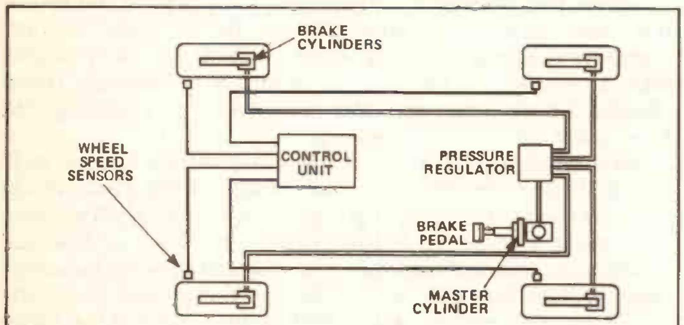


Fig. 12 Complex ABS systems regulate brake fluid pressure to all four wheels. The control unit calculates wheel slippages so that maximum coefficient of friction is guaranteed.

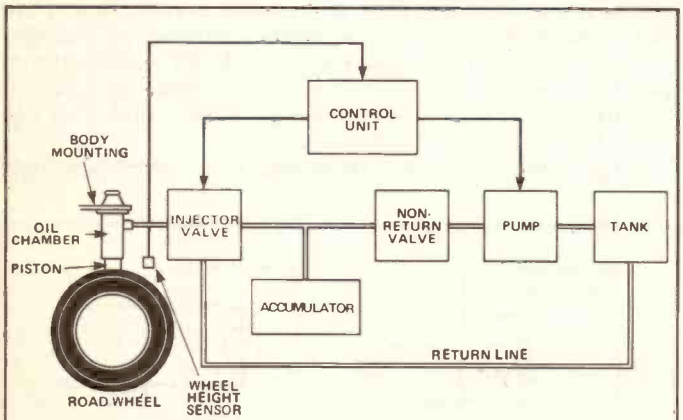


Fig. 13 Electronic 'spring' active suspension system developed by Lotus.

It is the suspension units themselves which provide the key to an electronic suspension system's performance. It's long been known that shock absorbers with high damping coefficients improve road handling and, indeed, one available unit merely acts as a variably dampened shock absorber — 'soft' when the car is travelling in a straight line at a constant speed' 'hard' when cornering, accelerating or braking. In principle, this unit has two oil chambers connected by a rotary valve. In one position oil flows between the chambers giving a low level of damping (the soft ride) but when the valve is rotated by 90° oil flow is prevented with a resultant high level of damping (the hard ride). Inevitably, the valve motor takes 100ms or so to operate.

A suspension unit of this type can't prevent body rolling or pitching. It merely attempts to reduce their effects on the car's road handling. The Lotus vehicle active suspension system *can* prevent rolling and pitching. Lotus is naturally reluctant to give too much away about the system as yet (trying to get information out of the company is like trying to get blood out of a stone!) but reading between the lines it's fairly apparent that the system hardware is just about complete and has, in fact, already been used in a range of vehicles — both racing and conventional. What does appear to be still undergoing change is the controlling software.

In principle the unit is formed by an oil chamber, sealed at one end, with an internal piston whose position in the chamber is determined by the amount of oil (Fig. 13). If oil is pumped into the chamber the piston is forced out, if oil is released from the chamber the piston retracts. Lotus' control method is simple enough. When the car experiences cornering, braking or acceleration such that one or more of the wheels is forced from a nominal position, oil is pumped into or released from the corresponding suspension units, returning the wheel or wheels to the nominal position again. Rather than physically pumping the oil into individual suspension units as and when required, which would take considerable time, the system maintains oil at a high pressure in a hydraulic accumulator, merely injecting the oil into a suspension unit's oil chamber when required.

If you've ever seen trial runs of Lotus cars fitted with this system you'll appreciate the virtually zero roll which it exhibits when cornering. In fact, it looks as though the system exerts a completely opposite rolling movement which seems to bank the car into a corner, much as an aircraft banks in a turn. This may not be as stupid as it seems, because system design has been in collaboration with the College of Aeronautics, at Cranfield Institute of Technology.

It's interesting to comment on the Lotus system, bearing in mind that each suspension unit is effectively an electronically programmable spring. It would be perfectly feasible to program the system's control unit to emulate any desired mechanical spring. In effect, you could choose whether your car felt like a Rolls Royce, or a Mini. Further, when you hear that Mercedes, too, is developing an active suspension system, there can be no doubt that we shall all be hearing a great deal more about active suspension and all aspects of the electronic car as time goes on.

ETI

CIRCUIT THEORY

Paul Chappell delves into a fantasy world where all electronics is plain and simple.

After the venture into the realms of mathematics in the past two issues, we're back on solid ground this month with fantasy boxes and down to earth things like that. The idea is to demonstrate with a few examples how circuit theory can remove irrelevant information from a circuit and leave the bare essentials exposed.

Imagine you are choosing a new hi-fi system. You've got the record deck, CD player, cassette deck and speakers all sorted out. You've also bought a power amp but you don't fancy the pre-amp that goes with it. The current pin-up of the hi-fi reviewers is a little darling called the Anadigital PRX-992. It has all the right numbers on its spec sheet, it gives enhanced depth planes and well defined median zonal parameters, it's analytical with a charming touch of naivety, witty and sparkling despite its deep and contemplative nature, it's virtuous and desirable. It's got everything you could ever wish for but will it match your power amp?

To find out, you check the data sheet to find the nominal output signal level and output resistance of the pre-amp. In other words, your view of the pre-amp shrinks down to the equivalent circuit shown in Fig. 1a. Gone are the direct central-register tonal complexes, the front-end nascent ramifications and the bi-valved molluscs. Your view of the pre-amp for matching purposes is nothing more than a signal generator and resistor.

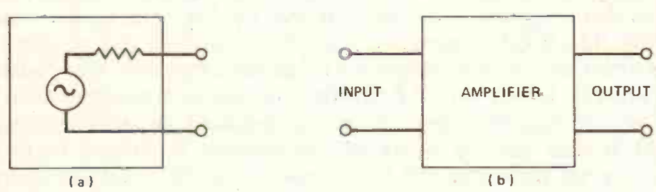


Fig. 1 Two and four-terminal representations of an amplifier.

This is quite some feat of simplification when you consider that to reduce the pre-amp to a two terminal network, the box must contain not only its entire circuitry, not only the CD player and its internal circuitry but also the entire national grid complete with power stations and zillions of miles of wire. Well done!

Of course, the signal source and resistor model does not attempt to explain what goes on *inside* the box. It just gives a representation of the way the box 'looks' to anything connected to its terminals. The model you use in any given situation depends on just what information you need. In other circumstances the four-terminal representation of Fig. 1b would be a better way to think of your amplifier.

Some of the simplifications you regularly perform are more subtle. When you buy a TL071 you have every confidence that *at its terminals* it will behave as if there were an op-amp inside the plastic lump. You *know* that what's really in there is a silicon crystal with a few odds and ends of impurities diffused into it. You *know* that anything approaching a full explanation of what the IC is really doing would involve an extensive understanding of semiconductor physics. For the purposes of circuit design you ignore all this. Your attention is focussed on the way it looks to anything connected to its terminals. The way it looks is like an op-amp.

Even the fact that it needs a power supply can fade from your mind. In circuit diagrams the power connections are as often as not left out completely. It's all part of the process of discarding irrelevant information. If the national grid is ever given any recognition for its contribution to your circuit, it is dismissed as a wavy line at the input to the power supply! The idea of simplifying a circuit or component to concentrate on the essentials is not new to you. All I hope to do in this article is to refine it a little.

Thévenin's Fantasy Box

The circuit theory which says it's OK to represent linear two terminal networks as a source and impedance is Thévenin's theorem. It's something you already use when you talk about the output impedance of an amplifier, the internal resistance of a battery and so on. Let's take a look at a few examples and see what it can do for us.

A simple example is the voltage divider shown in Fig. 2. Figure 2a shows the 'real' divider network — the box contains two resistors, a 10V power supply (and the entire national grid...). Figure 2b is the fantasy version containing a single voltage source (which works by magic) and a resistor. If Thévenin's theorem is correct, there should be no way you can tell, short of opening the boxes, which circuit is which.

First of all we have to decide what values to give to V and R. The open-circuit output voltage of Fig. 2a is clearly 5V, so if the fantasy box is going to fool anybody the value of V must also be 5V. If the output terminals of the real divider are shorted together, the current flowing between them will be 1mA (10V across 10k), so the fantasy box must also have a short-circuit current of 1mA, giving R a value of 5k0.

That's all very well. They match under open-circuit and short-circuit conditions but will they still match in between? If I get a 20V supply and use it to stuff current into the output terminal, what then? Do the two circuits still behave in the same way? The short answer is that being linear circuits, they will always match. If you are not convinced, try a few resistors, currents or voltages at the output and see what happens. A 5k0 resistor across the fantasy box will give an output voltage of 2.5V, for instance. The 'real' box should give the same. Get out your calculator and make sure!

In general, for resistor networks, the Thévenin voltage

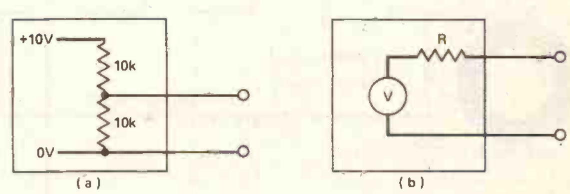


Fig. 2 A real potential divider network and the Thévenin fantasy box equivalent.

will be the 'real' open circuit output voltage and the resistor will be the open circuit output voltage divided by the short-circuit current.

D To A Converter

A simple way to make a D to A converter is the weighted resistor network shown in Fig. 3a. The problem with this approach is that a variety of non-standard resistor values are needed if reasonable accuracy is to be achieved. It also imposes widely differing loads on the digital inputs, which could be a problem if the circuit is driven directly from a CMOS IC.

Another way of tackling the problem is shown in Fig. 3b. This circuit imposes equal loading on all inputs and only requires one resistor value. (The 2R resistors can be made from two Rs in series or the Rs from two 2Rs in parallel). For a precision network, it is a lot easier to select resistors all of one value (without knowing *exactly* what that value is) than it is to manufacture or measure them to a specified resistance. A simple resistor bridge will do the trick.

If you haven't seen the R-2R network before, I think you'll agree that it's not immediately obvious why it works. At first sight it's clear that the less significant bits have to 'go through more resistors' but that's about all.

Suppose that the LSB is set to 1 and all the rest to 0. We can open a fantasy box for the LSB voltage and resistors R1 and R2 in just the same way as for the potential divider of Fig. 2. Inside the box will be a voltage source 8V and a resistor of value R (Fig. 3c).

Now we can draw R3 into the fantasy box. It has the effect of increasing the resistor value from R to 2R (Fig. 3d). To suck R4 into the box halves the voltage again and sends the resistor value back down to R. Adding in R5 sends it back up to 2R (Fig. 3e).

Now we begin to get the picture. Each step up the ladder halves the voltage and always gives a loading of 2R to the following stage. Having got the hang of it, we can quickly stuff the rest of the network into the fantasy box. Figure 3f shows the penultimate stage and Fig. 3g the ultimate simplification of the network with the LSB set.

Suppose the bit above the LSB is 1 and all the rest are zero. Notice that R1, R2 and R3 give a resistance to ground of 2R to this stage just as R2 did for the LSB. The same process of feeding the network into the fantasy box, starting one stage higher up gives Fig. 3h. The voltage is twice as big. For the next stage it will be 4V and for the final stage 8V.

Now, all this applies to the case when only one bit is set at a time. Do we need to go through all 16 possible inputs? (Or through all 256 for an 8-bit converter?) Not at all. Superposition tells us that the result of several bits being 1 (several voltages applied) is simply the sum of the voltages given by the individual switches, so we're done!

The output (for this example) is a voltage equal to the binary number represented by the input.

If the operation of stuffing the circuit into the fantasy box doesn't make its operation any clearer to you, remember my warning in the first article that you couldn't expect instant enlightenment. If you are not familiar with fantasy boxes it won't help at all. Meditate on this example for a while and you'll come to an understanding of Thévenin's theorem. Use the theorem a few times and it will become clear as daylight. You'll see.

Apart from the direct reduction of a complicated circuit to a simple one, there are many other reasons for representing a circuit in fantasy form. One might be that the actual mode of operation of the device is not particularly enlightening or helpful when it comes to designing circuits.

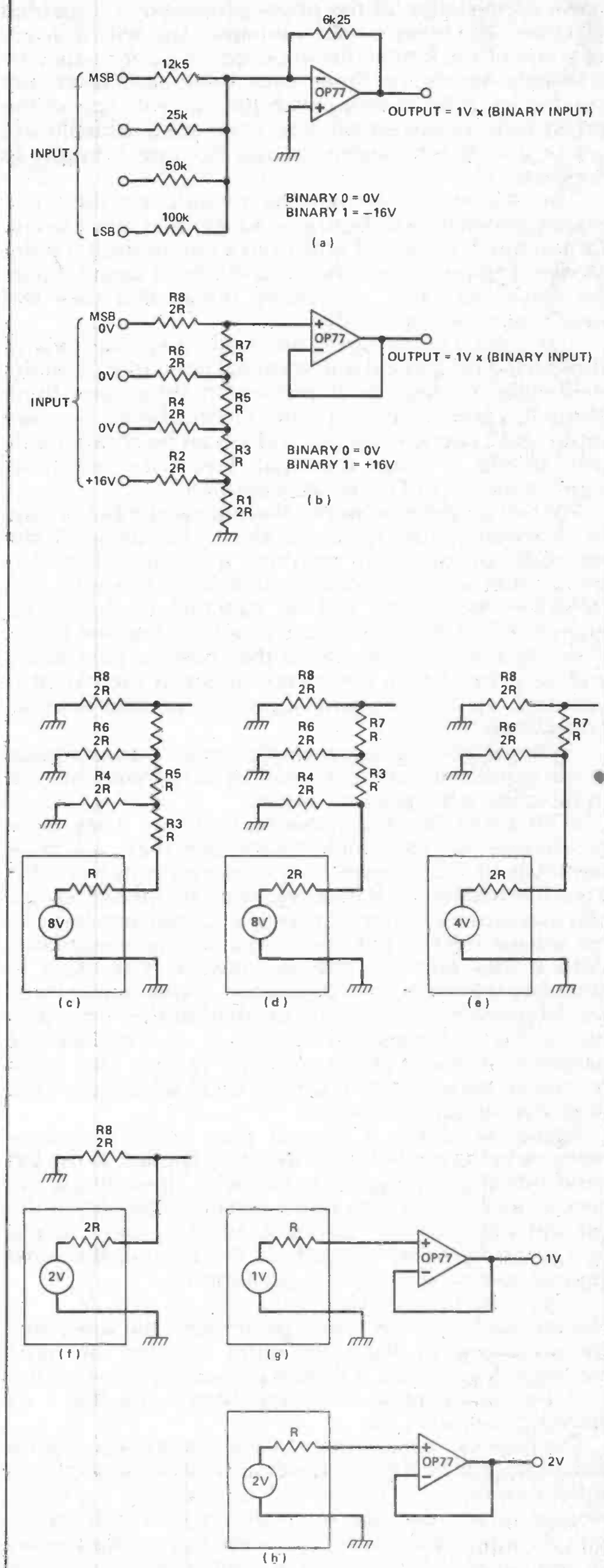


Fig. 3 (a) and (b) two possible resistor networks for D to A conversion. (c)-(g) Thévenin fantasy box eats resistors! (h) the result of the same simplification beginning one step further up the network (bit 1 set instead of bit 0).

Take transistors, for instance. Most engineers have a naive appreciation of the physics involved — a garbled electrons and holes model, perhaps. Most will be aware of some of the limitations imposed on performance by transistor geometry. Some may even have taken the trouble to come to terms with the current state of the art in semiconductor physics. How many actually use physical models to design circuits? Not one, I venture to suggest.

The reason is not that the models are incorrect, incomprehensible or boring — simply that they contain far too much irrelevant grot from a circuit design point of view. Engineers have their own kinds of fantasy boxes for semiconductors, containing things that they feel much more at home with.

Transistor fantasy boxes are really a special case of those used for general four terminal networks. (Spot the deliberate 'mistake'. *Four* terminals?) When you think about it, a good many electronic circuits have a two wire input and a two wire output and so can be conveniently put inside a four terminal box (the amplifier representation of Fig. 1a, for example).

For two terminal networks, there are a number of ways of describing how it 'looks' at the terminals. If the network contains only resistors, a simple Ohm's law description is quite enough. If it has capacitors and inductors too, it can still be summed up by an AC equivalent of Ohm's law (more about this another time!). If we allow sources too, there's the Thévenin equivalent, and also the Norton equivalent in which the circuit is summed up as a current source in parallel with an impedance.

All these aim to give the simplest possible description of the appearance of the network at its terminals but not to describe what goes on inside.

With a four terminal network, there are many more possibilities for the simple reason that there are more terminals to apply inputs to and take outputs from. For a passive two terminal network, you can apply a voltage and measure the current, or apply a current and measure the voltage and that just about exhausts the possibilities. With a four terminal passive network it is usual to stimulate it from both ends at once, giving rise to three sets of parameters according to whether the stimulus is two voltage sources (giving the g- or conductance parameters) two current sources (giving the r- or resistance parameters) or one of each, which gives the h- or hybrid parameters.

Figure 4a shows a general four terminal resistor network being excited by a current I_1 applied to the left hand side and a voltage V_2 to the right. The only way the circuit can respond is to give a certain voltage V_1 at the left and a current I_2 to the right. Since V_1 and I_2 could be caused by either or both of the stimuli, the most general summing up of the situation is:

$$V_1 = h_{11}I_1 + h_{12}V_2 \qquad I_2 = h_{21}I_1 + h_{22}V_2$$

The various h's are the hybrid parameters, the subscripts are according to the convention adopted by most electrical engineering text books — you can look on the 1 in the subscript as meaning 'input' and the 2 as meaning 'output'.

The physical interpretation of the parameters is quite simple. h_{11} will be the input resistance with a short circuit at the output, h_{12} is the reverse voltage gain, h_{21} is the forward current gain and h_{22} is the output conductance with the input open-circuit. Now you can see the reason for the name 'hybrid' — two are dimensionless, one is a resistance and one is a conductance. Quite a mixture!

The simplest fantasy of what could be inside the box to give these results is shown in Fig. 4b. Having said that this applies to resistor networks, how can it be of any use for representing transistors? Well, the parameters can obviously be used for any circuit which doesn't mind having a current imposed on its input and a voltage on its output and a transistor falls into this category. Furthermore, the behaviour of a transistor under certain circumstances turns out to be very much like a resistor network with gain. It was originally called a 'transfer resistor', after all.

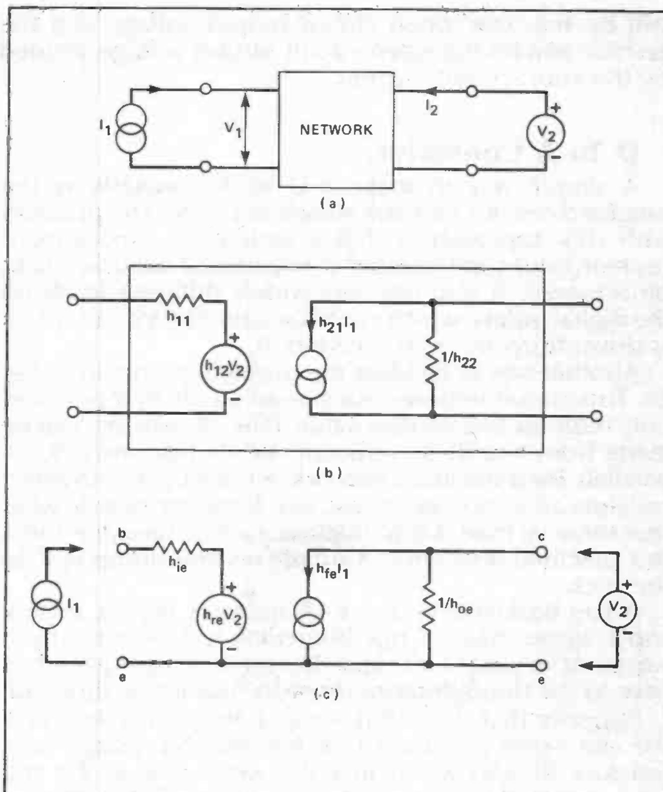


Fig. 4 (a) A general four-terminal resistor network stimulated by current I_1 and voltage V_2. 'Outputs' are V_1 and I_2. (b) One idea of what could be inside the box to give rise to the h-parameters. A model without sources is also possible. (c) A simple h-parameter model for a transistor in common-emitter mode. This is an AC model (no static DC currents and voltages are shown — in particular, $h_{12}V_2$ does *not* represent the 0.6V base-emitter voltage drop). It applies to signals small enough for the non-linearity of the base-emitter junction to be neglected, and low enough in frequency for internal capacitances to be ignored. There are a number of models derived from this. The source $h_{re}V_2$ is often left out since at normal operating currents it is negligible in comparison with $h_{ie}I_1$. A typical value of h_{re} for a small-signal transistor operating at a collector current of 1mA would be around 10^{-5} to 10^{-6}.

The IEEE recommend a slightly different set of subscripts from the ones shown above. For 11, use i for 'input', for 22 use o for 'output', for 21 use f for 'forward transfer', for 12 use r for 'reverse transfer'. In addition, for transistors a second subscript b,e or c is used to indicate common base, common collector or common emitter configuration. So the input resistance of a transistor in common emitter configuration is called h_{ie}, the forward current gain will be h_{fe} (recognise that one?) and so on.

For FETs, by the way, it is usual to use the g-parameters since they are happier responding to a voltage than to a current. You may have seen g_{fs} and g_{os} in data sheets — I'm sure you can work out the interpretation.

The h-parameter transistor model appears in a number of guises, some simpler than the one shown, some considerably more complicated. A detailed look at these models and their uses will have to wait for another day.

ETI

HARDWARE DESIGN CONCEPTS

Mike Barwise continues his look at using programmable logic devices with a study of PAL.

The only really significant restriction in choice of PROM (PLE) for a given logic function is the device size. This freedom is due to the exhaustive decoding of the AND array and the availability of all AND outputs to all OR inputs.

In a PAL there are seldom enough AND terms available for exhaustive decoding and the OR array has a fixed configuration in any given device. When it comes to selecting a PAL, early choice of a specific part is fundamental to success.

As the OR (sum) array is fixed, this is one of the first things to consider. Normal PALs provide from two to seven OR terms per output depending on device density but some recent additions to the Monolithic Memories Incorporated (MMI) range provide none (an AND-only array for simple decoders) or an option called 'product term sharing' which uses an intermediate programmable array similar to that in a PLA to provide up to fifteen OR terms which can be shared between each pair of physically adjacent outputs.

So how do you actually choose your PAL? First determine whether you want active high or active low outputs (or whether both must be available). This will limit you to type 'L' active low, type 'H' active high or type 'X' exclusive-OR devices. Then you must check how many input and output pins you need and how many outputs (if any) are to be fed into the device. This will usually limit your choice to less than half a dozen devices.

Next look at the layout diagrams of these devices and find one which has enough OR terms per output for the most OR-intensive sum-of-products equation in your set. Supposing for the moment that this reduces your choice to a couple of alternatives. Either device will usually serve your purpose but you should then check which device is cheaper/more easily obtained, or (if it is important to you) which offers the highest speed or the lowest power consumption.

This is of course something of an over-simplification. It takes a while to get the feel of PAL (just like anything else) but eventually most of the decision making becomes second nature.

Palasm — A Short Cut

Palasm is a proprietory PAL assembler from MMI, It accepts an ASCII input file and generates output files suitable for transmission to automatic programming equipment. The original Palasm 1 was crude and primarily dedicated to combinatorial logic generation. As the PAL family grew to include registered devices and larger arrays (currently up to 8K AND fuses and 16 input/output lines) Palasm was rewritten to accommodate these innovations.

The current Palasm 2.21 is a very different beast from the early versions. In fact it is a suite of programs which all work on the same data files. These are chained together via a menu (IBM PC version) to make them look prettier but they are just as easy to use individually in the correct sequence. The suite consists of:

- an input file syntax checker.
- a fuse matrix plotter.
- a device function simulator.

I will discuss each of these separately, as they all have interesting points. This is not a review of Palasm but the package is representative of its genre and I would recommend it to anyone who has an IBM compatible micro and about £150 to spare. It's certainly the cheapest of its kind.

The input to Palasm 2 is an ASCII file which uses a specific syntax. It can be prepared on any word processor which does not embed silly codes (Wordstar in non-document mode works fine). The file consists of an information header containing details of the device function name, author and so on (which is semi-optional), the PAL part number to be used and a list of the user defined pin names. Next come the Boolean equations which describe the required function. These use the standard symbols I introduced last month and the pin names declared in the header. Comments are allowed and do not affect assembly.

The final section of the input file is a 'simulation' specification. This consists of a sequence of statements instructing the simulator to manipulate and test the device file.

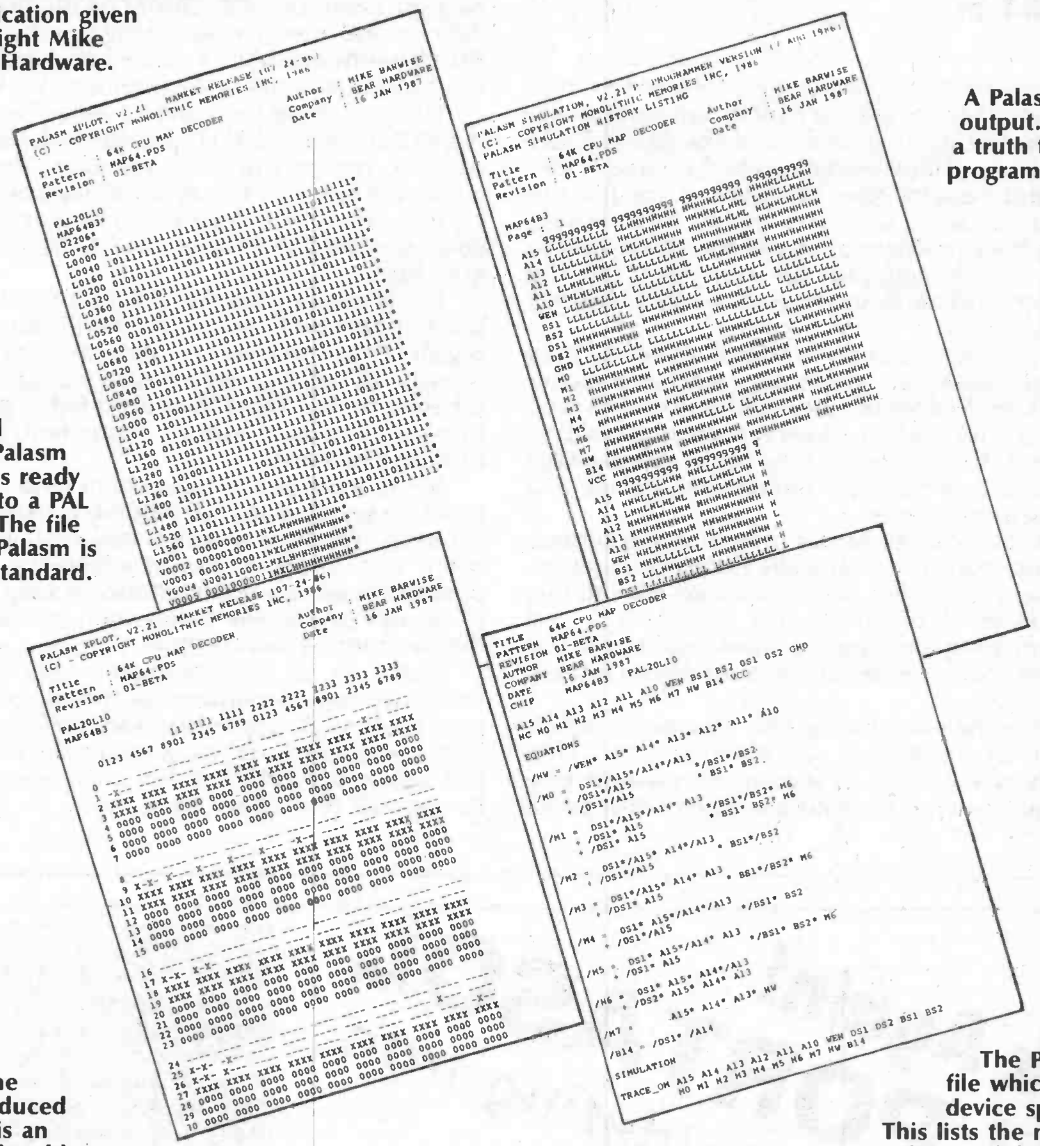
Instructions allow you to set the logic levels on input pins, to specify which outputs are to be examined and to clock sequential (registered) devices. A simple conditional and loop structure is available to allow brief specification of tests for long sequence state machines and the like.

Once you have prepared your input file, it is passed through the syntax checker. If it is error free (typing errors, not logical errors which with luck will be found by the simulator) then the fuse plotter is run. This takes the input file and correlates it with a map of the chosen PAL device. The resultant output is a printable fuse plot diagram together with a system file containing a compressed functional description of your logic, which will be used by the simulator. When the simulator is run and no errors are found, the final programming files are generated in several different formats for various programmers.

The simulation is really one of the most crucial

Palasm output. Please note that the device specification given here is copyright Mike Barwise/Bear Hardware.

A Palasm simulator output. In essence, a truth table for the programmed device.



The blowing files. The final result of the Palasm design process ready for loading into a PAL programmer. The file produced by Palasm is to the Jedec standard.

The map of the PAL fuses produced by Palasm. X is an intact fuse, 0 is a blown fuse and the dashes represent phantom fuses.

The Palasm input file which forms the device specification. This lists the names given to each pin of the PAL device and the boolean equations describing its function.

elements of Palasm, and probably the most difficult to use intelligently. Simulation is the one thing you just can't do effectively by hand, especially when you are designing sequential logic.

Palasm compares the simulation results with the input equations and a truth table is generated. It is also possible to request a specific check of the logic level on a given output, in which case an explicit error message is generated in addition to the truth table data if a match is not found. All output including error messages is sent to a disk as named files. This is quite an important point as a really good PAL design (particularly a good simulation) can take several days to get finished.

It is, however, perfectly possible to create a simulation that proves nothing. In order to simulate your device properly, it is essential to not only have a very clear idea of what should happen but an excellent idea of what should *not* happen. Tests must be included for potential 'stuck' hazards, invalid inputs and so on. Remember: none of us write perfect simulations first time round. The simulation will probably still be updated several times after the PAL has appeared to assemble correctly. If things seem to have gone too smoothly, there's usually something evil hiding which will let you down with a thump after your PAL master has been blown (bang goes £25!).

An example problem is the modulo-10 counter. To create this in a binary system, you must somehow shorten the count of a modulo-16 counter. You still need four bits but the MSB is only partially used. This is very readily expressible in sum-of-products terms and everything looks very simple. However, most useful counters are loadable. So what happens if you load the counter with, say, 14? It should upwards count between 0 and 9, or from its preloaded value to 9, so it won't like you for asking it to count *upwards* from 14 to 9!

The only really safe way of determining what will happen is a simulation. The very ease with which a device function like this can be specified almost guarantees that hazards will often remain hidden.

I will leave this matter for the time being as much more detail in the absence of concrete examples could prove highly indigestible. I will from now on be using PALs (as an alternative to discrete TTL) in support of other concepts in this series when necessary. It is via these practical applications that you will probably gain the best insight into PAL design methods. I will round off now with a few comments on the limitations of PALs.

When Not To

PALs might seem the absolute ideal for low cost logic implementation. For those who cannot warrant the use of full custom silicon, what more could be done? There are, however, some critical limitations to their usefulness.

The first and most obvious limitation is the PAL pin count. Any application which is highly input/output intensive can be a problem as you may not be able to find a device with enough pins for your signal set. The second problem (primarily in sequential logic) is device compatibility.

To simplify implementation of complex user-defined functions, many PALs have arrays of pre-defined higher level elements (exclusive-OR gates, arithmetic networks, registers and so on) built in. However, the organisation of such elements in a given part may not be exactly what you need. There may not be a suitable PAL device in a given manufacturer's series.

There is no low cost universal programming system, as most manufacturers use radically differing programing algorithms. The upshot is that you may have to mix parts from different manufacturers (which is a real problem when programming) or think again and use more PALs than you expect whenever your design is really complex.

It is worth repeating that a PAL assembler which allows design for more than one manufacturer's chip series is likely to cost a lot of money. An example of a problem design is a function with one 8 bit bi-directional data port and four asynchronous flip-flop registers plus their control lines. The one thing you can't do in any MMI PAL currently available is create a bi-directional port. Your inputs and outputs must therefore be kept separate.

The next thing you can't do except in two part series (RA PAL and MEGAPAL) is provide independent clocks to separate registers in the same chip. Thus the function above will need three conventional cheap PAL chips to create but it can be done even cheaper in TTL using four chips (two 74LS373/374 plus two 74LS74) and maybe a little glue logic.

PAL is a very powerful product for the right kind of job. It is best for the creation of decoders, counters, shift registers and *non-random* state sequence generators. It is really advisable to use a design tool for it as the hazards inherent in the kind of functions PAL is good for and the hazards associated with its implementation are difficult to debut by hand.

For combinatorial logic, semi-random and random function generation, PLE (PROM) is likely to be the best solution. Although a design tool such as PLEASM (from MMI) can improve design efficiency, it is perfectly possible to design PLE freehand, as long as you don't try to do the excessively fancy, such as feedback into the device from its own output.

That's all on programmable logic for now. I will introduce new departures as they appear. Next month I am going to describe hardware FIFO memories. These have come a long way since I introduced FIFO concepts (ETI September 1986) and they are now so cheap and easy to use that they really are a must.

ETI

HARD TIMES

Paul Chappell looks at designing circuits using analogue multiplier ICs.

The hi-fi power meter in the June issue made use of an analogue multiplier IC, the SG1495. It's an interesting little device and as there was not enough room to say too much about it then I'm going to take a look at it in detail here.

Most ETI readers will know that the circuit of Fig. 1a has a voltage gain for small inputs which depends on the current, i. More precisely, the gain is proportional to this current.

In the days before circuits came packaged in little black plastic lumps this 'long-tailed pair' was used for all manner of signal processing applications. In its simplest form, the current source is replaced by a resistor. This gives a reasonable approximation to a constant current because the voltage across it is held constant by Q2. The output can be taken from either collector depending on whether an inverted or non-inverted version is required, or from both for a differential output. You will almost certainly have seen the circuit in its 'naked' form as the input of discrete component amplifiers and it is still widely used inside black plastic lumps — including the SG1495!

Replacing the current source with Q3 and R3 (Fig. 1b) gives a simple voltage controlled amplifier. Increasing the control voltage gives more current to Q1 and Q2, giving greater voltage gain at the signal input. Reducing the control voltage has the opposite effect.

If you think about it for a moment, you'll realise that a voltage controlled amplifier and a voltage multiplier are one and the same thing! Suppose that R3 is chosen so that 1V on the control input gives a gain of 1, then 2V gives a gain of two, 5V gives a gain of five and so on. If 2V is applied to the signal input and 5V to the control input, the output will be 2V (input) x 5 (gain) = 10V. In other words, the two voltages have been multiplied together.

The circuit of Fig. 1b has far too many shortcomings to be considered as a practical multiplier circuit. The first problem is that besides altering the gain, the control voltage also varies the DC level of the output signal.

If the circuit is set up so that 1mA tail current gives a DC level at Q1 and Q2 collectors of, say, 3V below the positive supply, increasing the current to 2mA not only doubles the gain (the effect we want) but also shifts the DC level down to 6V below the positive rail! If the control voltage varies rapidly, as in a tremelo circuit, this level shift will be seen as an unwanted low frequency signal (Fig. 1c).

In an audio VCA this would be called 'control voltage breakthrough' or something of the sort. A simple high-pass filter (a capacitor and resistor will do) is an easy cure. The control voltage is likely to vary very slowly in comparison with the audio signal and so the filter will separate the wanted signal from the unwanted one.

This is no good for a multiplier. Both inputs must be given an equal status — both able to accept equally high frequency signals. It should also be able to multiply very low frequency signals or DC levels so no capacitors are allowed.

The cure is quite simple and doesn't even involve changing the circuit. The output due to the signal and control inputs acting together causes the voltages across R1 and R2 to change in opposite directions whereas the DC shift caused by the control voltage alone will cause them to change in the same direction. If the output is regarded as being the *difference* in voltage at Q1 and Q2 collectors, the problem disappears!

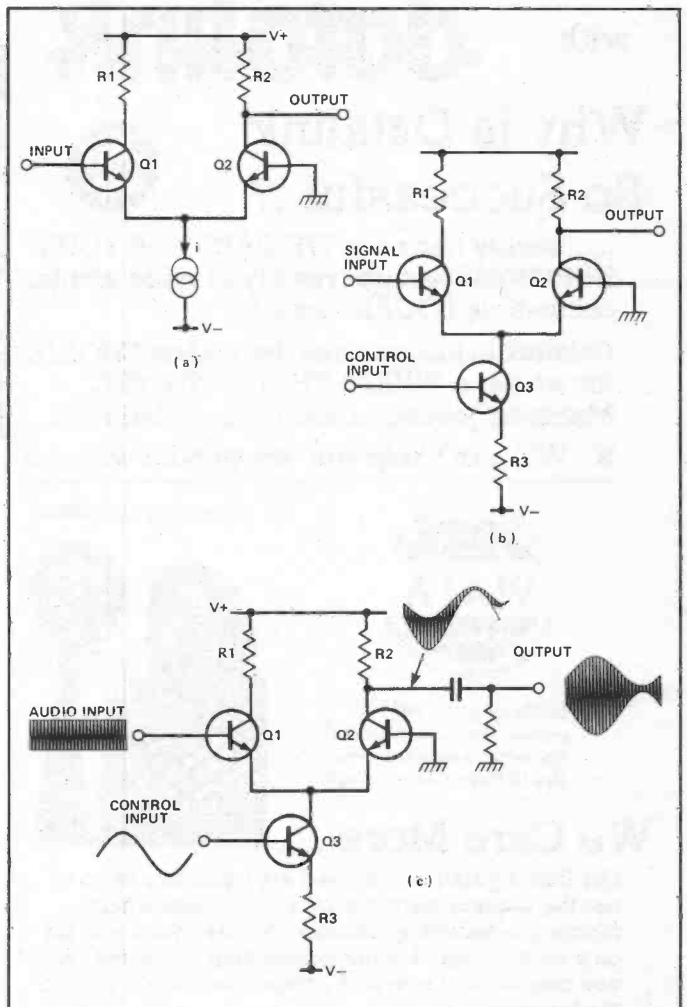


Fig. 1 A 'long tailed pair' (a) the basic circuit. (b) replacing the current source to give a voltage controlled amplifier. (c) the unwanted DC level shift.

As it stands, the circuit of Fig. 2a is a two quadrant multiplier. The first voltage input can vary above or below zero, giving positive ($v_0(1) > v_0(2)$) or negative ($v_0(1) < v_0(2)$) outputs. The second voltage input (I'm going to have to stop calling it the control input if we're talking about multipliers) can only be positive. It can vary the magnitude of the output but can't reverse it.

Figure 2b is the basis of a full four quadrant multiplier. It is simply Fig. 2a twice. If v_2 is zero (with respect to its own reference voltage of $-\frac{1}{2}$v) v_1 will be amplified equally by each pair Q1, 2 and Q5,6. If v_2 rises, Q1,2 will amplify more and Q5,6 less. If v_2 falls, Q5,6 will amplify more and Q1,2 less.

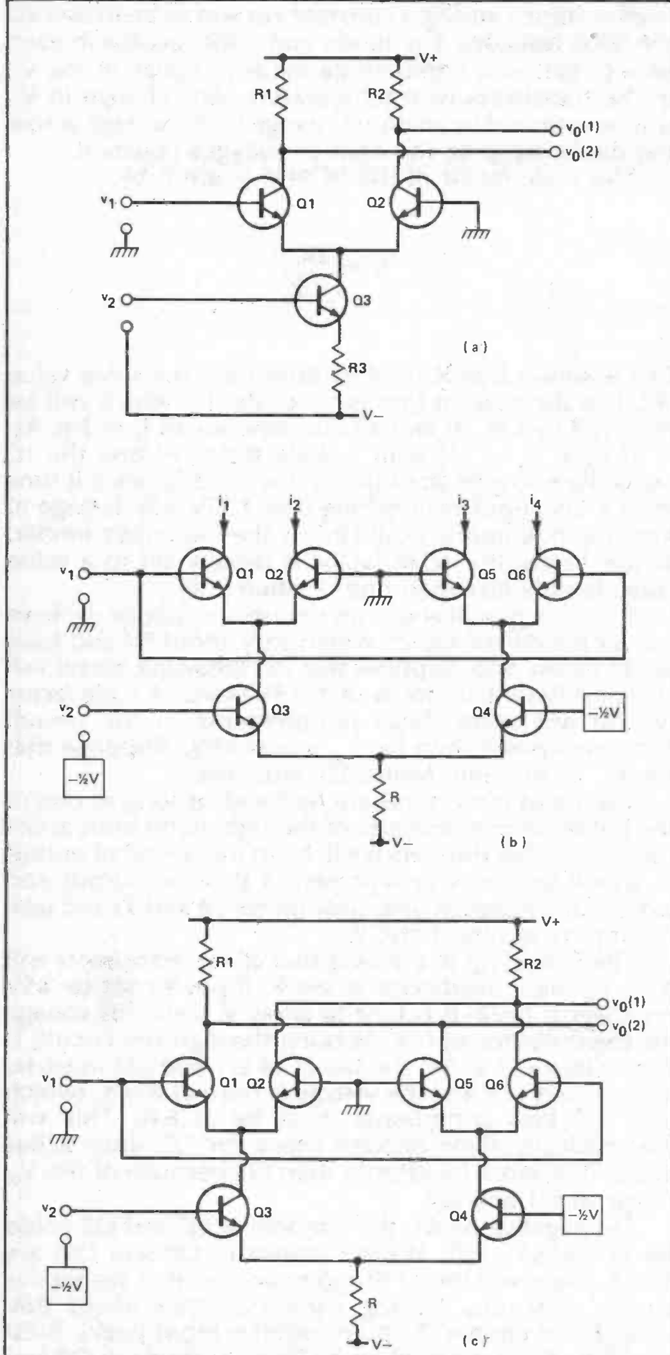


Fig. 2 (a) The basic two quadrant multiplier circuit. (b) doubling up to give a four quadrant multiplier. (c) cross-connecting the collectors.

Think about i_1 and i_3 for a moment. As v_1 varies, i_1 will be modulated in phase with it. Because v_1 drives Q5/6 from the 'opposite side', i_3 will also vary in proportion to v_1 but will be inverted. If v_2 is zero, the magnitude of the changes in i_1 and i_3 will be the same, but in opposite directions. If the currents are added, the net result will be no change at all. If v_2 is above zero, the 'in-phase' current i_1 would predominate. The result of adding i_1 and i_3 would be a net current change in phase with v_1. If V_2 is below zero, variations in i_3 would be greater that those in i_1 and the combined signal would be inverted.

With the two sets of collectors cross connected as in Fig. 2c, the circuit is a full four quadrant multiplier. Another benefit of the cross connection is that there is no longer any problem with shifts in DC level because any increase in current in Q3 is matched by a decrease in Q4 (and vice versa). When these currents are summed again only the wanted differential signal remains.

Taking a differential output still has certain advantages, though. In particular, it cancels any common mode signals caused by imperfections in the current source (or resistor in this case!) and by variations in the base currents of Q1, 2, 5 and 6.

One of the remaining niggles about Fig. 2c is that although it is a perfectly good multiplier, it will only accept very small input signals. Take v_2, for instance. Increase it by 500mV and for all practical purposes Q3 will be taking all the current and Q4 will have none. Long before this point is reached the non-linearity of Q3,4, will have become painfully obvious, so inputs really have to be restricted to a few tens of mV.

Figure 3a shows a differential pair which has been modified to take much larger inputs and maintain excellent linearity. If v_{in} is at 0V there will be no voltage across R (and therefore no current through it), so Q_A and Q_B will each have a current i from their respective current sources. Increase v_{in} and the voltage developed across R will cause some current to flow from Q_A into Q_B's current source. Q_A will have far more than its fair share of current and Q_B will have less.

Assuming constant V_{be} drops for the two transistors, the current change in either collector will be v_{in}/R (but

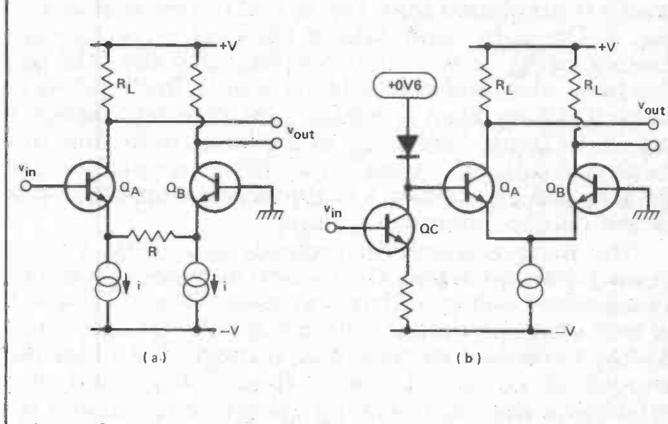


Fig. 3 Alternative methods of increasing the signal handling of the differential pair.

in opposite directions!). The differential output voltage will be $2v_{in}R_L/R$ (by Ohm's law!) so the voltage gain will be $2R_L/R$. Therefore, decreasing R will give increased gain. Unfortunately it will also give poorer linearity, so component choice means selecting a balance between the two.

Another way to increase the signal handling of a differential pair is shown in Fig. 3b. Transistor Q_C produces a current proportional to the input voltage (it gives a fairly linear voltage to current conversion for inputs above one v_{be} drop). The current is passed through a diode which gives a voltage drop proportional to the log of the current. This 'compressed' voltage is then used to drive the differential pair input.

If the diode and Q_A's base-emitter junction are matched (not too difficult on an IC), the compression in the diode will be the reverse of the exponential voltage to current relationship of the transistor and the overall result will be linear!

To return to Figure 2c, the remaining problem is that the inputs and output are all referenced to different voltage levels. Input v_1 varies about 0V, v_2 varies about −½V and the outputs lie somewhere around +½V. It would be convenient to have both inputs and the output

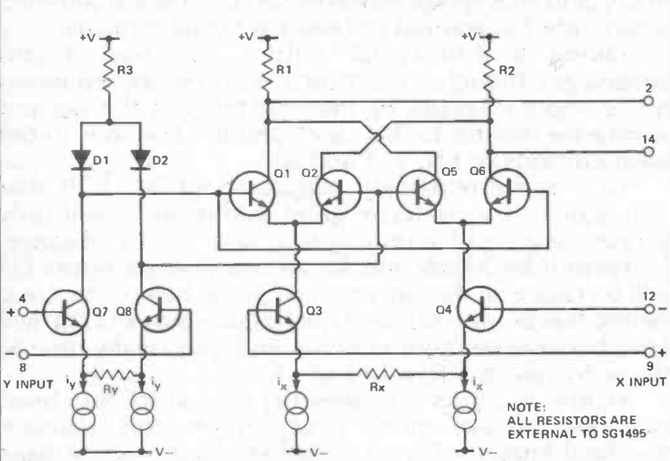


Fig. 4 A simplified circuit of the SG1495.

varying around 0V. In the SG1495 we don't get it but in some more complicated multipliers we do.

Figure 4 shows a simplified circuit of the SG1495, which is developed from Fig. 2c and the ideas shown in Fig. 3. The right hand side of the circuit corresponds closely to Fig. 2c with the exception that the Q3,4 pair has been modified to take larger inputs. Both transistor bases (Q3,4) are taken to external pins allowing differential inputs, or (more likely) one of the bases to be held at a reference voltage — usually 0V. Offset cancellation can be achieved by allowing a slight variation on either side of the chosen reference voltage.

The Y input, which corresponds to V_1 of Fig. 2c, has its own differential pair. The current differences produce 'compressed' voltage differences across D1 and D2 which in turn drive the output differential pairs Q1,2,5,6. Since R3 has a constant current of $2i_Y$ through it, it holds the anodes of D1 and D2 at a fixed voltage and also establishes the DC operating voltage of Q1,2,5 and 6.

Both inputs to the SG1495 can vary about 0V but both output voltages must then be set above 0V to allow the output transistors room to work. The IC is usually followed by some kind of combining and level-shifting network to turn the differential output into a single ended output varying about 0V. In other multiplier ICs, the components to do this are often built in.

Design procedure

The SG1495 is in a very raw state in comparison to most ICs. It allows a great deal of flexibility — the designer can choose his own balance between scale factor, linearity, operating currents and voltages, and so on. The frequency response is comparatively good — in practical circuits the main limiting factor is the interaction between the output resistance and the capacitance of the PCB and following circuitry. The price paid for this flexibility is that the IC can't simply be regarded as a black box. Component values have to be chosen with a weather eye view to what's going on inside.

Figure 5 shows the complete internal circuit of the IC with some essential external resistors added (marked with an asterisk). The input transistors are Darlington pairs rather than single transistors. The current sources i_X and i_Y are replaced by their transistor equivalents. The currents are generated by holding the transistor bases at a fixed voltage which in turn holds the emitters at a fixed voltage, causing a constant current to be drawn via the 500R resistors. The diode and 500R resistor in each base circuit is to compensate for any change in the V_{be} of the transistors with temperature. Any change in V_{be} will be matched by an equal change in the voltage across the diode, keeping the emitter voltages constant.

The scale factor of the SG1495 is given by:

$$K = \frac{2R_L}{I_3 R_X R_Y}$$

This assumes that R1 and R2 both have the same value (R_L). I_3 is the current into pin 3 of the IC, which will be mirrored by Q9, 10 and so corresponds to i_y of Fig. 4a.

If $v_1 = v_2 = 5V$, with a scale factor of one the IC would have to give an output of 5 x 5 = 25V. Since it runs from ± 12V supplies (anything over ± 15V will damage it) this is a little impractical! Unless the inputs are limited to low levels, the scale factor is usually set to a value considerably less than one — often 1/10.

To take a practical design example, suppose we have two single ended inputs which vary about 0V and have peaks below ± 5V. Suppose that the following circuit will accept differential inputs of ± 2.5V peak. A scale factor of 1/10 will meet these requirements — the overall relationship will then be $v_{out} = v_1 x v_2 x 1/10$. Suppose that the IC is running from ± 12V supplies.

The input pins to use are optional (as long as one of the left hand pins and one of the right hand ones aren't used!) The only difference will be in the 'sense' of output — which pin rises to represent a positive output and which for a negative one. Ground pins 8 and 12 and take the inputs to pins 4 and 9.

The first thing to check is that all the transistors will have enough 'headroom' to work. If pin 9 rises to +5V on a signal peak, it is best to allow at least this voltage for the collector of Q3. Working through the circuit, if Q3 collector is at 5V, the bases of Q1 and Q2 must be set at about 5.7V and the voltage at pin 1 of the IC (which sets the bias conditions) must be at 6.4V. This will automatically allow enough space for Q7, since it has about 0.7V more headroom than Q3 because of the V_{be} drops in Q1 and Q2.

On negative peaks, the emitters of Q7 and Q3 could be as low as —6.4V. If the currents in Q9 and Q11 are 10mA, there will be 5V dropped across their respective emitter resistors, leaving each transistor about 0.6V collector to emitter drop on negative input peaks. A bit too close for comfort but with lower currents in Q9 and Q11 there shouldn't be any problem.

Do Q1,2,5 and 6 have enough space? If their bases are at 5.7V, the collectors should be a little below 9V for maximum output swing, giving a highest possible range of ± 3V for each collector. It's not a good idea to use the entire swing, since if one collector is at V+ it means that the transistor is entirely starved of current and the distortion from the IC at or close to this condition is horrifying to contemplate!

With our maximum output requirement of ± 2.5V, each collector will have to rise or fall by 1.25V on peaks from its static voltage, so there's enough leeway. (But if we had demanded a scale factor of more than about 1/5 for the same input range, we'd be making unreasonable demands on the IC). In this case we can afford to be a little more generous with Q3,4 collector voltage, so let's pencil in a voltage of 7V for pin 1 and static voltages of 9V for pins 2 and 14.

This preliminary check can be carried out with rough values in your head. If the voltages are tight enough to need precise values, best reduce the scale factor or 'pot

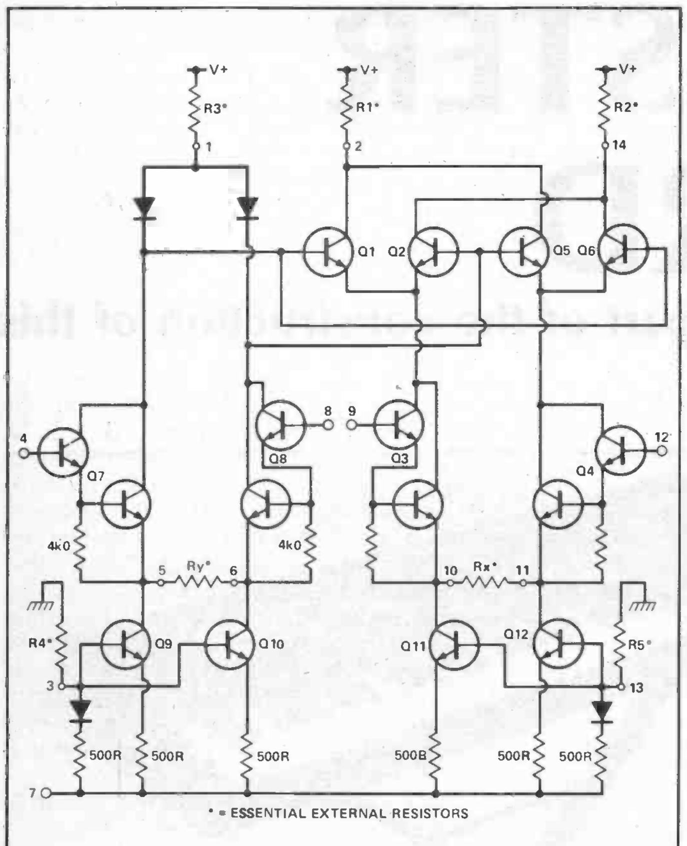


Fig. 5 The full internal circuit of the SG1495.

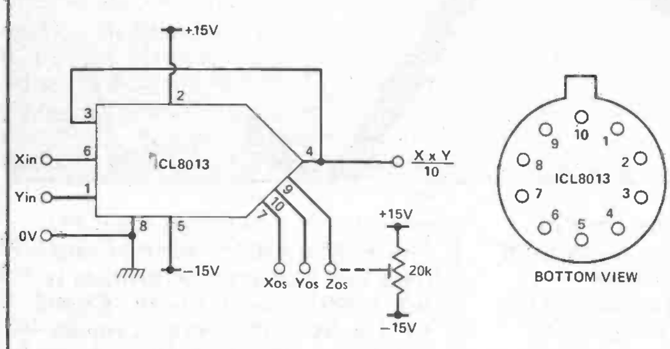


Fig. 6 The simpler ICL8013 multiplier.

down' the inputs. There is going to be some slop in the calculations anyway from the practical consideration of 5% resistor tolerances and so forth.

For the moment, let's set the currents i_x and i_Y arbitrarily at 1mA. If the inputs are to accept voltages of 5V, the absolute minimum value we can then give to either R_x or R_Y is 5k0 – this is the value which will starve one or other of the input transistors entirely of current on input peaks. This would give very nasty distortion on the inputs, so best make R_x and R_y about twice the calculated value (the larger the better!) Pencil in a value of 10k for the moment.

If I_x is 1mA and the voltages at pins 2 and 14 are to be 9V, this settles the values for R1 and R2: they must be 3k0 (or the nearest preferred value).

Now let's see how close we are to the required value of K.

$$K = \frac{2 \times (3 \times 10^3)}{10^{-3} \times 10^4 \times 10^4} = \frac{6}{100}$$

This is too low! To increase it, there are three possibilities:

- Increase R_L. This also means reducing the value of i_x to maintain the static voltage at pins 2 and 14 at 9V, which in turn will decrease the margin for 'current starving' Q3 and Q4 via the 10k resistor.
- Reduce I_3. This will decrease the margin for 'current starving' Q7 and Q8.
- Reduce R_x, R_Y, or both. This will slightly increase the distortion on one or both inputs.

Choosing the best compromise, leave I_3 alone, increase R1 and R2 to 3k3, giving marginally less potential swing at the output, and reduce R_x and R_Y to 8k2. The value of K now becomes:

$$K = \frac{2 \times (3.3 \times 10^3)}{10^{-3} \times 8.2 \times 10^3 \times 8.2 \times 10^3}$$

$$= \frac{6.6}{67.24} \simeq \frac{1}{10}$$

The small error in scale factor (and anything due to resistor tolerances) can be trimmed by a slight adjustment to i_Y.

The remaining component values can now be calculated as a matter of routine: R3 must drop 5V at a current 2mA ($2xi_Y$) and so will be 2k5. The nearest preferred value of 2k7 will be suitable.

R4 must give a voltage drop of 10.8V at 1mA (12V less 1mA through 500ohms = 0.5V, less one diode drop at 1mA = 0.7V). 10k in series with a 2k preset will allow for slight adjustment of I_3 to trim the scale factor.

R5 must also nominally be 10k8. A value of 12k will compensate for the slightly increased values of R1 and R2 (3k3 rather than the calculated 3k0 for a 3V drop).

Input offset can be trimmed by allowing slight adjustment to the voltage on pins 8 and 12 rather than grounding them.

A few general principles to bear in mind when calculating component values are:

- i_x and i_Y should not exceed 10mA to avoid excessive heating of the IC.
- For best frequency response and lowest phase shift, the values of R1 and R2 should be as small as possible.
- Within reason, giving R_x and R_Y values greater than the calculated minimum will reduce distortion in the input circuits. It will also reduce the scale factor, so a suitable balance must be found between the two.
- Most of the IC parameters which can be varied interact with each other. Don't change one value without checking its full effects. If every step you take to bring the IC closer to your requirements seems to be counterbalanced by an opposite effect, it could be that you are making unreasonable demands on the IC. Consider 'potting down' or amplifying the inputs or output.

If all this is too much for you, another multiplier, the ICL8013 (Fig. 6) costs around five times as much but is almost as easy to use as an op-amp and will give working circuits with very l‌ ‌le trouble. **ETI**

MIDI MASTER KEYBOARD

John Yau gets soft for the last part of the construction of this milestone project.

The final stage of the construction of the ETI Midi Master Keyboard is the installation of software to run the whole system.

This is provided in the form of a 16K ROM (a 27128). Only around 2.75K of this is actually used, the rest is left for further expansion of the system. A hex dump of the used parts of the ROM is given here (Listing 1) and this can be laboriously entered by hand into a computer equipped with an EPROM programmer. Alternatively ready-programmed EPROMs are available (see Buylines).

Once the system hardware is all built and a programmed EPROM is installed in the CPU board (as IC17) the whole MIDI Master Keyboard can be tested and set up.

Testing

Power on the system and look to see if the LEDs light up correctly. On power-up, the double digit display remains blank while the lit LEDs correspond to those of MIDI CHANNEL A, GROUP I and BANK A. All the other LEDs should be blank.

If the double digit display lights up when a program number is selected (by pushing a numeric keypad button) and if the MIDI TRANSMIT LED lights up whenever any note on the keyboard is held down then you can take comfort in knowing the system is most likely functioning properly. Final verification will depend on monitoring the MIDI OUT data and checking that all the keypad functions are working properly.

The best way to check if the hardware is transmitting the correct MIDI data is to monitor the MIDI OUT data stream with the ETI BBC micro MIDI interface from the April 1987 issue. With the MIDI monitor program running, any byte of transmitted MIDI data from the MIDI OUT of the keyboard is printed on the screen. It will then be easy to verify if the MIDI messages from the keyboard are correct.

If the basic level of operation cannot be attained it will be necessary to trace some signals around the CPU to try to locate the fault. The two essential diagnostic tools are an oscilloscope and a microcomputer MIDI interface to monitor any data coming out of the MIDI OUT connector.

After power-up check the clock signals to the 6502A (2MHz at pin 37 of IC7), 6522A (2MHz at pin 25 of IC18) and the 68B50 (500kHz at pin 4 of IC4) are present and correct. If the 6502A has correctly gone through its power-up reset sequence and is communicating with the 6522A properly, the VIA should be generating the periodic 2ms interrupt signal. This should be present at pin 21 of IC18 (6522A) and pin 4 of IC7 (6502A).

If there is no sign of this signal or if the hardware seems completely dead then the CPU kernel (the 6502A, address and data bus to memory devices) is not functioning properly. Check for shorts in the copper tracks making up the address and data buses on the CPU board and also check that a through-pin hasn't been missed.

Setting Up

The only setting up to be done lies within the joystick section of the hardware. Monitor the MIDI data with the ETI BBC micro MIDI interface or a similar device. Move the modulation joystick lever and adjust RV2 so that in the position of highest modulation, the transmitted data byte is 127.

The pitch bend joystick is slightly more tricky to set up. On power-up the pitch bend joystick is read and defined to be in the neutral position (data value 64). The target is to get the system to send zero in the lowest joystick

```
0000 78 D8 A2 FF 9A A9 03 8D 00 0C A9 15 8D 00 0C A9
0010 FF 8D 02 09 A9 00 8D 03 09 A9 40 8D 0B 09 A9 A0
0020 8D 04 09 A9 0F 8D 05 09 A9 80 8D 03 0A A9 FF 8D
0030 00 0A A9 81 8D 01 0A A9 01 8D 02 0A A2 00 A9 00
0040 8D 00 0B 95 0C E8 E0 48 D0 F9 A2 00 95 54 E8 E0
0050 48 00 F9 A2 00 95 A2 E8 E0 1E D0 F9 85 01 85 00
0060 85 08 85 C6 85 9E 85 C8 85 C7 85 9F A9 04 85 C9
0070 AD 42 C2 85 0A AD 43 C2 85 0B A9 64 85 CD 85 CE
0080 A9 F0 85 05 A9 F1 85 06 A9 00 85 07 A9 80 85 9C
0090 85 9D A9 00 85 A0 85 D3 A9 00 85 D4 AD 00 0B 85
00A0 D1 A9 80 85 A1 A9 C0 8D 0E 09 58 18 90 FD 48 8A
00B0 48 98 48 08 AD 04 09 A5 01 C5 00 F0 09 A8 B9 00
00C0 02 8D 01 0C E6 01 A2 00 BD 00 08 BD 00 08 85 03
00D0 B5 0C D0 10 A5 03 C9 03 F0 03 4C 91 C1 A9 01 95
00E0 0C 4C 91 C1 C9 01 D0 62 A5 03 C9 03 D0 0B B5 54
00F0 C9 3F B0 02 F6 54 4C 91 C1 C9 01 D0 09 A9 00 95
0100 0C 95 54 4C 91 C1 A9 02 95 0C A5 C3 F0 03 4C 91
0110 C1 A4 00 E4 07 90 08 A5 CD 85 CC A5 05 D0 06 A5
0120 CE 85 CC A5 06 29 9F 99 00 02 C8 E6 00 86 04 A5
0130 CC 38 E5 04 99 00 02 E6 00 B5 54 A8 B1 0A A4 00
0140 99 00 02 E6 00 A6 04 18 90 47 A5 03 C9 01 D0 39
0150 A9 00 95 0C 95 54 A4 00 E4 07 90 08 A5 CD 85 CC
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0170 B6 04 A5 CC 38 E5 04 99 00 02 C8 B5 54 99 00 02
0180 E6 00 E6 00 E6 00 18 90 08 C9 02 D0 04 A9 02 95
0190 0C E8 E0 48 F0 03 4C C8 C0 A5 01 C5 00 F0 09 A8
01A0 B9 00 02 8D 01 0C E6 01 A5 08 D0 06 20 04 C3 18
01B0 90 75 C9 01 D0 06 20 0C C3 18 90 6B C9 02 D0 06
01C0 20 14 C3 18 90 61 C9 03 D0 06 20 1C C3 18 90 57
01D0 C9 04 D0 06 20 43 C3 18 90 4D C9 05 D0 06 20 6C
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0200 90 25 C9 09 D0 06 20 71 C7 18 90 1B C9 0A D0 06
0210 20 C0 C7 18 90 11 C9 0B D0 06 20 6E C6 18 90 07
0220 C9 0C D0 03 20 EC C6 E6 08 A5 08 C9 0D D0 04 A9
0230 00 85 08 28 68 A8 68 AA 68 40 00 F0 40 F0 80 F0
0240 C0 F0 00 F1 40 F1 80 F1 C0 F1 00 F2 40 F2 80 F2
0250 C0 F2 00 F3 40 F3 80 F3 C0 F3 00 01 02 03 04 05
0260 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21
0270 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
0280 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53
0290 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69
02A0 70 71 72 A5 9E D0 07 A5 9C 29 0F 18 90 0A A5 9D
02B0 29 0F 18 90 03 AA CA 8A 18 65 C8 AA A4 00 A5 9E
02C0 F0 07 A5 06 86 9D 18 90 04 A5 05 86 9C 29 CF 99
02D0 00 02 C8 8A 99 00 02 E6 00 E6 00 20 9B C3 60 A5
02E0 9E F0 05 A5 06 18 90 02 A5 05 25 D2 A4 00 99 00
02F0 02 C8 A5 CA 99 00 02 C8 A5 CB 99 00 02 E6 00 E6
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0310 A9 FD D0 0E A9 B2 85 C5 A9 FB D0 06 A9 BA 85 C5
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0390 85 C3 18 90 05 E8 E0 0D D0 DE 60 A5 9E F0 09 A5
03A0 CE 85 CC A5 9D 18 90 06 A5 CD 85 CC A5 9C A8 29
03B0 80 F0 07 A9 FF 8D D0 0A D0 6B 98 29 40 D0 0D AD
03C0 01 0A 29 3F 09 80 8D 01 0A 18 90 0A AD 01 0A 29
03D0 3F 09 40 8D 01 0A 98 29 30 D0 0C AD 02 0A 29 F0
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0560 C8 29 CF 09 20 85 C8 20 A3 C2 18 90 39 C9 08 D0
0570 0E A5 C8 29 CF 09 30 85 C8 20 A3 C2 18 90 27 C9
0580 0D D0 23 A5 C8 49 40 85 C8 20 A3 C2 18 90 17 A5
0590 C2 F0 0C 29 80 D0 0F A5 C2 20 B5 C2 18 90 07 A5
05A0 C7 F0 03 20 9B C3 60 AD 01 0A 29 FB 09 20 8D 01
05B0 0A A5 CC C9 64 90 0B 38 E9 64 AA BD 5A C2 8D 00
05C0 0A 60 38 A9 64 E5 CC AA BD 5A C2 8D 00 0A AD 01
05D0 0A 09 04 8D 01 0A 60 A5 C7 F0 27 A5 C3 29 7F C9
05E0 03 80 22 A5 C2 F0 1B AA A8 29 80 D0 15 CA 8A 09
05F0 F0 A6 9E D0 05 85 05 18 90 02 85 06 B9 5A C2 8D
0600 00 0A 18 90 6B C9 04 D0 24 A5 C2 F0 60 AA A8 29
0610 80 D0 5A CA B6 C9 B9 5A C2 8D 00 0A 8A 0A AA BD
0620 3A C2 85 0A E8 BD 3A C2 85 0B 18 90 40 C9 03 D0
0630 19 A5 09 D0 38 A5 C4 F0 34 A8 B9 5A C2 8D 00 0A
0640 A9 48 38 E5 C4 85 07 18 90 23 C9 0C D0 1F A5 09
0650 D0 1B A5 C4 F0 17 18 69 44 85 CC A5 9E D0 07 A5
0660 CC 85 CD 18 90 04 A5 CC 85 CE 20 A7 C5 60 A5 CF
0670 C5 D1 90 10 38 E5 D1 C9 08 90 24 18 69 80 90 18
0680 A9 FF D0 14 A5 D1 38 E5 CF C9 08 90 12 85 04 A9
0690 80 38 E5 04 B0 02 A9 00 C5 A1 F0 22 18 90 08 A5
06A0 A1 C9 80 F0 19 A9 80 85 A1 4A AA 90 04 A9 01 D0
06B0 02 A9 00 85 CA 86 CB A9 EF 85 D2 20 DF C2 A5 D0
06C0 4A C9 02 90 11 C5 9F F0 22 85 CB 85 9F A9 01 85
06D0 CA D0 11 18 90 15 A5 9F F0 11 A9 00 85 9F 85 CB
06E0 A9 01 85 CA A9 BF 85 D2 20 DF C2 60 A9 F7 8D 00
06F0 09 AD 01 09 AA 29 01 C5 A0 F0 29 85 A0 A5 A0 D0
0700 0C AD 01 0A 29 F7 8D 01 0A A9 00 F0 0A AD 01 0A
0710 09 08 8D 01 0A A9 7F 85 CB A9 BF 85 D2 A9 40 85
0720 CA 20 DF C2 8A 29 02 C5 D3 F0 19 85 D3 A5 D3 D0
0730 04 A9 00 F0 02 A9 7F 85 CB A9 BF 85 D2 A9 41 85
0740 CA 20 DF C2 8A 29 04 D0 06 A9 00 85 D4 F0 21 A5
0750 D4 D0 1D A9 7F 85 D4 A5 9E F0 05 A5 9D 18 90 02
0760 A5 9C C9 80 B0 0A 29 0F AA E8 8A 29 0F 20 B8 C2
0770 60 A9 00 85 D5 85 D6 AD 02 0A 29 0F 8D 02 0A A0
0780 10 8D 00 0B A2 06 CA D0 FD AD 00 0B 18 65 D6 85
0790 D6 90 02 E6 D5 88 D0 E9 29 0F C9 08 90 06 A9 01
07A0 85 04 D0 04 A9 00 85 04 A5 D5 0A 0A 0A 0A A8 A5
07B0 D6 4A 4A 4A 4A 85 D9 98 05 D9 18 65 04 85 CF 60
07C0 A9 00 85 D8 85 D7 AD 02 0A 09 80 8D 02 0A A0 10
07D0 8D 00 0B A2 06 CA D0 FD AD 00 0B 18 65 D8 85 D8
07E0 90 02 E6 D7 88 D0 E9 29 0F C9 08 90 06 A9 01 85
07F0 04 D0 04 A9 00 85 04 A5 D7 0A 0A 0A 0A A8 A5 D8
0800 4A 4A 4A 4A 85 D9 98 05 D9 18 65 04 85 D0 60 00
3000 7F 40 2A 20 19 15 12 10 0E 0D 0C 0B 0A 09 08 08
3010 07 07 07 06 06 06 06 05 05 05 05 05 04 04 04 04
3020 04 04 04 04 03 03 03 03 03 03 03 03 03 03 03 03
3030 03 03 02 02 02 02 02 02 02 02 02 02 02 02 02 02
3040 7F 47 31 25 1E 19 16 13 11 0F 0E 0D 0C 0B 0A 0A
3050 09 09 08 08 07 07 07 07 06 06 06 06 05 05 05 05
3060 05 05 05 04 04 04 04 04 04 04 04 04 04 03 03 03
3070 03 03 03 03 03 03 03 03 03 03 03 03 03 03 03 02
3080 7F 5B 47 3A 31 2A 25 21 1E 1C 19 18 16 14 13 12
3090 11 10 0F 0F 0E 0E 0D 0C 0C 0C 0B 0B 0A 0A 0A 09
30A0 09 09 09 08 08 08 08 08 07 07 07 07 07 07 07 06
30B0 06 06 06 06 06 06 06 06 05 05 05 05 05 05 05 05
30C0 7F 5E 4B 3E 35 2E 29 25 21 1F 1C 1A 18 17 16 14
30D0 13 12 11 11 10 0F 0F 0E 0E 0D 0D 0C 0C 0B 0B 0B
30E0 0A 0A 0A 0A 09 09 09 09 08 08 08 08 08 08 07 07
30F0 07 07 07 07 07 07 06 06 06 06 06 06 06 06 06 06
3100 7F 62 4F 43 3A 33 2D 29 25 22 20 1E 1C 1A 18 17
3110 16 15 14 13 12 12 11 11 10 0F 0F 0E 0E 0D 0D 0C
3120 0C 0C 0B 0B 0B 0A 0A 0A 0A 0A 09 09 09 09 09 08
3130 08 08 08 08 08 08 08 07 07 07 07 07 07 07 06 06
3140 7F 63 51 45 3C 35 2F 2B 27 24 21 1F 1D 1B 1A 18
3150 17 16 15 14 13 12 12 11 10 10 0F 0F 0E 0E 0E 0D
3160 0D 0C 0C 0C 0B 0B 0B 0B 0A 0A 0A 0A 0A 09 09 09
3170 09 09 08 08 08 08 08 08 08 07 07 07 07 07 07 07
3180 7F 66 55 49 40 38 33 2E 2A 27 24 22 20 1E 1C 1B
3190 19 18 17 16 15 14 14 13 12 12 11 10 10 0F 0F 0F
31A0 0E 0E 0D 0D 0D 0C 0C 0C 0C 0B 0B 0B 0B 0A 0A 0A
31B0 0A 0A 09 09 09 09 09 09 09 08 08 08 08 08 08 08
31C0 7F 6A 5B 4F 47 3F 3A 35 31 2D 2A 28 25 23 21 20
31D0 1E 1D 1C 1A 19 18 18 17 16 15 14 14 13 13 12 12
31E0 11 11 10 10 0F 0F 0F 0E 0E 0E 0D 0D 0D 0C 0C 0C
31F0 0C 0C 0C 0B 0B 0B 0B 0B 0A 0A 0A 0A 0A 0A 09 09
3200 7F 6C 5D 52 4A 43 3D 38 34 30 2D 2B 28 26 24 22
3210 21 1F 1E 1D 1C 1B 1A 19 18 17 16 16 15 14 14 13
3220 13 12 12 11 11 11 10 10 0F 0F 0F 0E 0E 0E 0E 0D
3230 0D 0D 0D 0C 0C 0C 0C 0C 0B 0B 0B 0B 0B 0A 0A 0A
3240 7F 6E 62 58 4F 49 43 3E 3A 36 33 30 2D 2B 29 27
3250 25 24 22 21 20 1F 1E 1D 1C 1B 1A 19 18 18 17 16
3260 16 15 15 14 14 13 13 13 12 12 11 11 11 10 10 10
3270 0F 0F 0F 0F 0E 0E 0E 0E 0E 0D 0D 0D 0D 0D 0C 0C
3280 7F 73 6A 62 5B 55 4F 4B 47 43 3F 3C 3A 37 35 33
3290 31 2F 2D 2C 2A 29 28 26 25 24 23 22 21 21 20 1F
32A0 1E 1E 1D 1C 1C 1B 1A 1A 19 19 18 18 18 17 17 16
32B0 16 16 15 15 14 14 14 14 13 13 13 12 12 12 12 11
32C0 7F 79 73 6E 6A 66 62 5E 5B 58 55 52 4F 4D 4B 49
32D0 47 45 43 41 40 3E 3C 3B 3A 38 37 36 35 34 33 32
32E0 31 30 2F 2E 2D 2D 2C 2B 2A 2A 29 28 28 27 26 26
32F0 25 25 24 24 23 23 22 22 21 21 21 20 20 1F 1F 1F
3300 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
3310 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
3320 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
3330 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
3340 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
3350 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
3360 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
3370 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
3380 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40
3390 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40
33A0 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40
33B0 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40 40
33C0 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F
33D0 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F
33E0 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F
33F0 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F 7F
3FF0 FF FF FF FF FF FF FF FF FF FF FF FF 00 C0 AE C0
```

Listing 1. The hex dump of the used sections of the 27128 EPROM.

position and 128 for the highest position.

Two adjustments are required in order to achieve this, the gain control RV1 and also the relative position between the potentiometer and the joystick lever. Adjusting the gain (RV1) in combination with finely adjusting the potentiometer centering should achieve the correct results. An important point to note is that the hardware must be powered off and then on again after any adjustments so that the new neutral position is registered by the software.

Operation

The Program Select will probably be the most frequently used keypad request. The 128 possible program numbers are segregated into two groups (I and II) of 64. Each group is partitioned into four banks (A, B, C and D) of 16 and the numeric keys 1 to 16 which are used to select the program within the selected bank. If your synthesiser has, say, only 32 stored voices which can be selected by MIDI then only banks A and B will be used. All other selections will simply be a repeat of what's available in banks A and B.

Note that a MIDI program change is transmitted when any bank or group button is pressed as well as any numeric button.

Output Stream

The MIDI Master Keyboard's versatility is greatly enhanced by transmitting data through a programmable MIDI channel and by having a dual channel MIDI output stream. On power-up, all data is transmitted via the channel A output stream, on MIDI channel 1.

To change the MIDI channel the channel button must be held down and a numeric button 1-16 selected. The change can be verified by pressing the channel button on its own again so that the newly selected MIDI channel number is displayed.

If the channel B button is pressed, all data is transmitted on the MIDI channel that has been programmed into the B output stream (default on power-up is channel 2).

The only exception to this rule is when a split point has been programmed, in which case all notes to the left of the split point will be transmitted on the channel A output stream, whilst all notes to the right will be transmitted on channel B.

The dual output stream capability, although primarily intended for implementing the split point facility, can also be used to remotely change programs on MIDI digital effects units such as the YAMAHA SPX90. The effects unit is simply set to receive on MIDI channel B, so that it responds to any program change requests made (when current output stream is set on channel B) from the function keypad.

Split Point

If the 'SPLIT' button is pressed and held down the double digit display will show the currently selected split point. The number 1 corresponds to the leftmost key and 72 is the rightmost key. The power-up default is 720 so that all the notes are directed towards channel A.

To program a new split point the procedure is to simply press the selected note on the keyboard whilst holding down the SPLIT button. Once selected, release the SPLIT button and the new split will now be effective.

Transpose

When a split point is in effect, both parts of the keyboard are transposable independently. The currently selected output stream decides which part of the keyboard is to be affected when the transpose function is selected.

HOW IT WORKS — SOFTWA

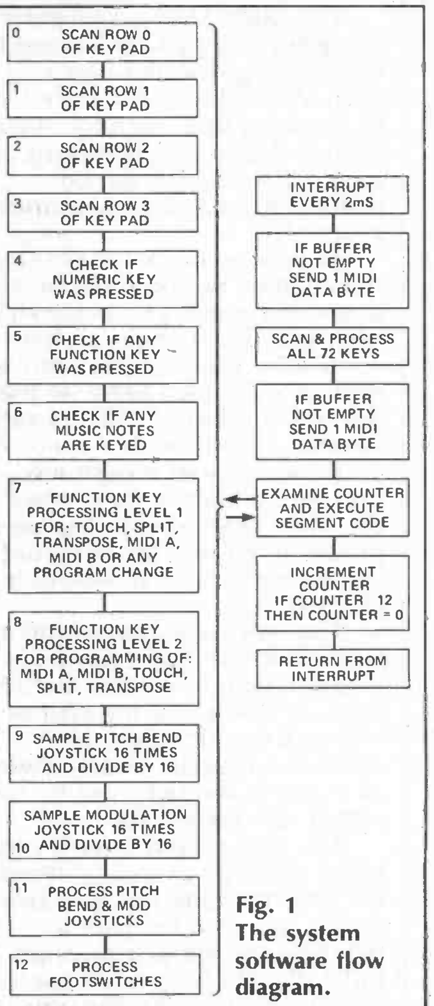


Fig. 1 The system software flow diagram.

The most time-critical part of the system software is the part which does the keyboard scanning. Not only does it have to scan the keyboard polyphonically and detect key strikes and releases, it also has to determine key strike velocities. Such demands require complete scans of the keyboard to occur at precise time intervals. The smaller the time interval, the greater the velocity sensing resolution.

This is achieved by placing the key scanning code at the start of an interrupt routine which executes every 2ms. The periodic 2ms signal which interrupts the 6502A processor is generated by the internal timer in IC18 (6522A VIA). Also high in priority is the section of code which empties the buffer containing data to be transmitted via MIDI. When the buffer is being emptied, two bytes of MIDI information can be transmitted every 2ms interrupt period. Such a data rate is sufficiently fast to ensure delays in response are insignificant.

Since the key scan and MIDI buffer empty routines typically take up about half the available 2ms time slot there is some spare time allocation for other processing tasks. Figure 1 shows the structure of the software.

On power-up, once everything has been initialised, the main program divides into an endless loop so that thereafter the only real processor activity comes from the periodic interrupt routines.

The code pertaining to the house-keeping activities is segmented into 13 parts. A software counter is maintained so that in successive interrupt routines the 13 sections of code are executed in turn. Segmentation of the house-keeping routines is necessary because of the limited amount of spare time in each 2ms time slot.

The house-keeping routines were segmented so that the time slot for each segment, when added to the worst case duration of the keyscan routine, would not exceed the 2ms duration of the interrupt period.

Calculations show that in the extreme case when about a dozen notes are played at once (Martian musicians take note!) it is possible to exceed the 2ms time allocation. This however, is not at all catastrophic since all that happens is that a velocity count is missed, which hardly affects the overall dynamics of the MIDI keyboard.

Keyboard Scanning

The current physical state of any of the 72 keys on the keyboard can be obtained by examining locations 0800H to 0847H which are memory mapped directly to the keyswitch hardware. However, for the software to determine when to send out MIDI note on/off events it must also know the state of all the keys from the previous scan. This is achieved by storing the states of the keys in 72 zero page RAM locations.

The contents of each of these RAM locations shows an identifier code (0-3) for each of the four possible sequential states that a key can be in — 'transition going up' and 'transition going down'.

When a key is processed, its current state is compared with its last state (from the previous scan). Any necessary action is taken and the RAM location describing the previous stage is updated according to the sequential state diagram of Fig. 2.

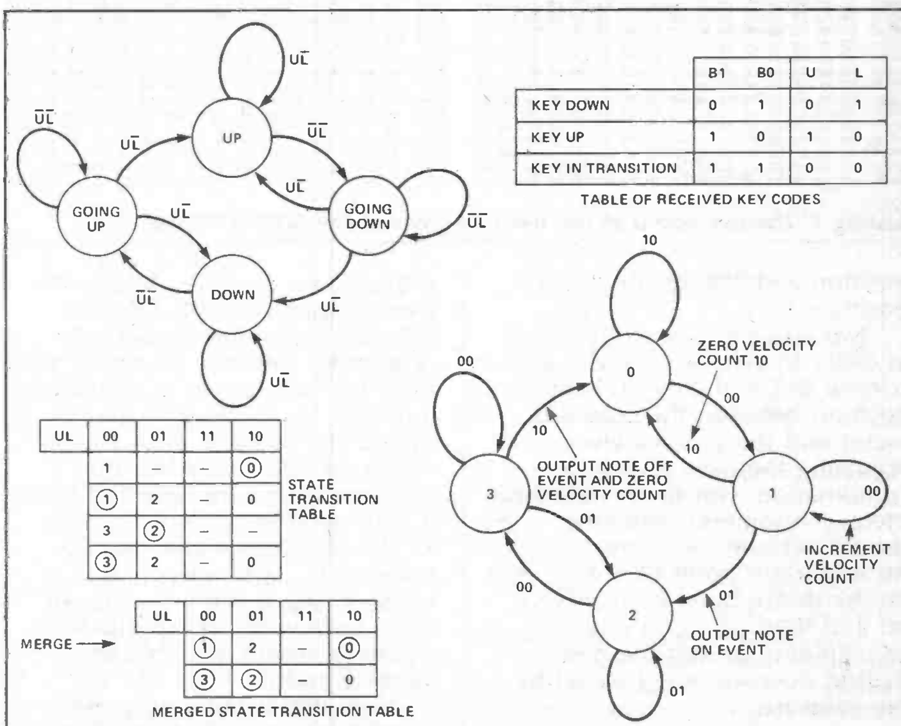
The sequential state diagram shows how each key state traverses into a new state as a function of the current key-switch position and its previous state. The two digit binary numbers are the primary variables and indicate the state of the upper and lower bus bars (U and L) for a particular transition.

Most of the process or key strike velocity sensing is tackled by the software. When a key is struck, it leaves state 0, moves through state 1 and ends up in state 2. The velocity of the key can be determined by timing how long the contact spring stays in the air gap between the two bus bars.

This is achieved in software by counting the number of 2ms scan periods that the keyswitch stays in state 1, the 'transition going down' state. So in addition to the key state RAM locations there are a further 72 zero page locations that serve as velocity counters for active keys.

The maximum count allowed is 63, so the time period that a key spends in state 1 is measured to be in the range 0 to 128ms, with a resolution of 2ms. In practice, most key strikes are well within half that time period range.

When a key is struck, the contact spring may initially make or break contact several times with the upper bus bar. Zeroing the velocity count for every state 1 to state 0 transition ensures that the velocity sensing is not upset by switch bounce, by ensuring that the time period is always measured from the last point of contact with the upper bus bar to the time of first contact with the lower bus bar.



	B1	B0	U	L
KEY DOWN	0	1	0	1
KEY UP	1	0	1	0
KEY IN TRANSITION	1	1	0	0

TABLE OF RECEIVED KEY CODES

UL	00	01	11	10
	1	–	–	0
	1	2	–	0
	3	2	–	–
	3	2	–	0

STATE TRANSITION TABLE

UL	00	01	11	10
MERGE	1	2	–	0
	3	2	–	0

MERGED STATE TRANSITION TABLE

Fig. 2 The keyboard state diagram.

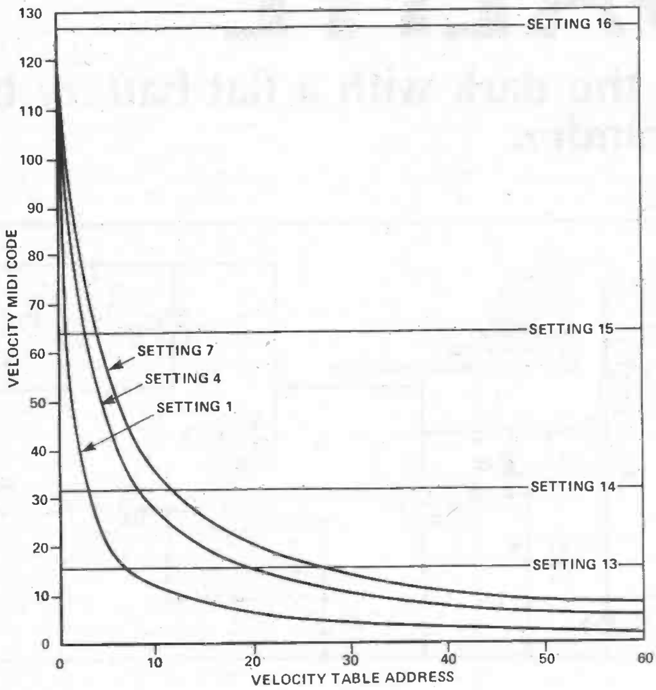


Fig. 3 Touch sensitivity curves.

The velocity count for a key cannot be used directly since it corresponds to a time period, not a velocity. We need to derive a suitable velocity byte from the time period count. This is easily achieved by using the time period count to index a look-up table containing suitable velocity values. The software permits a choice of 16 look-up tables giving 16 different touch response settings (shown in Fig. 3).

Note that the last four look-up tables are filled with contant values of 16, 32, 64 and 127 respectively. These non touch sensitive settings add versatility to the keyboard operation, since touch sensitivity is not always desired.

MIDI Data

Transmission of MIDI data is accomplished by maintaining a first in first out (FIFO) buffer in RAM. The buffer size is 256 bytes and occupies page two of the processor's RAM workspace. There are two pointers, one for the output and one for the input, to maintain the operation of the FIFO buffer. If the processor decides that a MIDI event is to be transmitted it places the relevant data bytes in the FIFO queue. Thereafter two bytes of data from the queue are sent to the ACIA in every 2ms interrupt period until the buffer is empty again. The buffer size is sufficiently large to ensure it never overflows. A 256 byte size was also chosen because of ease of management with eight bit pointers.

When a note on/off event is to be sent an offset is added to the note number before transmission. On power-up, the offset defaults such that when middle C is pressed or released, the resultant note number sent is 60 — the correct MIDI code for middle C.

The keysplit facility is implemented by maintaining a RAM location which holds the note number of the programmed split point. On transmission of a MIDI note event, the note number is compared to the split point. If it is less than the split point note number, the data is directed to the MIDI channel associated with channel A. Otherwise it is directed to channel B. On power-up, the split point defaults to 72 (the rightmost note) so that all output goes to channel A.

Joystick Software

The positions of the two joysticks are read continually as part of the housekeeping software. In order to counteract least significant bit fluctuations in the readings (due to the finite resolution of the A/D converter), each joystick position reading is the result of averaging over a set of 16 successive samples.

The centering joystick lever can never be expected to spring back to precisely the same neutral position so it was necessary to implement a dead-band in software.

BUYLINES

The EPROM software to drive the MIDI Master Keyboard is available from the author for £16. A programmed 27128 EPROM is supplied along with the source code in BBC Basic/assembler on disk. Orders and enquiries should be sent to John Yau, 7 Maurice Place, Edinburgh EH9 3EP.

Photocopies of the source code may also be obtained from the ETI Photocopy Service, 1 Golden Square, London W1R 3AB for £4 (make your cheque payable to ASP Ltd).

For example, if we wish to transpose the part of the keyboard to the left of the split point then the currently selected output stream has to be channel A. To implement the transpose facility, first of all press the TRANSPOSE button. The present setting is then displayed on the dual digit display in the form of an offset in semitones from middle C.

A number with the leftmost decimal point lit means that the offset is negative. A number on its own implies a positive offset.

In its non-transposed state the number displayed is 0. To program a new transpose setting, hold the TRANSPOSE button down and select a note on the keyboard. Pressing middle C will result in a zero offset and pressing any other note will result in the keyboard being transposed by the relative offset in semitones from middle C.

Note that once a non-zero transpose setting has been programmed the LED above the TRANSPOSE button will remain lit.

Touch Sensitivity

The present touch sensitivity is displayed when the TOUCH button is pressed and held down. To program a new touch setting, hold the TOUCH button down and press a number 1-16. Release the two buttons and verify the change by pressing TOUCH on its own again. You can also verify the change by playing the keyboard!

Footswitches

The footswitch sockets are intended for use with push-to-break switches which is consistent with the commercial equipment. Pushing the pedal hold switch should result in the hold LED lighting up as well as the appropriate MIDI messages being transmitted. Successive switching of the patch advance footswitch will result in successive program number changes within the currently selected bank of 16. The last footswitch switches portamento in and out via MIDI (not all synthesisers will make use of this).

Acknowledgements

The author wishes to thank the following people who helped to make this project possible: Alistair Houston for etching the PCBs, Moray Rumney for the photography, Ron and Ian C. for the metalwork. Thanks also to Glyn, Ian A., Mitch, Lynsey and Shona.

ETI

REMINDALITE

Bob Noyes won't be left in the dark with a flat battery thanks to this handy car lights reminder.

With the modern trend to get as many electrical functions in the car on to as few steering column stalks as possible, some form of monitoring is desirable to ensure that nothing has been switched on accidentally or left on inadvertently, because just looking at the stalks can be misleading.

Most functions, such as windscreen wipers, washers, heated rear windscreen and so forth will be switched off when the ignition is, independently of their own function switches. However, the lights can be left on with the ignition off and the resultant drain on the battery, if prolonged, may result in an unpleasant surprise at the next attempt to start the car. With the Remindalite, this problem should be a thing of the past.

The Remindalite sounds several high-pitched buzzes in the event of the lights being switched on with the ignition off or if the ignition is switched off while the lights are on. After a few seconds the buzzing stops as it can be valid to have the lights on, but it brings the situation to your attention.

Construction

The board can be simply built with no particular problems as long as the usual care is taken with the orientation of the diodes, capacitors and semiconductors. LED1 can be mounted either on the board *or* separately in the car dashboard. Provision is made on the board for either alternative.

When the board has been built and thoroughly inspected the following tests can be made before connecting it into the car.

For test purposes a 1k0 resistor should be connected between B and D on the terminal strip to simulate the resistive load of the car's electrical system (without it the following test routine will not function).

A 12 volt supply is required with 0V connected to terminal D. The supply should be switched off between tests to allow C1 to discharge.

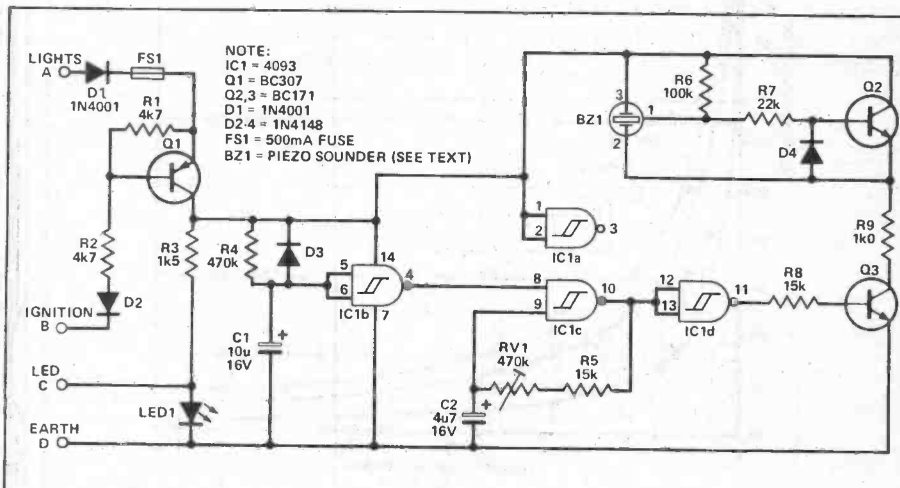


Fig. 1 The circuit diagram of the Remindalite.

PARTS LIST

RESISTORS (all ¼W 5%)	
R1, 2	4k7
R3	1k5
R4	470k
R5, 8	15k
R6	100k
R7	22k
R9	1k0
CAPACITORS	
C1	10µ 16V tantalum
C2	4µ 16V tantalum
SEMICONDUCTORS	
IC1	4093
Q1	BC307
Q2, 3	BC171
D1-4	1N4148
LED1	Red LED
MISCELLANEOUS	
BZ1	Piezo buzzer
FS1	500mA fuse and fuse holder

PCB; case; cables and connectors; 4 way terminal strip; nuts and bolts.

With 12V connected to terminal A (the lights) and terminal B (the ignition) disconnected the LED should light and the buzzer sound a series of beeps. With terminal A disconnected the LED should be off and the

HOW IT WORKS

The unit is powered only when the lights are on. Q1, a general purpose PNP transistor, is wired so that with 12 volts on terminal B, it is biased off by R1 when the lights and ignition are both on. With Q1 switched off, IC1 is deprived of power.

If the ignition is turned off, terminal B falls to 0V and is held there by the resistive load of the HT coil, alternator coils and so on. Q1 turns on via the potential divider R1, R2 and its collector, at 12 volts, supplies power to IC1 and LED1 via its current-limit resistor R3.

Q1 remains on while the lights are on and the ignition off. To prevent the piezo buzzer sounding continuously, a pulse generator is formed around IC1b. As C1 charges up through R4 the output pin 4 remains high (+12V) until the voltage on C1 reaches about 8 volts. At this point, pin 4 goes low and remains low until the lights are turned off and C1 can discharge through D3, R3 and LED1. To lengthen this period R4 can be increased in value or to decrease it R4 can be reduced.

From the time Q1 switches on until C1 reaches 8V, IC1 pin 4 will be high, enabling the oscillator built around IC1c. This is a simple oscillator with a time constant of (RV1+R5) C2. RV1 is provided to allow the user to tune the piezo buzzer to give the most noticeable bleep.

The piezo buzzer in conjunction with Q2, D4, R6 and R9 forms a self-contained oscillator that will oscillate at the optimum frequency to give the highest sound output level. Although it only draws a few milli-amps this is more than a CMOS gate can safely provide and so Q3 is used as a current amplifier.

buzzer silent regardless of the connection to terminal B.

When these checks have been carried out satisfactorily the unit is ready to fit. Remove the 1k0 test resistor from terminals B and D.

As the unit is going to be left in the car for the rest of its life, a PCB protective lacquer should be sprayed over both sides of the board to stop corrosion in years to come.

Fitting

The car's electrical circuit diagram should ideally be consulted so that the colour of the two wires that need to be located can be ascertained. Otherwise the sidelight live connection can be found by following the sidelight wire back into the loom and the switched side of the ignition circuit can be found on the ignition switch.

The car's battery positive terminal should be disconnected before actual connections are made to prevent an accidental short while wiring. The 0V terminal D can be connected to any convenient bodywork nut and bolt, screw, etc.

After the three connections are made to the car's system and the LED fitted to the dash (if it hasn't been mounted on the PCB) the battery can be re-connected and a full test of the unit made.

When all the tests have been completed satisfactorily, the Remindalite should be tucked up out of the way. If the LED is mounted on the PCB and showing through a hole in the top of the box, it should be placed in such a position that it can be seen.

ETI

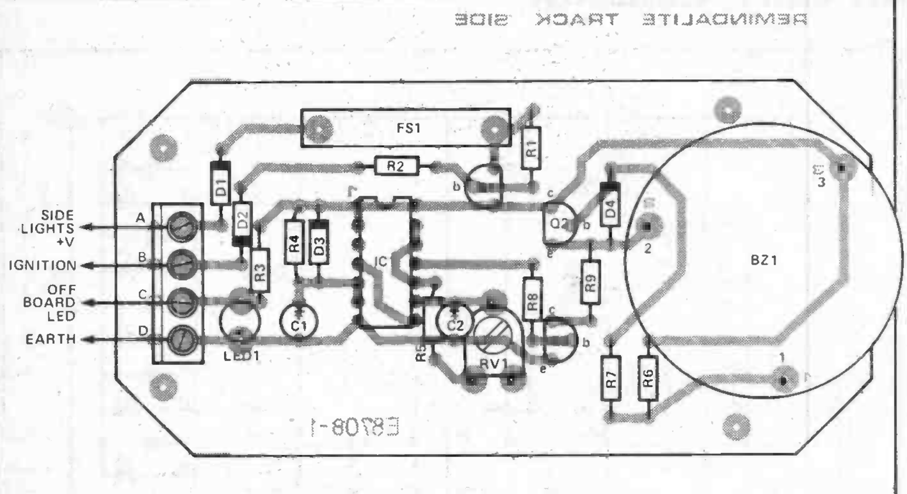


Fig. 2 The component overlay for the Remindalite PCB.

BUYLINES

The piezo buzzer used was from Electromail (Tel: (0536) 204555) as part number 248-369. Any suitable plastic case may be used. The PCB is available from the PCB Service. See the back of this issue for details.

SONIC REV COUNTER

Conserve petrol and extend the life of your engine with this novel rev counter from Gary Calland.

Most cars today are supplied with a rev counter. Those that do have a tiny panel meter stuck in the corner of the dashboard which is virtually impossible to read.

Rev counters are not unnecessary novelty devices specifically designed to make a car look sporty (even though they do this well) but are useful money-saving instruments. By running your engine at its optimum speed, savings in fuel and wear and tear can be reduced.

Commercially available rev counters usually display their information by using a small moving coil meter. This is unsatisfactory as a small meter needle is difficult to see, especially at night when the meter is illuminated by a small bulb. This bulb will inevitably burn out rendering an irritable and intricate replacement process.

This rev counter overcomes these problems by using a 10 LED colour coded bargraph display. This attractive display can be easily read day or night and will last more or less indefinitely.

The colour coding means the display is easy to understand as green LEDs mean the engine is running within limits while red LEDs mean it is being over-revved. However, for a more accurate interpretation, each LED corresponds to approximately 600 revs.

Commercial rev counters can also be difficult to install. Usually this entails wrapping pick up coils around various parts of your

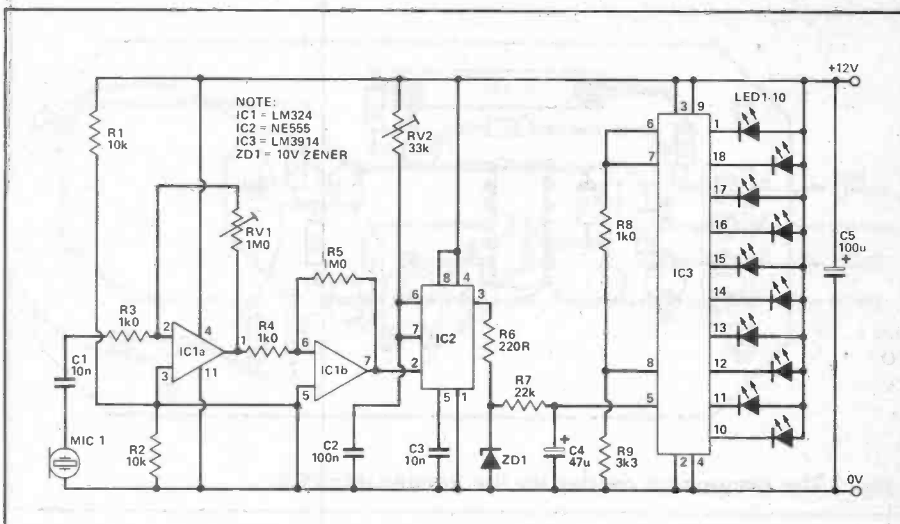


Fig. 2 The circuit diagram.

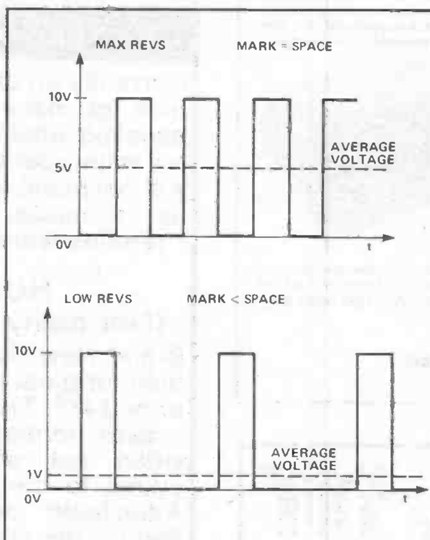


Fig. 3 The mark-to-space ratio of the pulses at maximum and at low revs.

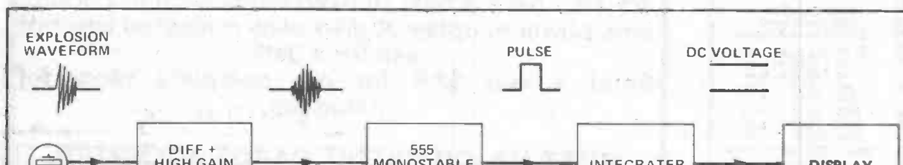


Fig. 1 The principle of the Sonic Rev Counter.

HOW IT WORKS

The explosions from the engine are picked up by the crystal microphone and differentiated by C1 to produce a sharp spike waveform. This is then amplified by IC1 which is a quad op-amp chip. Only two of the op-amps are used, wired as inverting amplifiers. The gain of the amplifiers is set by R3, R4, R5 and RV1. RV1 allows the gain to be varied from about 100 to 1,000,000.

The amplified spike is fed to the trigger input of IC2 which produces a pulse of constant period. This period is set by RV2 and C2 and is such that at maximum revs the mark-to-space ratio is one, so the average voltage of these pulses is half a pulse voltage.

The amplitude of the pulses is set to 10V by R6 and ZD1 to ensure a constant pulse voltage regardless of variations in supply voltage. The pulses are averaged into a DC voltage by the intergrator formed by R7 and C4 and this is fed to the input of IC3 which is a LED bar graph driver chip.

To light all 10 LEDs an input voltage of 5V is needed which is the average voltage of the pulses at maximum revs. Hence at maximum revs, all the LED's light, at half maximum only half the LED's light, and so on. See Fig. 3.

engine, either the distributor or high tension spark plug leads. The coil picks up the magnetic field generated when a spark plug lead is energised and this is used to give an indication of the revs, as with higher revs, the spark plugs are energised more frequently. The electronics associated with this method can be fairly complex and expensive.

This rev counter works on a novel principle. It is triggered by the explosions from each cylinder (Fig. 1). For every revolution of a four cylinder car engine, two cylinders fire. These explosions are picked up by a small crystal microphone mounted in the engine compartment and converted into revs by relatively simple electronics.

Installation is very quick and easy as all that has to be done is to wire up the supply leads and then mount the microphone in the engine compartment.

Construction

All the components including the LEDs are mounted on one PCB. Start by soldering in the resistors, then the capacitors and finally the semiconductors. The overlay of Fig. 4 should be referred to for the correct orientation of all the polarised components and the ICs.

The counter may be mounted directly into the dashboard to give a professional finish. Alternatively, the counter may be fixed into a plastic case. If the latter is chosen, a slit should be carefully drilled and filed for the LEDs in the front and two holes drilled in the back for the supply and microphone leads (see Fig. 5).

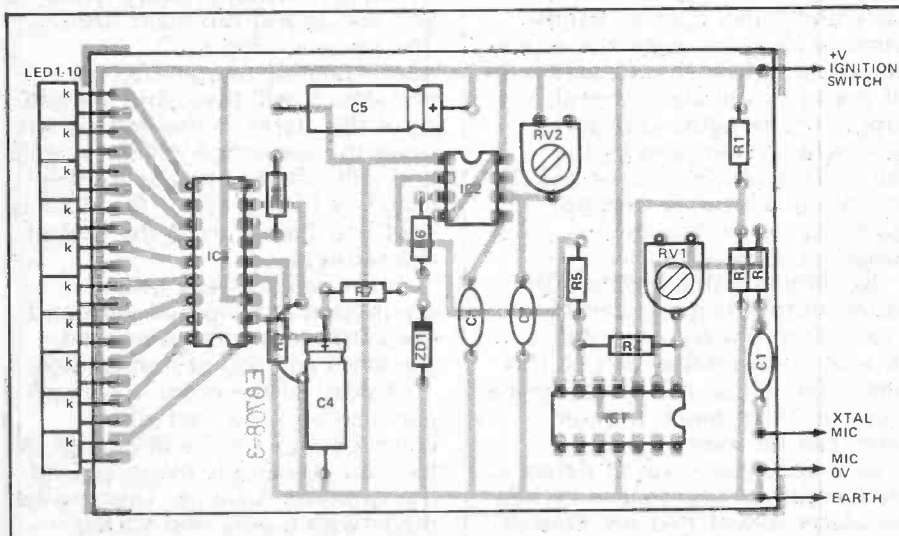


Fig. 4 The component overlay for the Sonic Rev Counter.

PARTS LIST

RESISTORS (all ¼W, 5%)	
R1, 2	10k
R3, 4, 8	1k0
R5	1M0
R6	220R
R7	22k
R9	3k3
RV1	1M0 horiz preset
RV2	33k horiz preset
CAPACITORS	
C1, 3	10n polyester
C2	100n polyester
C4	4µ7 electrolytic
C5	100µ electrolytic
SEMICONDUCTORS	
IC1	LM324
IC2	NE555
IC3	LM3914
ZD1	10V 400mW zener
LED1-7	Green LED
LED8-10	Red LED
MISCELLANEOUS	
MIC1	Crystal microphone insert

PCB; plastic case 120 x 80 x 35mm; power and screened signal cable; mounting bolts.

The supply leads should be wired up to the ignition switch so that power is only supplied when the engine is running. The microphone should be mounted as close to the engine as possible and screened cable used to connect it to the rev counter, as this will reduce noise pick-up.

Setting Up

Once everything is mounted, the rev counter can be adjusted for correct operation. First, start up the engine, let it idle and adjust RV1 and RV2 to the midway position. RV1 is the microphone gain control and should be set so that the LEDs just respond to the engine. Care must be taken to ensure that the gain is not so high as to pick up other nearby noises such as other car engines. Once this has been done, RV2 should be adjusted so that the first two LEDs just light up when the engine is idling. Test the rev counter by revving the engine. A faster response may be obtained if C4 is changed from 4µ7 to 3µ3.

ETI

BUYLINES

All the components used in this project are widely available. The PCB is available from the PCB Service as detailed at the back of this issue.

CAR ALARM

Protect your car and its contents with this cheap and simple alarm from Bob Noyes.

The number of car thefts increases daily and the old adage 'lock it' is a little outdated as car thieves seem to be able to open, steal from or even drive away just about any car they choose.

In order to protect what is probably the second largest investment the average family makes, some further protection is required.

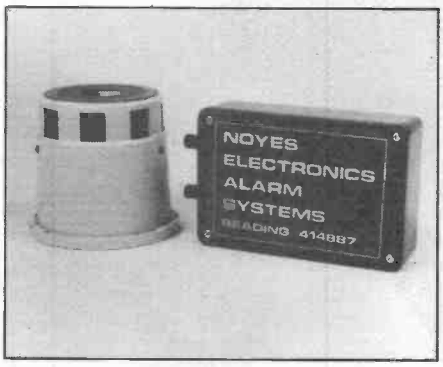
Motor theft, as the police call it, takes two forms — breaking into a car to steal from it (sometimes shopping but more commonly parts of the car such as the radio or CB rig) and the actual theft of the car. Some protection against both is necessary.

Although at first glance, these requirements seem simple enough, other practical factors need to be considered which complicate the issue — for instance how to switch it on and off. Drilling holes in the outside bodywork of the car is out of the question because this tends to introduce rust around the switch. It will also get spattered with mud and spray from passing traffic making the switch inoperative after a time.

Magnetic key fobs and infra red controllers, at first glance look a possible way of actuating and de-actuating from outside the car but in practice need to be used in one position around the car and this is not always easy when parked in awkward places. Both systems add to the time taken by the driver to gain access to the car, something not appreciated in the rain.

The only practical way is a delayed exit and entry but this can introduce a period when a would-be car radio thief has broken in and started hacking away at the wiring of the radio before the alarm sounds. Although the radio is unlikely to be removed in this time, a great deal of damage can be done.

The alarm described here is of the delayed entry and exit type but has the added advantage that when the alarm has been tripped by opening the door or boot an internal buzzer sounds. This,



although not very loud, indicates that an alarm has been set off and something else is about to happen. This should be enough to deter a thief as the last thing he wants is to be seen around a car with an alarm sounding.

Another important factor in an alarm is what form the output takes. Most commercial alarms sound their horns and lights intermittently. This, although very effective, doesn't do much for the horn, lights or battery as these draw an enormous amount of power and are usually controlled by a relay whose contacts arc and spark when switching these currents.

The contacts can weld themselves together sounding the horn and the lights continuously until the battery is flat. The alarm timer which all alarms must have cannot cancel a welded relay! As well as the possible damage because of the high currents, thick and bulky hard to handle wires need to be used. For safety, the alarm switch should switch off all power to the alarm and the supply to the lights and horns used when controlled by the alarm. This would mean a switch capable of 25A or so and not many alarms on the market supply such switches.

To eliminate this problem the sound output is generated by a rotary siren having a maximum current consumption of 1.2A.This allows the whole installation to be fused at 2A so much thinner wires can be used.

As a secondary line of defence, the car can be immobilised when the alarm is switched on. One of two methods can be used. If the car is fitted with standard mechanical points, a capacitor can be switched in across them. The value should be in excess of 22µ but with a working voltage of 600V or more. This is switched into circuit by an independent set of contacts on the alarm switch.

In most modern cars an optical or magnetic sensing system is used in place of the points. In these cases it is best to leave well alone as damage can be caused by connecting a capacitor in the wrong place so a switch is placed into the 12V supply side of the electronic ignition module. This can be found using a meter or by following the cars' circuit diagram. Again it is wired back to the alarm key switch.

Operation

On leaving the car the alarm is activated by the key switch. This allows about seven seconds to get out and shut the door. After this time the alarm becomes active and is indicated by the exit delay LED extinguishing (it comes on when the alarm is switched on). The alarm is now active and opening the door will start the following sequence which once started cannot be stopped by shutting the door. Only the key switch will stop it.

The internal buzzer sounds eight times over about a five second period. During this time the alarm should be de-activated by the key switch. Failure to do this will sound the main siren. The siren sounds for approximately one and a half minutes. It will then shut off and reset the alarm. If the door is left open the sequence will start again and will not stop unless the key switch is turned off or the door is shut and then only at the end of the sequence.

If the radio or any other equipment is tampered with and the earth connection removed, the siren will sound immediately.

Instead of the radio, a caravan can also be protected when connected to a car and parked. A loop connection is made around the caravan's A frame. This can be made with a plug and socket arrangement in such a way that the plug must be removed or the wires cut in order to steal the caravan. In both cases, the alarm will sound instantly. Of course provision must be made to short the wires together when the caravan is not being towed. This can be achieved with a shorting plug kept in the socket when not protecting the caravan.

HOW IT WORKS

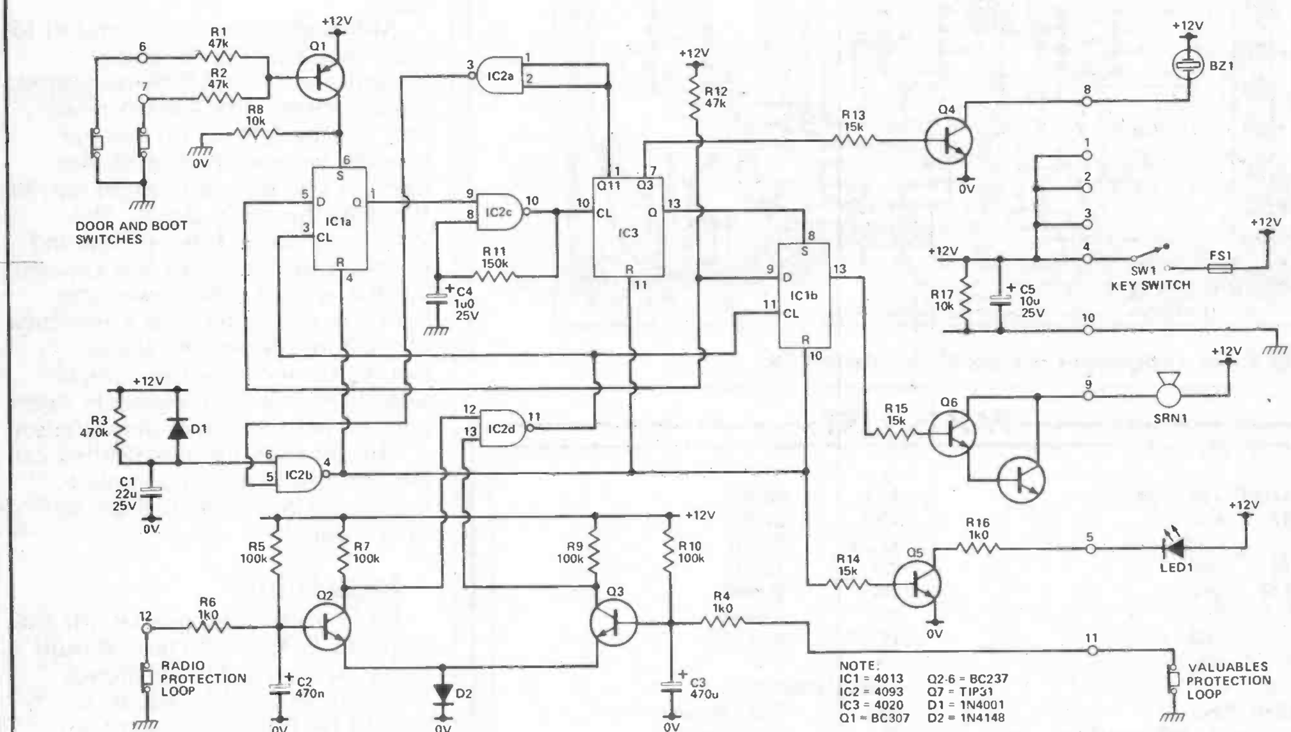


Fig. 1 The circuit diagram of the car alarm.

Fig. 1 shows the full circuit diagram of the alarm. When the alarm is on and the exit delay timed out, opening any one of the doors or boot will close the light switches and turn on Q1 via R2 or R1. This produces a high on ICla and will set the latch causing the output to go high starting the oscillator (IC2c) which runs at about 25Hz. Pulses from this are fed to a binary counter IC3, the outputs of which control the following sequence of events. After eight pulses from the oscillator, Q_3 goes high and is high for eight more pulses before going low and repeats this throughout the sequence. The Q_3 output is taken to Q4 via R13 to give current amplification and power a small buzzer. This is the internal buzzer which sounds eight times before the main siren. After 128 clock pulses, Q_7 goes high and sets latch IClb. This is the siren latch, and when set it causes the siren to sound via R15 supplying Q6, Q7 which are wired in a Darlington configuration.

After a total of 2048 clock pulses, Q_{11} becomes high which is inverted by IC2a. The resulting low on IC2b causes a short reset pulse which resets ICla, IC3 and IClb. The alarm has now gone through a complete sequence and is ready to be set off again should the need arise.

The delayed exit is produced by IC2b. After switch-on C1 is slowly charged via R3 while charging IC2 pin 4 is high. This turns on Q5 via R14 to illuminate the exit LED via its current limit resistor R16. When C1 has charged to about eight volts, this will cause pin 4 to fall to 0 volts, a high must appear on pin 5 due to the counter being reset causing a low on Q_{11} which is inverted by IC2a.

The delay exit time may be increased by increasing the value of R3. D1 provides a discharge path for C1 when the alarm is switched off. R17 provides the load for the discharge path.

The delayed entry is provided by the 128 clock pulses required to set the siren state during which time the alarm should be turned off. By this method of sequencing various time configurations may be achieved by simply selecting the outputs from IC3 to lengthen or shorten the timings. For example, taking the reset from Q_{11} (pin 1) to Q_{12} (pin 2) will double the length of time the siren sounds to nearly three minutes.

If an attempt is made to remove the radio or other protected items, the siren sounds instantly. This is done by using the latches ICla, IClb. Pins 11 and 12 of the alarm are held low by connecting them to the chassis of the radio or connecting them to 0 volts via the loops described earlier. If one of these two connections is removed either Q2 or Q3 is turned on by their bias resistors R5, R9 respectively. This in turn puts a low on IC2d pins 12 or 13 which causes the output pin 11 to go high. This low to high transition is used to clock the two latches ICla, b. The circuit now follows the same count routine as before except that the siren latch has already been set eliminating the 128 clock pulse delay, but it is turned off in the same way after 2048 clock pulses.

The timings rely on the oscillator running at about 25Hz. The speed of this oscillator can be increased by reducing R11 and slowed down by increasing its value. However, do not reduce below 15k as this may damage the IC.

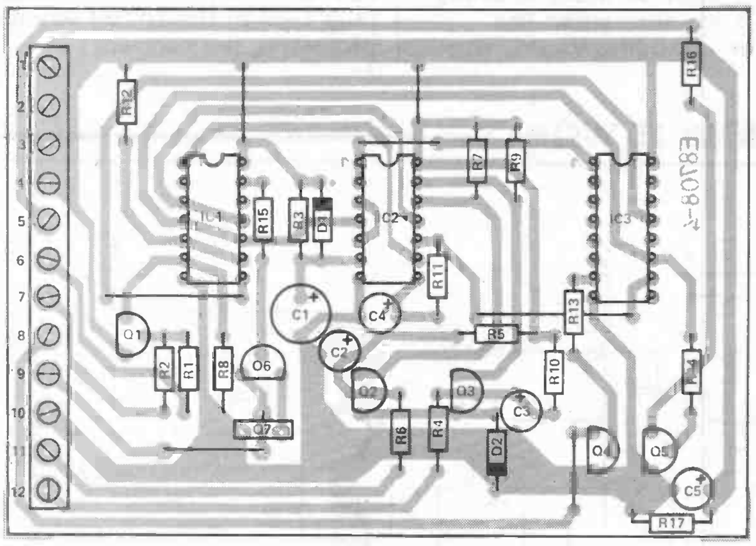


Fig. 2 The component overlay of the alarm PCB.

PARTS LIST

RESISTORS (all ¼W, 5%)

R1,2,12	47k
R3	470k
R4,6,16	1k0
R5,7,9,10	100k
R8,17	10k
R11	150k
R13-15	15k

CAPACITORS

C1	22μ 25V tantalum
C2,3	470n 25V tantalum
C4	1μ0 25V tantalum
C5	10μ 25V tantalum

SEMI CONDUCTORS

IC1	4013
IC2	4093
IC3	4020
Q1	BC307
Q2-5	BC237
Q6	TIP31
D1	1N4001
D2	1N4148
LED1	Red LED

MISCELLANEOUS

BZ1	Piezo Buzzer
FS1	2A inline fuse
SRN1	12V siren or bell
SW1	DPDT Key Switch

PCB; plastic case; connectors and cable; 12 way terminal strip; extra switches on doors and boot if necessary; nuts and bolts.

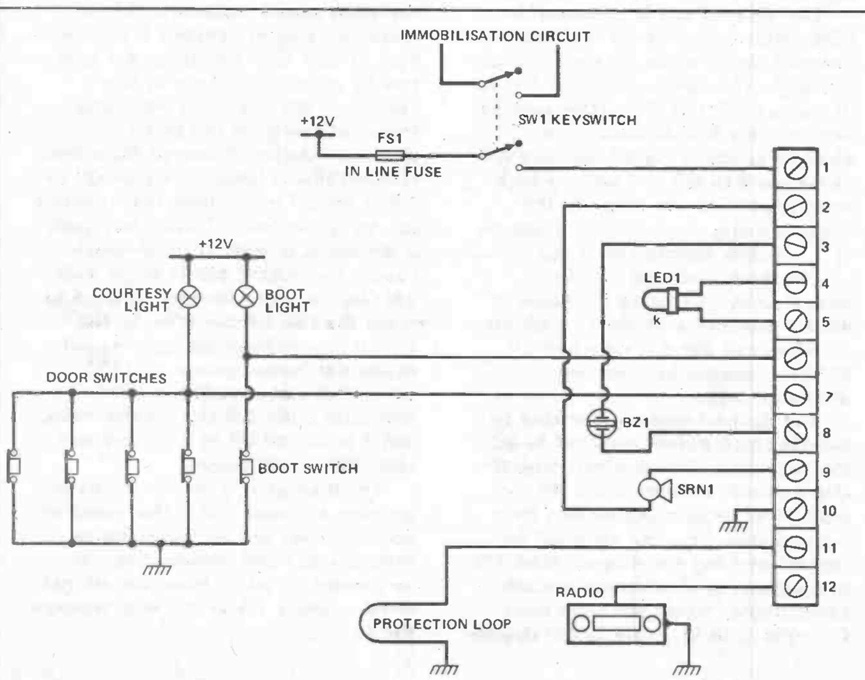


Fig. 3 Installing the alarm.

The same method can be used to protect such articles as cases and the like carried in the car. The set up must be that to remove the protected articles, the plug must be undone or the cable cut, similar to the type of thing used in shops to protect goods on view.

Although primarily intended for cars, this alarm is ideal for caravans as the CMOS integrated circuits draw very little current and can be left on for several months without flattening the battery. The delayed circuit can be fitted to the main doors. The instant circuit can be connected to the wind up leg of the caravan so that with the leg down the contacts are made (use a mercury tilt switch). When the leg is wound up to drive the caravan away the tilt switch contacts open and set off the alarm immediately.

The lid over the gas bottles can also be protected in a similar fashion as these bottles are a thief's delight.

Installation

Fig. 2 shows the overlay for the alarm PCB. Construction should cause no particular problems.

Before fitting the alarm, it should be fully tested on the bench using a power supply and simple swithes on pins 6, 7, 11, 12. To simulate the car courtesy light, connect a 47k resistor between pins 1 and 6 of the alarm. This will hold off Q1 unless turned on by a low on pins 6 or 7.

When happy that the alarm works under all possible valid switch configurations it should be considered ready to fit. As it is going to stay in the car (which can be a hostile environment) the PCB should be fully cleaned and sprayed with a PCB protective varnish to prevent the copper tracks from being eaten away by dampness.

Test all points of the car's electrical system that are to be used with a meter to check they perform as expected. It is a good idea to disconnect the positive side of the battery while fitting the alarm to prevent any accidental shorts. **ETI**

BUYLINES

None of the components should prove difficult to obtain. Suitable buzzers and 12V sirens are available from Riscomp. The PCB is available from the PCB service.

REAR WIPER ALARM

When a strange scrunching sound comes from the back of the car and an acrid burning smell issues from the rear windscreen wiper you'll wish you'd fitted this wiper alarm from A J P Williams.

Although many cars are now fitted with rear windscreen wipers, these are rarely given the same attention to design detail as the front wipers. The rear windscreen wiper is easily left on long after the rain has stopped as it is out of sight (and therefore out of mind).

Some cars' rear windscreen wipers are not designed for continuous use. A press on the wiper stalk is required for each sweep of the rear wiper. Such systems are easily altered with a bypass switch to operate continuously and with the addition of another relay such a modification requires little in the way of extra wiring (see Fig. 1). However, this puts the single-sweep wiper motor even more at risk of overheating or even burning out.

This rear wiper alarm detects the extra current flowing through the wiper motor when it is labouring on dry glass and sounds an audible alarm to remind the driver to turn it off.

The current flowing through the wiper motor is determined by comparing the voltage across a low resistance in series with the motor with a reference voltage. When the reference voltage is exceeded a self-contained piezo beeper is sounded to warn the car driver.

Construction

The wiper alarm is constructed on a single circuit board. This should present no problem of construction. Care should be taken to ensure the correct orientation of the voltage reference (IC2), the transistor (Q1) and the two electrolytic capacitors (C1, 2).

The unit is most easily installed near the rear windscreen wiper motor. Many cars include trim panels on the inside of the car around the rear screen. The PCB can be bolted behind one of these with the sounder unit protruding through the trim panels. The PCB should be thoroughly coated with protective laquer or varnish before installation to prevent corrosion and short circuits from damp.

The low value resistor R1 can be conveniently made with six 0.22R resistors in parallel. Three watt wirewound resistors are convenient to use although 1W resistors are ample.

The earth side of the wiper motor must be isolated from its original earth connection. The earth side of the motor is connected directly to the motor casing in some cars and so it is necessary to isolate the motor in its mounting from the car chassis. Rubber bushes around the mounting can be used for this.

Frequently the motor is mounted on rubber bushes anyway for protection against vibration. In such cases the insulation of the motor should just be checked with a multimeter.

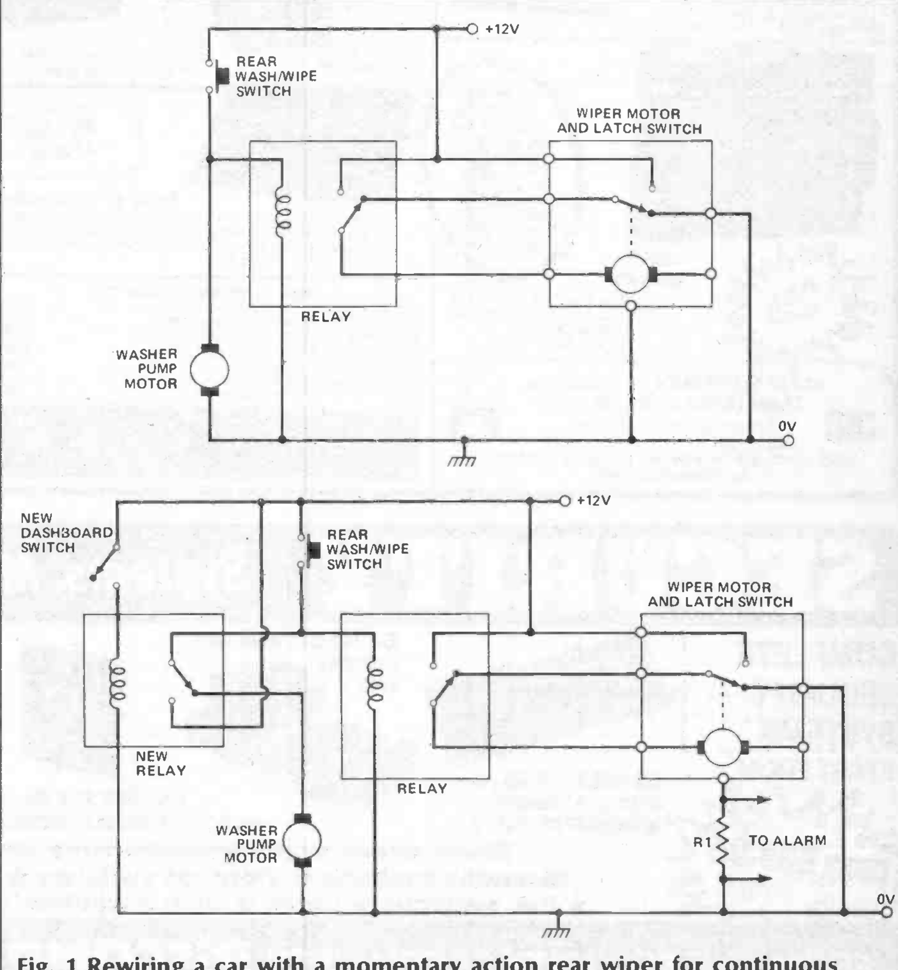


Fig. 1 Rewiring a car with a momentary action rear wiper for continuous operation in conjunction with the wiper alarm.

HOW IT WORKS

The earth end of the wiper motor is taken via a very low value resistor (R1) to earth. When the wiper is operating under relatively wet conditions, the voltage drop across R1 is in the order of 50-60mV. When the screen is dry, this voltage rises to 90-130mV. R1 is such a low value so that the voltage across the motor itself (and its performance) is not significantly affected.

The voltage aross R1 varies throughout the wiper's sweep across the screen and the drier the screen the greater is the voltage variation. Some voltage smoothing is desirable so the average cycle voltage can be detected. The simple RC network of R3, 4, C1, 2 is sufficient.

However, the large value required of C1, 2 suggests the use of electrolytic capacitors. In most cases the leakage current of normal electrolytic capacitors is excessive. This reduces the detected voltage across R1. Although the leakage current can diminish after the unit has been on for a while this is an unpredictable effect and cannot be relied on. So the capacitors, C1, 2 must be low leakage types.

IC1 is an LM324 quad op-amp. This chip was chosen (although only two of the op-amps are used) because it can sense right down to the negative supply rail with a single rail supply.

IC1a is a non-inverting amp which gives a high input resistance and a voltage gain of 31.37. So, when the input voltage (across R1) is 40mV, the voltage at its output is 1.26V. IC2 is a bandgap voltage reference which stabilises the voltage at the negative input to IC1b to a nominal 1.26V.

IC1b is configured as a regenerative comparator. When the voltage at the output of IC1a exceeds the reference voltage the comparator output approaches the supply voltage, switching on Q1 and operating the piezo sounder.

RV1 and R2 form a potential divider to reduce the average voltage across R1 to a level producing 1.26V at the output of IC1a when the wiper motor starts to labour.

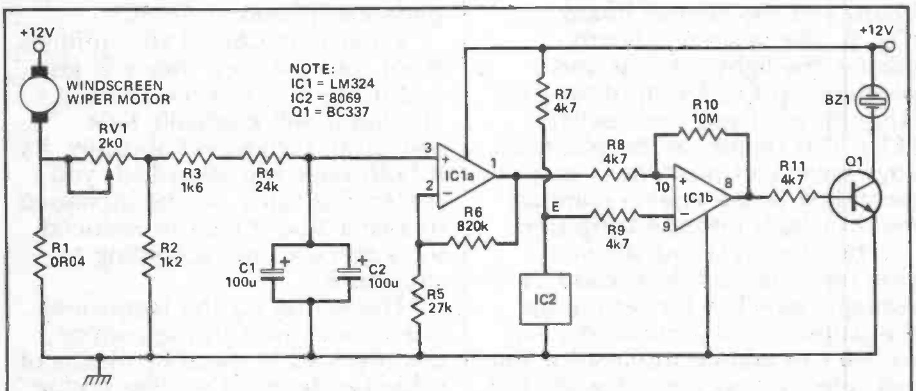


Fig. 2 The circuit diagram of the wiper alarm.

Setting Up

The circuit can be simply set up before permanent installation in the car. Spray the screen with water and turn on the wiper. After around 12 seconds of spraying and wiping, stop the spray and wait for the wiper motor to start labouring as the screen gets dry.

Adjust RV1 so that the alarm just operates as the motor labours. Repeat the process until the alarm sounds correctly just as the screen dries out. The unit should then give sterling service for a good many years.

ETI

PARTS LIST

RESISTORS

R1	0.04R (see text)
R2	1k2
R3	1k6
R4	24k
R5	27k
R6	820k
R7, 8, 9, 11	4k7
R10	10M
RV1	2k0 multiturn preset

CAPACITORS

C1, 2	100μ 6V tantalum

SEMICONDUCTORS

IC1	LM324
IC2	8069 voltage reference
Q1	BC337

MISCELLANEOUS

BZ1	Piezo buzzer

PCB; connecting cable; cable connectors; case; nuts and bolts.

BUYLINES

Suitable piezo buzzers are available from Maplin and Riscomp. The low leakage tantalum capacitors (C1, 2) are available from Cirkit as part 05-10701. The PCB is available from the PCB Service.

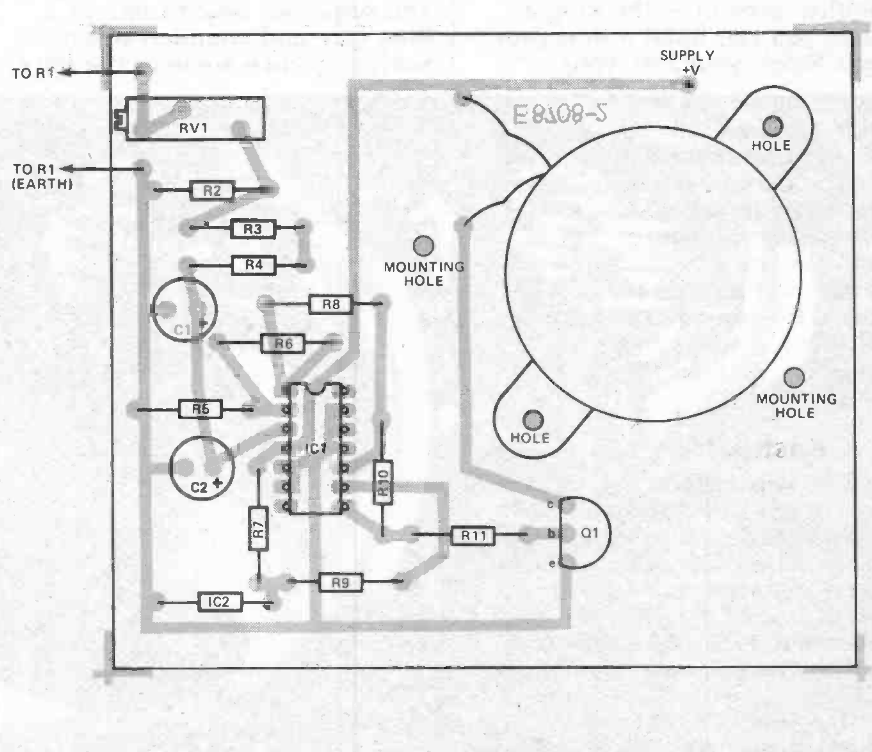


Fig. 3 The component overlay of the wiper alarm PCB.

KNIGHT RAIDER

Paul Chappell's car now bears a striking resemblance to the mechanical star of a certain TV show. Now, which could that be...?

Deciding what readers might like to build is a perennial problem. Oddly enough, new ideas are not hard to come by — especially as there is a constant stream of letters beginning 'Why don't you design a project to...' This is all very well but do many readers really want a whistling ear-pencil? Do they honestly need an indoor sundial? Often the answer is obvious (of course you want an indoor sundial) but occasionally we get taken by surprise.

A case in point was Phil Walker's Knite-Lite (ETI November 1984). Who would have guessed that a circuit to move a light backwards and forwards along a line of LEDs would be so overwhelmingly popular?

Well, we're not fools at ETI. We know when we're on to a good thing. Amongst the many sacks of readers letters about the project, a goodly number wanted to know how to adapt the circuit for use on the front of their respective motor cars. So here is the definitive version — the Knight Raider. You can build it into your Range Rover, your Fiat, your tricycle, your pedal car or your shopping trolley. It has eight different light sequences, each more spectacular than the last and it will drive anything from torch bulbs to powerful car lamps.

The Knight Raider has two main sections: the sequence board and the control board (Fig. 1). The sequence board creates the light patterns and provides up to 2A output for each lamp (more if you use beefier FETs). This board can be placed in any convenient position — in a metal box in the engine compartment or built into the lamp unit.

The control board sits in a case on your car's dashboard. It contains switches for setting up the patterns and a mimic display so you can admire the results. You can select a new pattern while the old one is still running — it will change only when you press the 'Pattern Start' button.

Construction

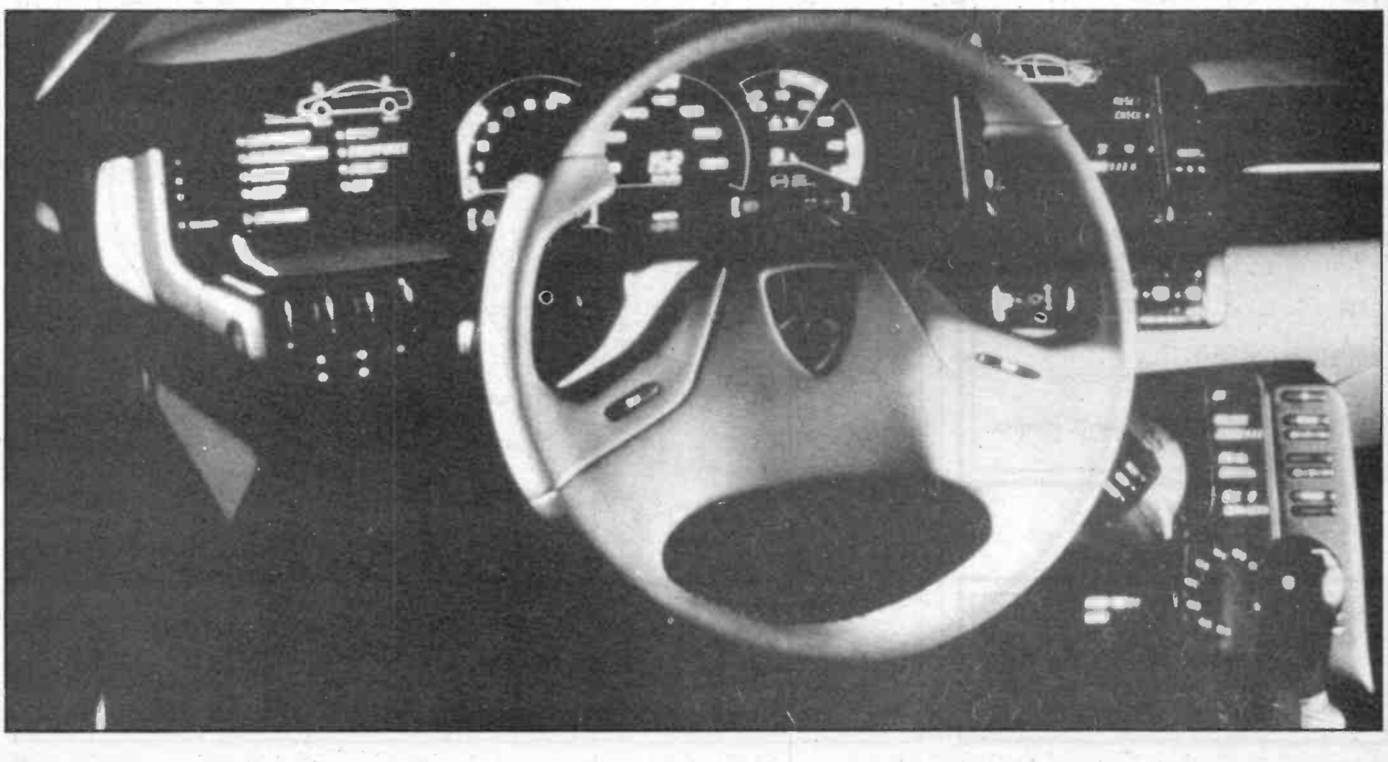
The component overlays for the two PCBs are shown in Fig. 2. The sequence board requires a little care and attention when soldering since some of the tracks and pads are fairly closely spaced. You will need a soldering iron with a fine tip and (preferably) 22swg solder rather than the thicker 18swg. Inspect the board carefully after soldering to make sure there are no solder bridges between adjacent tracks, particularly around the ICs.

Capacitors C6-C13 are optional. If you put them in, they will give a blurring effect to the pattern. The lights will gradually fade instead of turning off abruptly. Try it both ways and see which you prefer. The value can be increased to give a slower fade or reduced for a quicker one, according to your taste.

The wiring for the lamps and interconnections to the control box are held in place by means of cable ties to avoid putting undue strain on the PCB tracks (and to keep them tidy!)

It is a good idea to moisture-proof the PCB, even if you put it in a weather-proof box. A low cost

Paul's car has many minor electronic modifications. The Knight Raider control board can just be seen protruding from the ash tray.



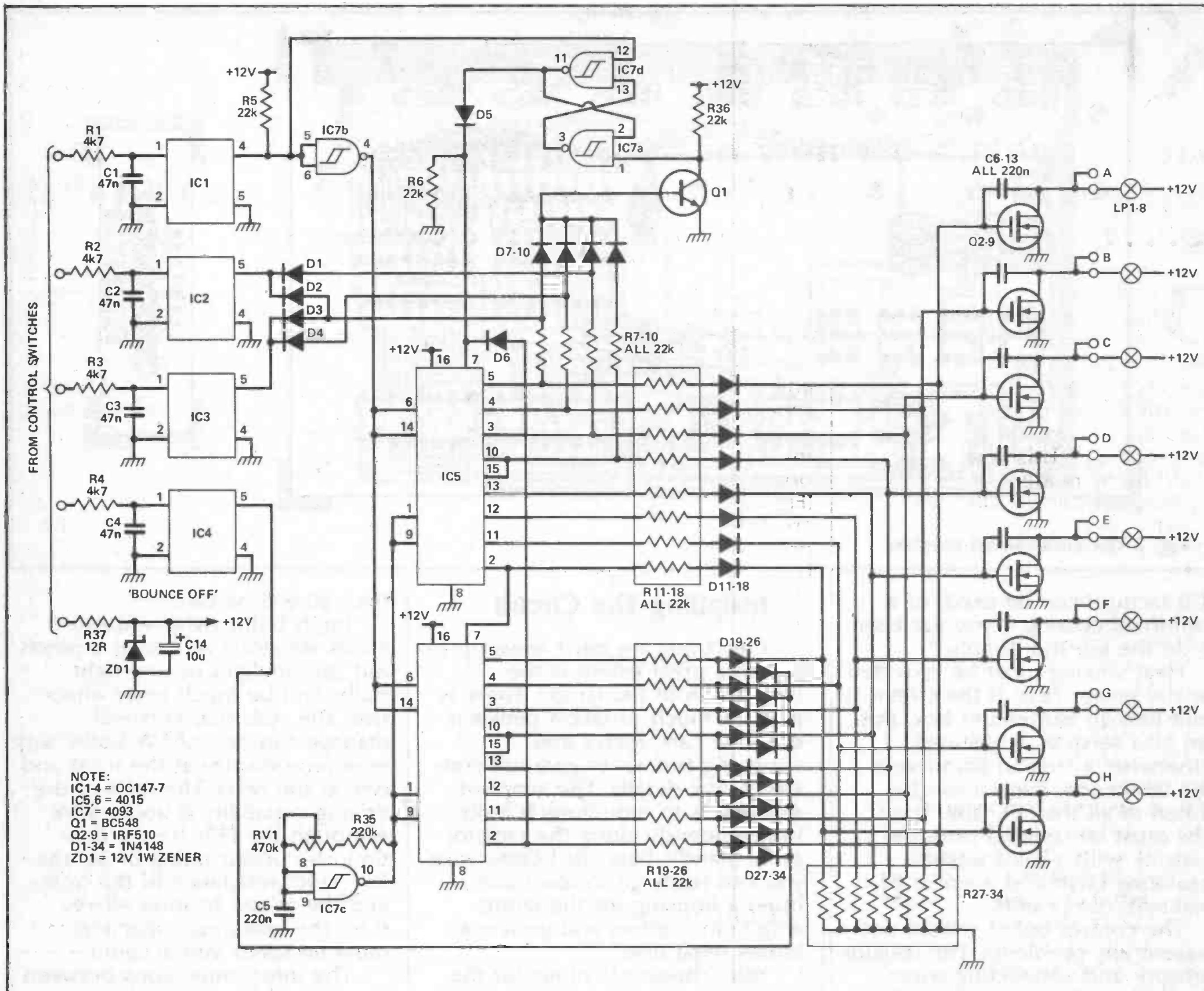


Fig. 1 (a) The sequence board circuit diagram.

HOW IT WORKS

There are 1001 ways to make a pattern run across a series of lamps but the most flexible is surely the humble shift register. Since these like to shift in one direction only, IC5 takes the pattern from left to right and IC6 from right to left (or the other way around, depending on how you arrange the lamps). Diodes D11-18 and D19-26 give a 'wired-OR' function to allow either register to turn on the lamps without interaction. Diodes D27-34 allow the 'reverse' shift register to be cut off so the pattern runs in one direction only if IC4 is activated. The pattern is re-circulated (even if the outputs from IC6 are turned off) via D6.

The lamps are driven by power MOSFETs Q2-Q9. The capacitors C6-C13 slow the turn-off times, giving the pattern a 'comet's tail' of gradually extinguishing bulbs.

IC7c is a simple oscillator which sets the step rate for the pattern, with RV1 allowing adjustment to suit your taste. IC7b resets the shift registers when a new pattern is selected. IC7a and d, in conjunction with IC2, 3 and the feedback from the shift register outputs determine the number of lamps lit. IC2 and IC3 can be activated at any time without disturbing the pattern — nothing happens until IC1 is activated.

The opto isolators IC1-4 are included for noise immunity in the interface between the two boards. There are a number of ways to achieve the same end but opto isolators can be bought cheaply these days, so — why not? If this circuit ever picks up spurious trigger signals from the wiring, I'll eat my boots!

A circuit of this type can be made to do all kinds of tricks. We thought eight possibilities would be enough (four block lengths with or without 'bounce'). If it isn't then connecting pin 7 of IC6 to pin 7 of IC5 (instead of to pin 2 of IC5) will give patterns which begin simultaneously at both ends, meet in the middle and separate again. This can give rise to some complex sequences. Happy experimenting.

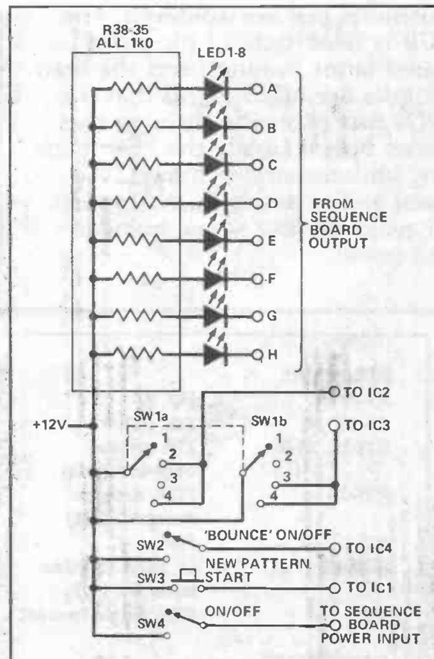


Fig. 1 (b) The control board circuit diagram.

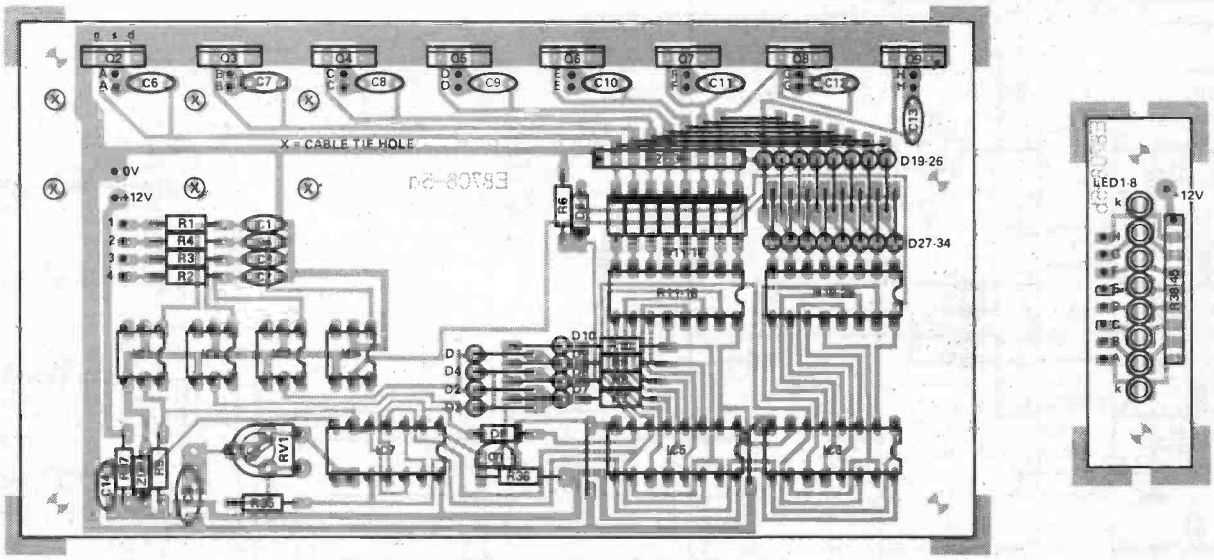


Fig. 2 The component overlay.

PCB lacquer can be used, or a conformal coating if you are keen to do the job thoroughly.

Heat sinking *must* be provided for the power FETs. If the circuit is built into an aluminium box, this can also serve as a heat-sink. Otherwise, a strip of aluminium (the thicker the better) can be bolted to all the FET tabs. The tabs must be isolated from the heatsink with a mica washer, insulating bush and a smear of heat-sink compound.

The control board should not present any problems. The resistor network and connecting wires should be soldered in place first. Then the LEDs are pushed through the PCB in their correct positions but not soldered. The PCB is fixed behind the front panel (after drilling!) and the lead lengths are adjusted so that the LEDs just protrude through the panel holes. Finally the LED leads are soldered and trimmed. We used self-adhesive PCB supports to avoid drilling screw holes in the panel.

Installing The Circuit

One thing we must leave up to you to a great extent is the installation of the lamps. There is just too much variation between different cars, cycles and shopping trolleys to give full constructional details. The simplest solution is to mount each bulb independently along the radiator grille (handle-bars, etc.) Otherwise, you can really go to town and build a housing for the lamps with colour filters and goodness knows what else.

Your choice of colour for the lamps must be tempered to some extent by consideration of what may cause confusion to other drivers (or get you arrested!)

If the circuit is to be used for a child's pedal car or tricycle then no such restrictions apply. You will, however, need to give some consideration to providing a suitable power supply. The main loading on the supply is from the bulbs. If your battery can drive these with about 50mA to spare then all will be well.

Torch bulbs (with suitable series resistors) will do at a pinch but car sidelight or rear light bulbs will be much more effective. The specified FETs will manage two sets of 5W bulbs with ease (one display at the front and one at the rear). The limit of the driving capability is about 20W. Although the FETs have a continuous current rating of 3A, the low 'cold' resistance of the bulbs and the added heating effects from the smearing capacitors must be taken into account.

The interconnections between the control box, sequence generator and lamps are shown in Fig. 3. A rear display can be added by simply paralleling the rear bulbs with the front ones. The wiring can be considerably simplified if you're willing to settle for just one preset pattern and forego the mimic display — by hard wiring IC2, 3 and 4 to your chosen pattern, all that is needed is the 'pattern start' button for IC1 and an on-off switch.

ETI

PARTS LIST

RESISTORS	
R1-4	4k7
R5-10, 36	22k
R11-18, 19-26	22k resistor network (DIL)
R27-35	220k resistor network (SIL)
R37	12R
R38-45	1k zeco resistor network (SIL)
RV1	470k horiz. preset
CAPACITORS	
C1-C4	47n ceramic
C5-C13	220n ceramic
C14	10µ 16V tantalum
SEMICONDUCTORS	
IC1-4	OC147-7
IC5, 6	4015
IC7	4093
Q1	BC548 (or any general purpose silicon NPN small signal transistor)
Q2-9	IRF510
D1-34	1N4148
ZD1	12V 1W zener
LED1-8	LEDs any size, style, colour
MISCELLANEOUS	
LP1-8	12V bulbs (see text)
SW1	2 pole 4 way rotary switch
SW2, 4	SPST toggle switch
SW3	SPST push button

PCBs; aluminium box or heatsink for sequence board; plastic case for control board; FET mounting hardware; knob for rotary switch; PCB mounts; waterproofing spray; connection wire.

BUYLINES

The sequence PCB will be a snug fit in box type 21-95005 from Cirkit (Tel: (0992) 444111). Suitable protective lacquer aerosols are available from the same source. The low cost version is stock no. 51-11005 at £1.84 + VAT. The conformal coating is stock no. 51-11112 at £3.68 + VAT. The most expensive parts are undoubtedly the FETs. These are available for £1.27 + VAT from Electromail (Tel: (0536) 204555). You may get a better price by shopping around. Any high gain opto-isolators can be substituted for the types specified. Single transistor types will work but require lower values for R1-4.

A set of parts for the project is available from Specialist Semiconductors Ltd, Founders House, Redbrook, Monmouth, Gwent. The PCB, components, mounting hardware etc, for the sequence board (part K101A) cost £11.90. The FETs supplied are 5A jobs but you may need extra heat-sinking to take advantage of the higher current. The set does not include a box. The PCB, case, components, switches and hardware for the control board are K101B at £6.90. Postage on any order is 60p.

Bulbs can be obtained from any motoring shop, connecting wire from Woolies and the PCBs from our PCB Service in due course.

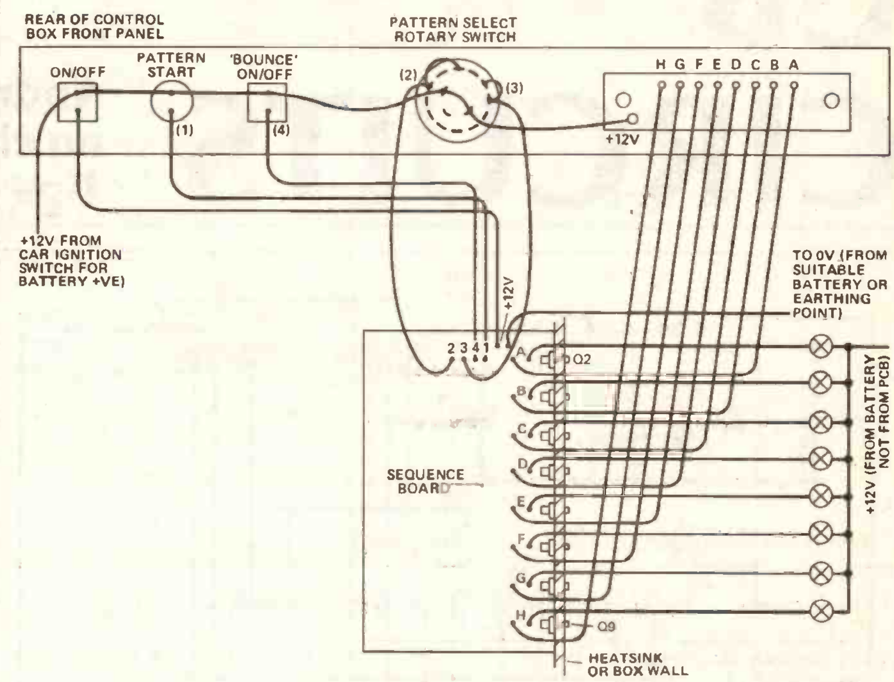
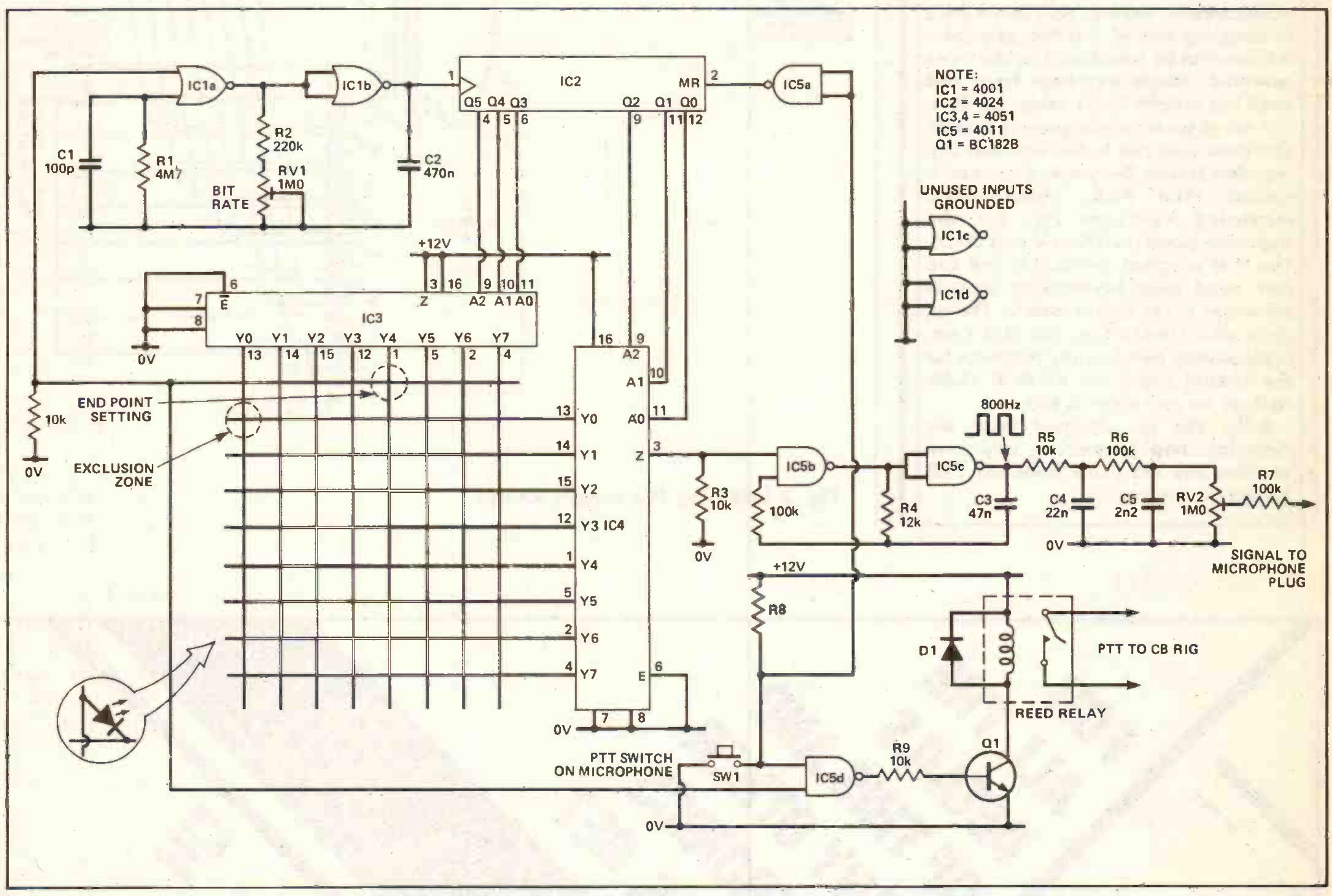


Fig. 3 Installing the Knight Raider.

CB CIRCUITS

Andrew Armstrong goes on channel with a few Tech Tips for CB fans.



Initials Sender

This gadget sends the operator's initials in morse code at the end of a transmission. It may be mounted in a separate box and connected in series with the microphone lead or it can be mounted inside the rig if there's room.

The heart of the unit is the diode matrix used to program what is actually sent. The two 4051 analogue switches address each intersection of the grid lines in turn. At each point where there is a diode, a logic one is presented at the output of IC4. While this output is at logic one, the 800Hz oscillator (IC5b,c) oscillates. When it is pulled down to logic zero by R31, the oscillator stops.

The output from this oscillator is a harsh and unpleasant squarewave. This is filtered to make it sound better by the double RC network and then is fed to the microphone input of the rig in parallel with the microphone. R7 prevents this extra connection from loading the microphone signal too heavily.

The control of the system is logical, relying on a gated oscillator and a resettable counter. The 4051s are addressed by the outputs of a 4024 binary counter. While the microphone press to talk switch is held down, the counter is held reset, and the 4051s are switched to the top left hand square, the 'exclusion zone'. This square cannot be used. If a diode is connected here, the tone sounds all the time you try to talk.

When the PTT switch is released, IC2 starts to count, at a rate set by the gated oscillator built around ICla,b. The output oscillator is gated on and off in a manner corresponding with the diodes in the matrix and the initials are transmitted. The PTT relay is held on because the end point line is at logic zero.

Eventually, IC3 addresses the line to which is connected the end point setting diode. When this is energised, the gated oscillator (ICI) is stopped so that the counter cannot advance any further and the PTT relay is switched off.

The circuit can be powered from the rig's 12V supply but this should be thoroughly decoupled on the board. If the relay used is of too low a resistance (if an ordinary relay is used instead of a reed) the BC182 may be unable to switch it on, driven as it is by about 1mA from a CMOS gate. In this case a small power MOSFET such as a VN10 may be used or a Darlington transistor would be suitable.

Some CB rigs route the receive audio signal via the microphone socket and use a changeover switch in the microphone to switch it on. In this case a changeover relay must be used and connected to the same pins as the switch.

Compressed Power Microphone

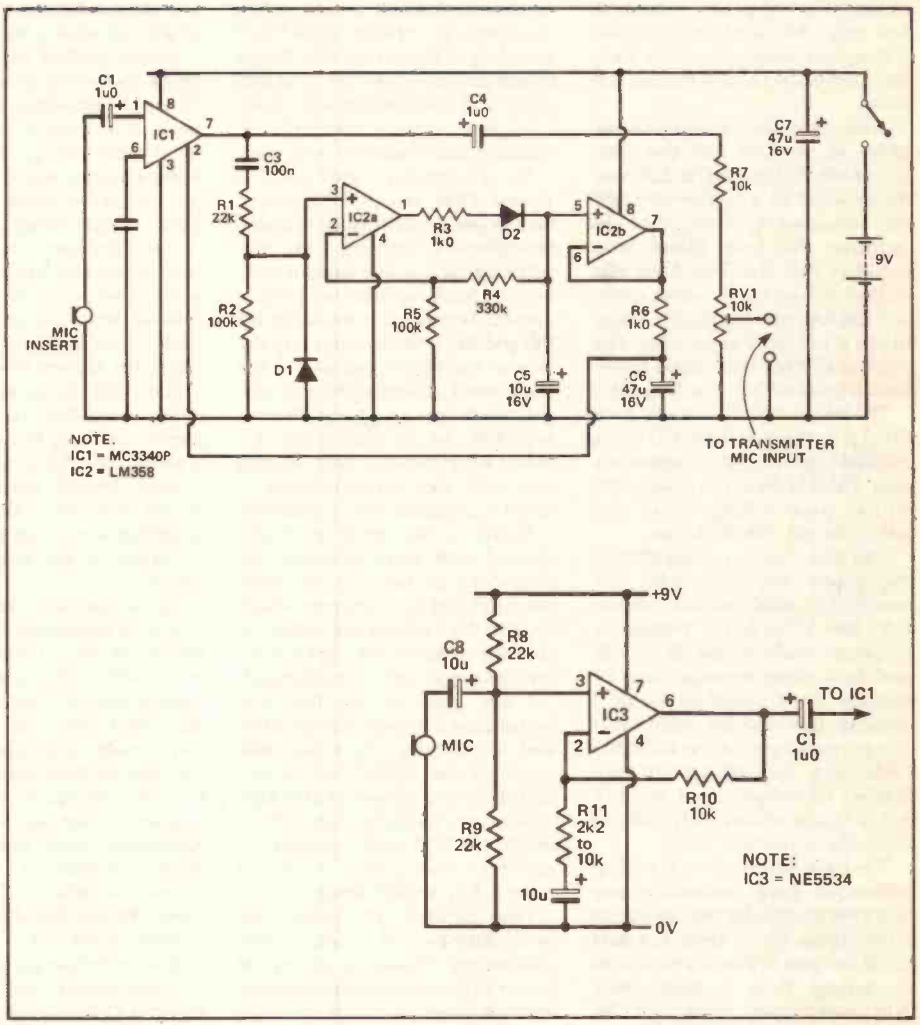
Power microphones provide more gain and hence better apparent signal at the receiver but it is possible to overdeviate using ordinary power microphones. This design adjusts its own volume setting to provide the correct modulation all the time. It is equally applicable to AM (amplitude modulation) or SSB (single sideband) in amateur radio equipment.

The signal from the microphone is fed through an electronic attenuator IC which can provide between 13dB gain and about 70dB attenuation, although it is unlikely that more than a few dBs of attenuation will be required.

ICI starts to reduce its gain when the control voltage, fed in on pin 2, exceeds about 2V. The output of ICI is fed via a preset output level control (RV1) to the microphone input of the rig and also to a peak detector circuit which controls the attenuation.

The gain of the peak detector as shown is approximately 3½ so the output voltage of ICI will be about 400mV RMS at the onset of attenuation and will reach about 500mV at the highest likely signal level. Some rigs may work better with R7 omitted, to provide maximum input signal, while others will find 500mV too high a signal and would require RV1 to be set low.

The output from ICI is AC coupled into the input of the peak detector so that the output of the detector is relative to 0V rather than the output bias level of ICI. To avoid latchup of IC2a, negative signal excursions are limited by D1. To permit this, R1 is included to prevent distortion of the output waveform. The attack time of the peak detector is very fast, with R3 serving to prevent noise spikes from causing problems while the decay time constant is set by C5, R4, and R5. The component values would suggest a decay time of 4.3s but in practice it is less than this because the control voltage has to fall only from about 2.5V to increase the gain from the minimum to the maximum likely to be required in practice. The gain will actually increase in about one second. If a slower response is required, C5 may be increased.



The output of the peak detector is buffered because the control voltage input of IC1 is of a low impedence. R6 and C6 are used to prevent any audio ripple on C5 from modulating the output.

Some microphone inserts may not give sufficient signal to make the compressor work properly, in which case the extra gain stage shown should be used. The feedback divider resistor, R11, should be chosen to give just enough gain bearing in mind the maximum input signal specified for IC1 is 500mV RMS. Note the reversed connection of C1.

RF pickup on the microphone may interfere with the correct operation of the circuit. If this happens, connect a 1k0 resistor in series with the microphone followed by a $2\mu2$ capacitor to earth. This should cure all such problems.

When all is complete and working, RV1 should be adjusted to provide maximum deviation without 'bleedover' to adjacent channels. To do this, connect the transmitter to a dummy load, and listen on another CB rig. The rig you listen on may work best with a few inches of wire in its antenna socket, or it may pick up enough signal without any form of antenna. Do not allow receiver overload to fool you into thinking bleedover is happening when it isn't.

ETI

PLAYBACK

Regular ETI readers may recall that I am interested in the subject of compact disc in general. Last year I reviewed the D50 mark 2 Discman from Sony. Now Sony has introduced a new model, the D100.

Sony claims the design philosophies of the D50 and the D100 are totally different. The D50 was designed to fit a certain size and the designers were told to produce the best player they could in that size. The D100 was designed from the opposite angle, as a full function top quality player made as compact as possible. The result is that the D100 works better and is smaller than the D50 mk2!

The player with its battery pack fitted is as thick as three CD cases stacked together but occupies less area. The weight of the player with battery pack is 820g, about half being the 6V 1Ah batteries.

The specification of the D100 is impressive: full sixteen bit D-A conversion, total harmonic distortion less than 0.01%, frequency response 20Hz to 20kHz ± 1dB, and 'Sony Super Strategy Cross Interleave Reed Solomon Code.' I assume this last to mean this player makes use of the full error correcting capabilities of the coding technique used for CD. Many machines use only half the available correction code.

The basic Reed Solomon coding technique uses redundant bits and checksums not only to detect a corrupted bit (or bits) in a data word but also to identify which bit is wrong. Even a completely corrupted data word can be reconstitued. Some current players use less sophisticated correction.

The programming functions of the D100 are similar to those of the D50. There is the usual facility to play tracks in any memorised order or to play them in a random order. Tracks or sections can be repeated indefinitely and the track search permits jumping from track to track or skipping fast forward or reverse through a track, while monitoring quite coherent snatches of the sound. The liquid crystal display shows the programming and track information with the option to show current or remaining track number and time.

For a suggested retail price of almost £300, you get the player, battery pack, mains power supply, headphones, carrying strap and soft case and a line output connecting lead. An infra-red remote control accessory is available for £50 and the receiver plugs into the side of the player. For use in the car, a shock absorbing mount with goosneck arm and power lead is available. As an alternative, for those who possess well sprung cars with flat parcel shelves, a simple car power lead is available.

There is no need to fiddle around with wires to install the player in a car because the other car accessory is an adapter which fits into the cassette slot of the car stereo and feeds the signal from the CD player into the tapehead.

I am glad to say that the performance justifies the facilities and accessories. As a portable machine, the CD100 can be carried about to a fair extent although it still loses tracking if jarred but unlike the D50 mk2 it appears to continue from where it left off once it has settled down.

The sound it gives on headphones is clear and convincing. There is plenty of power to listen to Iron Maiden but enough sheer precision for Peter Gabriel. I have rarely wanted to turn the volume control above 2 (on a scale of 10) and the stereo image is sharp and convincing.

The only criticisms I have of the machine are that it is still possible to make it lose track for a moment, and that the 'in the ear' headphones supplied with the machine do not suit all sizes of ears.

In the car the CD100's performance is limited by the quality of the car stereo. In my Maestro, it always worked perfectly on its shock absorbing mount but when I tested it just resting on the parcel shelf, it lost track on the occasional bone jarring thudunk from holey country roads. There were no problems while driving on better roads though.

If you do want to use the CD100 in your car, you will be pleased to know that it is very quick to remove from the car when you park — it's just too tempting a target for thieves if left on view.

The D100 stands up well in the living room hi-fi system. I compared it with my Philips CD104 on a variety of programme material. I have always considered the sound from the CD104 to be very good but to my ears the CD100 at a fraction of the size performed better.

By comparison, there was just a hint of harshness in the treble region of the CD104 on certain tracks with a high treble content, notably on Phil Collins and Kate Bush discs. On certain tracks (both Iron Maiden and Peter Gabriel) it seemed the bass response of the CD100 extended to a lower frequency than that of the CD104. Admittedly these effects are not large compared with the difference between CD and ordinary LPs but the difference was significant for CD.

The performance of the CD100 was noticeably worse than the Philips CD104 in one respect only. It wouldn't play the first track of my copy of Yes' '90125' properly. The Sony CD100 jumped through the last minute of track one as if switched to fast search. Other machines I have tried have had the same problem and only my trusty Philips machine could play that track. I don't know why but perhaps the depth of field of the laser optics is greater on the Philips machine.

As I have no reference discs (ETI contributors can't afford such things) I cannot say for sure which machine is 'correct' but the differences are of such an order that 'how do I prefer my music' is a reasonable approach. My ears prefer the Sony machine so I have sold the trusty Philips (with a pang of regret) and bought a Sony CD100.

Andrew Armstrong

KEYNOTES

Italian organ manufacturer Elka has jumped on the FM bandwagon with their EK44 and we can expect others to follow, now Dr. Chowning's FM patent has passed into the public domain. FM is obviously in no hurry to go away and so it is timely to review its potential.

Can FM be used to synthesise any given sound? Not in practice, no. Most sounds, real or imaginary, can only be produced by combined frequency and amplitude modulation. Only sounds devoid of an AC amplitude modulation component can be synthesised by FM with ease.

Unfortunately, it is the attack transient of a sound which the ear pays most attention to and the eight-parameter envelopes of the DX7 are insufficient to recreate the complexities of the attack transients of most acoustic instruments.

There are a few ways of cheating although no mathematically clean or even systematic method for working backwards from a desired spectrum to FM parameters has yet been published. FM is very good at generating lots of harmonics and the major problem actually lies in the elimination or attentuation of those which are not required. This can be achieved by mixing the outputs from a number of parallel modulation stages, each with different parameters, resulting in selective attenuation and enhancement of the various harmonics.

10 or 12 operators are necessary to put theory into practice in this way and once again the DX7 lets us down by implementing only 6 operators per voice.

Another trick is to make the simplifying assumption that phase relationships are unimportant in audio and to pre-process a required power spectrum with a phase-shuffling transform which reduces the peak factor of its corresponding waveform. Kid's stuff!

At the end of the day everyone throws up their arms in despair at all the complexity and resorts to random suck-it-and-see button pushing with the inevitable result that FM exhibits its own characteristic sound.

FM is not the general purpose elixir its proponents would have us believe. It is a technique which is cheap to implement in digital hardware. That is all.

Bruno Hewitt

ONCE OVER

At the All Electronics Show, Allbatteries exhibited a range of solar panels intended to charge batteries. These were specified to give useful outputs so I asked for information and a review sample.

Dave Hammond of Allbatteries told me of some uses to which the solar panels have been put. One of the obvious ones is to power remote data loggers. Almost as obvious is to power fan ventilation of greenhouses.

Another application which amused me was to power electrically operated gates some distance from the nearest mains power. Apparently it was cheaper to provide a solar panel and a sealed lead acid battery to provide the high peak (but low average) power requirements rather than to run mains cables to the area.

To prove that 'serious' people have a use for these solar panels, British Gas use one to charge a car battery which powers a transponder with a high power demand but a low duty cycle.

The mass market is also included, with a suggested use of charging a battery in a permanently parked caravan so that it will run a TV at the weekend.

An application in which the arrays should perform well is to charge batteries for 'ghetto blasters' in Africa, where they are popular and where batteries are scarce. With the amount of sun they get, one panel should do for a small village.

The arrays used for most purposes would be the Chronar range which uses amorphous silicon.

The sample I had was the Chronar 3, which costs £57.35+VAT. It is about a foot square and consists of a single sheet of solar cells in a smart plastic moulding. It has a power output socket in one corner and an LED which lights up when the plug is not inserted. It is specified at 210mA at 14.8V maximum power output. I tested mine charging a 12V pack of lead acid cells and here are the results:

Room lighting	damn all
Dim English day	7mA
Hazy sunlight	35mA
Full sunlight	61.5mA

The range extends from the Chronar 330, rated at 3.4V, 94mA, and costing £29 to the Solar Tech 1264-2 rated at 1150mA, 14.8V, and costing a mere £297.

Allbatteries, Tollpits Lane, Watford, Herts WD1 8QR.

Andrew Armstrong

BIRD'S EYE VIEW

The project to catch my eye this month is the finest example I've seen in a long time of how to spoil a good circuit by 'improving' it. It appeared in a rival magazine and is supposed to be a heart rate monitor (Fig. 1).

A little background first. Taking heart muscle signals from the hands or chest, the voltage levels involved are in the region of a few hundred µV to 1mV or so. In itself, amplifying this kind of voltage level presents no problem at all.

The trouble is that the human body is a fairly efficient aerial for anything from mains hum to radio broadcasts, with a touch of CB, fluorescent light noise and goodness knows what else thrown in for good measure. The noise can be several orders of magnitude greater than the signal. Also, the signals are presented from a very high source resistance, which gives problems of its own.

The process of sorting the signal from the noise is greatly eased by the fact that the bulk of the noise is in phase over the whole body, whereas the signal can be picked up as a voltage *difference*. The ideal 'front end' for a heart rate monitor will have a very high input resistance on both leads (to avoid attenuation of the signal) and a good common-mode rejection to remove the in-phase signals at source.

The special breed of amplifiers with these properties (and other desirable features) are known as instrumentation amplifiers. Sad to say, in IC form they cost from £30 to £100 each and so are out of reach of all but the most well-heeled amateur.

A reasonable facsimile of an instrumentation amplifier can be made from three ICs as in Fig. 2. To make the most of the circuit's high input resistance, the op-amps are biased via the source — in this case the body, where a third wire to the foot is a common way of going about it.

Common mode rejection is good as long as the ratio R10/R13 is exactly equal to the ratio R11/R12. In the absence of very tight tolerance resistors (a 0.1% mismatch in one single resistor is enough to degrade the CMRR to 66dB) trimming is necessary, so R12 would normally be a fixed resistor in series with a small preset. Properly adjusted the circuit can give excellent results.

So what of the 'improvements'? Capacitors C5, C7 and C8 have, I assume, been added to limit the DC offset of the first stage (although it seems like overkill to use all three).

The inclusion of C5 is particularly interesting. Assuming that C7 and C8 are in place, the offset at the output of IC1a and IC1b from amplification of their input offset voltages will not be enough to make C5 necessary. However, using a 'third wire' bias with inadequate electrodes (the author suggests brine-soaked cotton wool!) will result in a substantial difference in voltage from the amplifier's bias current. So (belt and braces) put in C5, add C3 and C4 at the input and give the op-amps on-board bias from R3 and R6.

This makes the third wire redundant — connecting it may encourage a little of the common mode noise current to flow along it in preference to the electrode leads but not so's you'd notice the difference. High frequency noise is 'filtered' by C6, C7 and C10, and there you have an improved circuit. Or is it?

The inclusion of C10 is a real schoolboy howler. It appears to be slugging out high frequency noise but in fact it's unbalancing the circuit at high frequencies and providing a beautiful path straight to the output for every bit of common-mode grunge in the circuit!

The input resistance is less than 1M0 for the frequencies of interest, so they will be attenuated and higher gain must be used. This increases noise and gives a boost to offset problems, making the electrolytics necessary which, in combination, give the circuit a long settling time and slow recovery from overload.

The advantages of the original circuit's high input resistance and potentially good common mode rejection (the point of using it in the first place) have been negated by the input bias and inclusion of C10.

In all, it reeks of a circuit 'improved' by aimless fiddling about. So what? If it works, why not use it? Well, my feeling is that if it takes three op-amps to do the job of one, rather worse than one would do it, I'll save my money and go for the one. As to whether it works, the text contains the ominous words 'Do not worry if the LED does not flash at a stable rate'. Come on, Prof. Pencilbend, the heart may not be quite metronomic but it's not *that* erratic unless there's something seriously wrong with you! I suggest you take another look at the circuit, or see a doctor. The choice is yours.

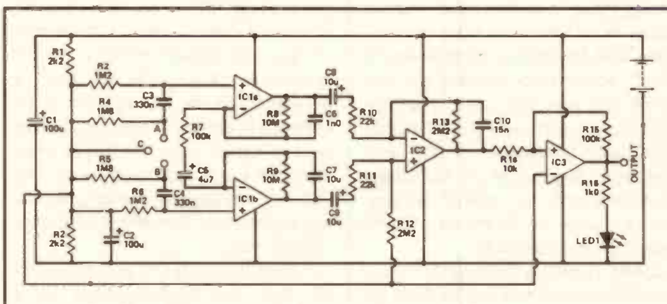


Fig. 1 The 'improved' circuit as published.

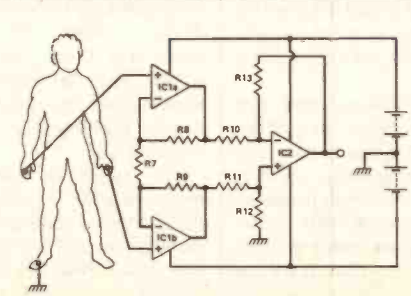


Fig. 2 The basic instrumentation amplifier circuit for amplifying small signals.

John Bird

OPEN CHANNEL

At long last (See Open Channel last month), British Telecom managed to get an engineer to my property and fit me with a master telephone socket — eleven weeks from my initial order.

This entailed a simple changeover from the existing connector block at the local line inlet point to the new socket and took less than twenty minutes work. Within an hour and a half I had fitted my requisite extension sockets around the premises, and then I had the opportunity to try out my new Mercury telephone.

I had already received my authorisation code from Mercury by post (in two parts, for security) and so I was able to program the phone, ready for use the moment I plugged it in. Programming takes less than five minutes. Although, programming the 50 available memories with numbers which one might commonly dial would obviously take somewhat longer.

Using the phone is simple enough. For local calls, you dial the BT local network anyway, so all you do is dial the number. This would be true for trunk calls via the BT trunk network too (although once the option is available to use the Mercury trunk network you would never do this because BT charges more than Mercury for trunk calls).

For trunk calls over the Mercury network you simply press the 'Mercury' button at the side of the numeric keypad and then dial the number you want.

The initial programming procedure mentioned above programs the Mercury button with two things: the Mercury network access number (131) and your authorisation code number (sshh, a secret). Interestingly, the access number is dialled in loop-disconnect mode (pulses) while the authorisation code and the telephone number is transmitted in multifrequency tones.

So, although you have to press an extra button when you make a Mercury call, the overall speed of connection is potentially much quicker than it is over the BT network. However, connection at the far end of your trunk call may be by clickety-click Strowger equipment (depending on the called user's local exchange) so this may not be true at all.

Whatever the speed of connection, trunk calls via Mercury are cheaper, so what the heck!

Another advantage of using the Mercury network is that Mercury bills you with an itemised listing of all calls you make, so you can keep an accurate track of calls and costs. This will be more than a little useful in trying to find out who's been phoning Aunt Sheila in Australia at 8 o'clock in the morning!

Aware of this advantage, BT is presently trying out the use of itemised billing with a number of customers in the City of London, Bristol and Bath. It will be a while before the facility is available nationally, though.

On The Tracks

British Rail is presently installing a communications network for its signalling equipment which will provide a terminal at each area signal station. Terminals will provide details of all signals, points and train routes throughout the area. Like the 08.35, it's a long time coming and a lot of commuters are waiting for it!

Smarter Than Average...

I've been reading and hearing a great deal recently about smart-cards — credit card sized bits of plastic with memory of some form or another, which are about to take over the very business the original cards pioneered.

Potentially, smart-cards can go much further than basic plastic cards in terms of use. Basic cards are useful in only one environment — cash/credit money deals. Smart cards, on the other hand, because of their memory capabilities, will be able to handle much more. Some uses already on the cards (excuse the pun) include travel arrangements (hotel bookings, flight bookings, car hire, etc) and restricting access to buildings or rooms only to certain personnel, as well as more mundane financial transactions.

Don't run out looking for your smart-card yet because there is no common system which all the potential cards will work on. So, as far as the customer is concerned, a smart-card is just another bit of plastic to carry around — some sales outlets may accept it, some may not.

Things won't change until two things occur, in stages. First, all the UK banks must agree to produce a mutually acceptable service. Next stage is a national, if not international, network with sufficient and adequate point-of-sales equipment at all outlets. It will be a long time yet before the real benefits of smart-cards become available.

Keith Brindley

BOOK LOOK

Build a Better Music Synthesiser. Thomas Henry (John Wiley and Sons) £10.70.

This month's offering is of the nature of a follow up to the ETI music special of a couple of months ago (May 1987).

Sadly, this book comes from the other side of the Atlantic. Why is it there are far more books coming from over there than we manage to dream up here?

It's true there are five times as many of them over there than we can cram into these sceptred isles (frightening thought isn't it) but still...

Anyway, while the States has the monopoly on electronic literary achievements let's have a look at the latest.

In many ways it's amazing a book like this should ever see the light of day, these days. It's not that the book itself is not up to standard. It's just that nowadays the music industry giants have the whole business pretty well sewn up.

What is there left for the likes of you and me to do? We cannot compete with synths based on 741s built in shoe boxes!

Better And Better

Nevertheless, this book purports to inform us how to build a better synth (better than what?).

'You can always build a better synthesiser than you can buy' is the credo of Mr. Henry. This is an extremely dodgy statement at the best of times. Can the home constructor really compete with the LSI chip design and manufacturing facilities of Yamaha and Casio? I think not.

There is much the amateur can do but the construction of a 'better' synth is not one of them.

The synth which this book shows you how to build is certainly unlikely to be found on the dealers' shelves. This is not because it is 'better' but because it is an old fashioned design, superceded by commercial products making use of digital technology.

The synth in question is a modular affair — just the kind of thing this hallowed mag used to publish around five years ago. All the usual modules are there — voltage controlled amps, oscillators and filters, envelope generators and of course a keyboard.

The majority of the book is concerned with describing the circuits to fulfill the functions of these modules. However, the start is devoted to explaining the pinciples behind sound synthesis in general and this outdated synth design in particular. As a treatise on modular analogue synth design, I cannot really fault this section.

Although the modules are described as 'construction projects', they are really only circuits with accompanying explanations, theory and set-up details. There are no real construction details, no PCB or stripboard designs. With this kind of device this can be an acute omission. Careful board design can be the make or break of a good synth.

Foreign Matter

There is one other failing of this book and that's due not to the content but to its US origins. The appendices covering suppliers of components and sources of further information are, of course, absolutely useless in this country.

If a publisher wishes to bring a book across the great devide it would be so much more useful (for this kind of work, anyway) for a Brit to give it a going over first to correct this kind of thing. It will surely cost more to reprint a UK version but such care would also command better sales for the book and still be cheaper than starting from scratch in this country.

John Wiley please note!

All in all, it is difficult to justify over ten quid on this kind of work for most potential readers.

Nevertheless, for this kind of (heavily outdated) synth design, the book gives a good grounding. The beginner will not be able to progress far on this alone but a more experienced constructor, dabling in music for the first time, will find it valuable enough.

The experienced constructor of musical instruments and effects will be disappointed. The book breaks no new, nor even recent, ground.

However, it must be said that simple analogue synths are hard to come by these days. If it's just an uncomplicated sound maker you are after, the modular synth set out here will serve you well, cost you little and prove great fun to put together.

Malcolm Brown

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E8708-2 Rear Wiper Alarm .... G
E8708-3 Rev Counter .... F
E8708-4 Car alarm .... F
E8708-5 Knight Raider .... J

OOPS!

The Better Flanger (January 1987)
In the circuit diagram (Fig. 2) D1 is not labelled. This is connected to Q1. In the component overlay (Fig. 5) several components are missing. A link should connect the two pads to the left of C1. Q1 is situated next to D1 and connection point P4 is situated between R16 and R33. In addition, the positions of R16 and C11 should be swapped.

Photo Process Controller (February 1987)
In the circuit diagram (Fig. 2) the cathodes of diodes D3,5 are shown connected to 0V. They should connect to the junction of R16,17,18. In the overlay diagrams (Figs. 3 and 5) the flying leads are numbered incorrectly. Leads 7, 8, 9 and 10 at the top of Fig. 3 should be numbered 16-19. In Fig. 5 leads 6 and 8 from the top of R13 should be numbered 16 and 17. Numbers 9 and 10 from Q1 and Q2 should be 18 and 19. In addition the leads 11 and 'A' should be swapped.

Capacitometer (March 1987)
The circuit diagram (Fig. 1) should show pin 1 of IC1 connected to 0V. The zener diode (ZD1) should be connected between the junction of R10/R11 and 0V. The PCB foil is correct.

BBC Micro MIDI Interface (April 1987)
IC7 and IC8 (the 6N139 opto-isolator ICs) are missing from the parts list. In the Buylines section it is incorrectly said that these are available from Electromail as part 302-126. The isolator is available from Maplin as part number RA59P. Resistors R8,9 are missing from the overlay diagram (Fig. 4). These are located in the two pairs of pads below IC6. There should also be no 0V connection to the MIDI IN sockets, only to the OUT sockets (pin 2) so as to prevent earth loops.

Power Meter (May 1987)
The foil for the budget power meter was given 50% full size on the foil pages. The correct size foil appeared in the June issue.

MIDI Master Keyboard (June 1987)
The foils for the CPU board were given 64% full size on the foil pages. Photocopies of the correct size foils can be obtained by sending a SAE to the Editorial address.

Flat Alarm (June 1987)
In the circuit diagram Q2 is shown as an NPN transistor. It should be a PNP device as given in the parts list. IC4 is given in Fig. 2 as a 74LS260 and C5 as 470n. They should be 74LS132 and 4µ7 as in the parts list. R13 is incorrectly given as 280R in the parts list instead of 270R.

Nuclear Strategy Simulator (July 1987)
The bridge rectifier (BR1) on the overlay diagram has no polarity markings. It should be positioned with the positive at bottom left, connected to the track which connects to IC8 IN and C4 positive.

AD TOKEN

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HEATHKITS: IB3128 impedance bridge £100. IG1271 function generator £28. IB5281 RLC bridge £35. Tel: (0423) 871626.

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WANTED: ACORN ELECTRON ADVANCED USER GUIDE. Up to full retail price offered. Mr. H. Thurlow, 17, Coulton Avenue, Gravesend, DA11 8DZ.

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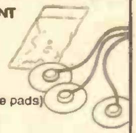

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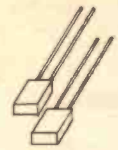

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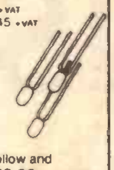

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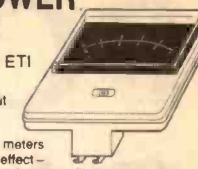

Measure the output power of your hi-fi with the ETI power meter. The meters can be back-lit for effect – the 'scale and 'power' legend will glow green to contrast with the red pointer. Two switched ranges give readings of 0-10W and 0-100W.

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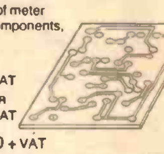

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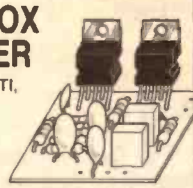
MATCHBOX AMPLIFIER

FEATURED IN ETI, APRIL 1986



No ordinary amplifiers, these. When our first customers took an interest, it was for the diminutive size (both modules will fit in a matchbox!), the total disregard for power supplies and speaker impedances, and the impressive power output from these little amplifiers. When they re-ordered, it was for the sound quality.

Two amplifier modules were described, both based on the powerful L165V IC. The single IC version will deliver over 20 Watts with a suitable speaker and power supply. The bridge version can provide up to 50W! Although the specified supply voltage and speaker impedance must be used to achieve maximum power, both modules are quite happy to work from any voltage between 12V and 32V, and will accommodate any type of speaker. The bridge version is ideal for giving a boost to car Hi-Fi systems, driving two 4 Ohm speakers in parallel on each channel for best effect.

Both designer-approved parts sets consist of a roller tinned printed circuit board and all components. The L165V ICs are also available individually, with a free mini data sheet giving specifications and suggested circuits.

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KNIGHT RAIDER

FEATURED IN ETI, AUGUST 1987

The ultimate in lighting effects for your Lamborghini, Maserati, BMW (or any other car, for that matter). Picture this: eight powerful lights in line along the front and eight along the rear. You flick a switch on the dashboard control box and a point of light moves lazily from left to right leaving a comet's tail behind it. Flip the switch again and the point of light becomes a bar, bouncing backwards and forwards along the row. Press again and try one of the other six patterns . . . An LED display on the control box let's you see what the main lights are doing.

The Knight Raider can be fitted to any car (it makes an excellent fog light!) or with low powered bulbs it can turn any child's pedal car or bicycle into a spectacular TV-age toy!

The control box parts set consists of case, switches, LEDs, PCB, components, hardware and instructions. The sequence board includes PCB, ICs, power FETs, components, hardware and instructions.

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BRAIN WAVE MONITOR

FEATURED IN ETI, SEPTEMBER 1987

ALPHA: HOW TO SUCCEED WITHOUT REALLY TRYING.

This was the title of a recent QED television program which showed how life can be dramatically improved with aid of alpha training. Alisdair McBeth overcame his shyness with girls, others became more confident, improved their sporting abilities, learned to cope with stress . . . and all without really trying!

Alpha monitors are not new, but good ones are hard to find. To detect a few uV of brain waves in the midst of noise that is tens of thousands of times as great is not easy! The ETI Alpha Monitor is probably the most powerful and effective design to be found outside an EEG laboratory. The sensitive circuit locks on to the all important alpha rythm and helps you to strengthen and control it. Quickly. Then you put it to work for you, strengthening your confidence and abilities day by day.

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Complete Parts Sets for ETI Projects

MAINS CONDITIONER

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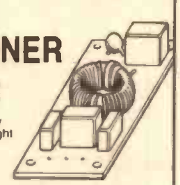


It is astonishing how many people buy or build top-flight hi-fi equipment, and then connect it to a noisy, spiky mains supply. Rather like buying a Ferrari and trying to run it on paraffin, you might think. Expecting crystal clear sound, the poor music enthusiast ends up with a muddy, confused mush, and feels that he has somehow been cheated. 'Is this hi-fi? My music centre sounded just as good!'

The domestic mains supply is riddled with RF interference, noise, transient spikes, and goodness knows what else. Computers crash, radios pop and crackle, tape recordings are spoiled and hi-fi sounds 'not quite right'. Why put up with it when the solution is so simple? The ETI mains conditioner is the lowest cost upgrade you will ever buy, and probably the most effective!

Our approved parts set consists of PCB, all components, toroid*, enamelled wire, fixing ties, fast response VDR*, and full instructions.

ETI MAINS CONDITIONER PARTS SET ONLY £4.60! + VAT

*Note: the toroid and VDR supplied are superior to the types specified in the article.

CREDIT CARD CASINO

FEATURED IN ETI, MARCH 1987

This wicked little pocket gambling machine measures only 3"x2"x½". It will play all kinds of casino games, including:

- Roulette
- Craps
- Pontoon

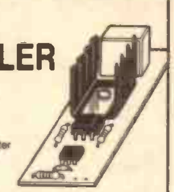
Our approved parts set comes complete with case; self-adhesive fascia; tinned and drilled printed circuit board; all components; hardware; full instructions and three different games to play!

CASINO PARTS SET ONLY £5.90! + VAT

Five extra games FREE with every order!

MAINS CONTROLLER

FEATURED IN ETI, JANUARY 1987



Have you ever wondered what people *do* with all those computer interfaces? 'Put your computer in control,' say the ads. 'The Spectrabeeb has eight TTL outputs.' What on earth can you control with a TTL output? A torch bulb?

The ETI Mains Controller is a logic to mains interface which allows you to control loads of up to 500W from your computer or logic circuits. An opto-coupler gives isolation of at least 2,500V, so the controller can be connected to experimental circuits, computers and control projects in complete safety. Follow your computer interface with a mains controller and you're *really* in business with automatic control!

The mains controller connects directly to most TTL families without external components, and can be driven by CMOS with the addition of a transistor and two resistors (supplied).

Your mains controller parts set contains: high quality roller tinned PCB; MOC3021 opto-coupler; power triac with heatsink, mounting hardware and heatsink compound; all components, including snubber components for switching inductive loads; transistor and resistors for CMOS interface; full instructions.

MAINS CONTROLLER PARTS SET £6.20 + VAT!

POWERFUL AIR IONISER

FEATURED IN ETI, JULY 1986

Ions have been described as 'vitamins of the air' by the health magazines, and have been credited with everything from curing hay fever and asthma to improving concentration and putting an end to insomnia. Although some of the claims may be exaggerated, there is no doubt that ionised air is much cleaner and purer, and seems much more invigorating than 'dead' air.

The DIRECT ION ioniser caused a great deal of excitement when it appeared as a constructional project in ETI. At last, an ioniser that was comparable with (better than?) commercial products, was reliable, good to build . . . and fun! Apart from the serious applications, some of the suggested experiments were outrageous!

We can supply a matched set of parts, fully approved by the designer, to build this unique project. The set includes a roller tinned printed circuit board, 66 components, case, mains lead, and even the parts for the tester. According to one customer, the set costs 'about a third of the price of the individual components'. What more can we say?

Instructions are included

DIRECT ION PARTS SET £9.50 + VAT

PROJECT BOX

PROJECT CASE WITH PP3 BATTERY COMPARTMENT

ONLY £2.60! + VAT

LM2917 EXPERIMENTER SET

Consists of LM2917 IC, special printed circuit board and detailed instructions with data and circuits for eight different projects to build. Can be used to experiment with the circuits in the 'Next Great Little IC' feature (ETI, December 1986).

LM2917 Experimenter Set £5.80 + VAT

RUGGED PLASTIC CASE

suitable for mains conditioner and mains controller.

ONLY £1.65 + VAT

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WHITE IONISER PARTS SET ONLY £9.80! + VAT

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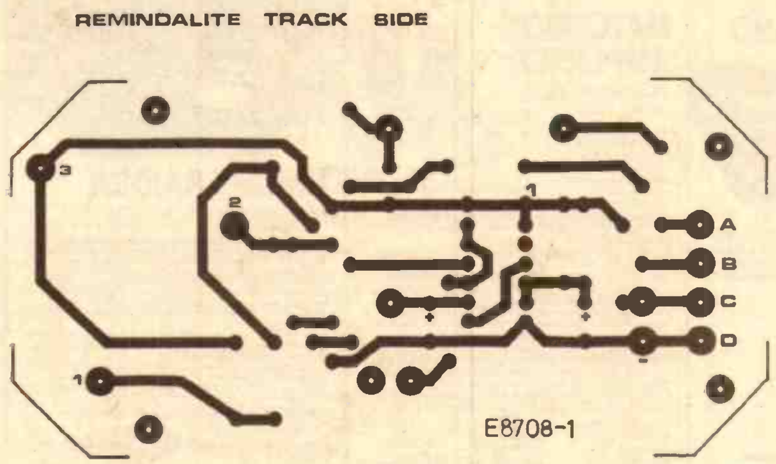
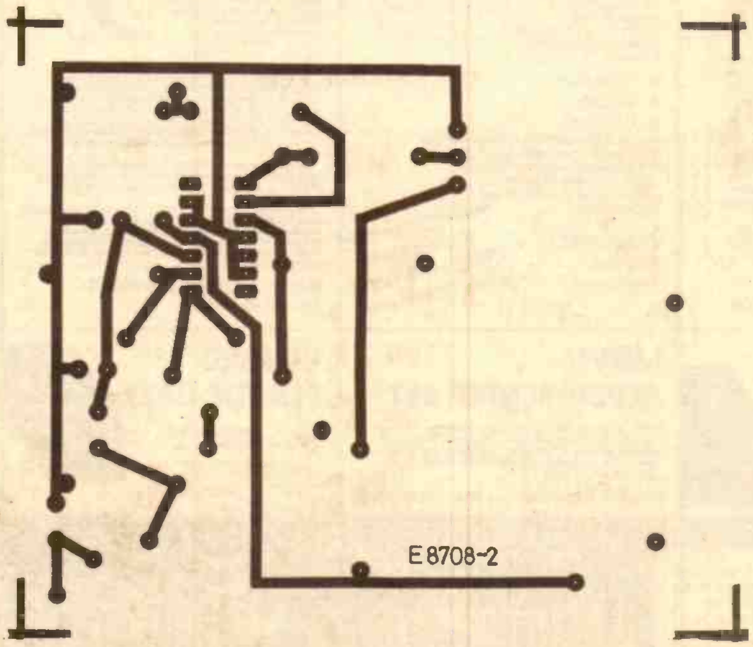
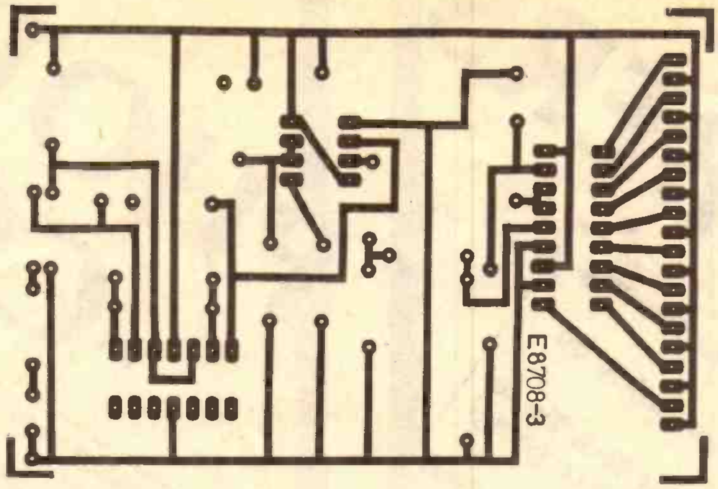


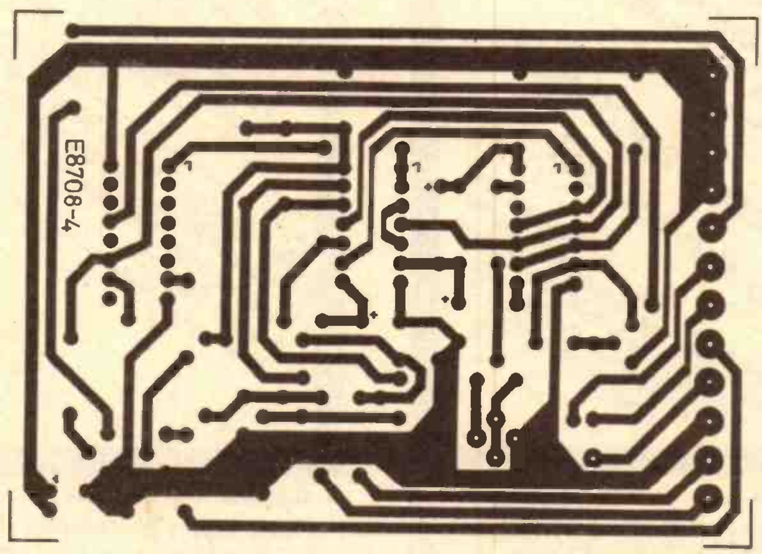
The Remindalite board.



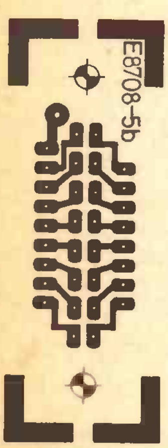
The PCB foil for the wiper alarm.



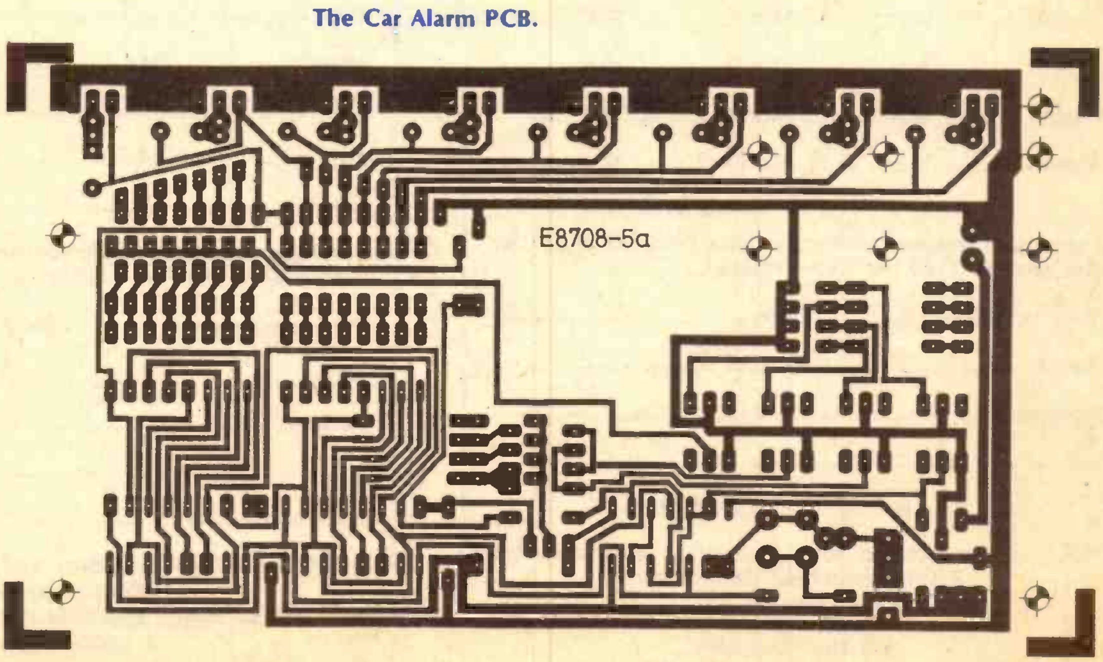
The Sonic Rev Counter PCB.



The Car Alarm PCB.



The Knight Raider control board.



The foil for the Knight Raider sequence board.

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- Minimum charge for **REPAIR-RESCUE SERVICE £4.50** plus any parts used will be charged at cost.
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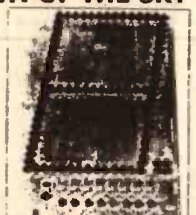
This kit is something new... a giant VU meter with 240V bulbs. The 12 bulbs are mounted as a lightcolumn which varies according to the sound level.
The input is galvanically seperated and the sensitivity is adjustable, so there is no danger when connected to a pre-amplifier or to a power amplifier.
- 12 triac outputs 400W each (non-cooled).
- Input impedance ca. 20 Kohm.
- Input sensitivity: adjustable from ca. 100mV to 3V at full scale.
- Power supply. 9 VAC/0,5A.

Price £36.85 + p&p

LIGHT UP THE SKY



20CM DISPLAY 'COMMON ANODE' KIT NR. K2567

This kit contains a 7-segment display consisting of 12 leds per segment and 4 leds for the decimal point. With the aid of a supplementary power supply, it is possible to connect this kit to any existing circuit equipped with common anode displays of any brand and any dimension.
If the digit and segment drivers of the circuit can supply sufficient current, it will be possible to connect in parallel two or more displays, or even, leave the small display of the circuit in place and connect the 20cm display in parallel.
This latter will not effect the brightness of the 20cm display due to the specia concept of the driver circuit.
- Common anode.
- Power supply: 22 to 26VDC non-stabilized.
- Minimum anode input voltage (on): 2V.
- Maximum anode input voltage (off): 1.2V.
- Segments input impedance: 10K.
- Segment current: static (R6-00) 40mA multiplex (R6=22ohm) 75mA.
- Total current consumption in static mode: maximum 400mA.
- Maximum power (U=22V) 8.8Watt.

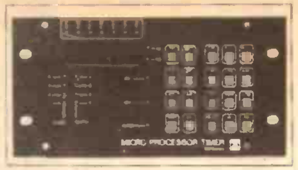
Price £30.26 + p&p

20CM DISPLAY 'COMMON CATHODE' KIT NR. K2568

This kit is in terms of appearance and application identical to K2567 'COMMON ANODE'.
As far as specifications are concerned, read cathode for anode.

Price £31.93 + p&p

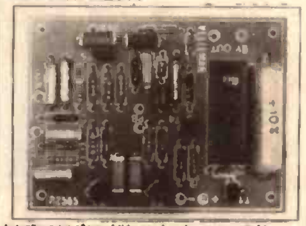
MICROPROCESSOR UNIVERSAL TIMER KIT NR. K1682



This unique timer is in principle a 24-hour clock provided with 4 relay switched outputs and a programmation period of 1 week. 20 switching programs can be memorized and via the membrane keyboard be programmed. Outputs or timing periods can be selected at random.
All program steps are indicated be leds.
A printed alu frontplate is included in the kit, making building-in of this timer a simple affair.
This microprocessor timer was primarily designed for industrial and labo purposes, but the amateur can use it in dozens of applications as well.
- 20 daily- or weekly programmable timerfunctions.
- Memory display of programmed timer functions per output or per day.
- 4 independent relay outputs (1 relay included).
- Display of: day of week - AM/PM - output - clock.
- ON/OFF - sleep.
- The timer is based on the TMS 1122 microprocessor.
- Transformer 12VAC/1A (not included).

Price £75.85 + p&p

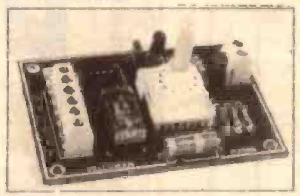
TAPE/SLIDE SYNCHRONIZER KIT NR. K2565



Actually, a lot of tape/slide synchronizers are available on the market. The price of these devices varies from expensive to very expensive.
Those owning a tape- or cassette recorder can with this simple and inexpensive device, record synchronizing pulses and use these pulses to control automatic slide projectors.
The circuit is small in size and can easily be housed.
- Power supply: 9 to 13VDC.
- Current consumption: 40mA.
- Output frequency (tone): 1.5KHz.
- Output amplitude: 250mV.
- Input sensitivity A: minimum 1.5V peak to peak.
- Input sensitivity B: minimum 100mV.
- Oscillator: AMV type.
- Input impedance (B): 1 KOhm.
- Output impedance: 15 KOhm.

Price £12.75 + p&p

SCREEN WIPER ROBOT KIT NR. 2599



Three different time intervals may be selected by using a multipole rotary switch. With small component changes, the intervals may be varied.
Some applications: windscreen wiper delay - diaprojector control - hazard warning via the brakinglights of the car.
In the manual you will find a complete description how to build this kit in a car, with wiring instructions to connect it to the existing wiper installation.
- Power supply: 12-15V DC.
- Intervals: 5-10-15 seconds.
- Relay output: 240V/2x3A.
- Relay output with two change-over contacts.
- Current consumption:
- Output 'OFF': 25mA.
- Output 'ON': 100mA.
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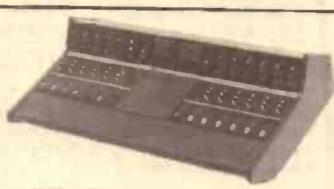

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