ELECTRONICS &

Wireless world

FEBRUARY 1984

85p

GPIB-to-BBC Micro interface

Morse on a ZX 81

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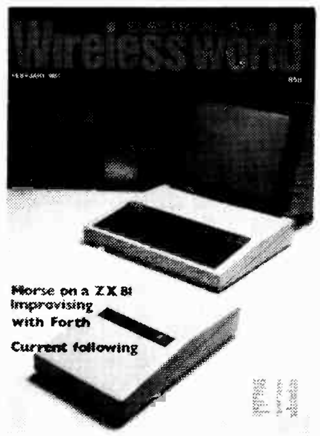

Acorn's GPIB/BBC interface – above – is described by its originator on page 24. Photo by courtesy of Acorn Computers and Optimus Graphic Design.

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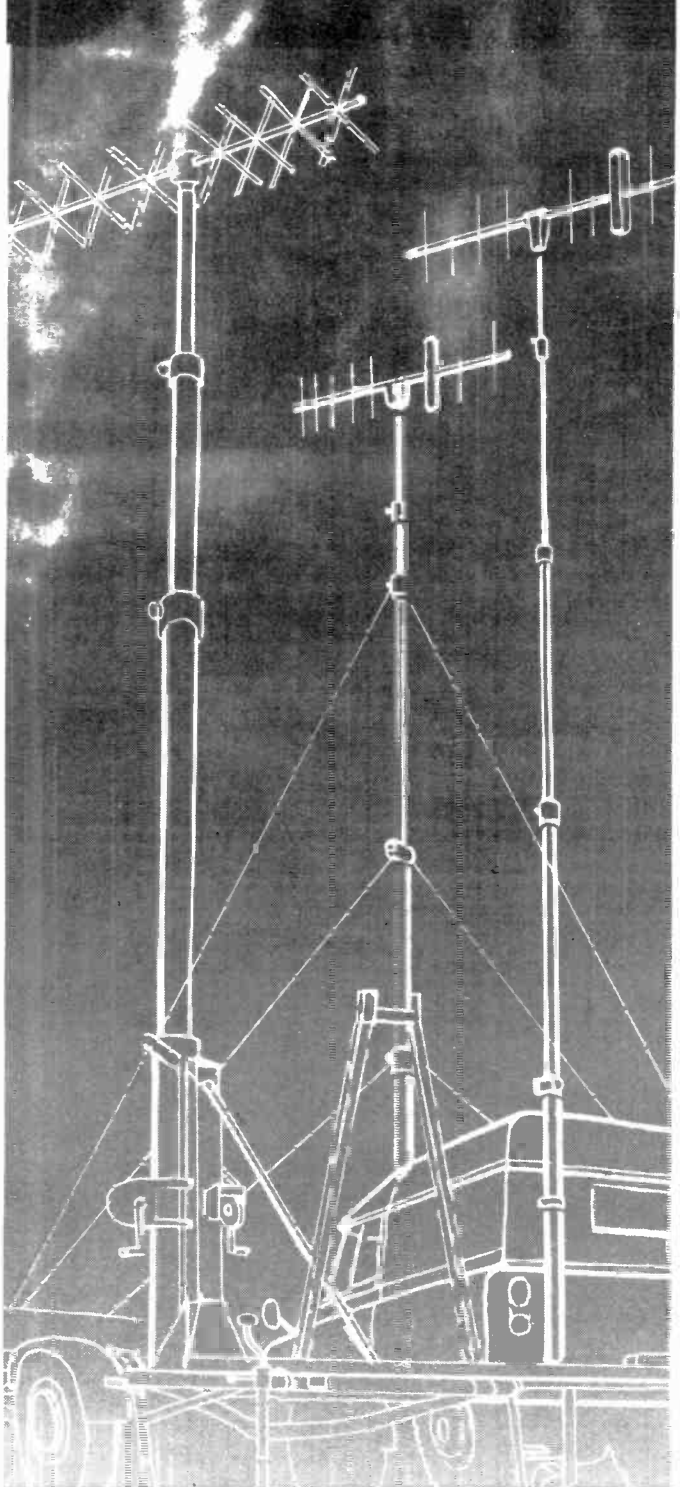

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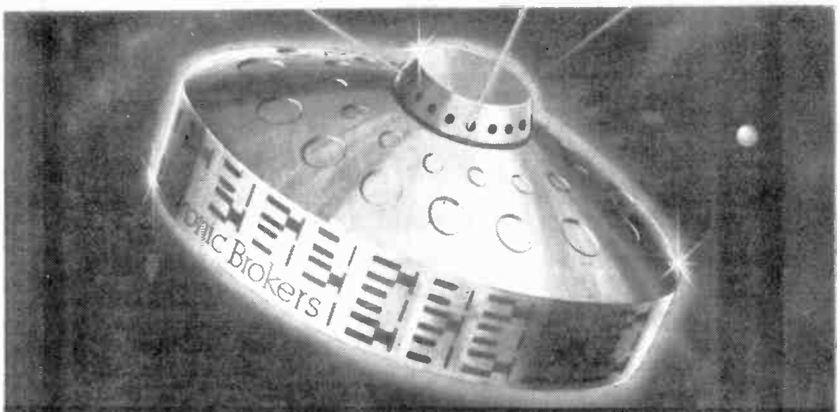

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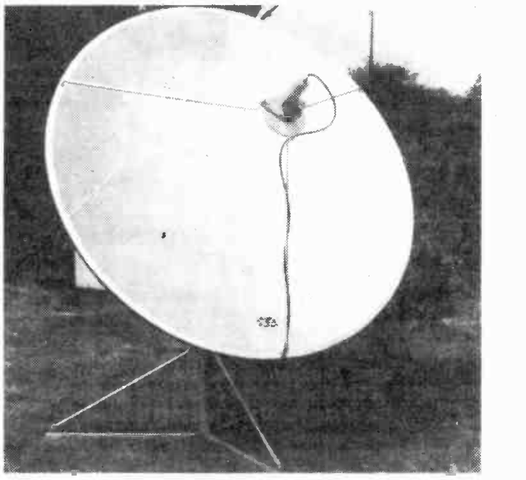

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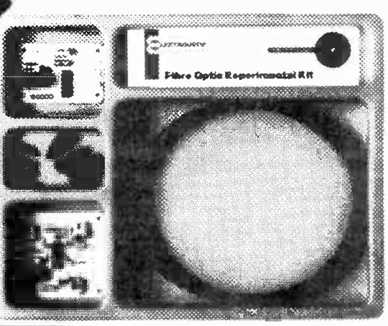

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4164-15	D2	4.33
4164-20	D2	3.95
4416-20	D2	6 60
4564-15		5.25
5516-25		7 73
6116-3	D1	3.72
6116-LP3	D2	4 67
2532-45	D2	3.50
2708-45	D2	3 25
2716-35	D1	4.50
2716-45	D1	3 50
2716-3	D1	4.50
2732-35	D1	4 58
2732-45	D1	3.75
2764-30	D1	3 92
2764-250NS TI		3.92
2764-250NS BBC		5 95
2564-30	D2	6.00
27128-30	D2	24.50

Buffers

81LS95	0 95
81LS96	0 95
81LS97	0.95
81LS98	0.95
8T26A (6880AP)	0.78
8T28A (6889)	0 78
8T95 (6885)	0 78
8T97A (6887)	0 78
8T98 (6888)	0.78

Data Convertors

ZN435	D1	3.70
UPD7002	D1	4.65
ZN425E-8	D1	3.13
ZN426E-8	D1	1.67
ZN427E-8	D1	5.75
ZN428E-8	D1	4.38
ZN429E-8	D1	1.33
ZN432CJ-10	D1	25.98
ZN432E-10	D1	10 88
ZN433CJ-10	D1	20 98
ZN440	D1	47.43
ZN447	D1	6 70
ZN448	D1	5.75
ZN449	D1	2.35
ZN441	D1	40.32

Crystals

A111B 1MHz	4.22
A112A 1.008MHz	3.42
A113A 1 8432MHz	2 88
A116A 2 4576MHz	1 00
A169A 3.6864MHz	1.55
A120B4MHz	0.85
A132A 6MHz	0 72
A140A 8MHz	1.00
A173A 9.8304MHz	1.40
A182A 19 6608MHz	2 07

UHF Modulators

UM1111 6MHz	2.17
UM1233 8MHz	3.25

Floppy Disc Controllers

8271P		53 33
FD1771P	D5	21 25
FD1791	D6	17 00
FD1793	D6	17 00
FD1795	D6	24.35
FD1797	D6	24.35
WD1691	D2	12.00
WD2143.01	D2	7 90

Regulators

78L05	0.26
78L12	0.26
78L15	0 26
7805	0.33
7812	0 33
7815	0.33
7905	0.46
7912	0 46
7915	0.46
LM309K	0 98
LM317K	1 92
LM323K	4.58
LM338K	5.21
78HGASC	8.13
78H05SC	6.28
78H12ASC	7.40
78S40DM	6.28
78S40PC	2.50

6800 Family

6800	D7	2 87
6802	D5	2 61
6803C		5.83
6809	D6	7.13
6810	D1	1.25
6821	D3	1.31
6840	D4	3.92
6843L		20 88
6845	D5	5.88
6850	D2	1 31
6862		0 00
6871-Al		14 17
68488	D2	5.78
6875		7.13
68B00	D7	4 30
68B09	D6	9 96
68B21	D3	1 88
68B10	D1	1.80
68B40	D4	5.50
68B50	D2	1.83
MC68B54P		7.75

Z80 Family

Z80A CPU	D2	2 42
Z80B CPU	D1	7.78
Z80A CTC	D1	2.20
Z80B CTC	D1	7.78
Z80A DART	D1	5 50
Z80A DMA	D2	6.95
Z80A P10	D1	2 20
Z80B P10	D1	7.78
Z80 SIO-0	D4	8.50
Z80A SIO-0	D4	9.00
Z80B SIO-0	D4	29 78
Z80 SIO-1	D4	8.50
Z80A SIO-1	D4	9.00
Z80B SIO-1	D4	29 78
Z80 SIO-2	D4	8 50
Z80A SIO-2	D4	9.00
Z80B SIO-2	D4	29.78
MK3886		7 00
MK3886-4		8 00

8080 Family

8085A	D4	3.07
8212		1.50
8216		1.37
8224		1 92
8228		3.25
8251A	D5	2.60
8253		3.33
8255A	D5	2.50

6500 Family

6502	D3	4 40
6502A	D3	4.67
6520	D1	2.67
6520A	D1	2.80
6522	D5	3.47
6522A	D5	4.40
6532	D2	5.33
6532A	D2	5.87

Linear & Interface Devices

6402		6.00
AY3-1015	D2	2.92
AY3-1270		6 50
AY3-8910	D6	4.48
AY5-3600	D2	7.37
DP8304	D1	1.92
L203		0.80
LF398		3.17
LM301AN		0.24
LM308AN		0.73
LM308N		0 47
LM311N		0 84
LM319		2.23
LM324N		0.32
LM339N		0.37
LM348N		0 53
LM358N		0 28
LM393N		0.34
LM725CN		1 33
LM741CP		0 18
LM747CP		0.48
LM748CP		0.22
MC1413P	D1	0.66
MC1416	D1	0.66
MC1458CPL		0 26
MC1495L		7.13
MC1496P		0.65
MC1723P		0.32
MC3242A		5 25
MC3302P		0.40
MC3340P		1.97
MC3357P		1.56
MC3423PL		0 67
MC3441AP		2.40
MC3446AP	D1	2.40
MC3447P		3.58
MC3448AP	D1	3.32
MC3470P		5.23
MC3480P	D5	6.47
MC3487P	D1	1.50
MC14411	D1	8.52
MC14412		11.87
NE555P		0.19
NE556CP		0.45
RO3-2513L	D1	7.82
RO3-2513U	D1	7 82
SN75107BN		0.58
SN75110AN		0 68
SN75150P		0.72
SN75154N		0.87
SN75159N		1 19
SN75160AN		2 15
SN75161AN		2.35
SN75162AN		3 31
SN75172NG		1 64
SN75173N		1.21
SN75174		1 64
SN75175		1.21
SN75182		0.62
SN75183		0 62
SN75188		0 44
SN75189		0 44
SN75451BP		0.24
SN75452BP		0.24
SN75453BP		0.24
SN75454BP		0.24
SN75468N		1.08
SN75491AN		0.46
SN75492AN		0.61
TL010CP		0.38
TL061CLP		0.28
TL062CP		0.47
TL064CN		0 89
TL066CP		0.28
TL071CP		0.28
TL072CP		0.47
TL074CN		0 91
TL081CP		0 24
TL082CP		0.41
TL084CN		0.85
TL091CP		0.41
TL092CP		0.60
TL094CN		1 37
TL487CP		0.55
TL489CP		0.55
TL494CN		1.66
TL496CP		0.30
TL507CP		1 02
ZN450E		5.25
ZN451E		6 38
ZN451KIT		25.65

DIL Sockets

Pin	Tin	Gold	W/W
8	0.10	0.24	0.58
14	0.12	0.28	0.77
16	0.13	0.32	0.86
18	0.16	0.32	1.08
20	0 17	0.41	1.23
22	0.17	0.48	1 31
24	0.20	0.63	1.44
28	0.23	0.57	1 59
40	0.33	0.99	1.96

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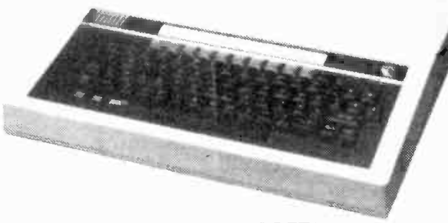

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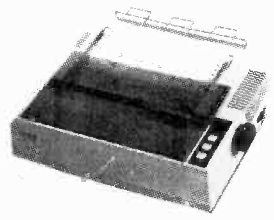

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2×28-way	**190p**	–
1×43-way	**260p**	–
2×43-way	**365p**	
1×77-way	**600p**	
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7411 25p
7412 25p
7413 40p
7414 60p
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7421 25p
7422 30p
7423 30p
7425 35p
7426 30p
7427 30p
7428 30p
7430 25p
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7433 25p
7437 25p
7438 60p
7439 36p
7440 25p
7441 70p
7442A 60p
7444 70p
7445 90p
7446A 90p
7447A 75p
7448 90p
7450 25p
7451 25p
7453 25p
7454 25p
7460 30p
7470 30p
7472 36p
7473 30p
7474 40p
7475 40p
7476 35p
7480 48p
7481 120p
7482 120p
7483A 75p
7484A 90p
7485 90p
7486 36p
7489 170p
7490A 45p
7491 60p
7492A 50p
7493A 45p
7494 90p
7495A 48p
7496 60p
7497 120p
74100 120p
74104 50p
74105 55p
74107 45p
74109 45p
74110 60p
74111 55p
74112 170p
74116 120p
74118 120p
74119 100p
74120 100p
74121 40p
74122 45p
74123 90p
74125 50p
74126 50p
74128 70p
74132 43p
74136 45p
74141 70p
74142 175p
74143 200p
74144 200p
74145 90p
74147 120p
74148 120p
74150 150p
74151A 60p
74153 60p
74154 120p
74155 55p
74156 55p
74157 55p
74159 150p
74160 55p
74161 55p
74162 55p
74163 55p
74164 60p
74165 75p
74166 90p
74167 200p
74170 150p
74172 250p
74173 65p
74174 60p
74175 60p
74176 55p
74177 50p
74178 90p
74179 90p
74180 55p
74181 140p
74182 50p
74184 120p
74185A 120p
74190 60p
74191 60p
74192 60p
74193 60p
74194 50p
74195 50p
74196 48p
74197 48p
74198 120p
74199 120p
74221 100p
74251 60p
74259 150p
74265 55p
74273 150p
74276 120p
74278 100p
74279 55p
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74LS28 20p
74LS30 20p
74LS32 60p
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74LS83A 46p
74LS85 60p
74LS86 30p
74LS90 32p
74LS91 60p
74LS92 40p
74LS93 32p
74LS95B 50p
74LS96 90p
74LS107 33p
74LS109 33p
74LS112 33p
74LS113 30p
74LS114 32p
74LS122 60p
74LS123 120p
74LS124/629 150p
74LS125 45p
74LS126 45p
74LS132 42p
74LS133 30p
74LS136 30p
74LS138 42p
74LS139 42p
74LS145 90p
74LS147 120p
74LS148 120p
74LS151 50p
74LS153 50p
74LS154 150p
74LS155 40p
74LS156 40p
74LS157 40p
74LS158 35p
74LS160A 60p
74LS161A 60p
74LS162A 75p
74LS163A 90p
74LS164 60p
74LS165A 75p
74LS166A 120p
74LS168 140p
74LS169 110p
74LS170 100p
74LS173A 120p
74LS174 60p
74LS175 54p
74LS181 120p
74LS183 120p
74LS190 60p
74LS191 60p
74LS192 60p
74LS193 60p
74LS194A 50p
74LS195A 50p
74LS196 60p
74LS197 54p
74LS221 90p
74LS240 120p
74LS241 120p
74LS242 75p
74LS243 75p
74LS244 140p
74LS245 175p
74LS247 70p
74LS248 70p
74LS249 70p
74LS251 45p
74LS253 45p
74LS256 200p
74LS257A 45p
74LS258A 45p
74LS259 120p
74LS260 35p
74LS261 80p
74LS266 25p
74LS273 140p
74LS275 175p
74LS279 35p
74LS280 180p
74LS283 50p
74LS290 55p
74LS292 900p
74LS293 50p
74LS295 70p
74LS297 900p
74LS298 90p
74LS299 200p
74LS321 240p
74LS323 200p
74LS324/624 150p
74LS348 140p
74LS352 70p
74LS353 70p
74LS356 175p
74LS363 180p
74LS364 180p
74LS365A 36p
74LS366A 36p
74LS367A 36p
74LS368A 36p
74LS373 120p
74LS374 120p
74LS375 60p
74LS377 120p
74LS378 85p
74LS379 120p
74LS390 75p
74LS393 120p
74LS395A 100p
74LS399 120p
74LS445 100p
74LS465 120p
74LS466 120p
74LS467 120p
74LS490 130p
74LS540 120p
74LS541 150p
74LS608 700p
74LS610 £19
74LS612 £19
74LS624 150p
74LS626 150p
74LS628 150p
74LS629 150p
74LS640 200p
74LS640-1 250p
74LS641 200p
74LS642-1 250p
74LS643 200p
74LS643-1 250p
74LS644 200p
74LS645 200p
74LS645-1 250p
74LS668 70p
74LS669 70p
74LS670 120p
74LS674 550p
74LS682 250p
74LS684 400p
74LS687 450p

74S00 45p
74S02 45p
74S04 60p
74S05 60p
74S08 60p
74S10 40p
74S11 50p
74S20 40p
74S22 50p
74S30 40p
74S32 70p
74S37 60p
74S51 75p
74S74 75p
74S85 300p
74S86 90p
74S112 90p
74S113 90p
74S114 90p
74S124 300p
74S132 110p
74S133 60p
74S138 110p
74S139 120p
74S140 60p
74S151 180p
74S153 180p
74S157 250p
74S158 195p
74S163 300p
74S174 250p
74S175 320p
74S188 150p
74S194 300p
74S195 300p
74S196 300p
74S225 650p
74S240 250p
74S241 300p
74S244 300p
74S251 250p
74S257 250p
74S258 250p
74S260 70p
74S261 300p
74S283 300p
74S299 550p
74S373 400p
74S374 400p

4000 CMOS

4000 16p
4001 16p
4002 16p
4006 50p
4007 16p
4008 45p
4009 24p
4010 24p
4011 16p
4012 16p
4013 25p
4014 48p
4015 40p
4016 22p
4017 40p
4018 45p
4019 40p
4020 48p
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4022 45p
4023 18p
4024 36p
4025 16p
4026 80p
4027 20p
4028 36p
4029 45p
4030 20p
4031 125p
4032 70p
4033 125p
4034 140p
4035 55p
4036 200p
4037 110p
4038 75p
4039 225p
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4042 40p
4043 40p
4044 40p
4045 105p
4046 50p
4047 50p
4048 50p
4049 24p
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4051 48p
4052 48p
4053 50p
4054 75p
4055 75p
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4059 450p
4060 55p
4063 75p
4066 27p
4067 225p
4068 16p
4069 20p
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4071 16p
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4076 48p
4077 27p
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4082 16p
4085 40p
4086 40p
4089 125p
4093 30p
4094 65p
4095 75p
4096 70p
4097 290p
4098 90p
4099 60p
4500 575p
4501 28p
4502 60p
4503 45p
4504 75p
4505 400p
4506 120p
4507 35p
4508 130p
4510 48p
4511 45p
4512 48p
4513 195p
4514 100p
4515 100p
4516 50p
4517 260p
4518 48p
4519 30p
4520 50p
4521 90p
4522 60p
4526 60p
4527 60p
4528 50p
4531 55p
4532 70p
4534 400p
4536 270p
4538 70p
4539 60p
4541 90p
4543 75p
4553 245p
4555 45p
4556 45p
4557 300p
4560 120p
4566 160p
4568 250p
4569 170p
4572 35p
4583 75p
4584 36p
4585 50p
4599 290p
4724 150p
14411 750p
14412 850p
14416 300p
14419 270p
14490 350p
14495 450p
14500 575p
14599 290p
22100 350p
22101 700p
22102 700p
40014 36p
40085 90p
40097 45p

LINEAR ICs

AD7581 £15
ADC0808 990p
AN103 200p
AY1-5050 99p
AY3-1270 750p
AY3-1350 350p
AY3-8910 400p
AY3-8912 500p
AY5-3600 600p
CA3019A 80p
CA3028A 120p
CA3046 70p
CA3048 220p
CA3059 350p
CA3060 350p
CA3080E 70p
CA3086 60p
CA3089E 200p
CA3090AQ 375p
CA3130E 90p
CA3130T 110p
CA3140E 45p
CA3140T 90p
CA3160E 100p
CA3161E 150p
CA3162E 450p
CA3189E 300p
CA3240E 110p
CA3280G 200p
D7002 390p
DAC0800 £2
DAC0808 £2
DG308 300p
HA1366 190p
HA1388 250p
ICL7106 700p
ICL7611 95p
ICL7650 400p
ICL7660 250p
ICL8038 300p
ICM7217 750p
ICM7555 100p
ICM7556 140p
LC7120 300p
LC7130 325p
LC7137 350p
LF347 150p
LF351 48p
LF353 95p
LF355 95p
LF356P 95p
LF357 110p
LF13331 350p
LM10C 325p
LM301A 25p
LM307 45p
LM308CN 75p
LM310 120p
LM311 70p
LM318 150p
LM319 160p
LM319N 160p
LM324 30p
LM334Z 90p
LM335Z 140p
LM339 40p
LM348 65p
LM358P 60p
LM377 225p
LM380 75p
LM381AN 180p
LM382 120p
LM386 90p
LM387 120p
LM389 95p
LM391 150p
LM392N 60p
LM393 100p
LM394CH 300p
LM709 36p
LM710 50p
LM711 70p
LM725C 300p
LM733 60p
LM741 18p
LM747 70p
LM748 35p
LM1011 480p
LM1014 150p
LM1801 300p
LM1830 250p
LM1871 300p
LM1872 300p
LM1886 500p
LM1889 350p
LM2917 200p
LM3302 75p
LM3900 50p
LM3909 85p
LM3911 125p
LM3914 250p
LM3915 250p
LM3916 250p
LM13600 110p
M51513L 230p
M51516L 500p
MB3712 200p
MB3730 400p
MC1310P 150p
MC1413 75p
MC1458 35p
MC1493 100p
MC1495L 350p
MC1496 70p
MC3340P 160p
MC3401 50p
MC3403 65p
MF10CN 360p
MK50240 900p
MK50398 790p
ML920 800p
MM57160 620p
MN6221A 600p
NE531 140p
NE544 190p
NE555 18p
NE556 45p
NE564 420p
NE565 120p
NE566 155p
NE567 140p
NE570 410p
NE571 400p
NE592 60p
NE5532P 200p
NE5533 160p
NE5534P 110p
NE5534AP 140p
PLL02A 500p
RC4136 60p
S566B 225p
SAA1900 £16
SAO1024A 1150p
SFF96364 800p
SN76488 500p
SN76489 400p
SN76495 400p
SP0256AL2 £10
TA7120 150p
TA7130 160p
TA7204 150p
TA7205 90p
TA7222 150p
TA7310 150p
TBA231 120p
TBA800 80p
TBA810 100p
TBA820 80p
TBA950 225p
TC9109 750p
TCA210 350p
TCA220 350p
TCA270 350p
TCA940 175p
TCA965 120p
TDA1004A £4
TDA1008 320p
TDA1010 250p
TDA1022 500p
TDA1024 120p
TDA1170 300p
TDA2002 325p
TDA2003 325p
TDA2004 400p
TDA2006 320p
TDA2020 320p
TDA7000 350p
TL061CP 40p
TL062 65p
TL064 100p
TL071 30p
TL072 50p
TL074 100p
TL081 25p
TL082 45p
TL083 75p
TL084 90p
TL094 200p
TL170 50p
TL430C 70p
UA1003-3 935p
UA2240 120p
UAA170 170p
ULN2003A 75p
ULN2004 75p
ULN2068 290p
ULN2802 200p
ULN2803 200p
ULN2804 200p
UPC575 275p
UPC592H 200p
UPC1156H £3
UPC1185H £5
XR210 400p
XR2206 400p
XR2211 575p
XR2240 120p
ZN414 100p
ZN419C 190p
ZN423E 130p
ZN424E 130p
ZN425E 350p
ZN426E 300p
ZN427E 600p
ZN428E 450p
ZN429E 210p
ZN450E 750p
ZN459CP 250p
ZN1034E 200p
ZN1040E 670p
ZNA134J £23
ZNA234E 950p

VOLTAGE REGULATORS

FIXED PLASTIC

1A	+ve		-ve	
5V	7805	40p	7905	45p
6V	7806	40p	7906	45p
8V	7808	50p	7908	50p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	50p	7918	50p
24V	7824	40p	7924	45p
5V 100mA	78L05	30p	79L05	45p
6V 100mA	78L06	30p		
8V 100mA	78L08	30p		
12V 100mA	78L12	30p	79L12	50p
15V 100mA	78L15	30p	79L15	50p

OTHER REGULATORS

LM309K 1A 5V 140p
LM317K T03 250p
LM317T 100p
LM337T 225p
LM323K 3A 5V 450p
LM350T 350p
LM723N 30p
TL494 300p
TL497 300p
78S40 225p
78P05 900p
78H12 850p
78HGKC 600p
78H05KC 650p
78GUIC 200p
79GUIC 225p
79HGKC 700p
ICL 7660 250p
LM305AH 250p
SG3524 300p

OPTO ELECTRONICS

2N5777 48p
OCP71 180p
ORP12 120p
ORP60 120p
ORP61 120p
TIL32 55p
TIL78 55p
TIL31A 120p
TIL81 90p
TIL100 75p

OPTO ISOLATORS

ILQ74 130p
MCT26 100p
MCS2400 190p
MOC3020 150p
ILQ74 180p
TIL111 70p
TIL112 70p
TIL113 70p
TIL116 70p

0.125"
TIL209 Red 10p
TIL211 Gr 12p
TIL212 Yel 15p
0.2"
TIL220 Red 10p
TIL222 Gr 12p
TIL228 Yel 15p
Rectangular LEDs (R,G,Y) 30p

FND357 120p
FND500 140p
FND507 140p
MAN4640 200p
MAN8910 250p
NSB5881 570p
TIL311 600p
TIL321/3 130p
TIL330 140p
7750/60 200p
Bargraph 225p

DISPLAYS

DL704 140p
DL707 Red 140p
9368 250p
9370 300p

COUNTERS

74C925 £4
74C926 £5
74C928 £6
72168 £22
ZN1040 670p

DIL SWITCHES

4-way 90p
8-way 120p
6-way 105p
10-way 150p

TRANSISTORS

AD161/2 45p
BC107/8 13p
BC109C 14p
BC169C 12p
BC172 12p
BC177/8 17p
BC179 18p
BC182/3 10p
BC184 11p
BC187 30p
BC212/3 11p
BC214 12p
BC237 15p
BC327 16p
BC338 16p
BC461 25p
BC477/8 30p
BC516/7 40p
BC547B 14p
BC548C 12p
BC549C 16p
BC557B 14p
BC559C 16p
BCY70 18p
BCY71 22p
BD131 75p
BD132 80p
BD135/6 40p
BD139 40p
BD140 40p
BD189 60p
BD232 60p
BD233 75p
BD235 85p
BD241 60p
BD242 60p
BD379 60p
BD380 60p
BD677 40p
BF244B 35p
BF256B 50p
BF257/8 32p
BF337 30p
BFR39 25p
BFR40/1 25p
BFR79 25p
BFR80/1 25p
BFR96 180p
BFX29 40p
BFX30 27p
BFX84/5 40p
BFX86/7 27p
BFX88 27p
BFX89 180p
BFY50 30p
BFY51/2 30p
BFY56 33p
BFY90 80p
BRY39 45p
BSX19/20 24p
BU104 225p
BU105 190p
BU108 250p
BU109 225p
BU126 150p
BU180A 120p
BU205 200p
BU208 200p
BU406 145p
BUX80 500p
BUY69C 350p
E310 50p
MJ413 250p
MJ802 400p
MJ2501 225p
MJ2955 90p
MJ3001 225p
MJ4502 400p
MJE340 60p
MJE2955 100p
MJE3055 70p
MPF102 40p
MPF103/4 30p
MPF105 30p
MPSA06 30p
MPSA12 50p
MPSA13 50p
MPSA20 50p
MPSA42 50p
MPSA43 50p
MPSA56 32p
MPSA70 50p
MPSA93 40p
MPSU06 63p
MPSU07 60p
MPSU45 90p
MPSU65 78p
TIP29A 35p
TIP29C 40p
TIP30A 35p
TIP30C 40p
TIP31A 40p
TIP31C 45p
TIP32A 45p
TIP32C 40p
TIP33A 70p
TIP33C 80p
TIP34A 90p
TIP34C 120p
TIP35A 120p
TIP35C 140p
TIP36A 140p
TIP36C 150p
TIP41A 50p
TIP41C 55p
TIP42A 60p
TIP42C 65p
TIP54 160p
TIP120 75p
TIP121 75p
TIP122 80p
TIP125 75p
TIP126 80p
TIP142 120p
TIP147 120p
TIP2955 78p
TIP4055 70p
TIS93 30p
VN10KM 50p
VN66AF 90p
VN88AF £1
ZTX108 12p
ZTX300 13p
ZTX452 45p
ZTX500 15p
ZTX502 16p
ZTX504 18p
ZTX552 55p
ZTX652 60p
ZTX752 70p
2N697 25p
2N698 45p
2N706A 30p
2N708 30p
2N918 45p
2N930 18p
2N1131/2 36p
2N1613 25p
2N1711 25p
2N2102 70p
2N2160 350p
2N2219A 25p
2N2222A 25p
2N2369A 17p
2N2484 25p
2N2646 40p
2N2904/5 25p
2N2906A 25p
2N2907A 25p
2N2926 9p
2N3053 30p
2N3054 55p
2N3055 50p
2N3442 140p
2N3553 240p
2N3584 250p
2N3643/4 48p
2N3702/3 10p
2N3704/5 10p
2N3706/7 10p
2N3708 10p
2N3773 200p
2N3819 30p
2N3823 30p
2N3866 90p
2N3902 700p
2N3904 15p
2N3906 15p
2N4036 65p
2N4037 65p
2N4123/4 27p
2N4125/6 27p
2N4401/3 25p
2N4427 90p
2N4871 50p
2N5087 27p
2N5089 27p
2N5172 27p
2N5191 90p
2N5245 40p
2N5401 60p
2N5459 30p
2N5460 60p
2N5485 36p
2N5875 250p
2N6027 30p
2N6052 300p
2N6059 325p
2N6107 65p
2N6247 190p
2N6254 130p
2N6290 65p
2SC1306 100p
2SC1307 150p
2SC1957 90p
2SC1969 150p
2SC2028 80p
2SC2029 200p
2SC2078 160p
2SC2335 200p
2SC2612 200p
3N128 120p
3N140 120p
3N141 110p
3N201 110p
3N204 200p
40290 250p
40361/2 75p
40595 120p
40673 75p
40871/2 100p

DIODES

BY127 12p
BYX36300 20p
OA47 10p
OA90/91 9p
OA95 9p
OA200 9p
OA202 10p
1N914 4p
1N916 7p
1N4148 4p
1N4001/2 5p
1N4003/4 6p
1N4005 6p
1N4006/7 7p
1N5401/2 12p
1N5403/4 14p
1N5404/5 14p
1N5404/7 19p
IS920 9p

BRIDGE RECTIFIERS

1A 50V 19p
1A 100V 20p
1A 400V 25p
1A 600V 30p
2A 50V 30p
2A 100V 35p
2A 400V 45p
3A 200V 60p
3A 600V 72p
4A 100V 95p
4A 400V 100p
6A 50V 80p
6A 100V 100p
6A 400V 120p
10A 400V 200p
25A 400V 400p

TRIACS PLASTIC

3A 400V 60p
6A 400V 70p
6A 500V 88p
8A 400V 75p
8A 500V 95p
12A 400V 85p
12A 500V 105p
16A 400V 110p
16A 500V 130p
T2800D 130p
TIC 206D 60p
TIC 226D 75p
TIC 246D 110p

THYRISTORS

3A 400V 45p
8A 600V 180p
12A 400V 160p
16A 100V 180p
16A 400V 220p
C106D 45p
MCR101 36p
2N3525 130p
2N4444 180p
2N5060 30p
2N5061 32p
2N5064 35p

PCB MOUNTING RELAYS

6 or 12V DC Coil SPDT 2A 24V DC 160p
6 or 12V DC Coil DPDT 5A 240V AC 200p
6 or 12V DC Coil SPDT 10A 24V DC 240V AC 225p

2.7V-33V 400mW 9p
1W 15p

COMPUTER COMPONENTS

CPUs

1802CE 650p
2650A £12
6502 350p
6502A 500p
6800 225p
6802 250p
6809 650p
68B09 £12
6809E £9
68B09E £16
6800L8 £48
68705P3 £26
8035 350p
8039 300p
8080A 250p
8085A 350p
8086 £22
8088 £18
8748 £18
INS8060 £11
TMS1601 £12
TMS9980 £20
TMS9995 £12
Z8 £24
Z80 250p
Z80A 300p
Z80B £11

SUPPORT DEVICES

2651 £12
3242 800p
3245 450p
6520 280p
6522 310p
6522A 550p
6532 550p
6551 650p
6821 100p
68B21 220p
6829 £12.50
6840 375p
68B40 600p
6850 110p
68B50 220p
6852 250p
6854 700p
68B54 800p
6875 570p
8154 950p
8155 350p
8156 350p
8205 225p
8212 110p
8216 100p
8224 110p
8226 250p
8228 270p
8243 280p
8250 1150p
8251 300p
8253 390p
8255 300p
8256 £36
8257 400p
8259 400p
8279 440p
8284 350p
8288 £11
8755 £16
9901 £3
9902 £3
TMS4500 £14
TMS9911 £16
Z80P10 250p
Z80AP10 280p
Z80CTC 250p
Z80ACTC 280p
Z80ADART £7
Z80ADMA £9
Z80SI 0/1/2 £9

MEMORIES

2102-3L 120p
2111A 300p
2112A 300p
2114-2L 100p
2147 450p
4027-3 300p
4116-15 120p
4116-20 90p
4118-3 450p
4164-2 450p
4164-15 500p
4416-15 500p
4532-20 250p
4816AP-3 300p
5101 300p
5516 750p
6116-3 420p
6116LP-3 550p
6264-15 £35
6514-45 200p
6810 120p
74S189 150p
74S201 350p
74S289 150p
93415 600p
93425 600p
93L422 950p
X2210 TBA

ROMs/PROMs

74S188 140p
74S287 200p
74S288 140p
74S387 225p
74S473 475p

EPROMs

2532 350p
2532-30 700p
2564 600p
2708 300p
2716 250p
2732 350p
2732A £7
2732A-35 450p
2764-25 500p
27128-25 £18
27128-30 £15

CRT CONTROLLER

CRT6545 900p
CRT5027 £18
CRT5037 £18
EF9365 £36
EF9366 £36
MC6845 650p
MC6845SP £9
MC6847 650p
P8275 £27
SFF96364 £8
TMS9918 £60
TMS9927 £18
TMS9928 £20
TMS9929 £16

INTERFACE ICs

AD558CJ 775p
AD561J £20
AM25S10 350p
AM25LS2521 200p
AM26LS31 125p
AM26LS32 125p
D7002 390p
DAC80 £28
DM8131 275p
DP8304 250p
DS3691 350p
DS8830 150p
DS8831 140p
DS8832 250p
DS8833 225p
DS8836 150p
DS8838 225p
DS8880 170p
LF13201 450p
MC1488 55p
MC1489 55p
MC3418 950p
MC3446 250p
MC3459 450p
MC3470 650p
MC3480 850p
MC3486 500p
MC3487 300p
MC4024 325p
MC4044 325p
MC14412 750p
75107 90p
75110/12 160p
75114/15 160p
75121/22 140p
75150P 120p
75154 140p
75159 220p
75365 150p
75451/2 72p
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2.45760(L) 210p
2.45760(S) 275p
2.5 250p
2.662 250p
3.276 150p
3.5795 120p
4.0 150p
4.194 200p
4.43 125p
4.608 250p
4.9152 250p
5.0 175p
6.0 150p
6.144 175p
7.0 150p
7.168 175p
8.0 175p
8.867 175p
10.0 175p
10.50 250p
10.70 200p
11.0 300p
12.0 150p
14.0 175p
14.318 175p
14.756 250p
15.0 200p
16.0 200p
18.0 200p
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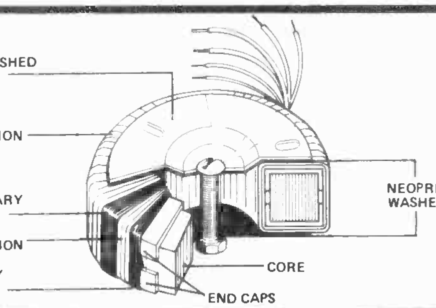

15 VA
62 x 34mm 0.35Kg
Regulation 19%

SERIES No	SECONDARY Volts	RMS Current
0x010	6+6	1 25
0x011	9+9	0 83
0x012	12+12	0 63
0x013	15+15	0 50
0x014	18+18	0 42
0x015	22+22	0 34
0x016	25+25	0 30
0x017	30+30	0 25

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30 VA
70 x 30mm 0 45Kg
Regulation 18%

1x010	6+6	2 50
1x011	9+9	1 66
1x012	12+12	1 25
1x013	15+15	1 00
1x014	18+18	0 83
1x015	22+22	0 68
1x016	25+25	0 60
1x017	30+30	0 50

50 VA
80 x 35mm 0.9Kg
Regulation 13%

2x010	6+6	4 16
2x011	9+9	2 77
2x012	12+12	2 08
2x013	15+15	1 66
2x014	18+18	1 38
2x015	22+22	1 13
2x016	25+25	1 00
2x017	30+30	0 83
2x028	110	0 45
2x029	220	0 22
2x030	240	0 20

80 VA
90 x 30mm 1Kg
Regulation 12%

3x010	6+6	6 64
3x011	9+9	4 44
3x012	12+12	3 33
3x013	15+15	2 66
3x014	18+18	2 22
3x015	22+22	1 81
3x016	25+25	1 60
3x017	30+30	1 33
3x028	110	0 72
3x029	220	0 36
3x030	240	0 33

120 VA
90 x 40mm 1.2Kg
Regulation 11%

4x010	6+6	10 00
4x011	9+9	6 66
4x012	12+12	5 00
4x013	15+15	4 00
4x014	18+18	3 33
4x015	22+22	2 72
4x016	25+25	2 40
4x017	30+30	2 00
4x018	35+35	1 71
4x028	110	1 09
4x029	220	0 54
4x030	240	0 50

160 VA
110 x 40mm 1.8Kg
Regulation 8%

5x011	9+9	8 89
5x012	12+12	6 66
5x013	15+15	5 33
5x014	18+18	4 44
5x015	22+22	3 63
5x016	25+25	3 20
5x017	30+30	2 66
5x018	35+35	2 28
5x026	40+40	2 00
5x028	110	1 45
5x029	220	0 72
5x030	240	0 66

225 VA
110 x 45mm 2.2Kg
Regulation 7%

6x012	12+12	9 38
6x013	15+15	7 50
6x014	18+18	6 25
6x015	22+22	5 11
6x016	25+25	4 50
6x017	30+30	3 75
6x018	35+35	3 21
6x026	40+40	2 81
6x025	45+45	2 50
6x033	50+50	2 25
6x028	110	2 04
6x029	220	1 02
6x030	240	0 93

300 VA
110 x 50mm 2.6Kg
Regulation 6%

7x013	15+15	10 00
7x014	18+18	8 33
7x015	22+22	6 82
7x016	25+25	6 00
7x017	30+30	5 00
7x018	35+35	4 28
7x026	40+40	3 75
7x025	45+45	3 33
7x033	50+50	3 00
7x028	110	2 72
7x029	220	1 36
7x030	240	1 25

500 VA
140 x 60mm 4Kg
Regulation 4%

8x016	25+25	10 00
8x017	30+30	8 33
8x018	35+35	7 14
8x026	40+40	6 25
8x025	45+45	5 55
8x033	50+50	5 00
8x042	55+55	4 54
8x028	110	4 54
8x029	220	2 27
8x030	240	2 08

625 VA
140 x 75mm 5Kg
Regulation 4%

9x017	30+30	10 41
9x018	35+35	8 92
9x026	40+40	7 81
9x025	45+45	6 94
9x033	50+50	6 25
9x042	55+55	5 68
9x028	110	5 68
9x029	220	2 84
9x030	240	2 60

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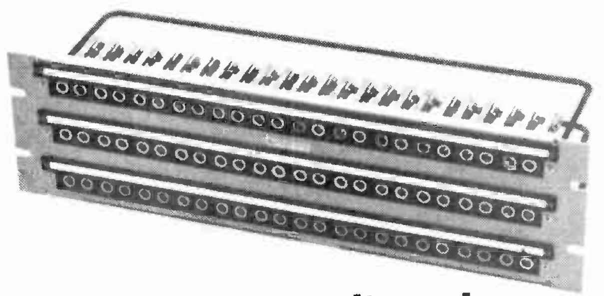

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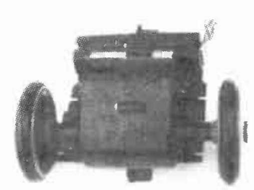

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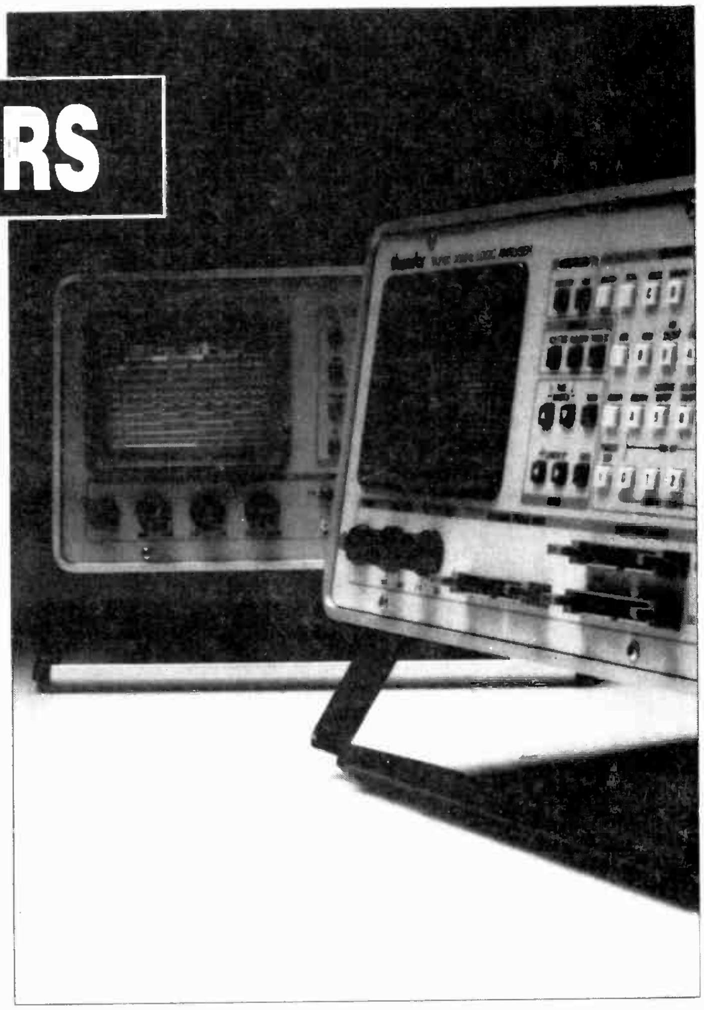

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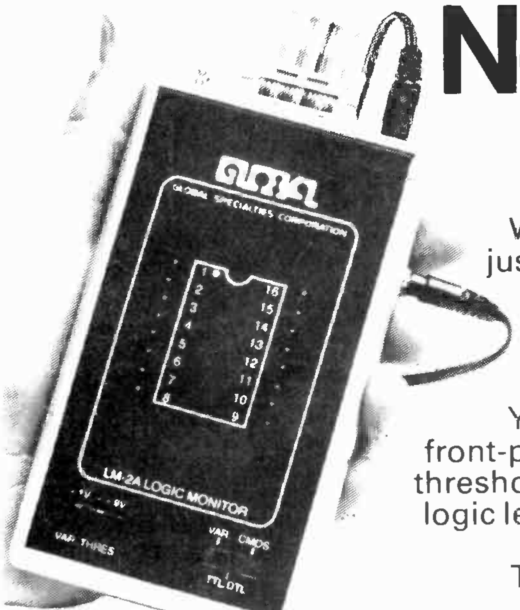

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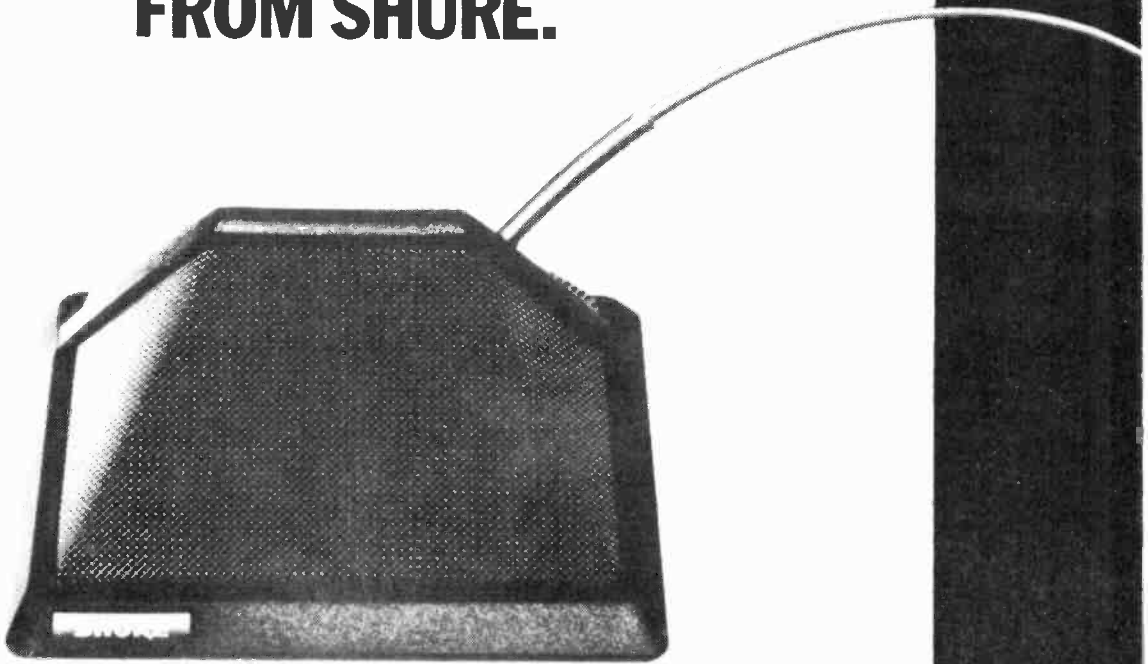

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Freedom – or licence?

To speak of culture is to brand oneself a poseur, a pretending aesthete, an unwordly, impractical bore. "When I hear anyone speak of Culture", Goering is said to have remarked, "I reach for my revolver". His other activities make it seem unlikely that he was impelled to deliver this thought by considerations of market potential, but nevertheless it seems to be in tune with the outlook of producers of software for the millions of stored-programme video display devices that nightly hypnotise a large part of the population.

In an ideal world, the 'freeing' of television programmes from the autocracy of established broadcasting organizations would be a step in the right direction. Why, it may be asked, should the viewing public be constrained by the views of three or four broadcasting authorities, when it can use a video recorder/player to display any one of thousands of programmes, and even make its own?

The world is, however, far from ideal. Freedom is always to be sought assiduously, but when it turns to licence, controls may be required as a regulator.

Engineering applied to domestic 'information systems' has an enormous capability – to inform, to entertain, to instruct and educate – the application of just one form, the v.c.r., being limited only by man's small imagination. People's breadth of view and understanding of others' problems and aspirations could be vastly enhanced by a proper choice of software. Freedom from the shackles of broadcast television as it currently exists could open wide the accumulated knowledge and wisdom of the world.

And what do we find? A wealth of material, certainly. But into which category of mental stimulation should one place an instructional film on ventilating the frontal lobe of the brain by means of a Black and Decker, or some such? Or, indeed, anyone of the cosy little stories designed to encourage the more flamboyant tendencies in the human psyche? The proliferation of such atavistic products of diseased minds is one, regrettable, result of 'freedom'.

The promise of dozens of extra channels of broadcast television by satellite and cable does not do much to encourage hope for the future, either, if the American scene is taken as an example.

Demoralising as it may be, it seems true to say that alternative viewing – that not originated by BBC or IBA – comes nowhere near exploiting the promise of the word 'freedom'. The IBA has to keep market forces well in mind, more so than the BBC, but there are overriding constraints on both organizations of public decency and overall quality. BBC and IBA have unparalleled reputations in both engineering and programme making. With the awful example of video tapes before us, it hardly seems sensible to allow optical, satellite or cable television to flout the laws governing broadcast television simply because they employ different media to carry the signal or because satellite is not, strictly speaking, broadcast. The dissemination of any kind of information to the public should not be solely a money-making venture.

Hearing and seeing

Engineers would find it easier to optimize high-fidelity sound systems and high-definition television if only they knew more about human hearing and seeing. It has, for instance, been said of the human auditory system that "The ear presents some of the most disputed problems of human physiology. Regarded purely technically the ear is of comparatively simple construction, so that one might hold the view that an accurate examination would immediately expose the purpose and function of each individual constituent part. Exactly the opposite is the case, and all theories are still full of contradictions."

In particular, the ability of many people to distinguish very small differences in pitch and the ability to locate the direction of sound from extremely small time differentials cannot be explained by the conventional theories. Similarly, the human visual system can detect vernier misalignments with an extraordinary accuracy that cannot be accounted for by simple optical or anatomical considerations – the so-called hyperacuity.

A controversial new theory of hearing has been advanced by Hugo Zuccarelli (*New Scientist*, November 10, 1983) who claims to have developed an electronic recording system that produces spatial effects in a monaural channel. He argues that the ear does not simply and passively receive sound. It also generates a sound wave that interacts with external sound to produce an acoustic hologram or interference pattern. As evidence in support of his theory he notes that several people have succeeded in recording continuous sound at about 1-2kHz emitted in the ears of individuals. Just as each piece of an optical hologram produced by coherent light contains the information for a solid image, so, he argues, the acoustic hologram developed in each ear provides full directional information. No details of his recording system have so far been released.

The question of whether conventional "stereo" is really necessary was raised also by Yoshimutsu Hirata in the October 1983 issue of *Wireless World* (pages 60-63) where he showed how ambience can be added to the mono sound transmitted by a.m. radio and television stations. Ever since the pioneer work by Alan Blumlein, engineers have been struggling to reproduce spatial effects without really being sure how the ear/brain system really works!

Current work on digital sound and vision seeks to overcome fidelity problems by transmission at very high data rates, even though human sensors are relatively slow acting devices. Sony, however, have managed to pack four digital stereo audio channels into a 6MHz channel for use with multichannel cable tv systems, basically using the Compact Disc format. Four hi-fi stereo channels, with 8 bits of synchronization and 4 service bits form a 168-bit word with a sampling rate of 44.1kHz and a data rate of about 7.4 Mbit/s.

Millimetric rain scatter

The effects of rain-scatter at frequencies between about 10 to 20GHz are well documented. Scatter signals can, for example, result in much interference to terrestrial microwave systems from the high-power up-link satellite communications terminals. Heavy rain can also be used by amateur 10GHz-band enthusiasts to provide extended range contacts from locations shielded by hills. But millimetric signals, although scattered by rain drops, are themselves severely attenuated by rain, with the result that rain-scatter effects tend to be far less evident.

A Japanese rain-scatter experiment in the millimetric range (34.8GHz) has been described by Jun Awaka, Kenji Makamura and Hideyuri Inomata in *IEEE Trans. Ant. & Prop.*, vol. AP31 no. 5, September 1983. Using 10-watt c.w. transmitter power with 10-metre dish aerials roughly 45km apart, it was shown that for a small percentage of time relatively strong signals could be received as a result of rain scattering. However for this to happen there has to be an isolated region of heavy rainfall at the scatter point but with no rain over most of the path. During the field test such conditions were infrequent.

Drive by data

Many schemes for providing traffic and vehicle-navigation information have been proposed but have floundered because of cost or lack of radio frequencies or both. However a new "Autoscout" system, developed by Siemens and Volkswagen, is currently undergoing road tests in Wolfsburg, Federal Germany. An on-board microprocessor control unit, plus magnetic field sensor, provides a form of inertial navigation, displaying both direction and bearing of the keyed-in destination on an l.c. display. However, information on local routes, detours etc are provided from beacon units mounted on traffic lights. Cost is kept low and spectrum problems overcome by the use of low-cost infra-red beacon transmitters. These continuously emit data on the main roads in the area. The vehicle control unit selects only data applicable to the destination the driver has keyed into his unit. It is claimed that Autoscout could even direct drivers to a specific building, garage or parking space.

If the idea catches on, quantity production could bring vehicle unit costs down to that of a good car radio, with correspondingly low costs for equipping traffic lights with infra-red beacons, it is claimed.

The Merriman Report appears to have removed any incentive for mobile two-way radio to switch to pilot-carrier s.s.b. in 5kHz channels. Yet J.P. McGeehan and A. J. Bateman of Bath University remain convinced that their system of feed-forward signal regeneration could overcome the severe multipath propagation effects shown up in the field trials a few years ago. They consider that the potential advantages of mobile s.s.b. on frequencies up to 1GHz should continue to be investigated. Their f.f.s.r. circuitry could be integrated on a single chip, using current large-scale integration techniques, as simple add-on circuitry to pilot s.s.b. systems.

Exit Radio Officers?

For some time, Inmarsat, the organization set up to provide satellite communication with the world's shipping, has believed that emergency position-indicating radio beacons carried on ships, lifeboats and fitted on buoys designed to float free from sinking ships, will form an integral part of a future global maritime distress and safety system. In the 1990s Morse radiotelegraphy will be replaced, Inmarsat believe, by a combination of satellite and terrestrial telephone and data communications. All countries are expected to make mandatory the carrying of low-power distress beacons. Ships equipped with satellite communication systems are already permitted in some countries to use their facilities in harbours and territorial waters, forbidden on h.f. and m.f.

Shuttle success

The in-flight 144MHz transmissions by Dr Owen Garriott, W5LFL, during a number of orbits of the Columbia space shuttle during the STS-9 mission certainly attracted world-wide publicity for the hobby. Even if the technical value of the experiment, using a low-power handheld transceiver, was questionable, it did mean that many more amateurs became interested in the calculation of orbital data, tracking and mixed polarization, etc. It also underlined how much terrestrial v.h.f. ranges are restricted by the curvature of the earth and local obstructions, with signals receivable during 8-minute windows from the 250km high spacecraft. Unlike for the Oscar satellites, standard 144MHz transceivers were all that was needed.

Dr Garriott also came up on a number of unscheduled occasions despite experiencing difficulties with his lightweight headset in high ambient noise. He recorded most incoming signals on tape, but succeeded in two-way contacts with a number of amateur stations including that of King Hussein, JY1.

Impressive also was the role of the

COMMENTARY

national societies, including RSGB, in providing their members with up-to-date information on the flight. Far less impressive, and of serious concern, was the amount of unnecessary interference, some deliberate, some caused by sheer bad operating.

AMATEUR RADIO

Grenada and Spratly

Similar publicity, but in more contentious circumstances, surrounded the activities of KA20RK/J37, an amateur station operated by Americans on Grenada during the invasion of the island by American and East Caribbean forces.

The US State Department waived limitations on third-party traffic and many of the transmissions from this only radio link with Grenada were used on tv and radio stations. The American government stated that it was "well pleased" with the role played by radio amateurs in keeping open this news channel, and providing information as to the safety of the American medical students and their families.

But from this side of the Atlantic the situation could be seen quite differently, opening up the risk of putting the whole question of reciprocal licensing and the licensing of foreign nationals into jeopardy. It is one thing to provide emergency communications during a natural disaster such as an earthquake or hurricane, but the events on Grenada can hardly be regarded in this light. It differs also from the use made of amateur radio in 1982 in the Falkland Islands on behalf of the government responsible for the issue of the licences!

The sensitivity of the Third World countries to anything remotely resembling "covert" amateur activities is well established but often overlooked by Americans and Europeans. The disaster, resulting in the loss of two lives, that overtook the 1983 German DX-pedition to the Spratly Islands (*WW*, July 1983, page 23) when the Siddartha was sunk by Vietnamese gunfire had overtones that were not widely reported at the time.

According to a lengthy report headed "Hide and seek spy" in *The Strait Times* of Singapore, one of the German survivors, Baldur Drobnica, was an official of the West German "Office for the Protection of the Constitution", a secret counter-intelligence organization. Although there is no reason to doubt that he was on holiday at the time, it led inevitably to suggestions that the expedition might not have been so innocent as it appeared and that, in any case, any expedition to these disputed islands unwisely courted disaster.

Those resident in the Far East point out that, to an extent not appreciated in the West, national security is there a highly sensitive issue. Any suggestion of amateur transmitters being involved in political or covert activities makes the position of licensed amateurs, particularly if not nationals of the country concerned, much more difficult. They urge that when planning such expeditions the greatest care should be taken not to bring upon the hobby such unfortunate publicity and unnecessary loss of life.

10.1MHz and s.s.b.

Last September I reported the mounting problems of international "planning" of the use of the amateur bands and questioned the extent to which the International Amateur Radio Union is justified in assuming a "regulatory role" without becoming more accountable to the wishes of a clear majority of radio amateurs. An example of IARU pressure on national societies had arisen in respect of the then use of s.s.b. by South Africans in the 10.1MHz band.

Dave Perry, ZS1SG, bandplanner for S.A.R.L., has written to point out that although the society approved s.s.b. operation on the band in 1982 this was changed at the 1983 a.g.m. and members are now advised to adhere to the IARU recommendations.

Nevertheless, he points out, many South African amateurs remain concerned about the validity of IARU's reasoning and initial assessment. SARL are to raise this subject at the 1984 IARU Region 1 conference.

South Africa is the only country in Region 1 south of the Mediterranean area with appreciable activity. The distances involved means that 10.1MHz is not being used for telegraphy during daytime, since the relatively small number of c.w. enthusiasts are usually not interested in working stations in their own country. Yet the band would be excellent for internal working on s.s.b., especially for mobile operation over distances up to 2000km.

SARL now finds it difficult to justify to its members the IARU's ban. In Europe circumstances are very different yet even those of us who are c.w. enthusiasts suspect that complete banning of s.s.b. on 10.1MHz, at all times of the day and night, is difficult to justify on a world-wide basis.

Cable and MDS

American amateurs continue to complain about the interference problems caused by signal leakage into and out of multichannel cable tv systems that often distribute some programmes in the 144MHz band or within or close to other amateur frequencies. The cable people, on the other hand, claim that there is no problem with correctly-installed well-maintained systems and tend to put at least some of the blame on to the significant number of viewers (including amateur radio enthusiasts) who run 300-ohm twin cable close to the coaxial cables in order to receive subscription channels without payment. Even where the tv programmes are encrypted or scrambled this is often of an unsophisticated type that enables those with technical knowledge to descramble the signals. The "pirate" coupling wires, it is claimed, are one of the main causes of leakage problems, with signals radiated from the twin wire.

Rather similar disputes have arisen from those increasingly used multichannel microwave distribution systems (MDS) in which the high-power omnidirectional microwave transmitters at about 2.15 GHz are used to send programmes, often initially carried over distribution satellites, to homes. In some locations MDS has considerable economic advantages over cable.

The MDS operators are convinced that many of their subscription channels are being pirated and in a recent lawsuit named 40 radio amateurs as being among some 3000 "pirate" viewers, on the evidence that they had 2GHz aerials on their roofs. The cases have now been dropped after most of the amateurs named had signed as affidavit that they had not used the aerials to receive Home Box Office subscription channels, and pointing out that the MDS frequencies are close to the 2.3 to 2.45GHz amateur band. But it is clear that the bad feeling between American radio amateurs and the cable and MDS oeprators has not yet ended.

I understand that interest is being shown in the UK in microwave distribution systems although these do not have any of the interactive facilities advocated in the Cable and Broadcasting Bill.

In brief

The 23-cm beacon, GB3WX, that incorporates weather telemetry, is now back in service . . . A number of earth-moon-earth tests are being organized on the 2.3GHz band where it is possible that some moon-bounced signals could be heard on dishes of only 4ft diameter. . . . The Bury Radio Society has a Ham Feast at Mosses Community Centre, Cecil Street, Bury, Lancs on February 5 . . . RSGB National VHF convention is at Sandown Park Racecourse, Esher, Surrey on March 24. . . . RSGB National Amateur Radio Exhibition is at the National Exhibition Centre, Birmingham on April 28-29.

PAT HAWKER, G3VA

IEEE488 interface for the BBC Microcomputer

The BBC Microcomputer lacked a GPIB (IEEE488) interface – until Intelligent Interfaces designed this one for Acorn.

by Andrew G. Ray

Many features of the BBC Microcomputer make it eminently suitable for use in the research and development laboratories of educational and industrial establishments. These include its fast structured Basic interpreter, high resolution colour graphics and a number of input/output interfaces for connecting peripheral equipment. However, it did lack an IEEE488 interface, an omission now rectified by Acorn Computers. This article includes a short introduction to the IEEE488 standard* and describes the hardware and software design of the interface.

The IEEE488 (GPIB) interface has been adbpted by major instrument manufacturers throughout the world as a means of connecting instruments such as digital voltmeters and spectrum analysers to one another and to a controlling computer to form automatic test equipment systems. A number of computer and peripheral equipment manufacturers have used the interface to connect computers to disc units, graphics plotters and so on.

The IEEE488 standard specifies a system for exchanging digital data in bit-parallel, byte-serial form at up to 1Mbytes between a number of devices in a local area. The interface makes use of two types of messages: interface messages used to manage the interface (commands) and device-dependent messages (data).

Up to 15 devices, including the controlling computer, can be connected using IEEE488 standard cable assemblies. These have a plug and socket at each end permitting star or linear interconnection of devices. The connectors are provided with two securing screws which allow them to be stacked on the socket of each device. The standard permits individual cable lengths of up to 4m and a total cable length in a system of 2m per device or 20m, whichever is the shorter. The cable consists of eight data lines, three handshake lines and five control and management lines. The three handshake lines are used to transfer data between devices; the slowest device determines the rate at which this occurs.

Each device in an IEEE488 system must have a unique address. Some devices have only one address (a primary address) whilst others have extended addressing (both primary and secondary addresses). Secondary addresses are often used to select different functions within the same device: for example an analogue-to-digital converter with a number of inputs may have the input selected by the secondary address.

A device can have the ability to send data (act as a talker), receive data (act as a listener) or do both (act as a talker-listener), or manage the system (act as a controller). Only one device in a system can act as system controller. This is the device which has the control function when the system is initialized.

In my experience, the use of even a fairly simple IEEE488 system transforms research and development work. Apart from the obvious advantage of speed, performing a test automatically has other advantages:

- repeatability, as the test is defined by the program running on the controlling computer
- fast analysis, as the computer can rapidly compare the results of different tests
- faster development, as the results of a test are almost instantly available.

The third advantage means that decisions in the course of development are based on facts rather than speculation and enable further tests to be planned in an informed fashion.

Complex IEEE488 systems, working at high data transfer rates, usually employ a minicomputer as controller. However, most systems consist of one or two instruments connected to a microcomputer and this offers an extremely cost-effective automatic test system.

The overall objectives in the design of the Acorn interface were to allow it to act as system controller and operate as controller, controller-talker and controller-listener with the ability to pass control to another device on the bus and request it back. Additionally, the interface was required to be easily used from any language running on the computer or a second processor.

Hardware

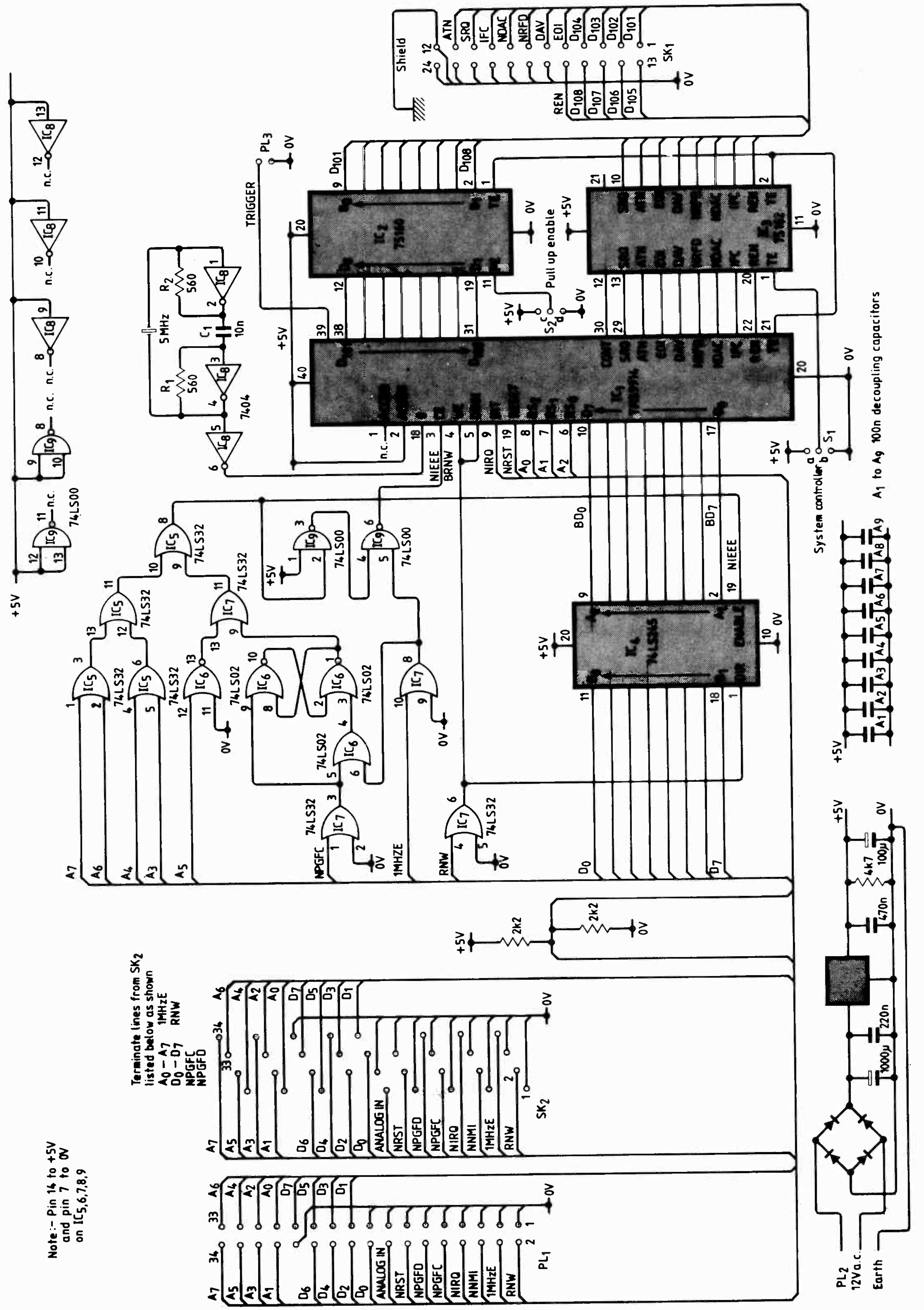
Two approaches to the hardware design were considered: the use of peripheral interface adaptors (p.i.a.) with t.t.l. open collector drivers and terminating resistors; or else the use of an l.s.i. general-purpose interface bus adaptor (g.p.i.a.) with IEEE488 bus transceivers.

The first requires all interface functions, such as source and acceptor handshakes, to be implemented in software. This imposes an unacceptable burden upon the processor and significantly reduces total system performance. In the second approach the g.p.i.a implements most interface functions, interrupting the processor only when action is required.

The 6502 microprocessor of the BBC Microcomputer has many tasks and makes extensive use of interrupts, and so the second approach was chosen. As the controller function was to be implemented, this restricted the choice of l.s.i GPIB adaptors. It soon became apparent that the Texas Instruments TMS9914A was the most suitable in that it was the most easily interfaced to the 6502 microprocessor and, together with the Texas SN75160A and SN75162A octal GPIB transceivers, resulted in a compact circuit board layout.

Connection to the 1MHz bus of the computer is via a 34-way ribbon cable. A 34-way header provides a feed-through connection to further 1MHz bus peripherals. Resistor packs provide optional 2.2kΩ pull-up and 2.2kΩ pull-down terminations for the 1MHz bus. All 1MHz bus lines are buffered. A clean NPGFC select signal is produced by an RS flip-flop formed by three gates on IC_6. Address decoding is performed by gates of $IC_{5, 6, 7}$. The read and write registers of IC_1 are located in page &FC between &FC20 and &FC27. Two gates of IC_9 are used to produce a chip-enable signal, qualified by

* The 488 general-purpose interface bus standard, which is identical with IEC625-1 apart from connectors, was described by P. R. Ellefson in 'IEEE bus standard' *Wireless World* June/July 1980 pages 75-8.


Note:- Pin 14 to +5V and pin 7 to 0V on IC5,6,7,8,9
Terminate lines from SK2 listed below as shown
A0 – A7 1MHzE
D0 – D7 RNW
NPGFC
NPGFD
Shield
SK1
SK2
PL1
PL2
12V a.c.
Earth
PL3
TRIGGER
Pull up enable
System controller
S1
A1 to A9 100n decoupling capacitors
5MHz
74LS00
74LS32
74LS02
7404
ANALOG IN
NRST
NPGFD
NPGFC
NIRQ
NNMI
1MHzE
RNW
ATN
SRQ
IFC
NDAC
NRFD
DAV
EOI
REN
NIEEE
BRNW

the buffered 1MHzE signal. This ensures the correct timing relationship between the processor and the TMS9914A. Note that both register select and data lines of IC_1 are designated using the Texas Instruments convention. This is opposite to that used for 6502-based systems, such as the BBC Microcomputer.

The crystal and IC_8 generate a 5MHz clock for IC_1. Trigger output from IC_1 is available at PL_3; however, this is not fitted in the standard interface. Link 1 determines whether the interface is system controller and link 2 determines whether the outputs of IC_2 are open-collector or three-state.

Software

To enable ease of use with any high level language and permit parameters to be passed as variables, the IEEE488 software was designed to appear to the BBC Microcomputer operating system as an additional filing system. The IEEEFS is selected by *IEEE, in the same way as other filing systems.

Communication between a language and the interface is via two channels. The first is the command channel used for transmitting IEEEFS commands and receiving information on the state of the interface. The second is the data channel used for reading and writing data to other 488 devices. IEEE commands are sent to the IEEEFS by PRINT# via the command channel. Data is sent to and received from other devices by PRINT# and INPUT#via the data channel. These channels must be OPENed before use.

The table lists the commands available. Full simple English syntax produces easily readable programs. However, the use of upper and lower case together with minimum abbreviations eg L. for LISTEN, makes rapid entry of programs possible. The experienced user of IEEE488 systems will appreciate the functions of most commands but the following facilities are worthy of note.

The state of the interface is available through the STATUS command which returns a 32-bit status word. For example, this can indicate whether the computer is controller in charge, or if another device is requesting service, whether a source handshake or timeout error has occurred, etc.

Although it is not part of the standard, an optional timeout after 2.5 seconds is provided to avoid waiting interminably for a device which never responds.

Data can be sent and received as strings of up to 255 characters or, through the use of the READ and WRITE BINARY commands, as longer sequences of binary-coded data.

The standard does not specify a particular delimiting character for strings. The END OF STRING command enables the default delimiter of linefeed to be redefined as either one or two characters.

The TRANSFER command permits the computer to carry out some other task while a talker sends data to a listener or listeners on the bus. The end of this sequence is indicated in the status word.

IEEE commands together with their minimum abbreviations

BBC DEVICE NO	B.
CLEAR	C.
DEVICE CLEAR	D.
END OF STRING	E.
EXECUTE	E.
GO TO LOCAL	G.
LISTEN	L.
LOCAL LOCKOUT	LO.
PARALLEL POLL DISABLE	PARALLEL POLL D.
PARALLEL POLL ENABLE	PARALLEL POLL E.
PARALLEL POLL REQUEST	P.
PARALLEL POLL UNCONF'GURE	PARALLEL POLL U.
READ BINARY	R.
REMOTE DISABLE	REMOTE D.
REMOTE ENABLE	REM.
REQUEST CONTROL	REQ.
SELECTED DEVICE CLEAR	SEL.
SERIAL POLL	SE.
STATUS	S.
TAKE CONTROL	TAK.
TALK	T.
TIMEOUT OFF	TIMEOUT OFF
TIMEOUT ON	TI.
TRANSFER	TR.
TRIGGER	TRI.
UNLISTEN	UNL.
UNTALK	U.
WRITE BINARY	W.

Commands are available that allow both serial and parallel polls to be conducted. All addressed and universal commands specified in the IEEE488 standard can be sent, e.g. GO TO LOCAL, LOCAL LOCKOUT etc.

The TAKE CONTROL and REQUEST CONTROL commands enable control to be passed to another device and requested back.

Example

The following example program in BBC Basic might be used for obtaining the frequency response of an amplifier. An input signal is provided by a programmable signal generator and the output signal is measured with a digital voltmeter.

In the example, lines 10 and 20 select the disc filing system and open a file for storing the results of the test. Lines 30, 40 and 50 select the IEEEFS and open the command and data channels.

Line 60 is used to specify the primary address of the computer. This can be any primary address not used by an instrument in the system.

Line 70 returns the IEEE488 system to a known state; line 80 enables the remote operation of the devices in the system; and lines 90 and 100 pass the primary addresses of the signal generator and digital voltmeter to the IEEEFS.

Line 120 commands the signal generator to listen and line 130 sets its signal amplitude and frequency. Line 140 commands

```
10 *DISC
20 result%=OPENOUT("RESULTS")
30 *IEEE
40 cmd%=OPENIN("COMMAND")
50 data%=OPENIN("DATA")
60 PRINT#cmd%,"BBC DEVICE NUMBER",1
70 PRINT#cmd%,"CLEAR"
80 PRINT#cmd%,"REMOTE ENABLE"
90 siggen%=OPENIN("7")
100 dvm%=OPENIN("3")
110 FOR frequency%=1000 TO 10000 STEP 100
120   PRINT#cmd%,"LISTEN",siggen%,"EXECUTE"
130   PRINT#data%,"0.1V,"+STR$(frequency%)+"Hz"
140   PRINT#cmd%,"UNLISTEN"
150   PRINT#cmd%,"TALK",dvm%
160   INPUT#data%,reading$
170   PRINT#cmd%,"UNTALK"
180   response=20*LOG(VAL(reading$)/(0.1*0.7071))
190   *DISC
200   PRINT#result%,frequency%,response
210   *IEEE
220   NEXTfrequency%
230 CLOSE#dvm%
240 CLOSE#siggen
250 *DISC
260 CLOSE#result%
```

Microprocessor programming simplified

A new technique for transferring a program directly to machine-code language avoids the necessity of writing the program out in high-level or assembly language

by Gemal A. M. Labib

To write a new program it is often necessary or desirable to set up the sequences in the form of a flowchart. This may then be translated into a computer language, be it high-level, assembly or machine-code depending on the facilities available to the user. In all cases the process of translation can be tedious and time consuming. In order to speed up the process, a simple method is presented here to enable flowchart steps to be entered directly into the system by defining a number of key functions with symbols. It is no longer necessary to key in assembly mnemonics or even remember their exact abbreviations. The symbol sequences can be added to the flow chart and then keyed in.

The proposed symbolic forms of the instruction set are presented in Table 1. Although this particular set is for the Intel 8085 processor, it may be adapted quite easily for use on other processors. The blocks at the left of each instruction represent the keys used, in their correct order.

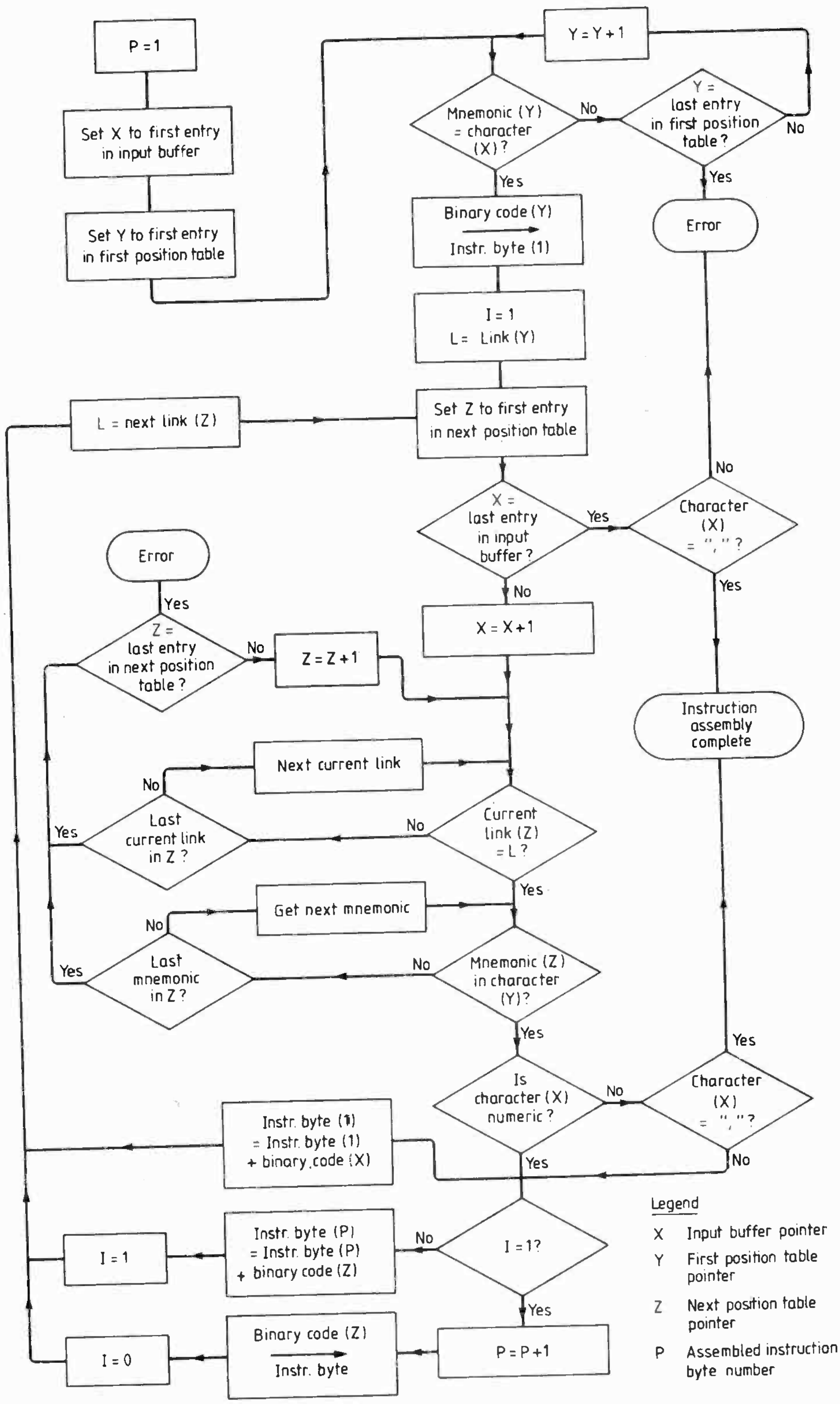
It can be seen that the number of keystrokes for each instruction is less than that required with the usual assemblers. There are few symbols and they are easy to remember. For example, the arrow keys, →, ←, are used for data transfer between registers, register pairs and memory as well as for jumps and return instructions. Similarly, the + and − signs are used for increment, decrement, add and subtract, as well as positive and negative condition flags. Although not shown in the table, every statement must end with a comma terminator.

The symbolic assignments of the keys are shown in Table 2. In order to minimize the number of keys required, two or three functions are assigned to most keys. Eight hexadecimal numeric keys are used as control keys for editing and program execution. The other keys are used to enter some instruction mnemonics and logic operators. 16 further keys are used for the other symbols shown in Table 1. The function of the eight control keys are as follows:

Stmnt start positions the cursor at the start of the current statement.

Clear deletes the statement at the cursor position.

Flowchart of the software that implements Tables 3 and 4.



Forward and **backward** position the cursor at the next or previous statement.
Delete and **insert** operate on individual keystrokes at the current cursor position.
Single step allows statements to be translated into machine-code and to be executed one at a time. Following the execution of a statement, control is returned to the operating system so that register and memory contents may be checked.
Run causes program statements to be transfered to a secondary buffer. They are translated into machine code as a whole, and the program executed.

A few notes may help to avoid syntax errors and simplify key entry. 1. Instructions dealing with register pairs should begin with the (rp) operand. 2. No statement should begin with a numerical operand or the Immediate marker. 3. The source and destination register, register pairs or memory operands may be reversed

Table 3: First position

Mnemonic	Binary coded hexadecimal	Next entry link
A	38	1
B	00	1
C	08	1
D	10	1
E	18	1
H	20	1
L	28	1
M	30	2
A	07	3
B	00	3
C	01	3
D	02	3
E	03	3
H	04	3
L	05	3
M	06	4
BC	00	5
DE	10	5
HL	20	5
SP	30	6
PSW	30	18
L	28	14
M	30	14
A	38	14
B	00	14
C	08	14
D	10	14
E	18	14
H	20	14

if the appropriate arrow symbol is included. 4. All instruction statements must be terminated by a comma.

The driving software that handles the machine-code translation operation of the entered statement is detailed in two tables. The data contained in the tables is specific to the 8085 processor but by following certain rules the software can be applied to a variety of processors.

Table 3, the first position table, contains three fields for each entry: the mnemonic field contains the ASCII codes for the symbols that may appear at the start of each statement; the binary code field contains the corresponding binary combination that will be transferred to the first byte of the assembled machine-code instruction; the next-entry link specifies the group of entries in Table 4 which are related to each symbol in Table 3. Table 4,

Table 1. Symbol sequences needed to produce the full instruction set. Variables r and rp represent registers or register pairs; d8 and d16 are single or double-byte constants.

Symbolic statement	8085 instruction mnemonic	Symbolic statement	8085 instruction mnemonic
r1 ← r2	MOV r1, r2	←	RET
r2 → r1		← C	RC
M ← r	MOV M, r	← nC	RNC
r → M		← Z	RZ
r ← M	MOV r, M	← nZ	RNZ
M → r		← +	RP
r ← I 0-F 0-F	MVI r, d8	← −	RM
M ← I 0-F 0-F	MVI M, d8	← even	RPE
rp ← I 0-F 0-F 0-F 0-F	LXI rp, d16	← odd	RPO
rp ← A	STAX rp	r +	INR r
rp → A	LDAX rp	r −	DCR r
A → 0-F 0-F 0-F 0-F 0-F	STA adr	M +	INR M
A ← 0-F 0-F 0-F 0-F 0-F	LDA adr	M −	DCR M
HL → 0-F 0-F 0-F 0-F 0-F	SHLD adr	rp +	INX rp
HL ← 0-F 0-F 0-F 0-F 0-F	LHLD adr	rp −	DCX rp
HL ← → DE	XCHG	+ r	ADD r
DE ← → HL		+ r C	ADC r
→ 0-F 0-F 0-F 0-F	JMP adr	+ M	ADD M
→ C 0-F 0-F 0-F 0-F	JC adr	+ M C	ADC M
→ nC 0-F 0-F 0-F 0-F	JNC adr	+ I 0-F 0-F	ADI d8
→ Z 0-F 0-F 0-F 0-F	JZ adr	+ I 0-F 0-F C	ACI d8
→ nZ 0-F 0-F 0-F 0-F	JNZ adr	rp + HL	DAD rp
→ + 0-F 0-F 0-F 0-F	JP adr	HL + rp	
→ − 0-F 0-F 0-F 0-F	JM adr	− r	SUB r
→ even 0-F 0-F 0-F 0-F	JPE adr	− r b	SBB r
→ odd 0-F 0-F 0-F 0-F	JPO adr	− M	SUB M
HL → PC	PCHL	− M b	SBB M
PC ← HL		− I 0-F 0-F	SUI d8
		− I 0-F 0-F b	SBI d8

Table 2: Key assignments

Original Key label	Assigned Label	Original Key label	Assigned label
0	CALL/NOP	K1	A/RSTO/PUSH
1	HLT/ROT	K2	B/RST1/POP
2	DAA/COMP	K3	C/RST2/Left
3	CMA/OR	K4	D/RST3/→
4	STC/EXOR	K5	E/RST4/←
5	CMC/AND	K6	H/RST5/Right
6	IN/RST	K7	L/RST6/C
7	OUT/INT	K8	M/RST7/nc
8	Stmnt Start	K9	HL/+
9	Clear	K10	BC/−
A	Delete	K11	DE/Z
B	Instert	K12	PC/nz
C	Forward	K13	PSW/even
D	Backward	K14	SP/odd
E	Single Step	K15	Stack Top/b/Immed.
F	RUN	K16	

Table 1. Symbol sequences needed to produce the full instruction set. Variables r and rp represent registers or register pairs; d8 and d16 are single or double-byte constants.

Symbolic statement	8085 instruction mnemonic	Symbolic statement	8085 instruction mnemonic
∧ r	ANA r	INT E	EI
⊙ r	XRA r	INT D	DI
V r	ORA r	INT M E	SIM
COMP r	CMP r	INT M D	RIM
∧ M	ANA M	NOP	NOP
⊙ M	XRA M	HLT	HLT
V M	ORA M	ROT L	RLC
COMP M	CMP M	ROT R	RRC
∧ I 0-F 0-F	ANI d8	ROT L C	RAL
⊙ I 0-F 0-F	XRI d8	ROT R C	RAR
V I 0-F 0-F	ORI d8	DAA	DAA
COMP I 0-F 0-F	CPI d8	CMA	CMA
rp PUSH	PUSH rp	STC	STC
rp POP	POP rp	CMC	CMC
HL ← → STK TOP	XTHL rp	CALL 0-F 0-F 0-F 0-F	CALL adr
STK TOP ← → HL		CALL C 0-F 0-F 0-F 0-F	CC adr
HL → SP	SPHL	CALL nC 0-F 0-F 0-F 0-F	CNC adr
SP ← HL		CALL Z 0-F 0-F 0-F 0-F	CZ adr
RST RST 0	RST 0	CALL nZ 0-F 0-F 0-F 0-F	CNZ adr
RST RST 1	RST 1	CALL + 0-F 0-F 0-F 0-F	CP adr
RST RST 2	RST 2	CALL − 0-F 0-F 0-F 0-F	CM adr
RST RST 3	RST 3	CALL even 0-F 0-F 0-F 0-F	CPE adr
RST RST 4	RST 4	CALL odd 0-F 0-F 0-F 0-F	CPO adr
RST RST 5	RST 5		
RST RST 6	RST 6	∧	AND
RST RST 7	RST 7	⊙	EXOR
IN 0-F 0-F	IN d8	V	OR
OUT 0-F 0-F	OUT d8		

the next position table, contains four fields for each entry: the mnemonic field is similar to that in Table 3, except that the position for the symbol is after the first position; the binary code field contains the corresponding binary combination that will be added to the contents of the first byte of the assembled machine-code instruction as long as the related symbol is not numeric (otherwise the binary code will be transferred to the second or third byte of the assembled instruction or added to that byte's contents depending on whether it is the first or second hexadecimal digit in the byte) the current entry link and next-entry link determine whether the symbol is a part of a symbolic sequence which will produce a valid instruction code.

The flow chart shows how the lists are used by the driving software, and how the translation is accomplished. It can be seen that there are a number of error traps so that it is impossible to terminate a statement with anything other than a comma; to key in more than eight symbols (including the comma) in any one statement; or to use any non-valid symbol combinations. The software described in the flowchart occupies about 280 bytes of memory. Features may be added such as the ability to display the next instruction address; and display the next statement number during program entry; to have a user-defined starting address; and to save programs on tape or disc in their symbolic format for further editing or modification.

When setting up the tables, the following rules should be adhered to:

1. The first position table: a. If symbol used at the start of a statement represents different instruction groups, it will have multiple entries in the table with the appropriate binary codes. These can be distinguished by having different next-entry links; b. Symbols that use the same key should always use the same ASCII code; c. Each entry will require three bytes of memory.

2. The next-entry table: a. All symbol sequences must be linked with and terminate with the comma entry; b. As for 1b above; c. Symbols with several different binary codes must not have the same current entry link; d. Each current entry link must have a corresponding next entry link; e. The minimum memory space required for each instruction is four bytes, expandable in segments of two bytes; f. Mnemonics having the same current entry and next entry links may be grouped together so that both fields are stored once only for the whole group. This will reduce the size of the table.

Table 4: Next position

Mnemonic	Binary coded hex.	Current entry	Next entry
←	40	1,2	7,8
B	00	7,8	32,32
C	01		
D	02		
E	03		
H	04		
L	05		
A	07	7,8	32,32
M	06	7	32
0-F	00-F0	12,16	13,17
0-F	00-0F	13,17	16,32
B	00	9,10	32,32
C	08		
D	10		
E	18		
H	20		
L	28		
A	38	9,10	32,32
M	30	9	32
→	40	3,4	9,10
←	01	5,6	11,11
I	00	11,15	12,16
←	06	14	15
PUSH	C5	5,18	32,32
POP	C1	5,18	32,32
	–	32	0

The tables printed here demonstrate the MOV, MVI, LXI, Push and Pop groups. By following the sequence of the flow chart any instruction within these groups may be assembled. For example, the instruction MOV AB; by reference to the 8085 instruction set it is found to have the hexadecimal code of 78. The Key depressions A, forward arrow, B, comma, used in conjunction with the links give the numbers 38, 40 and 00 which when combined give 78. WW

Edison's electrical indicator

Last November, on the Centenary of Edison's patent of the thermionic diode, James Franklin argued that Edison had no idea of the significance of his invention and that therefore this could not be taken as the birth of electronics. Here Desmond Thackeray of Surrey University replies

by Desmond Thackeray, Ph.D.

The interest *Wireless World* has in the realms of electronics brings with it the responsibility for acknowledging inventions (and their inventors) of significance. A use for one electronic invention of great importance, the thermionic diode, was patented by Thomas Edison[1] some 20 years before J. A. Fleming thought to use it as a wireless detector. In these two decades, and even before 1883 when my story starts, there was a great deal of investigation into the physics of rather gassy vacuum tubes and the emission from heated and cold surfaces. This work came to fruition in a number of useful inventions, such as the Braun cathode-ray oscillograph tube[2] of 1897, the Wehnelt oxide-coated cathode[3] of 1904 and the Cooper-Hewitt mercury pool rectifier[4] of 1903.

Fleming himself reported [5,6] in 1890 and 1896 that unidirectional current flowed through an Edison thermionic diode when its filament was heated by an alternating current (though these are not his own words). What Fleming had observed was the process of rectification; but apparently it had little significance to him at the time. One must remember that alternating power supplies were very much a novelty, and rejected by Edison himself.

So, naturally, Edison's American patent no. 307,031 filed November 15, 1883, for an "Electrical Indicator" did *not* cover the application of his thermionic diode to the conversion of the despised alternating current into his well-regarded direct current. And he did not claim novelty for the diode itself, seemingly regarding it as simply an electric lamp, the use of which as an electrical indicator, and for controlling generators, he wished to cover. Edison must have observed that the emission from his hot carbon lamp filaments only appeared when the filaments *were* visibly hot, and then increased super-proportionately as the filament current was raised. By connecting the filament to his power lines "changes in the candle-power of the lamp (filament), and consequently in the electromotive force of the source of supply, are made apparent". His diagram

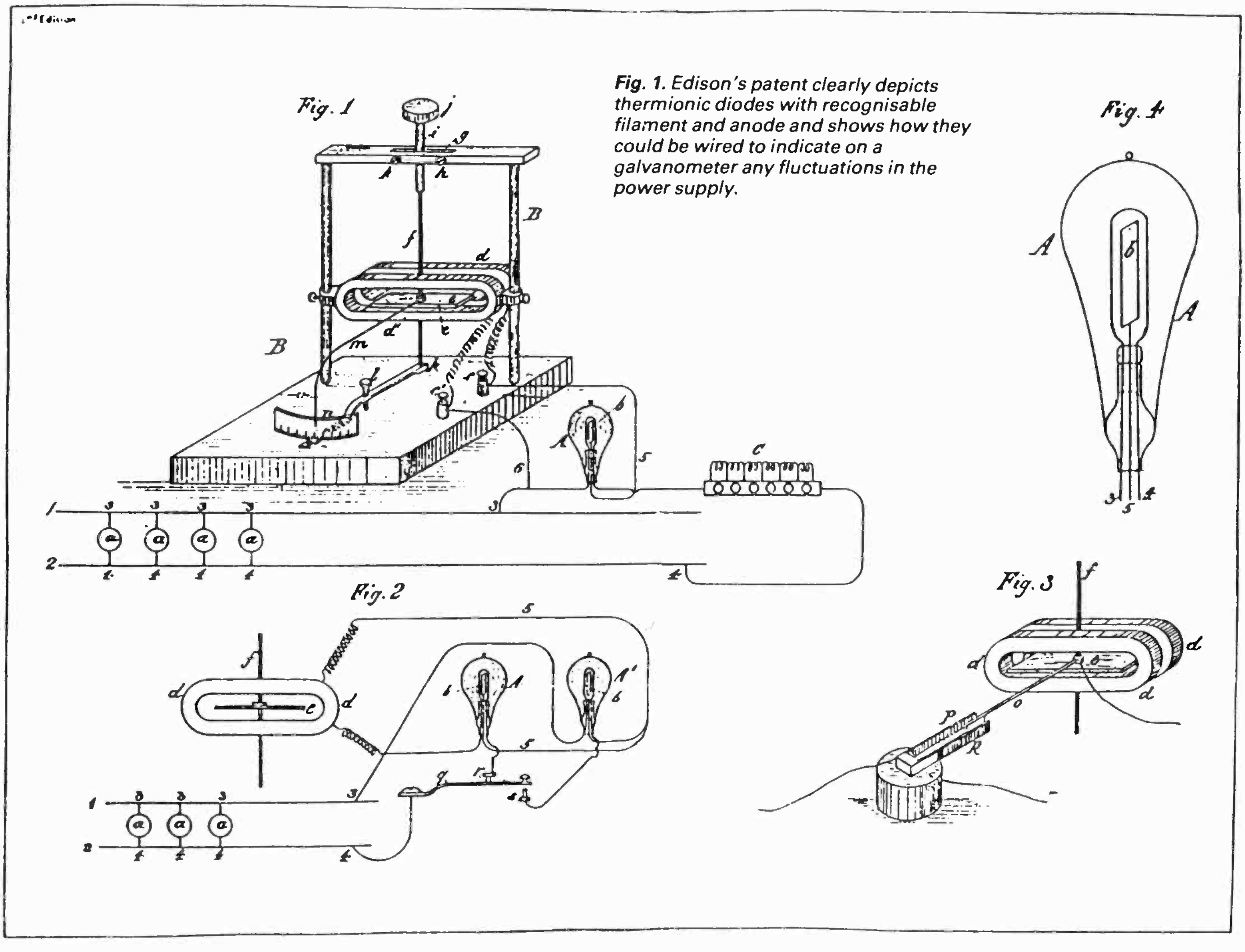


Fig. 1. Edison's patent clearly depicts thermionic diodes with recognisable filament and anode and shows how they could be wired to indicate on a galvanometer any fluctuations in the power supply.

(Fig. 1) shows a galvanometer in the plate (anode) circuit to display the changes in filament emission current. The arrangement no doubt exhibited a very high sensitivity to small changes in power line voltage. It seems therefore a completely practicable application of the thermionic diode in any situation where a plant engineer *actually required* a more sensitive indicator than say a conventional voltmeter with offset zero. But we cannot be sure that there was such a need.

Edison continues the quoted sentence "or . . . instead . . . are made to affect circuit controlling apparatus, automatic regulators or other electrical apparatus. . . ." Here he is envisaging the galvanometer as a relay; and later in the patent he specifies how this may be interfaced to the generator control via "a mechanism such as shown[7] in my patent no. 287,524". Whether or not this latter mechanism worked successfully hardly matters, because Edison could have used here any "sure-fire" interface, such as a reversible motor driving a field rheostat. Clearly, what Edison had invented in 1883 was not only a sensitive incremental electronic voltmeter, but also a complete electronic servo-controller of the discontinuous (or bang-bang) kind. Again we might wonder whether a control system of such high sensitivity (loop gain?) was actually needed, and would be used. There could also have been stability problems to solve. Writing in the magazine *Scientific American* in March 1969, George Shiers[8] draws attention to the historic importance of what he calls "this first patent in electronics"; but he does add the rider that it "was of no commercial value". I think that this is rather a brief dismissal of the topic, arising because Shiers' article is really concerned with the string of thermionic developments that were eventually to contribute to early wireless.

Even in wireless, generator regulation must have had some value; but the modest d.c. stability required so long ago could probably have been met adequately with simpler techniques, compound winding of the generator, or the buzzing relay once ubiquitous in automobile battery charging; and so Edison's invention lay idle. It seems to have been the exigencies of World War I, requiring sensitive valved receivers intolerant of such interference sources as buzzing relays, that prompted H. M. Stoller[9] to use a thermionic diode (called a Kenotron by the General Electric Company of America) to stabilise the output of an aircraft generator supplying thermionic tubes.

Gerald Tyne, in his *magnum opus* "Saga of the Vacuum Tube"[10], devoted more than a page to the TB1 Kenotron (Fig. 2) and said that "approximately 4,500 of these were delivered to the Signal Corps." Then if one turns to the contemporary account[11] by Van der Bijl in the "Thermionic Vacuum Tube", there is a circuit diagram of a regulator (as devised by Stoller) and some regulation curves.

"Edison triumphs at last" we might say? Sadly, not so; there is one little flaw here. The circuit shows that the plate current of the diode (20 to 130mA) actually flows through the differential field winding of the generator itself, so providing continuous regulation without steps. This was a simplification seemingly not envisaged by Edison in his original patent, though the wording "in any suitable manner" was obviously intended to pave the way for alternatives and afterthoughts.

The British version of the Edison patent ran[12] to a second edition in 1922; and Stoller was into hardware again[13] in 1929 with a more sophisticated regulator which added three triodes and a saturable reactor to the diode. This time he was regulating an alternating voltage, for the Edison invention (unlike other methods) would work just as well for regulating an alternating supply as it would when controlling a d.c. generator. Considering how bitterly Edison himself had once opposed alternating supplies, it seems ironic that this work of Stoller should have applied Edison's invention in just that field. Benson quotes[14] a number of later usages, during the next 20 years or so; but it is doubtful whether the users gave much credit to the patent Edison filed on November 15, 1883.

So, should we have been toasting Thomas Edison on November 15, 1983, for the first electronics patent ever? I think that we should. The Germans set us an example by honouring 100 years of the Edison effect itself, in organising a conference on electron tubes May 18-20, 1983, in the Garmisch-Partenkirchen congress centre. In its way, this helped to compensate for much neglect of Edison's invention, which preceded such currently important thermionic devices as the cathode-ray tube of Braun, the X-ray tube of Coolidge, and the flourescent lamp.

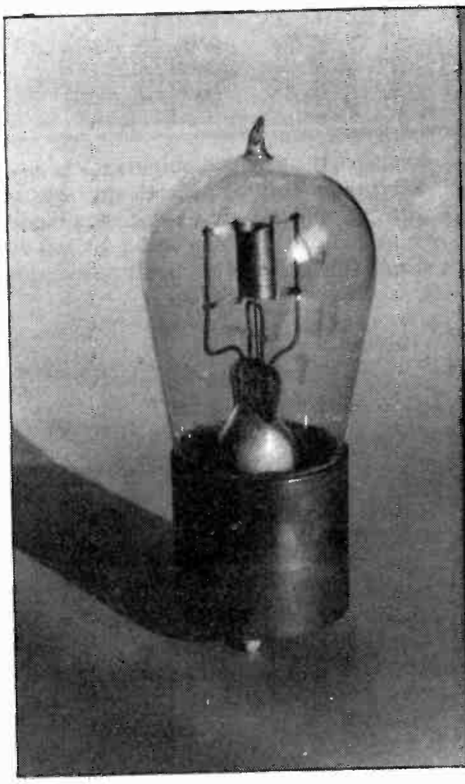


Fig. 2. Early regulator diode, the TB1, as used in American aircraft equipment during the first World War.

Fig. 3. One of the modern successors to the TB1, the GE10, though not equivalent in ratings, has a straight tungsten filament rather than the hairpin or carbon loop filament of the Edison tube.

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3. A. Wehnelt, German Patent 157845 of January 15, 1904.
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CIRCUIT IDEAS

Thermally-controlled power supply

Supply shown controls power in a low-resistance load such as a single turn of Nichrome wire using feedback from a diode temperature sensor located near the load. Voltage across the diode is compared with the current/temperature setting potentiometer by an op-amp. A second op-amp compares the summed outputs of the first comparator and output sensing resistor with the voltage across a reference diode. Output-current limiting with a 100mΩ resistor is about 7A. The circuit was used to control the temperature of a small zone-melting furnace with good results.

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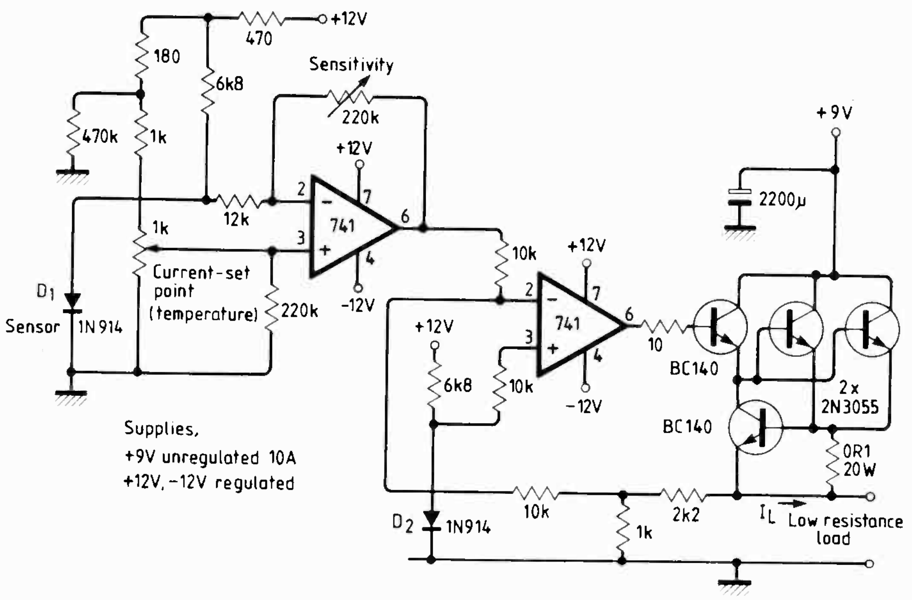


Don't waste good ideas

We prefer ideas with neat drawings and widely-spaced typescripts, but we would rather have scribbles on the "back of an envelope" than let good ideas be wasted.

Submissions are judged on originality or usefulness – not excluding imaginative modifications to existing circuits – so these points should be brought to the fore, preferably in the first sentence.

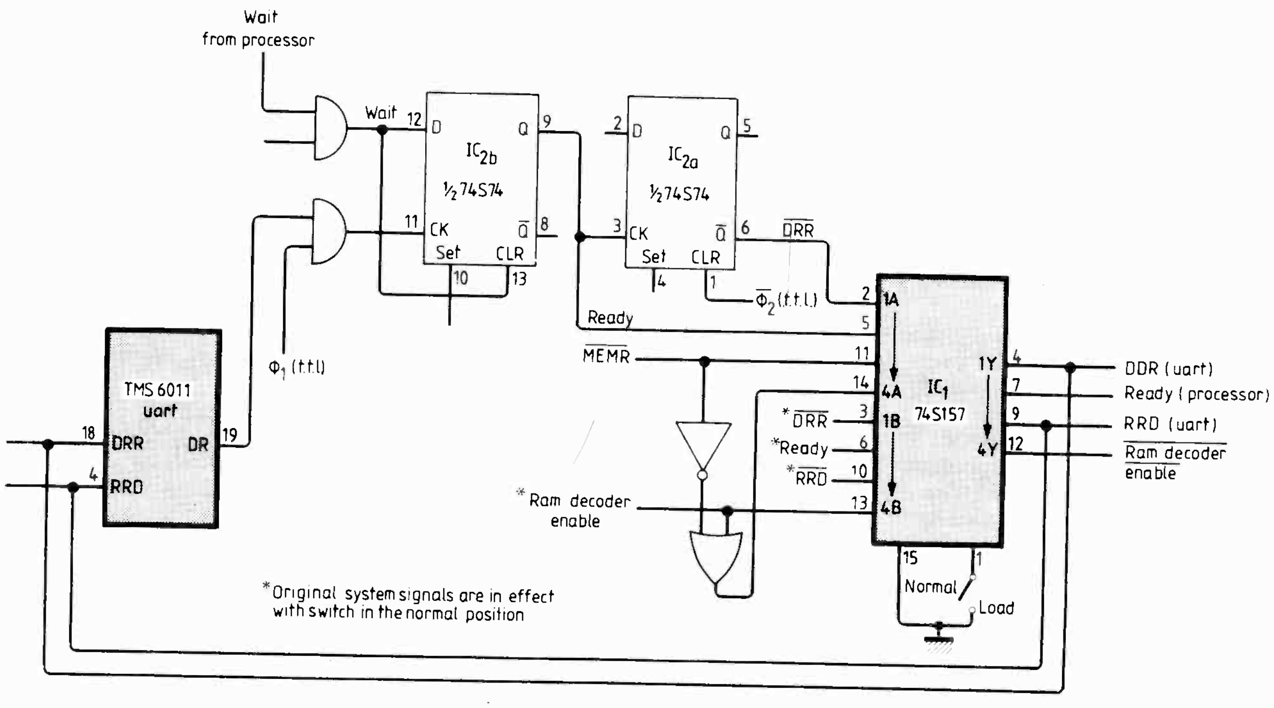
Minimum payment of £30 is made for published circuits, normally early in the month following publication.

Prom elimination

Using a circuit such as this one designed for 8080-based microcomputers, loading an operating system from cassette directly into ram means that no proms are required – not even for storing cassette-driving software. This increases system speed and reduces cost by allowing all of the microprocessor address space to be filled with rams.

While data is being loaded from cassette, this simple modification slows the microprocessor down to match the data rate of the cassette by forcing it into processor-wait states. Synchronization between the cassette data rate and the processor is automatic. With the switch set for loading, the processor ready input is controlled by this circuit, as are data-ready reset (DDR) and receiver-register disable (RRD) signals. With the reset button pressed the processor wait line goes low, forcing the ready signal at pin 9 of IC_{2b} low and, the processor enters the wait state.

When the cassette player is started, the uart data-ready (DR) output goes high for each byte received. On each low-to-high transition of this signal the high wait-state condition is transferred to the ready line from IC_{2b} and the processor is released from its wait state to process the byte received. Immediately after the IC_{2b} ready



Keyboard encoder

Besides being cheap, this keyboard encoder has roll-over protection, letters-only shift lock and can produce 128 ASCII characters and 128 control codes. It is not necessary to unlock the shift key to type single lower-case characters – an led status indicator prevents ambiguity. When function key S_5 is locked, shift lock is released so that bit seven may be active with shifted or unshifted characters or control codes, providing an eight-bit set of codes.

Circuit IC_2 is a 16-line decoder for keyboard scanning and IC_3 is a priority encoder for sensing. Input sequence of IC_3 is the reverse of the priority sequence to provide positive logic at the three data outputs. Each of the 16 decoder outputs is connected to three character switches to provide four least-significant ASCII bits. Switches one to three provide shift-lock, shift and control functions respectively and further optional switches four and five provide control lock and determine the state of bit 7 for special functions. Shift operates differently on letters and numbers by gating which controls bit 6.

Minimal screen flicker and program interruption will occur when the decoder is driven by vertical sync. from the v.d.u. I used a 7493 instead of developing software.

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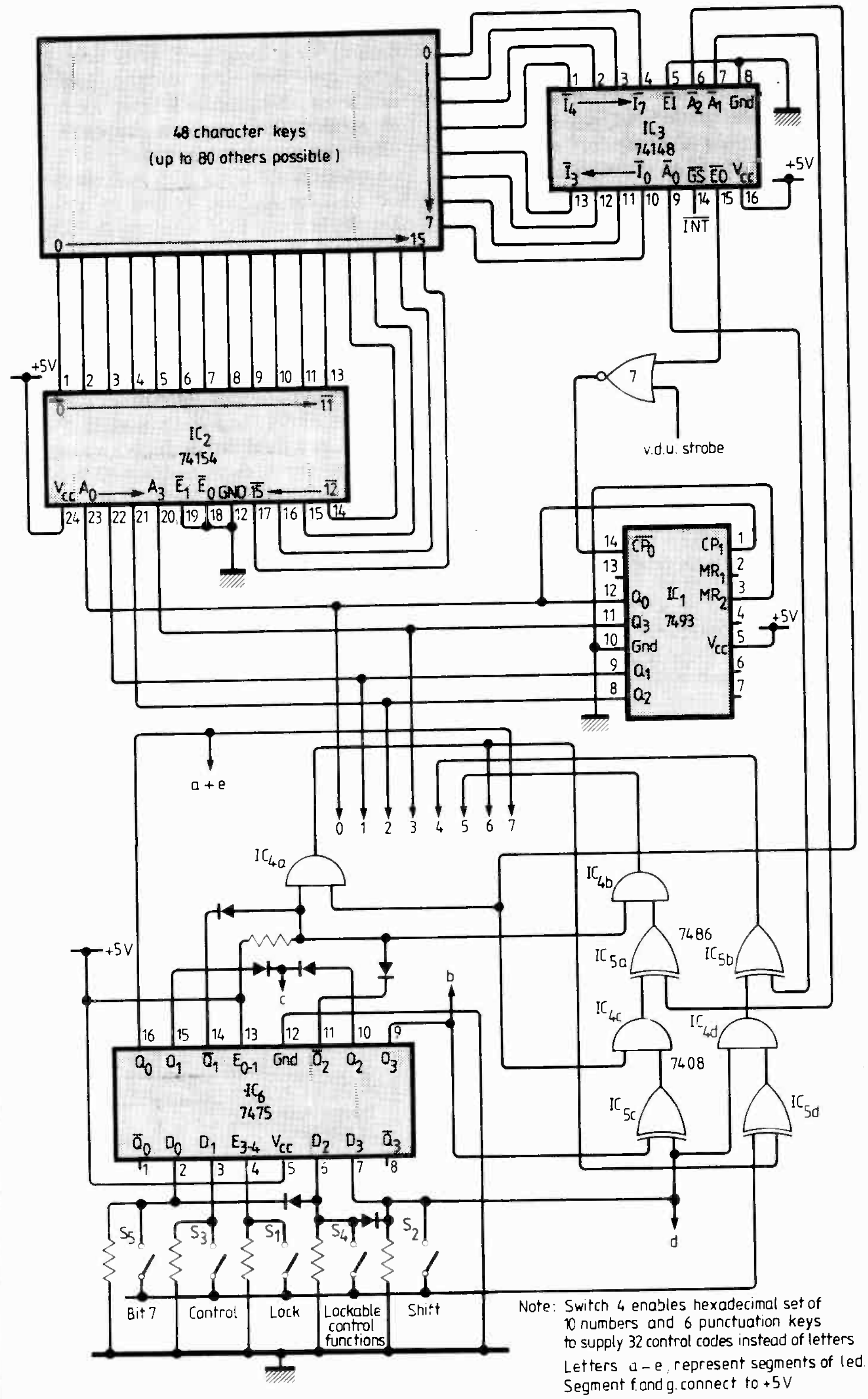
Keyboard connections

Row	ASCII column 7	6	5	4	3	2	1	0
0	P			@	0	SP		
1	Q	A			1			
2	R	B			2			
3	S	C			3			
4	T	D			4			
5	U	E			5			
6	V	F			6			
7	W	G			7			
8	X	H			8			BS
9	Y	I			9			TAB
10	Z	J			:			LF
11	(	K			;		ESC	
12		L	\			,		
13	)	M				−		
14		N	^			*		
15	DEL	O				/		



Note: Switch 4 enables hexadecimal set of 10 numbers and 6 punctuation keys to supply 32 control codes instead of letters
Letters a – e, represent segments of led. Segment f and g connect to +5V

output goes high, IC_{2a} forces the DDR line high and clears the uart data-ready output.

If the program retrieved from cassette is as follows

```
NOP
NOP
.
.
.
NOP
LXI   H, 0000₁₆
MVI   M, byte 1
INX   H
MVI   M, byte 2
INX   H
MVI   M, byte 3
.
.
.
INX   H
MVI   M, byte n
HLT
NOP
.
.
.
NOP
```

the processor stores the operating system programs contained in bytes 1 to n starting at memory location 0000. After the program is loaded, the switch is set to the normal position and the reset button pressed to execute the loaded program.

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High-resolution point display

This circuit was developed to display up to 512 points logged to 9-bit resolution on a tv point-digitizing system. Only 2K bytes of memory are used since it is not necessary to reserve a memory location for each possible coordinate on the screen.

Video memory consists of just two MK4801AN, 70ns byte-wide devices. During data loading, video memory is connected to data and address buses of the digitizing system (in this case Z80-based) at the points indicated on the diagram through software-controlled three-state buffers; outputs of these buffers are high-impedance while the display is in use. The memories are divided into four pages of 512 bytes designated X_0, X_1, Y_0 and Y_1.

Data outputs of X memory are connected to one side of an eight-bit comparator, the other side of which is fed by the lower eight bits of a nine-bit counter. This counter is clocked by an 8MHz crystal oscillator gated by a modified line-sync. pulse* which also resets the counter. Similarly Y-memory data output is compared with an eight-bit counter clocked by line-sync. pulses and cleared by a field-sync. pulse. The state of the line-sync. pulse from the TDA2571A sync. separator is latched on field-sync. pulses by the field-identifying bistable i.c. to determine which of the two fields of the 2:1 interlaced picture is currently being displayed. Output from the bistable i.c. (l.s.b. Y) is connected to A_9 of the Y memory and is used to select either page Y_0 or Y_1. The X counter's most-significant bit (m.s.b. X) is connected to A_9 of the X memory and selects either page X_0 or X_1.

Active-low comparator outputs feed a NOR gate, the output of which is injected into the video signal to produce a positive bright-up pulse when X and Y comparisons are true. This pulse is also used to clock a 9-bit video memory counter, connected to address lines $A_{0\text{-}8}$ of the video memory, which selects the next set of coordinates for comparison. After field 1, i.e. after one complete picture has been displayed, this counter is reset. Four bytes of memory are required for each point displayed and the two bytes not holding coordinates are filled with null characters, i.e. 01_{16} for X_0, Y_0, Y_1 and FF_{16} for X_1. During line and field blanking the comparators are disabled so coordinates represented by these bytes have no effect. Blanking pulses are regenerated from sync. pulses but this is not shown on the diagram.

Coordinates must be stored in the video memory in time-sequential order with field zero before field one and low-value Y coordinates in a field before higher values and the same for X coordinates within a line. Bytes stored in video memory are not true coordinates but related to them.

X coordinate <255 – store X coordinate directly in X_0 and put FF_{16} in corresponding X_1 location.
X coordinate >255, <511 – store X coordinate−256 in X_1 and put 01_{16} in corresponding X_0 location.
Even Y coordinate – store Y coordinate/2 in Y_0 and put 01_{16} in corresponding Y_1 location.
Odd Y coordinate – store (Y coordinate−1)/2 in Y_1 and put 01_{16} in corresponding Y_0 location.

Values of X and Y lower than say 10 will occur during the blanking period and will not be compared or displayed. Possible hexadecimal addresses for the four pages of video memory connected to the processor buses would be

X_0 1000-11FF
X_1 1200-13FF
Y_0 1400-15FF
Y_1 1600-17FF

Examples of five points loaded into video memory are shown in this table

Coordinates (Y,X)		Y0	Y1	X0	X1
40	40	20	01	40	FF
160	258	80	01	01	02
160	262	80	01	01	06
41	60	01	20	60	FF
301	286	01	150	01	30

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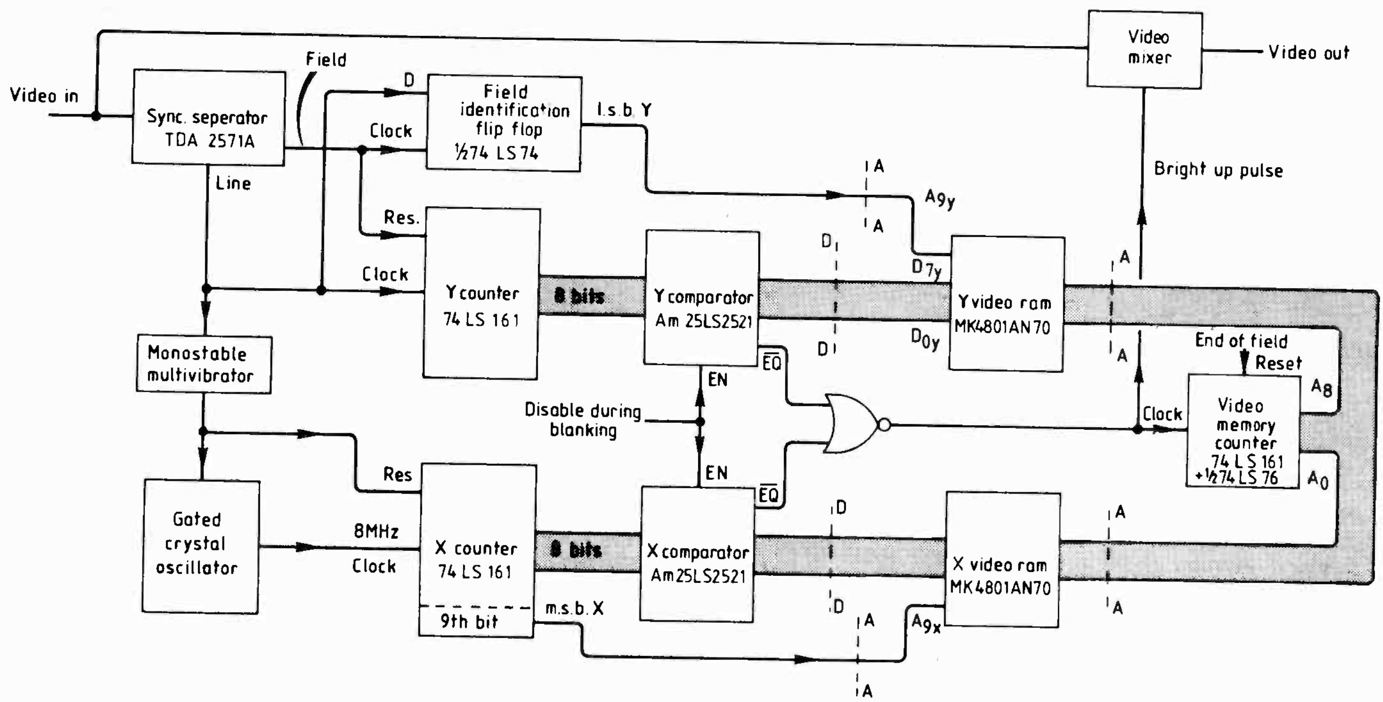
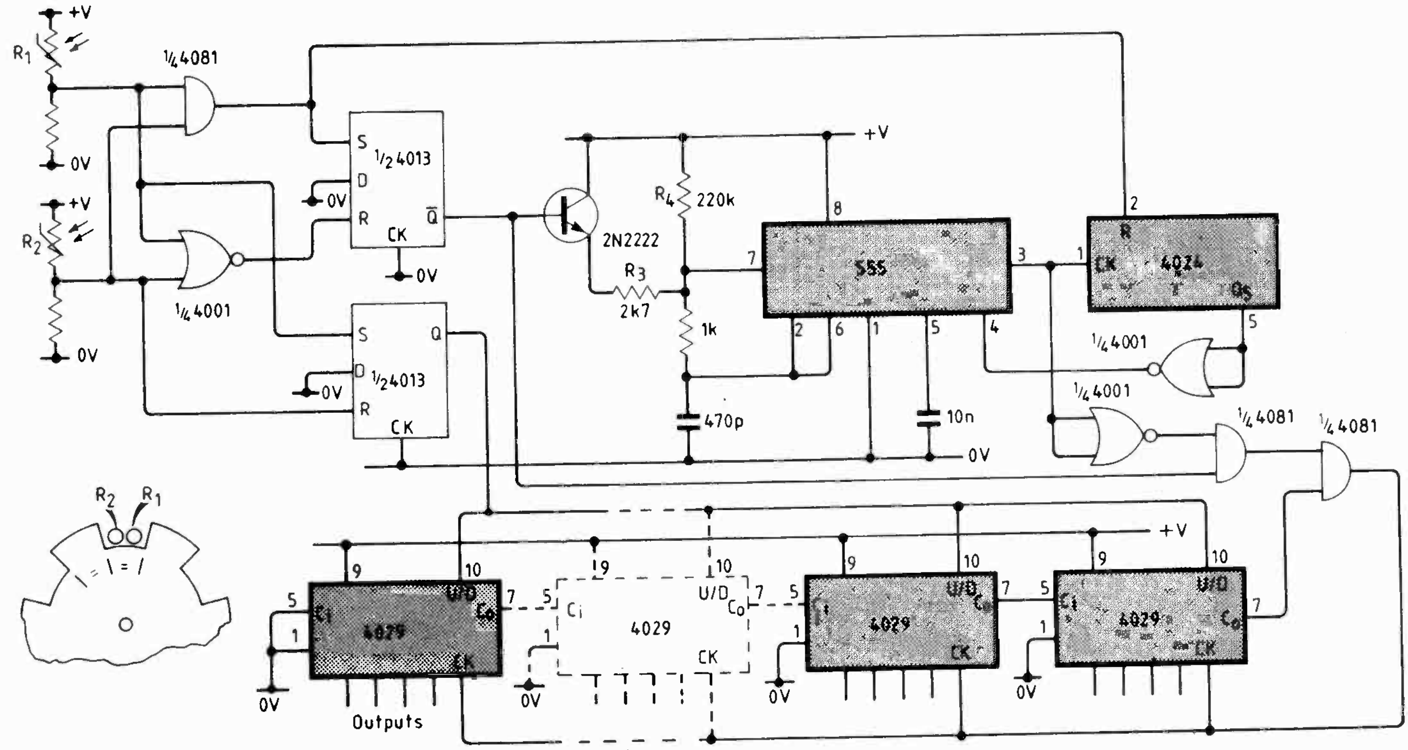
*Line sync. pulses from the TDA2571A have a 46% duty cycle and are satisfactory for field identification but must be modified for oscillator gating and counter reset.





Non-linear rotation sensor

Useful when both coarse and fine adjustments have to be made using the same rotary control, this circuit provides between one and 16 pulses for each slot passing the sensors, depending on the disc's rotary speed. These pulses increment or decrement counters depending on the direction of rotation of the disc. Any number of counters may be used, whether binary of b.c.d. Resistor R_4 is chosen to suit the disc and R_3 is to set the 555 timer to the highest frequency possible.

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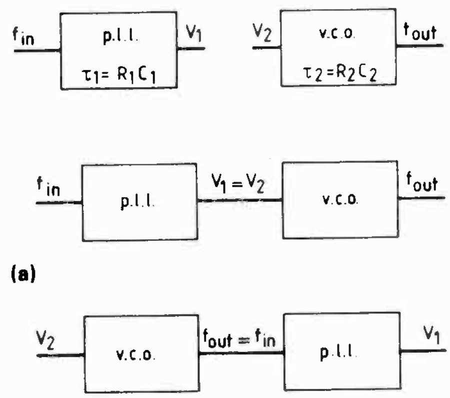

Fig. 1 (b)

Simple divide-by-fraction circuit

A stable p.l.l. with a frequency range of 0.01Hz to 100kHz may be obtained using the XR-2207 v.c.o. and an XR-2208 operational multiplier. These i.cs are used in two ways – to design a divide-by-fraction circuit shown schematically in Fig. 1(a) and a low-noise amplifier as shown in Fig. 1(b). In both cases the mathematical treatment is the same and can be derived using Fig. 1(a). Since

$$f_{in}=V_1/V_{cc}R_1C_1$$

and

$$f_{out}=V_2/V_{cc}R_2C_2$$

it follows that

$$f_{out}=\frac{R_1C_1}{R_2C_2}f_{in}=\frac{R_1}{R_2}f_{in}$$

for $C_1=C_2$. Also, the system functions as a simple divide-by-fraction circuit in which the fraction frequency is set by the ratio of R_1:R_2.

The same holds for Fig. 1(b). Under the assumption $f_{out}=f_{in}$,

$$V_1=R_1V_2/R_2$$

i.e. the circuit may be used as a low-noise amplifier. A practical circuit is shown in Fig. 2. Values of R_1' and C_1' can be calculated according to the lock and capture range as usual.

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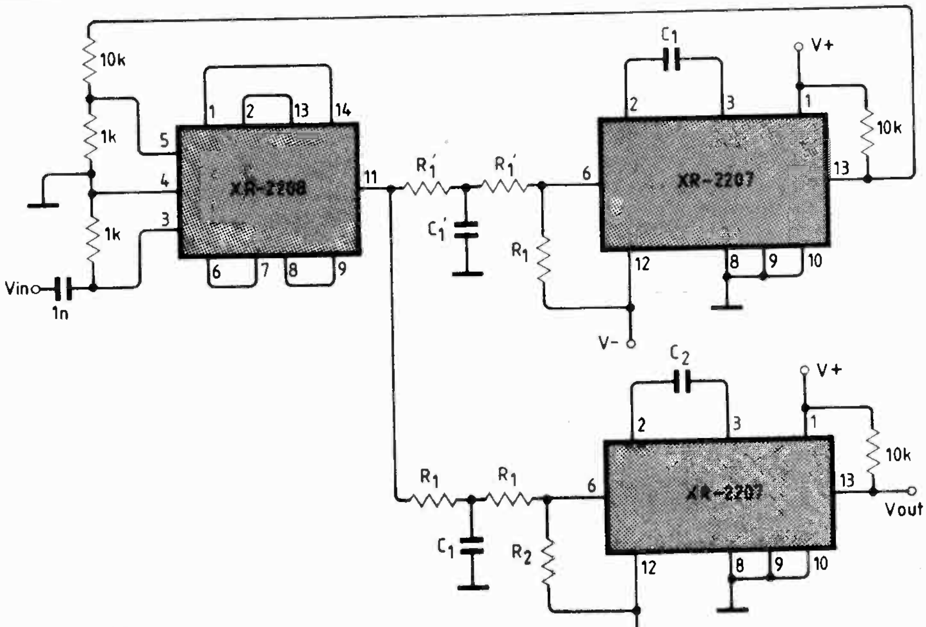

Fig. 2

Microcomputer organ interface – improvisation by Forth

Complete details of a vocabulary that will provide polyphonic improvisations when used with the Nascom 2 organ interface described in the June and July 1983 issues

by R. D. Easson

The Forth application to provide simple polyphonic extemporizations from a given theme was decribed in outline in last July's issue. Full details of this are now given, including the entire vocabulary (List 3) and a glossary.

The first steps were to find Forth and to put it in a convenient place in ram. This was done by assembling 8080 FIG-Forth release 1.1 (a public domain listing) under the Nascom Zeap editor assembler. Having removed most of the comments, a month of spare-time typing yielded a 40K edit buffer which took about 15 minutes to assemble. The origin was placed at 1500_{16}, leaving space below Forth for the essential parts of the organ interface plus a substantial scratchpad area for additional console fields. A Forth-compiled editor from the Forth Installation Manual was added, together with simulation of virtual memory, to suit a Nascom 2 with 64K of ram but without discs.

Forth uses postfix or reversed Polish notation, e.g. HEX 2 A + . when entered returns the answer C . Code groups are separated by spaces. Each group is interpreted as a word (a command, variable or constant) or, if it is not in the vocabulary, a number if possible. Thus FFFF is meaningless in standard Forth unless operation is in a suitable number base such as hexadecimal, which as above is achieved by the word HEX. In this simple example the two code groups after HEX are interpreted as numbers and are transferred to the stack. The + pops them into the HL and DE register pairs respectively, adds them and pushes the answers back onto the stack. The . (pronounced 'dot' although 'print' might be more appropriate) displays the answers and leaves the stack empty.

At first sight, a screen of Forth code such as List 2 might be incomprehensible whilst having a startled appearance because of the sprinkling of exclamation marks, but the mysteries soon fall away. ! is pronounced 'store' and it is a word which does just that, e.g. 9400 TUN ! stores the value 9400 (in whatever number base has been set, being 16 throughout this article) in the variable TUN, which was created with initial value 7400 by loading 0 of List 2. The complementary word is @, pronounced 'fetch'. C! and C@ are the equivalents for single-byte numbers, although these are kept on the stack as two-byte numbers, one byte being zero. Double-precision (four-byte) numbers are also provided for but are not used in this article. The letter U as in U. or U< indicates unsigned, so that positive 16-bit numbers can go up to FFFF. (Any number base can be used. If HEX B250 is entered and operation than changes to base 36 (by DECIMAL 36 BASE !) the number is returned by . as Z80).

Forth has two stacks. The principal one is referred to as the parameter or computation stack, or just as the stack. The other one is called the return stack, used mainly as a temporary parking area for numbers which would otherwise get in the way on the parameter stack.

DUP, SWAP, OVER, DROP and ROT (pronounced rote, short for rotate) and their four-byte equivalents rearrange the stack. ROT, for example, brings the third (two-byte) item to the top. DUP duplicates the top item; OVER duplicates the second item and pushes it on top; SWAP swaps the two top items; and DROP drops one item.

Conditional tests such as = take two parameters from the stack, replacing them with the true (1) or false (0) result, which is in turn destroyed when the test result is used.

An example of a definite loop occurs in List 2, line 1, as far as 'loop'. This also illustrates one use of the return stack. The 'limit' for the first loop (10H) and its 'index' (initially 0) are put to the return stack when the loop is executed. The Forth word I copies the top item on the return stack to the parameter stack, thus allowing the index to be used as a parameter in the loop itself, as in the same example from List 2.

Examples of indefinite (conditional) loops occur in List 2 lines 14 and 15 and in List 3 Screen 6 lines 2 and 3. Forth does not have a 'goto' instruction so that its users are forced to structure their programs and not to be quite so lazy as they might otherwise be.

Perhaps Forth is best known for its so-called self-compiling ability, meaning not that it compiles itself but that it is compiled by Forth. In many applications, such as the one described in this article, this need mean no more to the user than that Forth words may be strung together to form new words, as is done throughout List 2 and List 3. For example, line 7 of List 2 comprises the 'colon definition' of I.PDPS. When this is loaded, I.PDPS is compiled as a new word in the Forth dictionary. I.PDPS can then be used, which causes the words in its definition to be executed, i.e. the value of variable TUN is fetched, incremented, the result stored at 1430H, and similarly for IMP. I.PDPS will disappear after a cold start unless the appropriate Forth start-up parameters are changed. In this way a program can be developed on screens, which may be held in virtual memory or in ram, until a satisfactory version is obtained. This can then be loaded from cold and kept in the protected dictionary. It is not necessary to use the editing screens: the vocabularies of Lists 2 and 3 could be compiled directly.

For the application of Forth described in this article it is not necessary to delve into it more deeply, but ORCF from List 1 is taken as an example of a Forth word. Lines 8140 to 8155 comprise the 'head' and lines 8160 to 8240 form the 'body'. The code pointer distinguishes between the different kinds of word (machine code, colon definition, constant or variable). If ORCF were written in Forth rather than

```
ZEAP Z80 Assembler - Source Listing

1545                     ORG  1545H
1545                     ENT
1545 0A          NEXT    LD   A (BC)
1546 1E51                DEFS 1E51H
3397 00          DUMP    DEFB 0
3398 001D                DEFS 1DH
33B5 85                  DEFB 85H        ; UUCF1
33B6 55554346            DEFM /UUCF/
33BA B1                  DEFB "1+80H
33BB 9033                DEFW DUMP-7     ; Vocabulary-link to DUMP
33BD BF33        UUCF1   DEFW $+2        ; Code pointer
33BF C5                  PUSH BC         ; Save Forth IP
33C0 2A3014              LD   HL (1430H) ; Ready PDP
33C3 060D                LD   B 0DH      ; MSB of CFP to B
33C5 4E                  LD   C (HL)     ;) LSB of CFP to C
33C6 79                  LD   A C        ;) & to A
33C7 D6FF                SUB  £FF        ;) Finish if
33C9 2806                JR   Z 08H      ;) end of frame
33CB 23                  INC  HL         ; Inc PDP
33CC 7E                  LD   A (HL)     ;) Data to
33CD 02                  LD   (BC) A     ;) console field
33CE 23                  INC  HL         ; Inc PDP
33CF 18F4                JR   -0AH       ; Go back for more
33D1 C1                  POP  BC         ; Return Forth IP
33D2 23                  INC  HL         ; Inc PDP
33D3 223014              LD   (1430H) HL ; Park PDP
33D6 C34515              JP   NEXT       ; Goto Forth Interpreter
33D9 00                  DEFB 0
33DA 84                  DEFB 84H        ; ORCF
33DB 4F5243              DEFM /ORC/
33DE C6                  DEFB "F+80H
33DF B533                DEFW UUCF1-8    ; Voc-link to UUCF1
33E1 E333        ORCF    DEFW $+2        ; Code pointer
33E3 D9                  EXX  ; Save IP
33E4 0610                LD   B' 10H     ; Set byte count
33E6 E1                  POP  HL'        ;) Top stack item to HL'
33E7 D9                  EXX  ;           ) (2nd CF source & dest.)
33E8 E1                  POP  HL         ;) Next stack item to HL
33E9 D9                  EXX  ;           ) (1st CF source)
33EA 7E                  LD   A (HL')    ; Load byte from 2nd CF
33EB D9                  EXX
33EC B6                  OR   (HL)       ; Combine two CF bytes
33ED 23                  INC  HL         ; Inc CFP
33EE D9                  EXX
33EF 77                  LD   (HL') A    ; Combined byte to 2nd CF
33F0 23                  INC  HL'        ; Inc CFP'
33F1 10F7                DJNZ -7         ; Loop until done
33F3 D9                  EXX  ;            Return IP
33F4 C34515              JP   NEXT       ; Goto Forth Interpreter
33F7 85                  DEFB 85H        ; CC4/3
33F8 4343342F            DEFM >CC4/>
33FC B3                  DEFB "3+80H
33FD DA33                DEFW ORCF-7     ; Voc-link to ORCF
33FF 0134        CP43    DEFW $+2        ; Code pointer
3401 00                  NOP
3402 211814              LD   HL 1418H   ; Ready FU pointer
3405 D9                  EXX  ; Save IP
3406 0618                LD   B' 18H     ; Set byte count
3408 2A3214              LD   HL' (1432H) ; Ready output PDP (PO)
340B 110014              LD   DE' 1400H  ; Ready FO pointer (E' is
                     ;                       also register number)
340E 1A                  LD   A (DE')    ; Load FO byte
340F D9                  EXX
3410 96                  SUB  (HL)       ; Sub FU byte from FO one
3411 2807                JR   Z 9H       ; Hop if there's no change
3413 7E                  LD   A (HL)     ; Ready FU byte
3414 D9                  EXX
3415 73                  LD   (HL') E'   ; Regno. to data field
3416 23                  INC  HL'        ; Inc PDP (PO)
3417 77                  LD   (HL') A    ; Reg status to data field
3418 23                  INC  HL'        ; Inc PDP (PO)
3419 D9                  EXX
341A 23                  INC  HL         ; Inc FU pointer
341B D9                  EXX
341C 13                  INC  DE'        ; Inc FO pointer
341D 10EF                DJNZ -15        ; Loop until done
341F 3EFF                LD   A £FF      ; Ready frame byte
3421 77                  LD   (HL') A    ; Frame byte to data fld.
3422 23                  INC  HL'        ; Inc PDP (PO) to T posn.
3423 223214              LD   (1432H) HL' ; Park PDP (PO)
3426 D9                  EXX  ;            Return IP
3427 00                  NOP
3428 C34515              JP   NEXT       ; Goto Forth Interpreter
342B 83                  DEFB 83H        ; CF>
342C 4346                DEFM /CF/
342E BE                  DEFB ">+80H
342F F733                DEFW CP43-8     ; Voc-link to CC4/3
3431 3334        CF      DEFW $+2        ; Code pointer
3433 D9                  EXX  ;            Save IP
3434 D1                  POP  DE'        ; Destination from stack
3435 E1                  POP  HL'        ; Source from stack
3436 011800              LD   BC' 0018H  ; Set byte count
3439 EDB0                LDIR ;            Do CF transfer
343B D9                  EXX  ;            Return IP
343C C34515              JP   NEXT       ; Goto Interpteter
343F 85                  DEFB 85H        ; 2/MOD
3440 322F4D4F            DEFM /2/MO/
3444 C4                  DEFB "D+80H
3445 2C34                DEFW CF-6       ; Voc-link to CF>
3447 4934        MOD2    DEFW $+2        ; Code pointer
3449 E1                  POP  HL         ; Get data from stack
344A CB3D                SRL  L          ; Shift ( divide by 2 )
344C 54                  LD   D H        ;) Save quotient
344D 5D                  LD   E L        ;)
344E 210000              LD   HL 0
3451 3003                JR   NC 5       ;) Push carry flag
3453 210100              LD   HL 1       ;) to stack
3456 E5                  PUSH HL         ;)
3457 D5                  PUSH DE         ; Quotient to stack
3458 C34515              JP   NEXT       ; Goto Interpreter
345B 83                  DEFB 83H        ; 2*M
345C 322A                DEFM /2*/
345E CD                  DEFB "M+80H
345F 3F34                DEFW MOD2-8     ; Voc-link to 2/MOD
3461 6334        M2      DEFW $+2        ; Code pointer
3463 E1                  POP  HL         ; Get data from stack
3464 CB25                SLA  L          ; Shift (mult. by 2)
3466 3004                JR   NC 6       ;) Add carry if
3468 110001              LD   DE 0100H   ;) present and
346B 19                  ADD  HL DE      ;) push answer
346C E5                  PUSH HL         ;) to stack
346D C34515              JP   NEXT       ; Goto Interpreter
```

List 1. Four Forth words in machine code provide fast communication between the Forth stack and the interface console and data fields. Two further words hasten semitone transposition.

machine code it would have a different code pointer (the address of a machine code routine called 'do colon') followed by a series of two-byte numbers called the parameter field, being the code pointer addresses of the words which would form the body of the definition. When such a word is executed, each code pointer ultimately leads to a machine code routine, which might be many levels below it.

'Starting Forth' by Leo Brodie (Prentiss Hall, 1981) provides a more detailed introduction to Forth.

Forth as 'composer'

Following the installation of Forth, the next thing was an interesting test to see whether Forth and the organ interface software would co-exist. Fortunately they did. Four Forth words were then written to enable Forth to work in the interface data fields (in data format) and console fields. These were written in machine code (List 1) rather than Forth partly to achieve faster operation (a challenge to someone to prove that Forth is faster?) but mainly because the elements of three of them already existed, the extra one being ORCF.

The next objective was to achieve the simplest kind of improvisation, a parallel doubling of the theme at any chosen interval (and, as it happened, at any desired pitch for each part). Thus far, therefore, a sledgehammer to crack a walnut, but of course with further development in mind.

It took two weeks of spare time from the coexistence test to reach this objective, the additional nine-word vocabulary for which is shown in List 2, which also illustrates two console fields. T.OUT later became the two words TOR2 and OWT, but the other eight words all survive (albeit with sonme changes) in the current vocabulary (List 3) which was completed five weeks later. Certain weaknesses were identified in the vocabulary of List 2:

– use of hexadecimal addresses rather than variables and constants (this becomes tedious if more than a few such numbers are required)
– lack of clear functional allocation of console fields
– badly structured multiple function of T.OUT
– eccentric way of leaving the WHILE loop, with the bogus conditional in ?AA inefficient use of /MOD and 2 for the nine-bit divide and multiply by two required for semitone transposition. (The substitution of 2/MOD and 2*M also on List 1 speeded things up by a factor of three.)

```
1 LIST
SCR £ 1
   HEX    7400 VAR TUN  8400 VAR IMP
 : I.CF    10 0 DO 0 0D08 I + C! LOOP 7 0 DO FF 0D01 I + C!
   LOOP 80 0D00 C! 0D00 1400 CF> 0D00 1418 CF> 0D00 0D18 CF> ;
 : TU    0 0 10 DO 141F I + C@ 2* + DUP FF > SWAP 141F I
   + C! -1 +LOOP  DROP ;
 : TD    0 10 0 DO 0D20 I + C@ 2 /MOD ROT + 0D20 I + C!
   IF 80 ELSE 0 THEN LOOP DROP ;
 : I.PDPS  TUN @ 1+ 1430 ! IMP @ 1+ 1432 ! ;
 : DODE     1430 @ DUP @ 1432 @ DUP ROT SWAP !
   2+ 1432 ! 2+ 1430 ! ;
 : U.CFS   UUCF1 0D00 1418 CF>  0D00 0D18 CF> ;
 : T.OUT  TD TD TU TU TU 0D20 1420 ORCF CC4/3 1418 1400 CF> ;
 : ?AA   1430 @ 2- @ AAAA = IF ." Improvisation completed "
   QUIT THEN 1 ;
 : ORGANUM   I.CF I.PDPS BEGIN DODE ?AA WHILE
   U.CFS T.OUT REPEAT ;
OK
```

```
1400 80 FF FF FF FF FF FF FF
1408 00 00 00 00 00 00 00 00
1410 00 00 00 00 00 00 00 00
1418 80 FF FF FF FF FF FF FF
1420 00 00 00 00 00 00 00 00
1428 00 00 00 00 00 00 00 00
```

List 2. Nine-word vocabularly provides improvization as parallel "organum" in two parts. Two of the console fields as set by I.CF are also shown.

```
1 LIST
SCR £ 1
HEX 8400 VAR TUN 8900 VAR IMP 1 VAR PI 1 VAR PO 1 VAR P1
 1 VAR P2 1 VAR P3 1 VAR P4 1 VAR T1 1 VAR T2 1 VAR T3 1 VAR T4
 1 VAR BOF2 1 VAR BOF3 1 VAR TA 9900 VAR IMP2 9100 VAR IMP3
 0D00 CON FI 0D18 CON FD 1418 CON FU 1400 CON FO 0 VAR BOFMO
 1438 CON F1 1450 CON F2 1468 CON F3 1480 CON F4 1498 CON OF1
 14B0 CON OF2 14C8 CON OF3 14E0 CON OF4 0 VAR POFU 0 VAR POFD
 2 VAR POFHA 2 VAR POFHB

: U.CFI PI @ 1430 ! UUCF1 1430 @ PI ! ;
: I.CF   10 0 DO 0 FI 8 + I + C! LOOP 8 0 DO    FF FI I + C!
  LOOP 8 0 DO FI LOOP 80 FI C!   FD CF> FU CF> FO CF>
  F1 CF> F2 CF> F3 CF> F4 CF> OF1 CF> OF2 CF> OF3 CF> OF4 CF> ;
: TU   0 0 10 DO FU 7 + I + C@ 2*M + DUP FF > SWAP FU 7 + I
  + C! -1 +LOOP DROP  ;
: TD    0 10 0 DO FD 8 + I + C@ 2/MOD ROT + FD 8 + I + C!
  IF 80 ELSE 0 THEN LOOP DROP ;
OK
2 LIST
SCR £ 2
: TDB   0 6 0 DO FD C + I + C@ 2/MOD ROT + FD C + I + C!
  IF 80 ELSE 0 THEN LOOP DROP ;
: TRDHB  POFHB @ 0= 0= IF POFHB @ 0 DO TDB LOOP THEN ;
: CS   6 0 DO OF1 12 + I + @ 0= 0= IF I I LEAVE THEN LOOP ;
: CSCB CS OF1 12 + + 0= 0= IF DUP OF1 12 + + @ SWAP OF2 C + +
  @ = IF OF2 FD CF> TRDHB FD OF2 CF> THEN 1 THEN DROP ;
: TUA   0 0 6 DO FU B + I + C@ 2*M + DUP FF > SWAP FU B + I
  + C! -1 +LOOP DROP ;
: THUA   OF2 FU CF>  TUA TUA FU OF2 CF> ;
: THDA   OF2 FD CF>  TDB TDB FD OF2 CF> ;
: TRUHA  POFHA @ 0= 0= IF POFHA @ 0 DO TUA LOOP THEN ;
: CSCA   CS OF1 12 + + 0= 0= IF DUP THDA OF1 12 + + @ SWAP
  OF2 C + + @ = IF OF2 FU CF> TRUHA FU OF2 CF> THEN THUA
  1 THEN DROP ;
: AMS    CSCB CSCA ;
OK
3 LIST
SCR £ ?
: TRU  POFU @ 0= 0= IF POFU @ 0 DO TU LOOP THEN ;
: TRD  POFD @ 0= 0= IF POFD @ 0 DO TD LOOP THEN ;
: TOR2 TRD TRU FD 8 + FU 8 + ORCF ;
: TOR3 TRD TRU FD 8 + FU 8 + ORCF FI 8 + FU 8 + ORCF ;
: TU8  F 0 DO FU 9 + I + C@ FU 8 + I + C! LOOP 0 FU 17 + C! ;
: TD8 0 F DO FD 7 + I + C@ FD 8 + I + C! -1 +LOOP 0 FD 8 + C! ;
: TR1-2  6 0 DO TU8 LOOP TU ;
: TR2-1  6 0 DO TD8 LOOP TD ;
: TR2-P  4 0 DO TU8 LOOP TU TU TU TU TU ;
: I.PDPS  5 0 DO TUN @ 1+ LOOP PI ! P1 ! P2 ! P3 ! P4 !
  IMP @ 1+ PO ! ;
: CPU/O  PO @ 1432 ! CC4/3 1432 @ PO ! ;
: DODE   PI @ DUP @ PO @ DUP ROT SWAP ! 2+ PO ! 2+ PI ! ;
: OWT    CPU/O FU FO CF> ;
: U.CFS  U.CFI FI FU CF>  FI FD CF> ;
OK
6 TRIAD
SCR £ 6
: ?AA  PI @ 2- @ AAAA = 0= ;
: KWIT   ." Improvisation completed " QUIT ;
: ORGANUM   POFD ! POFU ! I.CF I.PDPS BEGIN DODE ?AA WHILE
  U.CFS DUP 3 = IF TOR3 ELSE TOR2 THEN OWT REPEAT DROP KWIT ;
: D1R   T1 C@ T1 1+ C@ T1 C! T1 1+ C! ;
: D2R   T2 C@ T2 1+ C@ T2 C! T2 1+ C! ;
: D3R   T3 C@ T3 1+ C@ T3 C! T3 1+ C! ;
: DU!  P1 @ DUP @ T1 ! D1R T1 @ DUP BOF2 @ 10 * + T2 ! BOF3 @
  10 * + T3 ! 2+ DUP DUP P1 ! P2 ! P3 ! ;
: STUP  I.CF POFD ! POFU ! BOF3 !  BOF2 ! I.PDPS DU! ;
: OOD1  PO @ DUP D1R T1 @ D1R SWAP ! 2+ PO ! T1 @ TA ! ;
: DOD2  PO @ DUP D2R T2 @ D2R SWAP ! 2+ PO ! T2 @ TA ! ;
: DOD3  PO @ DUP D3R T3 @ D3R SWAP ! 2+ PO ! T3 @ TA ! ;
: UDP1 F1 FI CF> P1 @ PI ! U.CFI FI F1 CF> FI OF1 CF>
  FI @ P1 ! ;
SCR £ 7
: UDOF2  POFU @ POFD @ < IF FD ELSE FU THEN OF2 CF> ;
: UDP2  F2 FI CF> P2 @ PI ! U.CFI PI @ P2 ! FI FU CF> FI F2 CF>
  TR1-2 FU FD CF> TRU TRD UDOF2 ;
```

List 3. Larger vocabulary provides organum and canon in two or three parts, variation on a theme ("melisma") and variation with accompaniment ("motet"). AMS harmonizes two of the parts.

```
: UDP3  F3 FI CF> P3 @ PI ! U.CFI FI F3 CF>
  FI FU CF> TR1-2 TR2-P FU OF3 CF> PI @ P3 ! ;
: TORCF   AMS FU CF> 8 + FU 8 + ORCF ;
: TORCF3  OF1 OF2 TORCF OF3 8 + FU 8 + ORCF ;
: UDBP   UDP1 UDP2 OF1 OF2  TORCF ;
: OIFT2  T2 @ TA @ - 1- T2 ! ;
: DOT1   P1 @ DUP @ T1 ! D1R 2+ P1 ! ;
: DIFT1  T1 @ TA @ - 1- T1 ! ;
: DOT2   P2 @ DUP @ T2 ! D2R 2+ DUP PI !  P2 ! ;
: DIFT3  T3 @ TA @ - 1- T3 ! ;
: DOT3   P3 @ DUP @ T3 ! D3R 2+ P3 ! ;
: WRAA   AAAA PO @ ! ;
: T2*    T2 @ 2* T2 ! ;
SCR £ 8
: UDRD2  T1 @ T2 @ = IF DOD1 UDBP DOT1 DOT2 ELSE T1 @ T2 @
  U< IF DOD1 UDP1 OF2 OF1  TORCF DIFT2 DOT1 ELSE DOD2
  UDP2 OF1 OF2 TORCF DIFT1 DOT2 THEN THEN OWT ;
: 2CLOOP  BEGIN  UDRD2 ?AA WHILE REPEAT WRAA  ;
: 2CANON   STUP 2CLOOP KWIT ;
: UDP2M  F2 FI CF> P2 @ PI ! U.CFI FI F2 CF> PI @ P2 !
   FI OF2 CF> ;
: UDRD.M  T1 @ T2 @ 2DUP = IF DOD1 UDP1 UDP2M DOT1 DOT2 2DROP
  ELSE U< IF DOD1 UDP1  DIFT2 DOT1 ELSE DDD2 UDP2M DIFT1 DOT2
  THEN THEN FI FU CF>  OWT ;
: MLOOP  BEGIN  UDRD.M ?AA WHILE REPEAT WRAA  ;
: MELISMA   STUP MLOOP KWIT ;
: UDRD3  T1 @ T2 @ U<  IF T1 @ T3 @ U<
  IF DOD1 UDP1 TORCF3 DIFT2 DIFT3 DOT1  ELSE T1 @ T3 @ =
    IF DOD1 UDP1 UDP3 TORCF3 DIFT2 DOT1 DOT3
    ELSE DOD3 UDP3 TORCF3 DIFT1 DIFT2 DOT3 THEN THEN  -->
fig
OK
9 LIST
SCR £ 9
  ELSE T2 @ T3 @ U<  IF T1 @ T2 @ =
    IF DOD1 UDP1 UDP2 TORCF3 DIFT3 DOT1 DOT2
    ELSE DOD2 UDP2 TORCF3 DIFT1 DIFT3 DOT2 THEN
  ELSE T1 @ T2 @ =  IF T2 @ T3 @ =
    IF DOD1 UDP1 UDP2 UDP3 TORCF3 DOT1 DOT2 DOT3
    ELSE DOD3 UDP3 TORCF3 DIFT1 DIFT2 DOT3 THEN
  ELSE T2 @ T3 @ =  IF DOD2 UDP2 UDP3 TORCF3 DIFT1 DOT2 DOT3
    ELSE OOD3 UDP3 TORCF3 DIFT1 DIFT2 DOT3 THEN
    THEN THEN THEN OWT ;

: 3CLOOP  BEGIN UDRD3 ?AA WHILE REPEAT WRAA  ;
: 3CANON  STUP 3CLOOP KWIT ;
: UDP2P  F2 FI CF> P2 @ PI ! U.CFI FI F2 CF>
  FI FU CF> TR1-2 TR2-P FU OF2 CF> PI @ P2 ! ;
OK
10 LIST
SCR £ 10
: UDBPP UDP1 UDP2P OF1 OF2 TORCF ;
: UDRD2P  T1 @ T2 @ = IF DOD1 UDBPP DOT1 DOT2 T2* ELSE T1 @
  T2 @ U< IF DOD1 UDP1 OF2 OF1 TORCF DIFT2 DOT1 ELSE DOD2 UDP2P
  OF1 OF2 TORCF DIFT1 DOT2 T2* THEN THEN OWT ;
: 2PCLOOP  BEGIN UDRD2P ?AA WHILE REPEAT WRAA  ;
: DU2!  P1 @ DUP @ T1 ! D1R T1 @ BOF3 @ 10 * + T2 !
  2+ DUP P1 ! P2 ! ;
: MOTET  BOFMO ! STUP 2PCLOOP IMP2 @ 1+ PO ! TUN @ 1+ P1 ! DU2!
  MLOOP IMP @ 1+ P1 ! IMP2 @ 3 + P2 ! P1 @ DUP @ T1 ! D1R
  T1 @ BOFMO @ 10 * + T2 ! 2+ P1 ! IMP3 @ 1+ PO ! 2CLOOP KWIT ;
OK
```

The operation of TU and TD (and, later on, TR1-2 etc) may be understood from the particular wiring sequence (chosen by chance before even translate mode has been planned) for the 128 connections to the keying registers. The three divisions of the organ for which the interface was designed are designated M1 (Manual 1 or Hauptwerk), M2 (Manual 2 or Rugpositiv) and Pedal, with 49 notes on each manual and 30 on the pedal, allocated as in Fig. 1. The odd feature of this arrangement is that a carry from the top (most-significant bit) of one register appears at the bottom of the register below it in the numerical sequence.

List 2 serves as an introduction to the larger vocabulary of List 3, in which the earlier weaknesses are corrected although Forth experts could no doubt find many more. In the shorter vocabulary, the only word which the user need know about is ORGANUM, which unlike the List 3 version does not take any parameters from the stack, so that it is necessary to edit and reload the Forth source code if different transpositions are required. In the List 3 vocabulary five words are available to the user: ORGANUM, 2CANON, MELISMA, 3CANON and MOTET, executed as described in the glossary. (Apologies for the fanciful use, or misuse, of some of these terms).

It is assumed for the harmonization rule that the improvisation is a strict duo or trio, that is, with a single line of notes on each of two or three divisions of the instrument.

An incidental point is that some of the words can be used degenerately (e.g. 0 0 0 0 MELISMA) to strip out the redundant information which can be caused by L in translate mode. The difference is not usually significant: a saving of perhaps 20% of memory.

I am indebted to Ernest Hart for

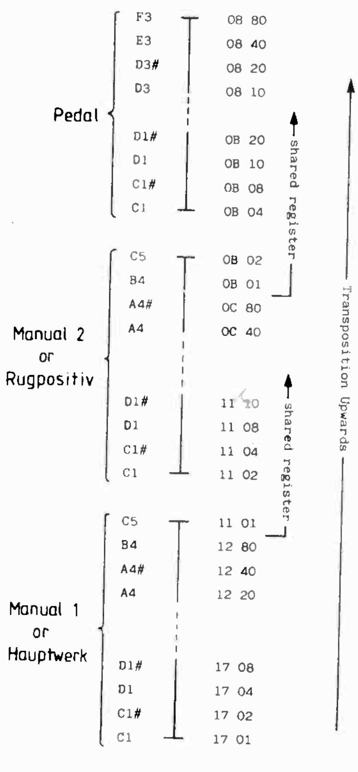

Fig 1. Allocation of the 16 keying registers. By accident rather than design, the register numbers count in the opposite sense to the bit numbers. Registers also overlap between divisions of the organ. Register and bit-number registers 0-7 are used for stops and thumb-pistons.

drawing my attention to the theme of Tallis' canon, arranged with remarkable forethought about 400 years ago to give the improvization vocabulary something to get its teeth into. The theme comprises four phases of eight notes, each having the same value. The phrases are

G G F# G G A A B
G C C B B A A G
D C A B B A A G
D E F# G B A A G

To get consistent results the theme needs to be in strict time, which can of course be achieved by the use of translate mode. If the notes are crotchets the first of each pair of repeated notes can be treated as a dotted quaver followed by a semiquaver rest. The possibilities appear endless – for example, by changing TUN and IMP one can produce an intricate three-part canon form from a melisma of a melisma of the original theme.

An improvement needed before the vocabulary is developed any further is to provide buffers in the console fields, between the three divisions of the organ, to avoid the ambiguities which can occur at the extremes due to the shared registers (Fig. 1). The structure of the two-part words could also be improved to provide any of the three permutations, and more could be done to provide variation of speed between parts, rather than just having T2* in UDRD2P. Beyond that, some rules for the movement in pitch of one part in relation to another might be useful. WW

Glossary

Variables

TUN start of input (theme) data field.

IMP, IMP2, IMP3 start of output (extemporization) data fields.

PI temporary pointer in input data field.

P1, P2, P3 pointers in input data field for the first, second and third parts.

T1, T2, T3 durations for the three parts, taken from the input data field and corrected for the movement of each part.

BOF2, BOF3 beat offsets for the second and third parts in semiquavers (units of 16 frames).

TA duration actual (relating to the output data field, to which the individual parts are referenced).

POFU, POFD pitch offsets (up and down) for Manual 2 part, in semitones.

POFHB, POFHA pitch offsets for harmonization rule, in semitones.

Constants define start addresses but their names are used for the fileds themselves

FI, FD, FU, FO input, transpose down, transpose up and output console fields (FU is also used as the most recent field for CPU/O. For this use, FO and FU are equivalent to console fields 1 and 2 in read mode).

F1, F2, F3, OF1, OF2, OF3 input and output console fields for each part.

Vocabulary
Words written in machine code

UUCF1 Update input console field FI (take pointer from scratchpad).

ORCF OR two console fields as specified by two stack parameters, leaving result on one of them (as specified by the second parameter).

CC4/3 compare FU with FO and read keying information to output data field (takes pointer from scratchpad).

CF> Transfer console fields as specified by two stack parameters.

2/MOD nine-bit divide by two (using Shift Right Logical).

2*M nine-bit multiply by two (using Shift Left Arithmetic).

Words written in and compiled by Forth

In some cases the explanation of a word is preceded by the pronounciation of its name.

U.CFI transfer PI to and from scratchpad for UUCF1.

I.CF initiate console fields.

TU transpose FU up one semitone (note – bit numbers increase but register numbers decrease with increase in pitch).

TD transpose FD down one semitone.
(see subheading Harmonization between M2 and M1 for screen 2 including AMS).

TRU transpose FU up POFU semitones.

TRD transpose FD down POFD semitones.

TOR2 TRD then TRU; OR FU and FD; leave result on FU.

TOR3 TRD then TRU; OR FU and FD; OR result with FI and leave it on FU.

TU8 transpose FU up eight semitones.

TD8 transpose FD down eight semitones.

TR1-2 transpose from M1 (Manual 1) to M2 (Manual 2).

TR2-1 transpose from M2 to M1.

TR2-P transpose from M2 to Pedal.

I.PDPS initiate pointers.

CPU/O transpose PO to and from scratchpad for CC4/3.

DODE do delay. Transfer duration from input to output data field.

OWT write to output data field. CPU/O and transfer FU to FO, ready for next FU.

U.CFS update FI and transfer it to FD and FU.

?AA query AA. Check whether the end of the input data field has been reached, usually by P2.

KWIT write "improvization completed" to VDU, then QUIT.

ORGANUM write output data field as parallel organum in n parts, from IMP. Execute as n POFU POFD ORGANUM (n = 2 or 3).

D1R reverse bytes of T1 to put l.s.b. first.

D2R, D3R complementary to D1R.

DUI store initial values of duration variables T1, T2 and T3 with beat offsets (BOF2, BOF3) for the second and third parts; update pointers.

STUP start-up (takes four variable values from stack).

DOD1 do duration 1. Write duration for first part to output data field and update TA.

DOD2, DOD3 complementary to DOD1.

UDP1 update console fields and pointer associated with first part (F1, OF1 and P1).

UDOF2 update OF2. Take FD as OF2 if POFU is less than POFD, otherwise take FU.

UDP2 update F2 and P2, then transpose the second part to M2 and by POFU or POFD, then update OF2.

UDP3 update F3, then transpose the third part to Pedal, then update OF3 and P3.

TORCF AMS, then transfer and OR two console fields (e.g. OF1 and OF2 for two-part canon) leaving result on FU.

TORCF3 similar to TORCF, but then adding the third part for three-part canon.

UDBP update both parts when both change together in two-part canon, then TORCF.

DIFT1 difference T1. Update T1 by TA to correspond with changes in parts 2 and 3.

DIFT2, DIFT3 complementary to DIFT1.

DOT1 do T1. Fetch the new value of T1 from input data field and update P1.

DOT2, DOT3 complementary to DOT1, but DOT2 also sets PI temporarily to stop the improvisation when P2 reaches the end of the input data field.

WRAA write AA AA as final duration in output data field.

T2* multiply T2 by two to make the pedal part play at half speed (see 2PCLOOP).

Two-part canon

UDRD2 update registers and durations for two parts. Write information to one frame of output data field for either part, or both, as appropriate.

2CLOOP two-part canon loop. UDRD2 until end of input data field is reached by PI (= P2, see DOT2).

2CANON write output data field as two-part canon; from IMP. Execute as BOF2 0 POFU POFD 2CANON. (Either POFU or POFD may be used, the other being zero, e.g. 20 0 7 0 2CANON will transpose the M2 part up by seven semitones).

Melisma

UDP2M update F2, P2 and OF2, without the transposition to M2.

UDRD.M update registers and durations for one frame of output data field as a single line from two input parts separated by BOF2.

MLOOP melisma loop. UDRD.M until the end of input data field is reached by PI (= P2, see DOT2).

MELISMA write output data field as cariation on the theme, from IMP. Execute as BOF2 0 0 0 MELISMA.

Three-part canon

UDRD3 update registers and durations for three parts. Write information to one frame of output data field for any part, any two parts, or all three, as appropriate.

3CLOOP three-part canon loop. UDRD3 until end of input data field is reached by PI (= P2, see DOT2).

3CANON write output data field as three-part canon, from IMP. Execute as BOF2 BOF3 POFU POFD 3CANON. (Either POFU or POFD may be used, the other being zero).

continued on page 43

Current followers

Adaptable universal op-amp can be used in any of four basic configurations

by F. J. Lidgey
Ph.D., B.Sc., M.I.E.E.

The conventional operational amplifier such as the 741 type is a very high voltage-gain stage, the single-ended output voltage being proportional to the difference voltage between the two input terminals. This basic amplifier is easily configured into two gain stages, a trans-resistance stage and a voltage-gain stage, as shown in Fig. 1.

It is not so simple to configure the conventional operational amplifier to produce a current gain stage with well-defined current transfer ratio, low input impedance and high output impedance; nor a transconductance amplifier with well-defined transfer ratio, high input impedance and high output impedance.

There have been a number of proposals to develop a universal operational amplifier which has a differential input and a differential output. Such a circuit has the distinct advantage that it may be configured into any of the four basic amplifier stages without the complex multiple-pair resistor-matching requirements that typify many current and transconductance amplifier circuits using conventional operational amplifiers.

Current-follower characteristics

A current follower is a circuit with extremely low (ideally zero) input impedance and an extremely high (ideally infinite) output impedance. The net performance when used with a signal source is to produce a current drive to a load equal in value to the short circuit current obtainable from the input signal source, as shown schematically in Fig. 2 (a). In contrast, Fig. 2 (b) shows the better known voltage follower. Comparing the two shows that the current follower is the antithesis of the voltage follower.

Practically, it is simple to configure the standard operational amplifier as a voltage follower, it being merely a special case of the voltage amplifier shown in Fig. 1. However, realisation of a current follower is not so straightforward. Nordholt* has shown that a current follower may be constructed using a balanced current source and sink with two series-connected Zener diodes strapped across the supply pins – Figure 3 (a) shows a schematic of the circuit. The result is that the amplifier is effectively biased with floating d.c. supplies and the circuit behaves as a conventional operational amplifier, with the exception that it has a differential output as well as input. This basic building block can be configured into almost any type of amplifier, as shown by Nordholt. In this article, attention is restricted to using this differential-input, differential-output operational amplifier as a current follower, as shown in Fig. 3 (b).

Practical current follower

Taking the circuit of Fig. 3 as a basis, I built the current follower shown in Fig. 4 for evaluation purposes. It is not suited for direct implementation as an integrated circuit, but it is feasible to produce a similar performance from a circuit which could be manufactured relatively easily as a single-chip device.

The section of the circuit associated with OA_1, Tr_1, D_1 and R_1 produces a constant-current source of about 20mA. Similarly the circuitry associated with OA_2, Tr_2, D_2 and R_2 produces a constant current sink of about −20mA. The potentiometer in the current source bias network provides trimming of the source to enable the output offset to be reduced to zero. The load current is limited by the maximum output available from the operational amplifier; for example, if OA_3 is a 741, then the limit is approximately ± 10mA.

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Analysis of the current follower

An incremental equivalent circuit of the current follower is shown in Fig. 5, the operational amplifier being modelled by the input impedance of R_i (typically $1M\Omega$), output impedance of R_o (typically 100Ω) and dependant generator $A.V_i$ in the output circuit, where A is

$$A=\frac{A_0}{(1+jf/f_p)}$$

A_0 is typically 10^5 or so and f_p is the internal compensation pole, typically at 10Hz, giving the amplifier unconditional stability when used with any value of resistive feedback. The amplifier's bias network is assumed to be ideal, giving a full differential input/output performance.

From the diagram the input current i_{IN} is

$$i_{IN} = i_{OUT} + i_i = i_{OUT} + v_{IN}/R_i \qquad (1)$$

Solving Kirchhoff's voltage law gives the input voltage

$$v_{IN} = -A.v_{IN} + i_{OUT}\,(R_o + R_L). \qquad (2)$$

Combining equations (1) and (2) to eliminate v_{IN}, the current transfer ratio is obtained,

$$i_{OUT}/i_{IN}=\frac{1}{1+(R_o+R_L)/R_i(A+1)} \qquad (3)$$

Generally $R_i\,(A + 1) \gg (R_o + R_L)$ and so

$$i_{OUT}/i_{IN} \approx 1 \qquad (4)$$

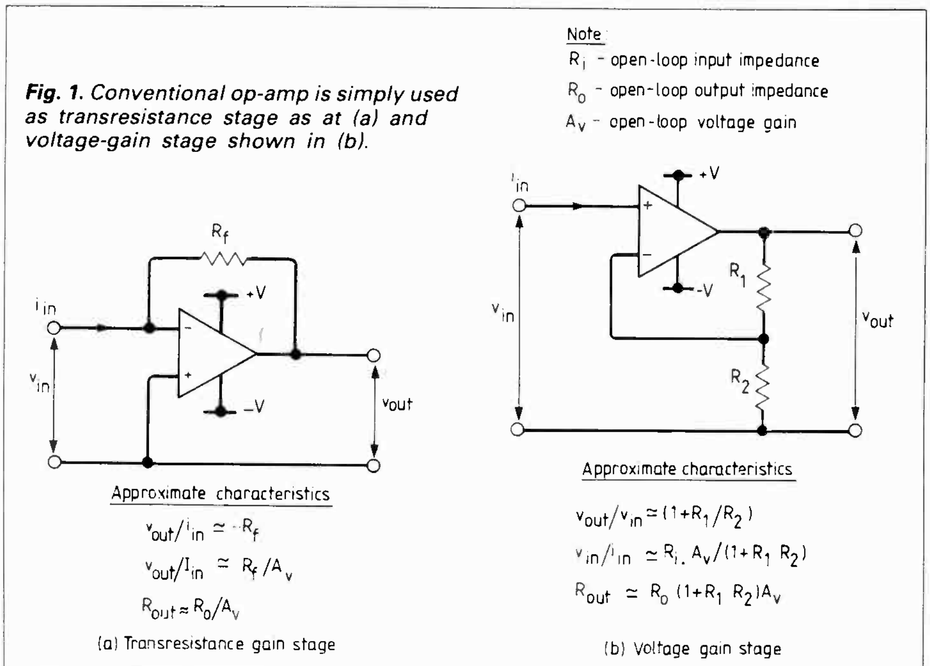
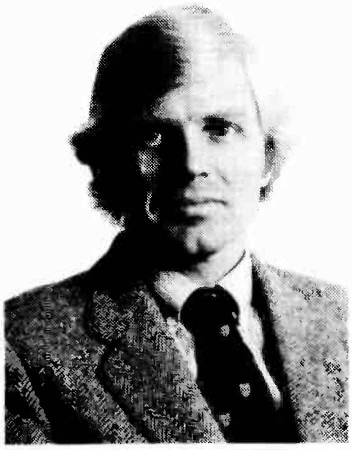


Fig. 1. Conventional op-amp is simply used as transresistance stage as at (a) and voltage-gain stage shown in (b).

* Nordholt, E. H. Extending Op-Amp Capabilities by using a Current-Source Power Supply.' *IEEE Trans. Circuits and Systems*, vol. CAS-29, no. 6, June 1982.



John Lidgey is Principal Lecturer in Electronics in the Department of Engineering at Oxford Polytechnic. He completed his Ph.D. in microwave electronics at Surrey University in 1973. After a period of four years teaching electronics at the University of Newcastle, Australia, he returned to England to take up his present post. His interests include design of microwave oscillators and the design and applications of operational amplifiers. He is also actively engaged in industrial electronics consultancy at the Polytechnic.

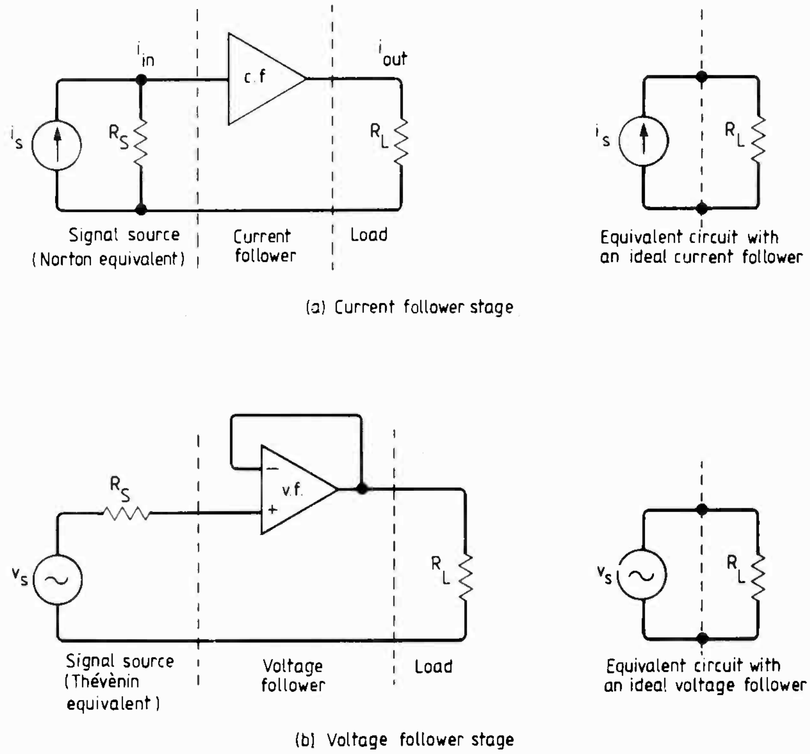


Fig. 2. *Current follower at (a) produces current into R_1 equal to current available into short circuit from i_s. Voltage follower at (b) ideally provides voltage across R_1 equal to open-circuit voltage from source.*

Using the binomial expansion, equation (3) gives

$$i_{OUT}/i_{IN} \approx (1 - E) \quad (4)$$

where $E = (R_o + R_L)/A(A + 1)R_1$ is the error in the current follower from the ideal. To assess the accuracy of the current follower E can be evaluated for particular values of the circuit components. For example, taking the typical values stated earlier for the operational amplifier gives the d.c. value of E as

$$E = 10^{-8}\,(1 + 0.01\,R_L)$$
$$E = 1.01 \times 10^{-7} \text{ for } R_L = 10k\Omega$$

The accuracy of the circuit is clearly excellent at low frequencies; however, the performance degrades at the higher frequencies where the product of $(A + 1).R_i$ reduces due to the high-frequency roll-off in the operational amplifier gain A.

Whilst equation (3) above is correct for the ratio of output current to input current the input current i_{IN} will not be equal to the Norton equivalent signal source current, i_S, unless the input conductance is infinite.

Referring to the circuit of Fig. 2 (a), the

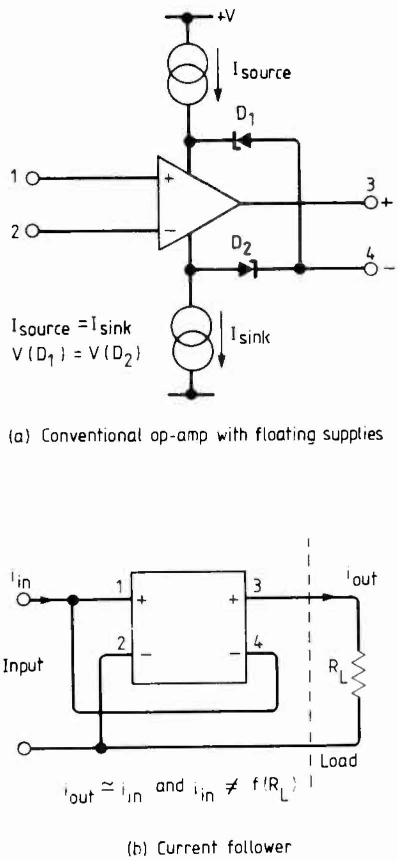
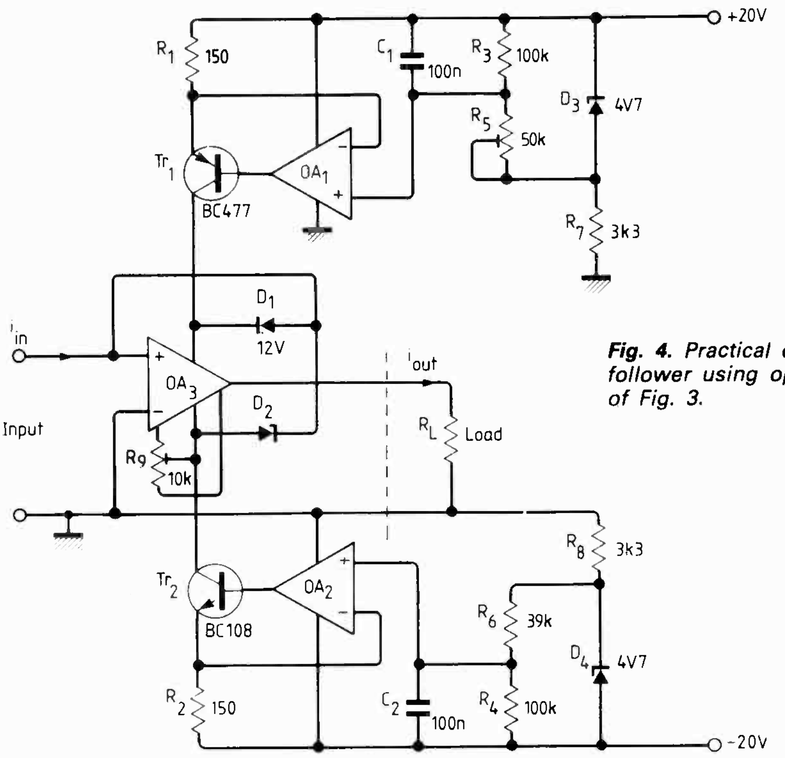


Fig. 3. *Op-amp using floating power lines and giving effective differential output. Current follower arrangement shown at (b).*



Note: $OA_{1,2,3}$ -741; OA_3 offset pot is trimmed to zero the output when the input is short-circuited and R_5 is used to zero the output when the input is open-circuited.

Fig. 4. *Practical current follower using op-amps of Fig. 3.*

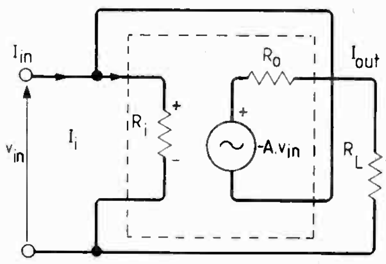


Fig. 5. Incremental model of current follower of Fig. 4.

significant parameter for assessment of the current follower is the ratio i_{OUT}/i_S. Now

$$i_{OUT}/i_S = (i_{OUT}/i_{IN}).(i_{IN}/i_S) \qquad (5)$$

and clearly one also needs to evaluate the second term i_{IN}/i_S. From Fig. 2 (a)

$$i_{IN}/i_S = R_S/(R_S + Z_{IN})$$

where $Z_{IN} = v_{IN}/i_{IN}$.
From equations (1) and (3), the input impedance Z_{IN} is given by

$$1/Z_{IN} = 1/R_i + (A + 1)/R_o + R_L) \qquad (6)$$
$$\therefore Z_{IN} \sim (R_o + R_L)/(A + 1) \qquad (7)$$

as the second term of the r.h.s. of equation (6) is dominant. Taking (4), (5) and (7) gives

$$i_{OUT}/i_S \sim R_S/R_s + (R_o + R_L)/(A + 1)) \qquad (8)$$

Equation (8) shows that if the operational amplifier gain A is high then the follower will behave almost ideally, i.e. $i_{OUT}/i_S = 1$. But, if the operational amplifier is a utility device with dominant-pole compensation, then by combining equations (3) and (8) the complete current transfer function is obtained

$$i_{OUT}/i_S = \frac{(1+jf/f_z)^2}{(1+K_1/(A_0+1))(1+K_2/(A_0+1))(1+jf/f_{p1})(1+jf/f_{p2})}, \qquad (9)$$

where $f_z = f_p(A_o + 1)$ is voltage gain-bandwidth product of the operational amplifier (GB), $K_1 = (R_o + R_L)/R_S$, $K_2 = (R_o + R_L)/R_i$,

$$f_{p1} = \frac{(A_0+1+K_1)}{(1+K_1)} \cdot f_p;$$

and $$f_{p2} = \frac{(A_0+1+K_2)}{(1+K_2)} \cdot f_p.$$

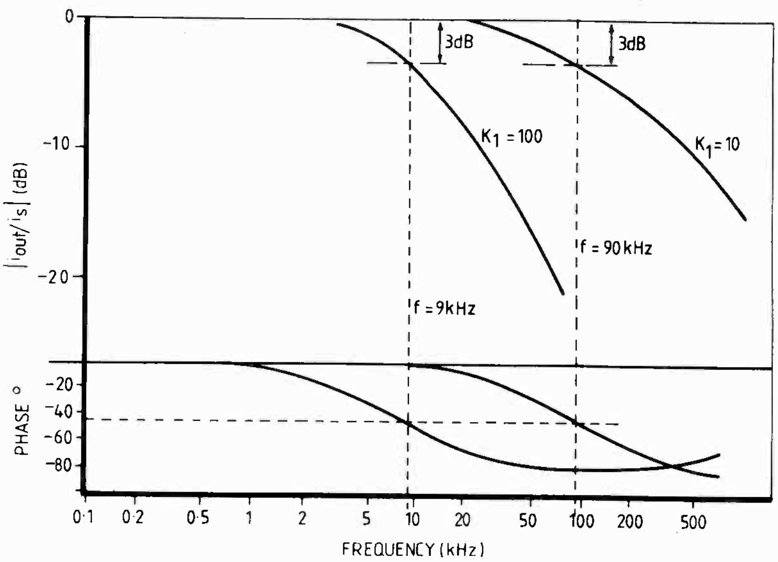


Fig. 6. Frequency response of current follower shown in Fig. 4.

It is likely that R_i, the input impedance of the operational amplifier, will be significantly higher than $(R_o + R_L)$ and so K_2 tends to zero and equation (9) reduces to

$$i_{OUT}/i_S \approx \frac{(1+jf/GB)}{(1+K_1/(A_0+1))(1+jf/(GB/K_1))} \qquad (10)$$

and for $K_1 \ll A_o$ this expression reduces still further to

$$i_{OUT}/i_S \approx 1/(1 + jf/GB/K_1) \qquad (11)$$

giving a -3dB frequency of $f = GB/K_1$.

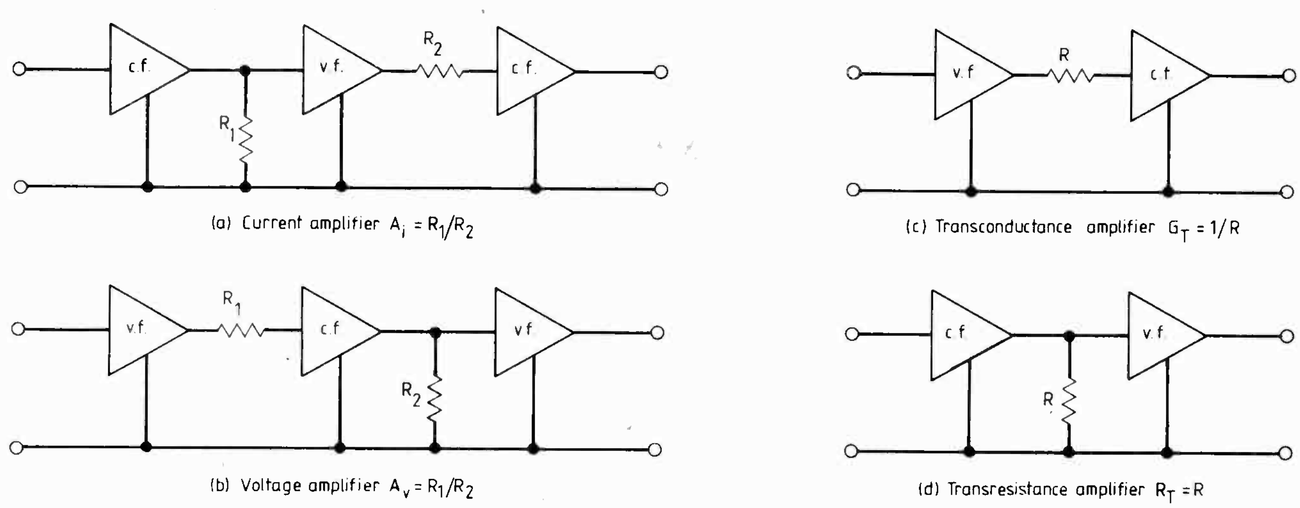
Figure 6 shows a plot of the current transfer function for the circuit of Fig. 4 using two different values of K_1. The performance of the follower is good, with measured upper -3dB frequencies in close agreement with the theoretical value predicted from equation (11).

Fig. 7. An i.c. with two current and two voltage followers would enable any of these circuits to be easily obtained.

Proposed general-purpose 'follower' amplifier

Using current followers and voltage followers as basic building blocks it is feasible to develop an extremely useful quad operational amplifier, the proposed circuit containing two voltage followers and two current followers. With this general-purpose integrated circuit it can be configured very easily into any of the four basic amplifier types.

Figure 7 shows the circuit diagrams for a current gain stage, a voltage gain stage, a transconductance and a transresistance stage based on the proposed follower i.c. As an example, examine the first shown, which is a current amplifier. The input into the first current follower provides a low input impedance and drives the input current through resistor R_1, converting the input into a voltage drive. The second drive of the amplifier is a voltage follower which transfers the voltage $i_{IN}.R_1$ to a low-impedance voltage source driving into R_2. As the third stage is a current follower with



(a) Current amplifier $A_i = R_1/R_2$

(c) Transconductance amplifier $G_T = 1/R$

(b) Voltage amplifier $A_v = R_1/R_2$

(d) Transresistance amplifier $R_T = R$

low input impedance, the input current drive to this third and final stage is $i_{IN}.R_1/R_2$, which is equal to the output current feeding the load R_L with

$$i_{OUT} = R_1/R_2 \ \ i_{IN}$$

and clearly the current gain is

$$A_i = R_1/R_2$$

Using this same approach it is relatively easy to verify the remaining three basic amplifier circuits shown in Fig. 7.

This proposal for a general-purpose 'follower' operational amplifier is extremely simple to configure into any type of analogue amplifier. Feedback is localized to each follower, there being no output to input feedback.

As a result, any phase lag from input through to output is insignificant in terms of controlling the stability of each of the amplifiers. The frequency response will depend somewhat on the values of voltage and current-defining resistors, but no instability is likely to be encountered if each of the followers is internally compensated, and a broad bandwidth is possible with careful choice of resistor values. It is interesting to note that none of the resistors are used as feedback components but as voltage-to-current and current-to-voltage converters.

It is feasible for a single i.c. to be constructed with two voltage followers and two current followers on the chip, thus providing a general purpose quad operational amplifier. With such an i.c. any of the circuits of Fig. 7 can then be constructed, the only additional components required being a maximum of two fixed resistors.

Thanks to R. D. Coombes and C. Toumazou for the experimental evaluation of the follower. WW

Microcomputer organ interface

Glossary continued

Two-part accompaniment

UDP2P	similar to UDP2, but the second part is transposed to Pedal.
UDBPP	similar to UDBP but with one part in Pedal.
UDRD2P	similar to UDRD2 but one part (Pedal) moves at half the speed of the other.
2PCLOOP	two-part accompaniment loop. UDRD2P until end of input data field is reached.

Motet

DU2I	store initial values of duration variables T1 and T2 for motet, after accompaniment has been written
MOTET	write output data field as "motet" in three parts, from IMP3. Firstly write the two-part accompaniment, from IMP2, then write Melisma from IMP, then combine the two witrh offset BOFMO, from IMP3. IMP3 < IMP2 so that the accompaniment might be overwritten. Execute as BOF2 BOF3 POFU POFD BOFMO MOTET (BOF2 is for the accompaniment, BOF3 for the melisma).

Harmonization between M2 and M1 (see Fig. 1 and associated text on register allocation. CSCB and CSCA are not symmetrical because of the one-bit offset between corresponding notes in M1 and M2, e.g. HC3 is 1401 and RB2 is OEO1. In these names above (and below) essentially mean "assume the M2 part is above (or below) the M1 one". Hence the curious name for THDA, which transposes the M2 part **down** (temporarily) to see whether it was **above** the M1 part).

TDB	transpose down below. Transpose the M2 part of FD down one semitone.
TRDHB	transpose down harmonization below. TDB by POFHB semitones.
CS	check semitones. Find which byte if any in the M1 part of OF1 is non-zero.
CSCB	correct semitone clash below. Compare the active byte (if any) in the M1 part of OF1 with the corresponding one in the M2 part of OF2. TRDHB if the M2 part was a semitone below the M1 one (i.e. if the bytes were equal).
TUA	transpose up above. Transpose the M2 part of FU up one semitone.
THUA	transpose harmonization up above. TUA OF2 twice. (See CSCA).
THDA	transpose harmonization down above. TDB OF2 twice.
TRUHA	transpose up harmonization above. TUA by POFHA semitones.
CSCA	correct semitone clash above. Compare the active byte (if any) in the M1 part of OF1 with the corresponding one in the M2 part of OF2. TRUHA if the M2 part was a semitone above the M1 one (THDA makes such bytes equal, THUA restores the offset).
AMS	augment minor seconds. CSCB then CSCA. (If POFHA = POFHB = 2, minor seconds between the M1 and M2 parts are augmented, i.e. turned into minor thirds).

IEEE488 interface

the signal generator to cease listening.

Line 150 commands the digital voltmeter to talk and line 160 obtains a voltage reading from the digital voltmeter as a string of ASCII characters. Line 170 commands the digital voltmeter to stop talking.

Line 180 converts the amplifier output voltage reading as an ASCII string to the amplifier's response in dB. Line 190 selects the disc filing system and line 200 prints the results to disc.

Line 210 reselects the IEEEFS for further measurements; lines 230 and 240 cancels the reference to the digital voltmeter and signal generator; and lines 250 and 260 close the results file on the disc.

For assembler programmers, all the IEEE commands are available through a single operating system OSWORD call which makes use of a command code in the parameter block.

For users who wish to simulate a simple talker-listener device, i.e. one not possessing the control function, the option select link must be changed to the not-system-controller position and the TMS9914A programmed directly. The excellent Texas Instruments TMS9914A General-Purpose Interface Bus (GPIB) Controller Data Manual contains all the information required to do this.

Every effort was made in the design of the interface and the writing of the User Guide to facilitate the use of IEEE488 instruments by the occasional user of the BBC Microcomputer and it is hoped that this article gives some idea of the potential of this powerful combination. WW

Literature received

An eight-page catalogue from Lascar Electronics describes the company's range of digital panel meters, which include l.e.d. and l.c.d. voltmeters with 3½ and 4½ digits and a choice of six- or eight-digit counter-timers. Lascar Electronics Ltd, Module House, Whiteparish, Salisbury.
WW 401

Maplin Electronics' 1984 catalogue runs to over 500 pages. For the first time it includes construction kits and educational courses by Heathkit, whose products Maplin now distribute. The catalogue is available from branches of Maplin or W. H. Smith for £1.33, or by post for £1.65 from Maplin Electronic Supplies Ltd, PO Box 3, Rayleigh, Essex SS6 8LR.
WW 402

The 1984 edition of *Hobby Herald*, BICC-Vero's catalogue of products for the hobbyist, lists several new items among which are some insulation-displacement connectors for use with ribbon cable and a range of British Telecom-style pluggable telephone connectors. *Hobby Herald* costs 50p from BICC-Vero Electronics Ltd, Industrial Estate, Chandlers Ford, Hampshire SO5 3ZR. Tel. 02415-62829. **WW 403**

More than 2½ million components are held in stock by Comway who have recently issued the 11th edition of their catalogue. It not only lists the available components but also has some useful specification and dimensional details. Along with semiconductor devices and microprocessor development systems is a range of connectors, switches and other hardware, Comway Ltd, Market Street, Bracknell, Berks RG12 1QP.
WW 404

LETTERS

BUS STANDARDS

I was pleased to see the article on the IEEE 696 (S1000) Standard in the December issue. I congratulate the author on an interesting and informative article. In passing, the author mentioned several other IEEE standards activities: 796, 896 and the Euro-STD bus; unfortunately, some of the information presented was out of date. I would like WW readers to be informed of the current status of these activities:

The Euro-STD bus evolved into the STE bus because the working group could not reconcile the signal specification of the STD bus with their goals of processor independence and longevity of the standard. The IEEE standards board approved the PAR (project authorization request) number P1000 to the working group in February, 1983. The P1000 specification now provides 20 address bits, 8 data bits, and a simple, but processor independent, asynchronous handshake. P1000 recommends single Eurocards and uses the IEC603-2 (DIN41612) connector. It is intended primarily for use in cost-sensitive applications which still require the modularity afforded by a bus. The P1000 draft is due to be voted out of the working group for public comment in January 1984. Information on the current status of the P1000 standard may be obtained from the European secretary: Timothy Elsmore, GMT Computer Systems, Newport House, 22 Hartfield Road, London SW19 3TD. I should point out that although the original Euro-STD bus is not now an IEEE effort, it is still the basis of several commercial products. GMT Computer Systems manufacture and market boards to the original Euro-STD bus specification.

The P796 (Intel's Multibus) specification (incorrectly called A796 in the article) was approved by the IEEE standards board along with the P696 specification in December 1982. Copies of both the 696 and 796 standards may be obtained from: IEEE Service Center, Attention CP Dept, 445 Hoes Lane, Piscataway, New Jersey 08854, USA.

The VME bus has been the subject of IEEE standardization efforts since January 1983. The IEEE standards board issued the PAR number P1014 for the 'versatile backplane bus' (VME) in September 1983. The P1014 working group are currently re-writing the VME specification in the IEEE standards format, and expect to complete their work in early 1984. Information and current status of the P1014 activity may be obtained from the Chairman: Wayne Fischer, 82 Shereen Place, Campbell, California 95008, USA.

The IEEE P896 work has progressed much further than is suggested in the article. Indeed, the work has now been completed and a proposed specification is available. The P896 working group voted to release their completed draft for public comment in September 1983. P896 is a very high performance backplane bus providing a 32-bit highway governed by a fully asynchronous and technology independent protocol. Although P896 has a decentralized arbitration scheme, multiple bus locking features, and an independent serial highway, making it ideal for fault-tolerant systems, it is primarily intended for high-performance general-purpose multiprocessor systems. P896 provides its complete signal-set on a single IEC603-2 (DIN41612) connector, and is intended for use on double and triple Eurocards up to 280mm deep. The UK IEE hosted a colloquium on the P896 specification in London on November 29 to provide UK industry with advance information on this potentially far-reaching standard.* Information on the P896 draft specification may be obtained from Andrew Wilson, Computing and Control Division, IEE, Savoy Place, London WC2R 0BL.

UK involvement with the IEEE bus activities is co-ordinated by the IEE Working Party on Backplane Buses at the IEE address given above. Other work on microprocessor standards is carried out in the BSI Committee ECL/OIS-1. I should like to point out to *Wireless World* readers that participation in (particularly the IEEE and IEE) standardization activities, is open to anyone who has the time and energy, as well as the technical knowledge, to contribute to these standards.

Paul L. Borrill
IEEE Microprocessor Standards Committee

* Reported in News January issue, page 45. Please read IEE for IEEE in line 10 of that item. – dep. ed.

BEHIND THE MICRO

From my experience when buying a micro a year ago, it seems that you make no mention of the biggest single difficulty confronting someone trying to choose a suitable machine. I do not expect you to overcome this difficulty, but it would have been wise if you had printed the very prominent warning "Many manufacturers' specifications are barely true and are carefully designed to mislead".

I wanted a machine for mathematical work, and was looking for something which you would describe as being in the basic price range of £2,000 to £3,000, i.e. a complete price of perhaps £10,000. I will give you two examples of misleading specifications. One manufacturer claimed to supply Fortran, but it did not emerge until late in the discussions that this was a very cut down subset of Fortran, lacking some essentials such as double precision variables. Another manufacturer said that Fortran was available on his micro, but it emerged that it was necessary to compile the source code on a bigger machine of his, and then transfer the object code to the micro. One manufacturer never mentioned this snag in any of his literature; the other one only mentioned it in very small print on a part of the sheet where you would not expect to find such information. A specialist dealer who stocked one of the machines was completely unable to understand (and still less to answer) technical questions in the area of languages.

In short, to get reliable information on which to base a rational choice is exceedingly difficult.

J. G. D. Pratt
West Horsley
Leatherhead

AURAL COGNITION

I owe many thanks to D. Wattson (Letters, September 1983) for the extraordinary precision with which he has stated the problem of aural interfacing between a cognitive biological unit (the brain and/or whatever else) and a multinoise environment.

It gave me the idea that if the buffering stated therein cannot be implemented with hardware, nature most probably resorts to software. The idea may appear original, but it is not mine. It appeared initially in the *WW* editorial of January 1982, viz. that nature interfaces with humans through programming. In the case of aural cognition, I think, nature makes use of variable microprogramming techniques, that obviously, like instruments, we are destined to utilize but are not yet able to understand.

Some experimental hints along these lines. A person (or animal) may be microprogrammed to fall asleep in a sound-polluted environment. Subsequent silence will set the flags of software interrupt, overflow will occur, forcing awakening. A second example: People exist that hear voices. Maybe flow of the microprogramming instructions energizes the interface (the ear) by an output, which bounces and returns to the unit, masqueraded as input. In this respect the program generates virtual inputs that do not manifest elsewhere in the world.

I began setting up experiments along similar lines. And I have had another idea: Declare the computer a severe mentally-handicapped configuration. Then program (microprogram will be the final objective) it toward cognitive research; e.g. the computer having memorized via transducers the sounds "a" and "b" to search in real time a stream of words and let all phonemes other than "ab" pass through unmemorized, but to operate software interrupt when there is "ab" or seems to be. It will not be easy.

G. Xenoulis
Toronto
Ontario

THE PERSUADERS

Your editorial in the October issue whilst putting forward a valid point of view was nevertheless somewhat confused.

Truth is absolute and can be neither accentuated nor minimized. Morality is a function of truth and therefore has no degree nor shades of grey, less than moral is immoral and morality is what we should be concerned about.

The society in which we live is immoral, as are all societies because they deny all human beings that most fundamental of human rights, the truth.

Education must be defined as teaching the truth and the methods by which truth can be comprehended.

Therefore it is evident that we do not educate our young, rather we indoctrinate them with the dogmas of our current society, paying little regard as to the relevance of our teachings to the truth.

The minds of children are naturally dedicated to the process of determining the truth but the continual brainwashing together with the instilling of irrational fear stimulates a child's emotions and inhibits logical thinking.

This is no more apparent than when following puberty the teenager exhibits a somewhat confused pattern of behaviour.

To achieve a moral society we must assert our dedication to the truth, to logic and discipline our emotions to the role of slave, not master.

By believing in illogical dogmas whether religious, political or whatever, we abdicate our responsibilities to the human race.

Norman Webster
Leyland
Lancashire

FOWBERRY ENERGY SAVER

It is good to see engineers turning their skills to the saving of natural resources, so I was pleased to read of Mr MacHarg's device which is saving energy in Fowberry Tower*. I too have been devoting some time to this subject, so I hope he will not object to me offering some comments.

I do not feel that the question of thermal lag and temperature overshoot is the fundamental one. After all the system, overshoots and all, is set up to give the desired average temperature, usually about 80°C, and the water temperature cycles by a few degrees about this. The temperature of the gas side of the heat-exchanger may briefly overshoot further, but the associated stored energy is small.

It seems to me that the main achievement of the Fowberry energy saver, as illustrated in Fig. 1, is to reduce the boiler temperature as demand falls. This must be a valuable objective. The 80°C set-point is appropriate for full output, either in extreme weather or when a rapid increase in temperature is required. Under normal steady conditions in the most common mild, damp weather, the heat demand is much less than this. To avoid guarantee claims, heating installers err on the side of over-capacity, and as fuel costs increase house occupiers improve their heat conservation. The result is a lot of powerful boilers running at a fraction of their full output. On a day when the outside temperature was 7°C my gas boiler was running with a duty cycle of 20%. Its own constant loss at 80°C is 7.5%, so over 37.5% of the input was going straight up the flue!

The efficiency, especially at part load, will be improved if the boiler temperature is reduced. A simple-minded calculation on my above example, assuming flue losses proportional to the temperature difference between the boiler and the combustion air, suggests that the boiler could be run at 32°C if the house is at 20°C, giving 20% of the fixed losses. Even if this is over-optimistic, and if boiler temperature has to be kept up to avoid corrosive condensation, the potential for saving is considerable.

I too considered using thermostat off-time as a measure of heat demand. The problem is that it is an awkward function of heat demand so an open-loop strategy which does not use a fairly accurate model will give far from optimal results. Hence in Fig. 1 only a 10°C reduction in boiler temperature has been achieved at most. What is needed is a variable which will respond to changes in boiler temperature, so that a closed-loop strategy may be employed.

The philosophy I have arrived at is to compare radiator flow and return temperatures. Assuming thermostatic valves on all radiators, the return temperature is 10-20°C below flow temperature with valves fully open, falling quite sharply towards room temperature as they commence to control. The economiser cuts off the boiler if this differential exceeds a limit of around 30°C and brings it back on when the differential falls to about 5°C, the pump staying on constantly. The result is a limit-cycling controller which adapts boiler temperature to hold the differential at an average of 17.5°C with the highest-set thermostat wide open. There is an overide when hot-water heating is demanded, since this is best served by a short interval at 80°C.

I have tested this scheme briefly using my ZX81 as the controller, and it certainly reduces average boiler temperature on a mild day to around 40-50°C. Heating time from cold and response to sudden valve-opening are unimpaired, the boiler temperature going straight to 80°C until the disturbance is corrected.

Because the ZX81 obliterates Radio 3 and crashes a little too frequently I am now building an analogue version (two i.cs) for a long-term trial, to see whether the potential 50% loss reduction is achieved.

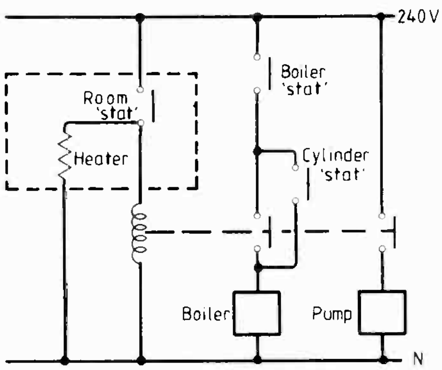
The possible improved performance over the Fowberry device is achieved at the cost of some convenience, since temperature sensors have to be fitted in the appropriate part of the system. It is only applicable where radiator thermostats are fitted. Systems with a single room thermostat inherently adapt the average boiler temperature to demand, but the lack of temperature control in the other rooms causes overheating, discomfort, or both.

C. Hargis
Bristol

* Diode D_5 should be reversed in the circuit on page 27 (December). The 78L12 i.c. regulates a 12-volt rail and not 5V as shown. Mr MacHarg tells us that capacitors C_3, C_6 and C_7 must be low-leakage types.

The pulsing boiler controller described in Mr MacHarg's article (December issue) possesses some disadvantages. If one increases the thermostat setting during a period of pulses of reducing width it must be irritating to have to wait whilst the controller decides that the boiler should run for longer bursts. The "short cycling" that a pulsing controller of this type produces is not desirable – supply dips – boiler condensation – wear and tear on the boiler starting gear – thermal expansion stresses etc.

An alternative that I have had in use for some



years uses one relay and is arranged to fire the boiler if the boiler thermostat and the room thermostat or the cylinder thermostat call for heat. Judicious selection of a boiler start-up time delay which "grades" with the room thermostat heater time lag will ensure that "short cycling" of the boiler will not occur.

In normal operation the boiler thermostat will only switch off when no room heating is required ie in warm weather. Boiler control is usually carried out by the room thermostat relay.

J. R. Ball
Timperley
Cheshire

The author replies

Everything introduced by man into his domain provides disadvantages (not the least the sheer expense of convenience), and the problem is always to reduce untoward priorities which are in effect resonances: integration is made easier by increasing frequency which tends to avert catastrophe by reducing big swings into little roundabouts. Firstly, I ask Mr Ball, how often he should wish to adjust his thermostat if it is carrying out adequately the function for which it was designed? If it possesses an off-position, turning it off for a few seconds would simulate high demand with immediate response from the energy saver: judging from his letter, his system is in dire need of some "optimization" because if his room thermostat only controls his boiler directly he must be wasting a lot of energy.

It is unclear what Mr Ball means by supply dips, but if he is referring to the supply of heat then the opposite is the case because by supplying a little and often greater constancy is achieved whereas with his own system which introduces a boiler delay temperature troughs are inevitable: the human body dislikes these and quite gladly turns up the temperature to overcome them, neglecting the slight but constant over-temperature which is thus provided wastefully between them if not actually enjoying it. Boiler condensation is a permanent potential hazard from the products of combustion, the degree to which the hazard is realised being largely determined by the time allowed for the boiler to cool down: timer-controllers and time-switches, including the human variety, are far greater culprits in this respect. He has a point over wear and tear on the starter gear, but even the cost of repeated replacement should be well offset by the saving of energy in all but the smallest installations. Thermal expansion stresses obviously would be increased in frequency but it is difficult to see how they would not be reduced in severity at the same time, both effects being desirable and good engineering.

A much more important point, brought to my notice by a well-known firm of burner manufacturers, is that it might be undesirable to use the energy saver with larger burners for which a pre-firing purge is provided: this blows clean and probably cold air through the boiler for periods of from 10 to 30 seconds before each ignition and obviously cools the boiler fractionally, and greater frequency of purging increasing the energy wastage up the flue. It is suggested that the energy saver may make the heart of an excellent and inexpensive "optimizer" when used with efficient thermostats, more particularly to control a central heating pump or other distribution means when a boiler serves a dual purpose including the heating of domestic hot water for which purpose it must run at a constant temperature. Those wishing to use one in this mode during the winter may care to devise a switching means so that its attentions may be channelled in the appropriate direction for the season, or, as he with the vested interest is bound to suggest with tongue in cheek, why not improve the operation of all thermostats by applying an energy saver to each and every item which is thermostatically controlled?

Following exhortations from the said burner manufacturers, further development has been carried out with the specific aim of producing improved "optimizer" characteristics which are an extension of the original thinking, the accent being upon greater versatility and thus only indirectly upon greater general energy saving. The possibility of supplying thick-film microcircuits is being investigated, obviating much assembly and testing time for those who may wish to set up in business assembling and selling the device at their own rate, but all this takes time and testing.

LETTERS

As the designers and manufacturers of a very successful energy saving product for gas boilers we were compelled to write to you after reading the design for the Fowberry Energy Saver.

Our energy-saving product is called the Gas-aver which has a patent application pending on the design. The unit principally inserts a fixed delay into the boiler off-period of about four minutes and has proved to give reductions of between 20 and 30% gas consumption in average domestic situations. We spent a lot of time experimenting with variable delays and quite complex self-regulating versions of our product but in the end our simple and cheap design (£40) has proved to be entirely adequate. The benefits of the more complex schemes were very small when the increased cost of the product was considered. The Fowberry design is complex and therefore more likely to fail in service, a factor which is very important when dealing with low cost consumer goods.

Mr MacHarg quite rightly points out that boiler-cycling, or 'hunting' as it is often called, wastes fuel but a number of his points are not accurate and the solution proposed, we feel, is probably only relevant to his own system which has the consideration of secondary heat input, something few of us have, let alone 80 tons of timber!

The initial argument concerns the thermal inertia of boilers. A lot of modern boilers use very low water content heat exchangers which have very little thermal mass and extremely good rates of exchange. These boilers suffer from the fact that there is little lag in heating the water back to the desired temperature setting and in fact tend to cycle more than boilers with cast exchangers which have greater thermal mass, and therefore lag.

The 'holiday cottage' effect only occurs, in our experience, when the boiler is undersized for the heating installation. In practice we find that boilers are often oversized which as any heating engineer will tell you is by far the best way. This oversizing allows for additional radiators and also compensates for crude heating requirement calculations. Both our own measurements and users reports show that our design has never caused a noticeable change in room temperature or comfort levels.

One of the losses caused by cycling is the gas wasted during ignition. Since the boiler doesn't light immediately some gas goes straight up the chimney followed by the familiar 'whoosh' sound. The Fowberry design actually causes the boiler to pulse during the On period and this must waste some considerable amounts of gas in itself! The pulsing action will also confuse some boilers such as the Potterton Netaheat, which has its own relay-based timer arrangement for the ignition sequence, a process which takes approximately 45 seconds.

The Fowberry design also has some basic omissions. The first omission is a bypass switch which is necessary for boiler maintenance and also in case of unit failure. The second omission is the facility to work with 24V control systems. Glow-Worm boilers, which have been nearly 50% of our installations, all use 24V systems, and a number of new designs are using 24V with integral transformers within the boiler.

Should Mr MacHarg feel that we have been unjust in our comments then we add that we will gladly challenge his design in a domestic situation under controlled conditions.

David V. Goadby
Pixel-Plus Ltd
Nailstone
Warwickshire

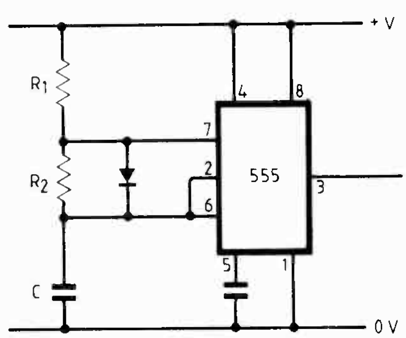
I was alarmed to see the suggestion that sheets of polythene should be nailed over ceiling joints and insulation. While this may cause no problems in a large and well ventilated house, there is a very real danger of condensation occurring within the loft insulation of a small, well sealed modern house. The problem arises because the combination of a near airtight structure and a high occupancy (in terms of persons per cubic metre) frequently leads to high temperatures and high levels of water vapour in the house. This water vapour will, to a greater or lesser extent depending on the particular construction, penetrate through the ceiling and into the insulation. While the base of the insulation will be close to the internal temperature of the house, the top will be close to the much lower loft air temperature, and condensation of the percolating water vapour in the upper, colder sections of the insulation is very probable. Sporadic, short lived outbreaks of condensation can usually be tolerated if there is an airflow over the insulation allowing fairly rapid drying out, but if Mr MacHarg's suggestion were implemented, ventilation would be eliminated and the condensed water would remain for long periods and help to promote an outbreak of dry rot.

The heat saving adduced by Mr MacHarg for his polythene sheets is truly minimal if adequate insulation is installed: the penalties could be very severe. The advice to readers is quite unequivocal – don't do it.

Nicholas Pillans
Thames Polytechnic School of Architecture
Dartford
Kent

555 MARK/SPACE CONTROL

The "555 mark/space control circuit" of Filanovsky and Piskarev (Circuit Ideas, September, p.68) can be simplified to:



C charges through R_1 and the diode, and discharges through R_2. The diode gives a constant offset during the charge time of $\approx$0.6V, effectively reducing V+ by this amount and so slightly increasing the charge time (by a predictable amount). Discharge time is unaffected.

Replacing R_1 and R_2 with variable resistors will produce an independent control of on and off times.

John Bonell
Leicester Forest East

CURRENT DUMPING REVIEW

About the September and October articles:

1. The distorting dumper V_{be} is there modelled by a voltage generator. Then the circuit becomes linear, allowing the effect on output of this generator to be studied by itself. As mentioned, current despatched by it through Z_1 of Fig. 11 (all references are to the October article) meets an unpredictable emitter input impedance at Tr_2. This is due to the presence of R_{12} as seen through the emitter, and it results in some loss of current through the 180Ω shunt path. Thus Tr_2 current gain enters the balance condition through the new factor λ, to yield

$$\lambda \cdot \frac{Z_4}{Z_1} = \frac{Z_3}{Z_2} + \frac{1}{gZp}\left[1 - k + \frac{Z_3}{Z_0}\right] \qquad (9)$$

The meaning of the symbols is explained. The third term is called the gain term, because it depends on the parameter g of the driver amplifier. Mr Baxandall (Letters, December issue) supports the view that this term is much too small to figure, given the tolerance errors likely to be present in the other terms.

He also insists on ignoring λ, and proposes to stick to $Z_4/Z_1 = Z_3/Z_2$. Then, with 5% components, each side of his equation may depart 10% from its designed value due to tolerance errors. This unbalance is measured by defining a quantity e such that when his left hand side is multiplied by $(1-e)$ it again becomes equal to the right hand side. His e may rise in size to 0.2 or so. The reasoning would hold for (9) if λ was absent.

But λ is present, and nothing has been found against it. As explained, it may descend to 0.65 if Tr_2 has its minimum gain. Baxandall has set $Z_4/Z_1 = Z_3/Z_2$, and if the 5% errors possible in these components conspire with this value of λ then the left hand side of (9) above falls to 0.53 of its right hand side. (Now $e = -1$.) Nearly 100% increase in the value of Z_4 is required to rectify matters! It is R_{12} which is causing the new factor λ and its uncontrollable variations. It must go.

Nonsense, replies Baxandall. The design is splendidly uncritical, and takes such things in its stride. But surely we are trying to find the correct value for Z_4? Is a 100% error of no interest? Actually the article already mentions apparatus to evaluate this suggestion. As just shown, ignoring λ instead of disposing of it has pushed up the maximum value of e by a factor of five. Equation 13 shows that crossover distortion promptly multiplies by five. Uncritical? Distortion follows e in direct proportion. It has been overlooked that an amplifier is a slave to its feedback loop, and any signal delivered to its input thereby is faithfully reproduced at the output. Accurate balance of (9) is essential, and R_{12} must be removed to kill the uncontrollable λ.

2. From the first patents onwards current dumping has been explained as a method for nulling the distortion caused by the variable dumper V_{be}. As this varies during the signal cycle it produces no effect at the output terminal. The easiest picture is perhaps the bridge model of Fig. 8, where the essence of the technique is revealed as setting the bridge balance equation off balance by a small but precise amount: the gain term in (9) above. Mr Baxandall supports the view that this term is too small to figure. Worse, there is a reason of principle why it must be ignored. It is real and constant, while the other two terms of (9) are imaginary and proportional to frequency. The gain term must be neglected, and the equation balanced without it. This throws out any current dumping, as the term has always been understood, and establishes the deafening thesis that the Quad 405 current dumping amplifier (as it is named) is not using the current dumping techniques.

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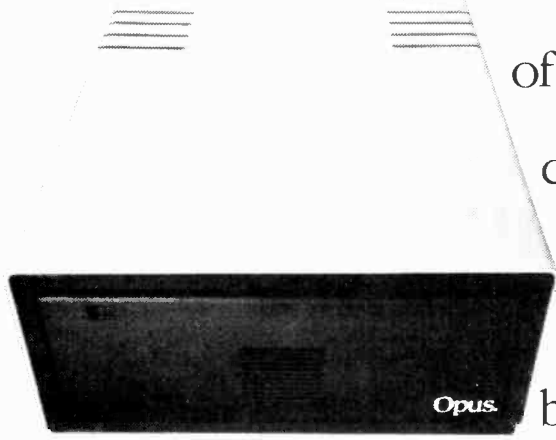

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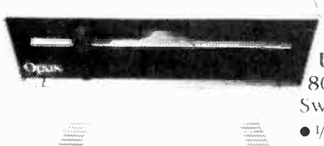

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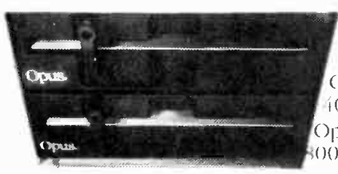

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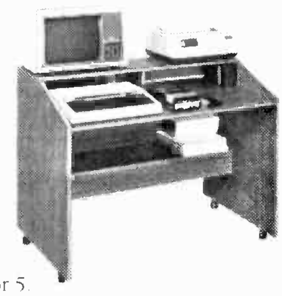

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LETTERS

Some may wish at this stage to change the established meaning of current dumping, so the same thesis is restated without using these words, in the form it had in the article: The bridge network in the Quad 405 has no power to cause nulling of the distorting dumper V_{be}. There is no escape from this: balancing (9) above without the third term cancels the coefficient of V in the feedback voltage C found in constraint (4) in Fig. 12. Thus no fraction of dumper V_{be} is fed back to the driver, contrary to what is required in Fig. 8.

As an example it was shown that once the gain term was abandoned, the amplifier could easily be converted into a traditional type of identical performance. Mr Baxandall observes that this is not a practical proposal, as the alternative is not stable at r.f. The error is admitted. But it only affects the example. The deafening thesis is unaffected, and the grounds for it untouched. Indeed, collecting and strengthening some of Mr Baxandall's remarks, his comments fuse with that thesis to yield the following key paragraph.

Admit that the Quad 405 is quite incapable of using the current dumping technique. Its feedback circuits have no power to null the dumper distortion, even if all components have zero tolerance error. Instead, its operation is to be explained in the following quite different manner. Firstly, drop the usual bias arrangements on the output transistors, thus disposing of adjustments and thermal problems. Then use a powerful driver amplifier together with massive negative feedback to remove the distortion so generated. But note that every powerful amplifier has a capacitor within it to ensure Nyquist stability. Observe that C in Fig. 11 is just that capacitor. Indeed if the driver triple is thought of as a single transistor then C is in just the classical position. Admit that C will cause a drop in the gain of the driver when it is handling the h.f. components introduced by the quasi-rectangular V_{be}, thus allowing measurable crossover distortion to reappear. So add L to modify the feedback at h.f. provided by the capacitor C. Remove R_{12} and ignore tolerance errors. Then use bridge technique ($Z_4/Z_1=Z_3/Z_2$) to cancel the V_{be} let through by C. However, this V goes on to distort the output volts E in the usual way. It is left to the usual negative feedback from E to reduce this (constraint 4 now shows feedback is given by hC=pE nearly.) No V is fed back. And certainly not the appropriate small fraction of it required to arrange cancellation of V in E. (This is current dumping.)

If sound, this key paragraph would require adjustments all round. Except for the stability errors admitted here, the two articles stand. Previous explanation of this amplifier is regarded as erroneous. L does nothing directly to cancel the effect of V on output. What it does is to cancel the crippling effect C would otherwise have on driver gain when it is handling the higher a.f. components of V. This restores the usual negative feedback at those frequencies. The inventive step is the addition of L. And UK patent 2278/74 with US patent 3,970,953 must be examined to discover how much is still relevant to this remarkable amplifier. But focus on the circuit itself, and introduce tolerance errors. With R_{12} removed e can rise in size to 0.2 only, and the correction provided by L to cancel the V let through by C is between 4/5 and 6/5 of that required. Distortion is indeed divided by five or more. (Two or more with R_{12} included as at present.) This good effect is clearly not enough to outweigh dropping the usual bias arrangements, and the amplifier must be expected to have higher crossover distortion than with bias but no L. These are worst-case figures and cannot simply be tested on a single specimen.

3. After theory, practice. Baxandall now observes that this discussion has lost meaning, because we have fallen below the distortion levels caused anyway by wiring pickup and the like. Figures would be needed in support. And if provided they furnish a point against the superior claims of this amplifier. Are the figures in line 1 of Table 1 that good compared to other amplifiers? (As Mr Baxandall observes, the arrangements discussed in lines 2 and 3 are unstable and thus must be withdrawn from the discussion.)

M. McLoughlin
Haberdashers' Aske's School
Elstree

Michael McLoughlin's analysis of current dumping contains some interesting observations, but clashes strongly with our earlier analysis (June, July 1978) and a later more complete paper of ours in the Journal of the Audio Engineering Society*. We shall address three relevant points in the debate.

Mr McLoughlin argues (part 1, page 41) that a feedforward explanation does not exclude other explanations, and suggests that Peter Baxandall's letter does not support feedforward. We disagree strongly. In negative feedback two or more signal paths to the output are not necessary. It may appear that there is only one, but that is because current dumping has intertwined the feedforward and feedback paths. It does not really matter how one "derives" current dumping, a feedback explanation alone is insufficient. We struggled many hours over these concepts, and are quite sure that no feedback taken *singly* from the load can achieve what current dumping does. Thus we are forced to include the concept of feedforward in the description of any circuit that is capable of complete cancellation of distortion in principle, although a *simple* feedforward scheme may not be evident in a particular realization of the concept.

A second point concerns the practicability of current dumping, using components of standard tolerance so that the bridge is not quite balanced. Table 1 of part 2 is quite misleading. It implies that a resistive bridge is better than a reactive one, and that a "traditional amplifier" is better than both. We wish Mr McLoughlin had tried out each of these options experimentally, for unless the theory is done fairly the comparison is not meaningful. Examination of our AES paper shows some comparisons, using a model experimental circuit, which contradict Table 1. When the bridge is unbalanced, there are error pulses, but they are very brief (microseconds) and do not give rise to a large harmonic distortion. On the other hand an unbalanced resistive bridge (ignoring for the moment the infinite implied gain-bandwidth of the amplifier A) results in roughly a square-wave error with substantial harmonic distortion. In a traditional amplifier the necessary finite gain-bandwidth (for stability and other reasons) generally gives greater error pulses than current dumping.

To make the process clearer, consider a current dumping amplifier that has a reasonably balanced bridge. The distortion error pulses will be small but not negligible. How shall we compare it to normal feedback? Can we short Z_4, the inductor? This increases the distortion greatly, by about the inverse of the relative bridge balance accuracy. In addition, the circuit stability usually suffers, because the inductor tends to feed back a stabilizing signal representing the derivative of the load current. It may be argued that, when Z_4 is shorted, Z_3 (the resistor) should also be removed to be more representative of a normal class B amplifier. This helps a great deal, actually, but does not approach the low distortion of the original slightly unbalanced current dumping circuit. In addition, removal of Z_3 significantly destabilizes many practical realizations, necessitating in some cases a reduction of the gain-bandwidth of A, resulting in a greater error. In any event, although there may be theoretical situations where a 10% bridge unbalance is worse than a "similar" traditional amplifier, we do not know of any practical cases where this would be true. Contrary to Mr McLoughlin's assertion, Z_2 or its equivalent cannot be removed in a traditional amplifier. It is necessary for feedback compensation in some form.

A third point is that Mr McLoughlin casts a doubt on our interpretation that eddy currents are at work in the inductor. We can assure him that the bridge was optimally balanced (by adjustment of Z_3) to produce our oscillograms in our AES article, the only circuit change being the type of inductor. Our Fig. 9 (b) and Fig. 10 contain distinctly different time constants, the latter being about twice as long as the former. With some effort the error residual could be calculated in each case, but to simply speculate on a few of the obvious time constants does not seem very fruitful to us.

In summary, we welcome many details of analysis and insight offered by Mr McLoughlin, but we disagree on some of the basic points. Not only is current dumping necessarily viewed as error feedforward, but its use in practice significantly improves the performance of audio power amplifiers. It should also be noted that there is nothing inherent in the "current dumping" concept which necessitates the "dumper" stage being class C (i.e. biased off). This clearly was a conscious design decision made by Quad to eliminate the need of quiescent current adjustment and it has been shown in experiments that the residual distortion is below audibility. In addition we believe that feedforward audio amplifiers by other manufacturers are clearly derived from the genius shown in the Quad 405.

L. Vanderkooy
S. P. Lipshitz
University of Waterloo
Waterloo
Ontario

The author replies

Nothing said about the Quad 405 in my articles appears to have been overturned. I made three incautious comparisons with other arrangements, and these had to be withdrawn on grounds of instability. Unfortunately these comparisons bulked large in the conclusions, which have now been rewritten to yield my letter above. Until it is clear whether they will prevail I prefer not to comment on anything other than the Quad 405. I agree that if e = 0.2 then a fivefold decrease in distortion is to be expected if a short on L is removed. Inverse of the relative bridge balance accuracy, as our friends suggest. This deals completely with their second point, as the other comparisons mentioned are

* John Vanderkooy and Stanley P. Lipshitz, "Feedforward Error Correction in Power Amplifiers," Journal of the Audio Engineering Society, vol. 28 1980, pp 1-16.

not related to the Quad 405. Their third point about the inductor is their own, and this damaging criticism of the Quad 405 would benefit by confirmation from a second authority.

This leaves their first point, that feedforward alone is the only correct explanation of current dumping. (See also the second sentence of their last paragraph above.) This assertion fully confirms my account of their views. But the italics indicate a great deal. Feedback, it seems, is not feedback unless it is taken *singly*, and from the load. Whereas feedforward apparently, may be *simple*, or a good deal more elastic. With this special language current dumping violates the feedback definition on both counts, and can only be feedforward.

But starting with Walker in the patents and continuing through Baxandall many authors have given perfectly correct explanations in terms of voltage fed back to the input from one or two points near the load. This use of the term feedback is entirely natural, even though it does violate the above curiously narrow definition. There is nothing wrong with this usage, and opposition to it should be dropped. Nothing is at stake: the equivalance of the two explanations (and three others!) was demonstrated in the Sept/Oct articles.

THUNDERSTRUCK

I must admit when I read Chirp's account 'Thunderstruck' in *WW* (Random Echoes, November) it was with some smug satisfaction, that it should happen to such an august company as IBM. Really it should be recognised that this is something which has arrived with microprocessors. The c.p.u. has only to skip one byte (or word) due to electrical interference and it will lose synchronism with the program it is executing. In general it will not regain synchronism of its own accord and the equipment it is supposed to be controlling will remain mute or continually 'doing something'.

These effects will not be evident in equipment which may do a '9-to-5' job, because the power-up reset each morning will keep everything in order, on the other hand those equipments which operate continuously can, for no explicable reason cease to function. This latter is in the category of 'press reset' and everything will be allright again.

On the subject of reset, this is another button which has been gained with microprocessors. It is either resoundingly prominent on the front panel, or coyly hidden around the back somewhere, or a magic theree key operation which performs the same function. Alternatively reset can be generated from a circuit at power-up which brings the equipment into the catagory of: 'If it goes screwey, switch off, wait a moment, then switch on again' – it'll be OK then!

It is so easy to blame exterior forces – the, 'It wasn't me' syndrome but there are opinions that invasion by alpha particles can disrupt the internal saved states of the c.p.u. and sent it 'bananas'. On this score it is interesting to note that Hitachi's 8k × 8bit ram has been constructed to allow for this (New Electronics March or April 83, I think).

What can be done? It should be an essential part of every microprocessor design to have some delay circuit completely separate from the microprocessor circuit and definitely not under software control which is kept reset. The input to this circuit should be one bit from the system which is simply toggled by the software at perhaps, say, 100ms or 1 second period, the output should go to the c.p.u. where a suitable interrupt can be generated should the toggling action stop, ie, c.p.u. lost. This can be thought of as a 'kickstart' or a kick in the pants to the c.p.u.! A word of warning, some microprocessors will ignore interrupts when they are lost and need a reset followed by the suitable input.

The type of circuitry which comes to mind is two monostables in cascade, e.g. 74LS123, the first as the 'hold-off' delay, the second to create the 'kickstart'. Another circuit that can be used if delays need to be some seconds is the 'Van Der Veen' timer, sketched above, designed by a former colleague of mine and named after him. Not posthumously I hasten to add.

By now you are probably asking yourself, 'How does this Joker know all this?', well, it happened to me! I would like to find an answer to the problem, perhaps this could be food for thought for those more qualified than myself to examine it.

Alan W. Roscoe
Enfield
Middlesex

SOFTWARE BY RADIO

With reference to your news item on page 39 of the December issue, concerning Radio West's 'Datarama' programme, I noted that no commencement date was given for the programme which transmitted home computer software, etc, but the intimation was that they were the first to do so.

Whilst only inspection of the transmission schedules reveals the real 'first' (I think Radio Victory in Portsmouth also claim the honour), I feel it should be noted that BBC Radio Leeds commenced transmission of a magazine-type programme for computer enthusiasts entitled "Abacus: the computer programme", transmitted fortnightly, started on the 5th October, 1982, and was presented by Dave Banks, Pete Bradley, Martyn Croft and the writer. The content was, and is still, of a magazine nature and included regular experimental transmissions of home microcomputer software, as well as news, reviews, and technical contributions.

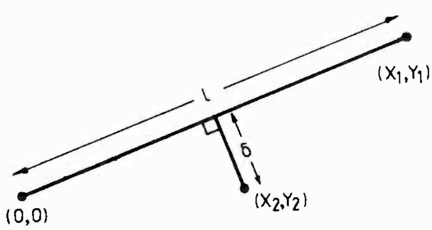
The programme is now in the third series, and we hope that software transmission will start again in the new year.

D. R. Coomber
Co-presenter, Abacus
Leeds

XY PLOTTER

In his article ("Computer-controlled xy plotter", January) P. N. C. Hill invites suggestions for an algorithm to draw a straight line between any two points on the plotting area. I have written software for a plotter similar to that he describes and have developed such an algorithm.

The algorithm involves tracking along the required line drawing line segments which follow it as closely as possible. At each step along the line there are two or three points to which a line segment might be drawn (by stepping the X motor, the Y motor or, if possible, both motors together). The point is selected which has the smallest perpendicular distance from the required line. A segment is drawn to this point and the process repeated until the line is complete.



In the figure the perpendicular distance of the point (X_2,Y_2) from the line from (0,0) to (X_1,Y_1) is

$$\delta = \mathrm{ABS}\left(\frac{X_1Y_2 - X_2Y_1}{l}\right)$$

where l is the length of the line from (0,0) to (X_1,Y_1). This theorem is derived from the formula for the Vector Product of two vectors. For any given line l is constant, therefore to determine which of a group of points is nearest to the line calculate $\mathrm{ABS}(X_1\,Y_2 - X_2\,Y_1)$ for each of the points and select the point giving the lowest value. The line is complete when $\mathrm{ABS}(X_2) \geqslant \mathrm{ABS}(X_1)$ and $\mathrm{ABS}(Y_2) \geqslant \mathrm{ABS}(Y_1)$.

It is necessary to adapt the above equations to allow the line to start from an arbitrary point instead of (0,0). All the variables may be expressed as integers to increase the speed of execution and to prevent accumulating errors.

Richard Griffiths
Whitchurch
Cardiff

TECHNOLOGY AND PEOPLE

"Why then is it such a common observation of human life, that those who do what they like rarely seem to like what they do?" – S. C. Elliston (Letters, December).

If we replace the first "like" with "choose" and introduce the time function of learning, the problem disappears: the discovery of dislike is retrospective.

If we then replace "choose" with "are pressurised by events to do", at least a part of the problem becomes clear: none of us has, ever has had, nor ever will have, complete freedom of choice, more especially in a period of mass-unemployment!

The more creative an individual is, the more free he or she is to choose, but the more attempts there will be to manipulate simply because the world takes man-made providence and Providence with a capital P, for granted.

There is also such a thing as monotony, a source of dislike, the permanent plateau of non-fulfilment in which no learning occurs with the consequent failure of information intake for pleasure-giving processing. Such monotony is commonly provided by an ignorant preoccupation with material pleasures – i.e. non-thinking pleasures such as eating, ambishing non-creatively, and mating, and throwing one's self about in an ape-like monkey-hop to some strange cacophony actually calculated to hold the mind in such ignorance while making a lot of lovely lolly. It seems perhaps that one should never cause or assist the process of thought in case it starts a rebellion! The true question really is, which is the worse evil – the destructive and vandalistic rebellion of non-thought, or the more constructive rebellion of thought?

Mr Elliston's question stems from the same sort of problem mentioned also in December by David A. Chalmers, being the absence of definition for the word "like": it also demonstrates some misunderstanding that the pleasure to which Professor Campbell refers is a subconscious one rather than the conscious one of the senses: one thinks for pleasure, but in the absence of information for processing one is limited to the simple experience of the frustration of not understanding the cause of one's frustration. One must experience the pleasures of thought before one may realise that one needs to know more if one is to experience further pleasure.

That is why the teaching process is so very, very difficult in the early stages, and even more so in the case of the autist.

J. A. MacHarg
Wooler
Northumbria

In his letter, published in *WW* November, 1983, W. M. Dalton hit a nasty land-mine that I first noticed some years ago. Let me first quote the moment when he hits it.

> "Let us start from known facts. (1) Light is an electromagnetic phenomenon: demonstrated by Faraday and Kerr. (2) Light is not a static problem: it is ocillatory (Hertz). (3) The electric and magnetic fields are at right-angles and *always* 90 degrees out of phase. Some recent textbooks show these in-phase – an unparadonable error."

I am anxious that Mr Dalton expands on why this error is unpardonable, and what disasters this error might lead us into.

First let me list some non-recent textbooks which show these in-phase.

G. W. Carter, Professor of Electrical Engineering in the University of Leeds, in his book The Electromagnetic Field in its Engineering Aspects, (Longman 1954) draws the $\bar{B}$ and E fields in-phase on page 271. Significantly, although he emphasises that E and B are at right angles (page 274) he never seems to say in the test that B and E are in phase.

A. F. Kip, Professor of Physics, University of California, Berkeley, in his book Fundamentals of Electricity and Magnetism, (McGraw-Hill 1962) draws the H and E fields in-phase on page 322. On that same page the text says that the two fields are perpendicular to each other, but does not state that they are in-phase. Again significantly, I cannot find mention in the text that they are in-phase.

O. Heaviside F.R.S., in his book Electromagnetic Theory Vol 3, 1912, in art. 452, page 4, wrote

> "The General Plane Wave . . . the slab may be of any depth and any strength, and there may be any number of slabs by side behaving in the same way, all moving along independently and unchanged. So $E=\mu vH$ expresses the general solitary wave, where, at a given moment, E may be an arbitary function of x . . "

[Replace μv by $\sqrt{\mu/\epsilon}$ – I. Catt]

Whereas some books (Carter and Kip) vaguely indicate that E and H are in-phase, other books seem to fail to discuss relative phase at all see for example Gullwick 1959, Bewley 1933. The trap was nicely set for Dalton, and he has my sympathy.

Now let us turn to my article in *Wireless World*, July 1979, entitled The Heaviside Signal.

> "We have shown that the passage of a TEM wave and all the mathmatics that has mushroomed around it does not rely on a causality relationship (or interchange) between the electric and magnetic field. Rather, they are co-existent, co-substantial, co-eternal."

In that article I compare and contrast two mutually contradictory versions of the transverse electromagnetic wave. I believe that the full realisation that E and H are in-phase deals a death-blow to one of those versions, the rolling wave, and leaves the other, the Heviside signal, the victor.

Because the differential of sin is cos and the differential of cos is minus sin, half-witted mathematicians have invaded the physics of the TEM wave and imposed a spurious story that E causes H causes E. Since sin, cos and –sin are 90 degrees out of phase, part of their phoney baggage is to imply that E and H are 90 degrees out of phase. (See my article in *WW* in March 1980.) Because the sine wave is amenable to mathematical high jinks, another part of their baggage is to imply that a TEM wave is sinusoidal. It's time we cleaned the claptrap out of electromagnetic theory.

Ivor Catt
St. Albans
Hertfordshire

FORTH PROCESSORS

In his comparison of processors for Forth language implementation and his subsequent reply to one of your correspondants (Letters, November) Brian Woodroffe has made some incorrect statements and unfair comparisons in relation to the I8088 processor.

Firstly, it is clear that his published code for the NEXT routine is far from optimal. It uses two instructions to ensure that on exit from the routine, the DX register is one greater than the BX register. This is clearly unnecessary since the 6809 code for NEXT performs no equivalent action, and any use of the value in DX can use BX instead – probably with less code involved since BX can be used as an index register while DX cannot. I can only assume that the 8088 code was translated from the 8085/Z80 code, which performs a similar (but in this case necessary) action, and that it is intended to work with other Forth routines translated from the 8085. It is equally clear that the 6809 code is in no way a translation of the 6800 code.

It is therefore possible to code NEXT as follows:

```
LODSAX
XCHGAX,BX
JMP   WORD PTR (BX)
```

which mimics the 6809 register usage and, being only four bytes long, can be coded inline. This is approximately twice as fast as the code given by Mr Woodroffe and therefore, on his figures, is about 50% faster than the 6809.

Mr O'Connor (Letters, September 1983) has already pointed out that the 8083 code for ADD can likewise be shortened. In his reply (Letters, November), Mr Woodroffe correctly points out that BP will not have a fixed relationship to SP but is wrong in asserting that Mr O'Connor's first example is incorrect. It appears that Mr Woodroffe is unaware that the 8088 can leave the result of an ADD or other operation in memory rather than in a register, and ADD [BP],AX does just that.

Another feature of the 8088 which is particularly useful in Forth is its ability to push and pop memory locations as well as registers, using all the usual addressing modes. Finally, the 8088 has several more registers than the 6809 making it possible, for example, to keep the top-of-stack item in a register instead of in memory. These features are adequate compensation for the drawback of not having a stack pointer relative addressing mode. To illustrate this, I show 8088 versions of the 6809 routines which Mr Woodroffe illustrates (Forth Language, November). These routines use the DI register to hold the top of stack operand, but even without this optimisation the code need be no larger than the 6809 versions.

Apart from these comparisons, I have enjoyed Mr Woodroffe's illuminating series on the Forth language.

D. Crocker
Woking
Surrey

APPENDIX. Some Forth routines in 8088 code. DI register holds top of stack value; initial DW $+2 and final NEXT macro omitted.

```
"+":      POP    AX
          ADD    DI,AX            ; 3 bytes
MINUS:    NEG    DI               ; 2 bytes
"@":      MOV    DI,[DI]          ; 2 bytes
"!":      POP    WORD PTR [DI]
          POP    DI               ; 3 bytes
DUP:      PUSH   DI               ; 1 byte
OVER:     MOV    BX,SP
          PUSH   DI
          MOV    DI,[BX]          ; 5 bytes
DROP:     POP    DI               ; 1 byte
```

CLOSED LOOP

Your correspondent James A. MacHarg (Letters, November) likens *Wireless World's* Letters section to the House of Commons; a more appropriate name, perhaps, would be Physics Commons. Physicists need these rare, popular outlets not just to air their views but also to realise their own shortcomings. We have all thought that we knew something until we try to explain it! Furthermore, a problem that may baffle one physicist may be obvious to another. If only the young Einstein had had the advantage of a Physics Commons the world would have been spared his silly theory of Special Relativity.

Mr Macharg's interpretation of my expression "closed loop" is fascinating. I was merely describing to electronic specialists the sort of closed-circuit arguments which are employed to uphold Special Relativity. One begins such closed-circuit arguments by assuming something is true. After that, one can argue along any circuit and prove that something really is true!

I take it that Mr MacHarg's explanation why phoney closed-loop arguments are used to support Special Relativity is because of the mind-boggling conclusions of that theory. Presumably, if one can accept that mass is energy then one can accept closed loop arguments! However, when the error in Special Relativity is corrected, mass becomes and energy becomes movement of that mass. One's mind is de-boggled overnight!

A. H. Winterflood
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Letters in reply to Ian McCauslands' article 'Problems in Special Relativity' appear on pages 71 & 72.

Active filter calculations

Using programmable calculators it is a simple matter to write a sequence of operations to allow transmission of bootstrap and Sallen and Key circuits to be calculated.

by J. L. Linsley Hood M.I.E.E.

The bootstrap and Sallen and Key filter circuits make convenient unity-gain circuit modules that can be implemented using standard operational amplifier gain blocks. With the availability of programmable calculators it is a simple matter to write a sequence of operations that allows the transmission of these circuits to be calculated for any desired component values, with greater potential accuracy and much less labour than would be involved in instrumental measurements. For my own interest I have done this exercise for the Texas Instrument TI58/59 calculators and for the Hewlett Packard HP-65.

While I have no doubt that better mathematicians than I would be able to simplify both the calculation and the resultant program, these do work and give accurate answers. In all cases, the program is written so that the circuit parameters Q and ω/ω_o are entered into the calculator memory stores, and the transmission in decibels is given when the desired frequency is entered and the program sequence initiated.

I have assumed that the operational amplifier behaves in an ideal manner, having a very high open-loop gain, giving unity gain in the voltage-follower mode and a sufficiently high input impedance for the effect of this to be neglected. This assumption is fully valid for the TL071. It is also assumed that the source impedance seen by the filter is low.

Third-order l.p. bootstrap filter

The first part of the transmission expression for a third-order low-pass bootstrap filter refers to the active circuit, and the second part to the passive RC element. The expression is

$$20\log_{10}\frac{\sqrt{[(1-k^2)+A^2k^2]^2+A^2k^6}}{(1-k^2)^2+A^2k^2}$$

$$+20\log_{10}\sqrt{\frac{A^2}{A^2+k^2}}$$

where $k=\omega/\omega_o$ and $A=1/Q$ and $\omega=2\pi f$. Turn-over frequency is

$$\omega_o=\frac{1}{\sqrt{C_1 C_2 R_1 R_2}}$$

$$\text{and } Q=\frac{\sqrt{xy}}{1+y}=\frac{\sqrt{R_1 C_2/R_2 C_1}}{1+C_2/C_1},$$

with $x=R_1/R_2$ and $y=C_2/C_1$. To use the program shown, enter the chosen values of Q and press B. Enter ω/ω_o and press A. Alternatively, enter f_T store 08, enter f, press C. Read out transmission in dB.

TI58/59 program

LRN			48	=	
1	2nd LBL		49	2nd LOG	
2	B	enter Q	50	x	
3	1/x	generates	51	2	
4	x^2	A^2	52	0	
5	STO		53	=	
6	0		54	STO	
7	R/S		55	4	2nd order
8	2nd LBL		56	RCL	
9	A		57	1	
10	x^2		58	+	
11	STO		59	RCL	
12	1	k^2	60	0	
13	x		61	=	
14	RCL		62	1/x	
15	0	A^2	63	x	
16	=		64	RCL	
17	STO		65	0	
18	2	A^2k^2	66	=	
19	+		67	$\sqrt{x}$	
20	(		68	2nd LOG	
21	1		69	x	
22	−		70	2	
23	RCL		71	0	
24	1		72	=	
25	)		73	STO	
26	STO		74	5	1st order
27	3	$1-k^2$	75	+	
28	=		76	RCL	
29	x^2		77	4	
30	+		78	=	
31	RCL		79	2nd FIX	
32	2		80	1	
33	x		82	R/S	
34	RCL		LRN		
35	1				
36	x^2		LRN		
37	=		83	2nd LBL	
38	$\sqrt{x}$		84	C	
39	÷		85	x	
40	(		86	RCL	
41	RCL		87	8	
42	3		88	1/x	
43	x^2		89	=	
44	+		90	2nd INV	
45	RCL		91	ENG	
46	2		92	A	
47	)		LRN		

In practice, it is probably more convenient in the design of the filter circuit to choose the required Q and operating frequency, and then derive the values of Rs and Cs for this.

The method is as follows. Try an arbitrary ratio of $C_2/C_1=y$ (say 1). Then

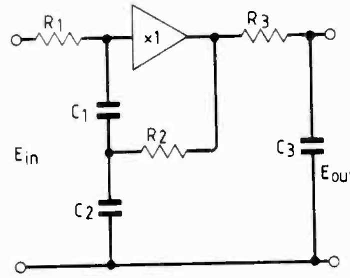


Fig. 1. Low-pass bootstrap filter of 20dB/octave for Q=2.2.

$$C_1\,(\mu F)=\frac{10^6}{2\pi f_o R_2 (1+y) Q}$$

$$R_1=R_2\frac{Q^2(1+y)^2}{y} \text{ and } C_3\,(\mu F)=\frac{10^6 Q}{2\pi f_o R_3}.$$

If this gives awkward or non-standard values, try another value for C_2/C_1.

Third-order h.p. bootstrap filter

The transmission expression in the case of a high-pass filter is

$$20\log_{10}\frac{\sqrt{[A^2k^2-k^2(1-k^2)]^2+A^2k^2}}{(1-k^2)^2+A^2k^2}$$

$$+20\log_{10}\sqrt{\frac{A^2k^2}{(1+A^2k^2)}}$$

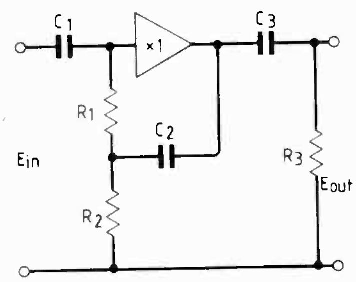


Fig. 2. High-pass bootstrap filter of 20dB/octave for Q=2.2.

TI58/59 program

LRN			10	0	k
1	2nd LBL		11	x^2	
2	B		12	STO	
3	1/x		13	2	k^2
4	STO		14	+/−	
5	1		15	+	
6	R/S		16	1	
7	2nd LBL		17	=	
8	A		18	STO	
9	STO		19	3	$1-k^2$

20	x^2		61	0	
21	STO		62	=	
22	4	$(1-k^2)^2$	63	STO	
23	+		64	7	2nd order
24	(		65	RCL	
25	RCL		66	6	
26	1		67	÷	
27	x^2		68	(	
28	STO		69	1	
29	5		70	+	
30	x		71	RCL	
31	RCL		72	6	
32	2		73	)	
33	)		74	=	
34	STO		75	√x	
35	6	A^2k^2	76	2nd LOG	
37	=		77	x	
38	1/x		78	2	
39	x		79	0	
40	(		80	=	
41	(		81	STO	
42	RCL		82	8	1st order
43	6		83	+	
44	−		84	RCL	
45	RCL		85	7	
46	2		86	=	
47	x		87	2nd FIX	
48	RCL		88	1	
49	3		89	R/S	
50	)		90	2nd LBL	
51	x^2		91	C	
52	+		92	x	
53	RCL		93	RCL	
54	6		94	9	
55	)		95	1/x	
56	√x		96	=	
57	=		97	2nd INV	
58	2nd LOG		98	ENG	
59	x		99	A	
60	2			LRN	

To use, enter Q, press B. Enter ω/ω_o, press A. Alternatively, enter f_o in store 9, enter f and press C.

Q and ω_0 are as in the previous case, but here $x=C_2/C_1$ and $y=R_1/R_2$. Again, it will probably be more convenient to choose the required Q and operating frequency, and then derive the necessary values for the Rs and Cs.

Method. Try an arbitrary value of $R_1/R_2=y$ (say=1). Then

$$C_1\,(\mu F)=\frac{10^6}{2\pi\, f_o\, R_2\,(1+y)\,Q}$$

$$C_2=C_1\frac{Q^2\,(1+y)^2}{y},\ \text{and}$$

$$C_3\,(\mu F)=\frac{10^6}{2\pi\, f_o\, R_3\, Q}.$$

A Q-value in the range 2 to 2.2 will give a reasonably flat response for the third-order filter. (For convenience I have defined Q in a manner that differs from the true circuit magnification factor and hope to be forgiven for this small transgression.)

The phase shift produced by these filters may be calculated as follows.

Low pass

$$\phi=\tan^{-1}\frac{K[A^2-2\,A^2k^2-Ak-(1-k^2]}{A[A^2\,k^2+(1-k^2)-k^4]}.$$

High pass

$$\phi=\tan^{-1}\frac{K\,(k^2+2A^2-1)}{A(A^2k^2-k^2+k^4-1)}.$$

Programs for the HP65 (or similar RPN calculators) are as follows.

To use, set MC to run, enter program. Enter value of Q, press A (displays Q).

HP65 high-pass and low-pass gain characteristics

1	LBL		44	RCL 6	
2	A	enter Q	45	RCL 5	
3	g		46	+	
4	1/x		47	f^{-1}	
5	STO 1	A	48	√	
6	f^{-1}		49	RCL 5	
7	√		50	RCL 4	
8	STO 2	A^2	51	f^{-1}	
9	DSP		52	√	
10	•		53	x	
11	4		54	+	
12	RCL 1		55	RCL 7	
13	g		56	÷	
14	1/x		58	E	
15	RTN	displays Q	59	STO 7	
16	LBL		60	RCL 2	
17	D		61	RCL 2	
18	STO 3	k	62	+	
19	f^{-1}		63	÷	
20	√		64	E	
22	STO 4	k^2	65	+	
23	RCL 2		66	RTN	
24	x		67	LBL	
25	STO 5	A^2k^2	68	C	enter
26	1		69	D	ω/ω_o
27	RCL 4		70	RCL 5	for hpf
28	−		71	RCL 4	
29	STO 6	$1-k^2$	72	RCL 6	
30	f^{-1}		73	x	
31	√	$(1-k^2)^2$	74	−	
32	RCL 5		75	f^{-1}	
33	+		76	√	
34	f^{-1}		77	RCL 5	
35	√	bottom line	78	+	
36	STO 7	of eqn	79	RCL 7	
38	DSP		80	÷	
39	•		81	E	
40	1		82	+	
41	RTN		83	RTN	
42	LBL B	enter ω/ω_o for lpf			
43	D				
73	2		86	1	
74	x		87	−	
75	+		88	RCL 1	
76	1		89	x	
77	−		90	÷	
78	RCL 2		91	f^{-1}	
79	x		92	Tan	
80	RCL 4		93	g	x≤y
81	RCL 3		94	1	
82	E		95	8	
83	+		96	0	
84	RCL 3		97	+	
85	−		98	RTN	

Enter value of ω/ω_o (k), press B. This displays transmission in dB for low-pass filter. RCL 7 shows transmission of active second-order filter. For high-pass filter, enter ω/ω_o and press C. RCL 7 again shows transmission of second-order part of circuit.

HP65 program for high-pass and low-pass phase characteristics

1	LBL	37	RCL 7	
2	A	38	RCL 4	
3	g	39	2	
4	1/x	40	x	
5	STO 1	41	−	
6	E	42	RCL 7	
7	STO 7	43	RCL 2	
8	DSP	44	x	
9	•	45	−	
10	4	46	RCL 5	
11	RTN	47	−	
12	LBL	48	RCL 2	
13	E	49	x	
14	f^{-1}	50	RCL 5	
15	√	51	RCL 4	
16	RTN	52	+	
17	LBL	53	RCL 3	
18	D	54	E	
19	STO 2	55	−	
20	E	56	RCL 1	
21	STO 3	57	x	
22	RCL 7	58	÷	
23	x	59	f^{-1}	
24	STO 4	60	tan	
25	1	61	g	x>y
26	RCL 3	62	1	
27	−	63	8	
28	STO 5	64	0	
29	DSP	65	−	
30	•	66	RTN	
31	0	67	LBL	
32	RTN	68	C	
33	LBL	69	D	
34	B	70	0	
35	D	71	RCL 3	
36	0	72	RCL 7	

To use, set MC to run. Enter program. Enter Q, press A. Enter ω/ω_o and press B for low-pass phase shift, or press C for high-pass phase characteristic.

As a check, both of the validity of the caculations shown above and of the program written for them, the predicted and measured characteristics of two circuit embodiments, the treble and rumble filter circuits employed in the modular pre-amplifier design (*Wireless World*, Oct. 1982 to Feb. 1983) are shown in Figs 5 and 6, and a steeper cut treble filter, having a Q of 2.2. and an f_o of 5.9kHz, is shown in Fig 7.

Sallen and Key filter

The widely used Sallen and Key circuit shown in Figs 3 and 4 can be used as a third-order filter with a following or preceding passive filter element, similar to that shown in Figs 1 and 2. It is, however, most commonly employed as a second-order filter element having an ultimate attenuation rate of −12dB/octave, and it is for this form that the equations and program below are derived. As previously, $\omega/\omega_0=k$ and $A=1/Q$, and here

$$Q=\frac{\sqrt{xy}}{1+x}$$

In the low-pass circuit, $x=R_1/R_2$ and $y=C_3/C_4$ and in the high-pass form, $y=C_1/C_2$ and $x=R_3/R_4$.

Transmission expressions are

Low pass $$\frac{(1-k^2)-jkA}{(1-k^2)^2+(kA)^2}$$

High pass $$\frac{k^2(k^2-1)-jkA(k^2)}{(k^2-1)^2+(kA)^2}$$

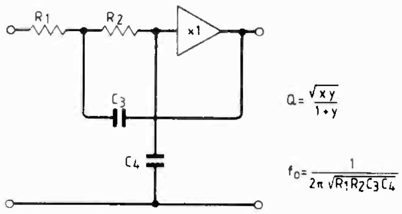


Fig. 3. Low-pass Sallen and Key filter of 12dB/octave

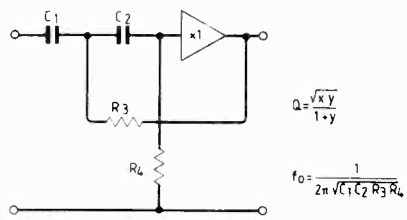


Fig. 4. High-pass Sallen and Key filter of 12dB/octave

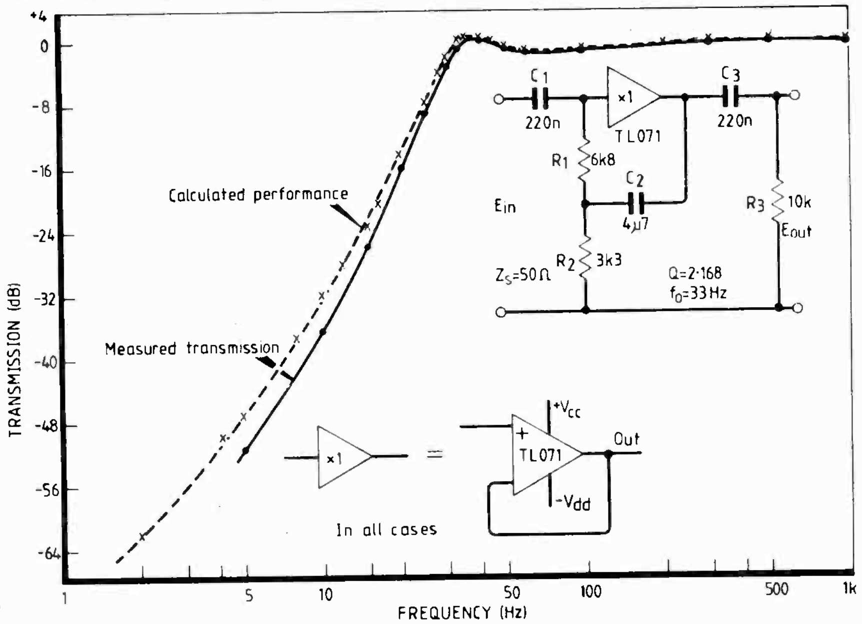


Fig. 5. High-pass bootstrap filter

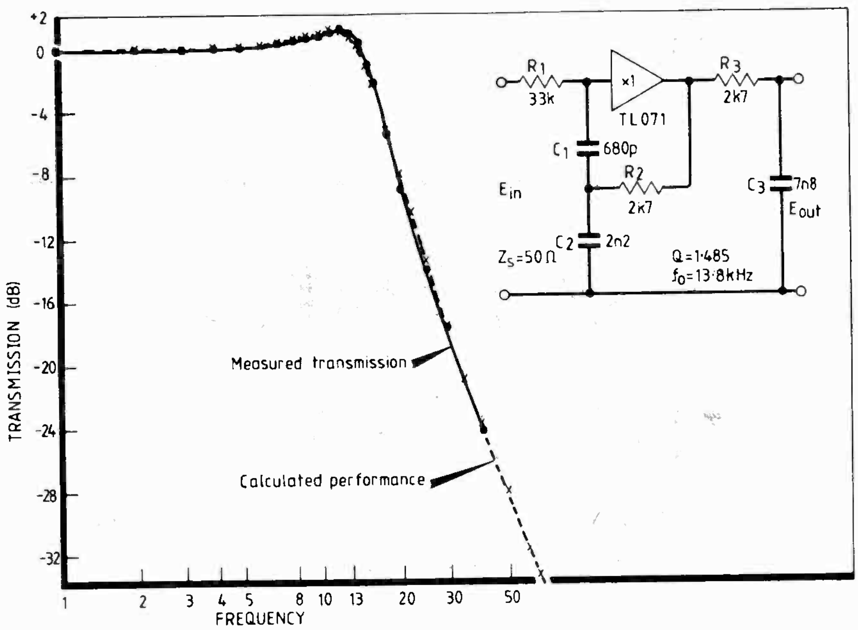


Fig. 6. Low-pass bootstrap filter. Frequency scale in kHz.

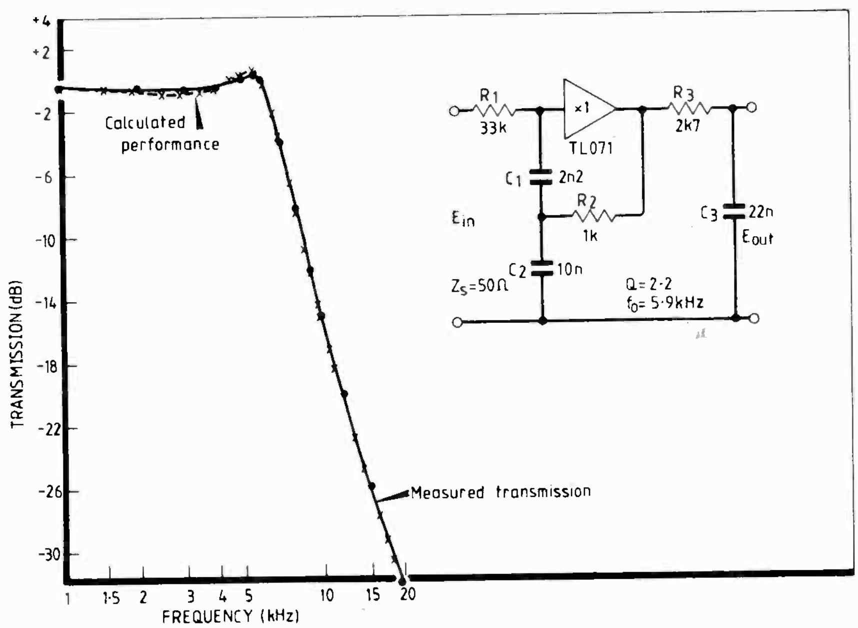


Fig. 7. Low-pass bootstrap filter with Q=2.2

TI58/59 transmission and phase for Sallen and Key filters

LRN			53	1
1	2nd LBL		54	=
2	A		55	STO
3	2nd CP		56	3
4	STO		57	x^2
5	0		58	+
6	x^2		59	(
7	+/−		60	RCL
8	+		61	0
9	1		62	x
10	=		63	RCL
11	STO		64	1
12	2		65	)
13	x^2		66	x^2
14	+		67	=
15	RCL		68	STO
16	0		69	4
17	x^2		70	RCL
18	x		71	0
19	RCL		72	x^2
20	1		73	x
21	x^2		74	RCL
22	=		75	3
23	STO		76	÷
24	3	denom	77	RCL
25	1/x		78	4
26	x		79	=
27	RCL		80	x→t
28	2		81	RCL
29	=		82	0
30	x→t		83	x
31	RCL		84	RCL
32	0		85	1
33	x		86	x
34	RCL		87	RCL
35	1		88	2
36	÷		89	÷
37	RCL		90	RCL
38	3		91	4
39	=		92	=
40	INV		93	INV
41	2nd P→R		94	2nd P→R
42	x→t		95	x→t
43	R/S		96	R/S
44	2nd LBL		97	2nd LBL
45	B		98	E
46	2nd CP		99	2nd LOG
47	STO		100	X
48	0		101	2
49	x^2		102	0
50	STO		103	=
51	2		104	R/S
52	−		LRN	

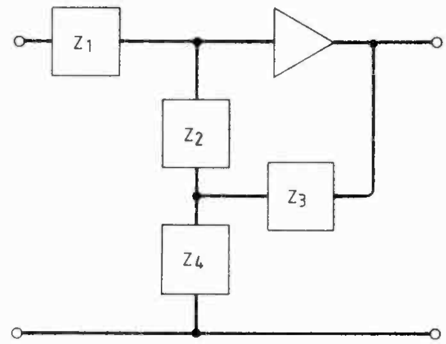
Enter Q, 1/x and store 01 (1/Q). To use, enter ω/ω_0, press A for low-pass. This displays gain. For high-pass, enter ω/ω_0, press B. This displays stage gain. In both cases, for phase press x→t. To obtain result in dB, press E.

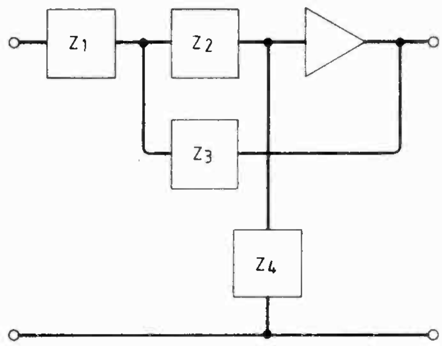
The HP65 program for the same circuit is shown below.

HP65 Sallen and Key filter transmission characteristics

1	LBL		23	RCL 2	
2	E		24	x	
3	f^{-1}		25	E	
4	√		26	STO 4	A^2k^2
5	RTN		27	RCL 3	
6	LBL	enter Q	28	+	
7	A		29	RCL 3	
8	E		30	RCL4	
9	g		31	+	
10	1/x		32	E	
11	STO 1		33	÷	
12	RTN	A^2	34	f	
13	LBL		35	√	
14	B		36	f	
15	E		37	LOG	
16	STO 2	k^2	38	2	
17	1		39	0	
18	RCL 2		40	x	
19	−		41	RTN	
20	E		42	LBL	
21	STO 3	$(1-k^2)^2$	43	C	
22	RCL 1		44	E	

45	STO 2	61	−
46	RCL 2	62	E
47	↑	63	RCL 1
48	1	64	RCL 2
49	−	65	x
50	x	66	+
51	E	67	E
52	RCL 1	68	÷
53	RCL 2	69	f
54	3	70	√
55	g	71	f
56	y^x	72	LOG
57	x	73	2
58	+	74	0
59	1	75	x
60	RCL 2	76	RTN





To use, set MC to run, enter program. Enter chosen Q value, press A. Enter ω/ω_o. Press B for low-pass tansmission in dB. Press C for high-pass transmission.

Appendix

The equations for the transmission of these two filter systems are shown below for the generalized form. The actual transmission for the h-p and l-p circuits can be obtained by substituting R or $1/j\omega C$ for the impedance blocks denoted by Z_1, Z_2, etc.

H or bootstrap filter

$$\frac{E_{out}}{E_{in}}=\frac{Z_2Z_3+Z_3Z_4+Z_2Z_4}{Z_1Z_3+Z_2Z_3+Z_3Z_4+Z_2Z_4}.$$

In the low-pass case, this becomes

$$\frac{1+j\omega R_2(C_1+C_2)}{1+j\omega R_2(C_1+C_2)-\omega^2R_1R_2C_1C_2}$$

and in the high-pass case

$$\frac{j\omega C_1(R_1+R_2)-\omega^2R_1R_2C_1C_2}{1+j\omega C_1(R_1+R_2)-\omega^2R_1R_2C_1C_2}.$$

Sallen and Key filter

$$\frac{E_{out}}{E_{in}}=\frac{1}{1+Z_1/Z_4+Z_2/Z_4+\dfrac{Z_1Z_2}{Z_3Z_4}}.$$

In the low-pass case, this becomes

$$\frac{1}{1+j\omega C_4(R_1+R_2)-\omega^2R_1R_2C_3C_4}$$

and in the high-pass case

$$\frac{\omega^2R_3R_4C_1C_2}{\omega^2R_3R_4C_1C_2+j\omega R_3(C_1+C_2)-1}.$$

These can be transformed into more easily manipulable forms, of the type quoted in the article above, by the use of the relationship

$$\omega_o=1/\sqrt{R_1R_2C_1C_2}$$

or its appropriate equivalent depending on the component numbering, and the simplifying relationships $R_1/R_2=x$ and $C_1/C_2=y$, again using the appropriate component numbering.

More active filter calculations

Time-saving programs for the TI59 calculator give poles and filter order for both Tschebycheff and Butterworth low-pass filters

by Kamil Kraus

As a rule, filter requirements are expressed by the maximal attenuation of the passband A_{max}, the minimal attenuation of the stopband A_{min}, and by the normalized frequency Ω. With these values only the filter order n and the poles $s_k=\sigma_k+j\gamma_k$ of the transfer function of a normalized low-pass filter need to be calculated. If the poles are known, the resonance frequency and the quality factor Q are easily obtained by

$$\omega_0=\sqrt{\sigma_k^2+\gamma_k^2},\quad Q=\frac{1}{2}\left[1+\left(\frac{\gamma_k}{\sigma_k}\right)^2\right]^{1/2}. \qquad 1$$

Hence the programs of both the Tschebysheff and Butterworth normalized low-pass filters have to give n and s_k as well.

1. As the Tschebysheff approximation is explained in detail in the reference[1], only the formulas needed to understand the programs are given. The loss of an order n Tschebysheff low-pass filter is

$$A(\Omega)=10\log\{1+[\epsilon T_n(\Omega)]^2\} \qquad 2$$

where the T-polynomial of order n is

$$T_n(\Omega)=\tfrac{1}{2}[(\Omega+\sqrt{\Omega^2-1})^n+(\Omega-\sqrt{\Omega^2-1})^n]. \qquad 3$$

The passband ripple A_{max} is related to ϵ by

$$\epsilon^2=10^{0.1A_{max}}-1. \qquad 4$$

Equations 2 and 3 are used to calculate the filter order n. After some manipulation[1] the expressions for the real and imaginary part of roots yield

$$\sigma_k=\tfrac{1}{2}\sin\frac{\pi}{2}\,\frac{1+2k}{n}(K^{1/n}-K^{-1/n})$$

$$k=0,1,2,\ldots$$

$$\gamma_k=\tfrac{1}{2}\cos\frac{\pi}{2}\,\frac{1+2k}{n}(K^{1/n}-K^{-1/n}), \qquad 5$$

where $$K=\frac{1}{\epsilon}+\sqrt{\frac{1}{\epsilon^2}+1}. \qquad 6$$

In program 1 we find n in $X\gtrless t$ and displayed before the pause, σ_k: STO00-STO07, γ_k: STO20-STO27.

Example. Given $A_{max}=0.4576$dB, $A_{min}=32$dB and $\Omega=2.0926$, we obtain n=4 and

STO00 $\sigma_1=-0.1800241922$
STO01 $\sigma_2=-0.4346168463$
STO20 $\gamma_1=1.021002054$
STO21 $\gamma_2=0.4229128979$.

2. The order n of the Butterworth normalized low-pass filter is calculated using the equation

$$n=\frac{\log[(10^{0.1A_{min}}-1)/(10^{0.1A_{max}}-1)]}{2\log\Omega} \qquad 7$$

and the roots are for n even

$$s_k=\exp\left[\frac{j\pi}{2n}(2k-1)\right]\quad k=1,3,5,\ldots \qquad 8$$

for n odd

$$s_k=\exp j\frac{\pi k}{n}\qquad k=2,4,6,\ldots$$

In program 2, n is displayed before the pause, σ_k: STO11-STO19, γ_k: STO20-STO29.

continued on page 57

Program 1.

```
LRN
000  76  2nd Lbl
001  14  D
002  43  RCL
003  00  0
004  33  X²
005  75  –
006  01  1
007  95  =
008  34  √X
009  42  STO
010  01  1
011  75  –
012  43  RCL
013  00  0
014  95  =
015  50  2nd |X|
016  45  Yˣ
017  43  RCL
018  05  5
019  95  =
020  42  STO
021  02  2
022  43  RCL
023  01  1
024  85  +
025  43  RCL
026  00  0
027  95  =
028  45  Yˣ
029  43  RCL
030  05  5
031  95  =
032  44  SUM
033  02  2
034  25  CLR
035  02  2
036  22  INV
037  49  2nd Prd
038  02  2
039  43  RCL
040  02  2
041  33  X²
042  65  x
043  43  RCL
044  04  4
045  85  +
046  01  1
047  95  =
048  28  2nd log
049  65  x
050  01  1
051  00  0
052  95  =
053  75  –
054  43  RCL
055  03  3
056  95  =
057  50  2nd |X|
058  22  INV
059  77  2nd X≥t
060  11  A
061  12  b
062  76  2nd Lbl
063  11  A
064  43  RCL
065  05  5
066  32  X≷t
067  43  RCL
068  05  5
069  66  2nd Pause
070  66  2nd Pause
071  66  2nd Pause
072  61  GTO
073  35  1/X
074  76  2nd Lbl
075  12  B
076  43  RCL
077  06  6
078  75  –
079  43  RCL
080  05  5
081  95  =
082  50  2nd |X|
083  67  2nd X=t
084  13  C
085  15  E
086  76  2nd Lbl
087  13  C
088  02  2
089  42  STO
090  05  5
091  25  CLR
092  01  1
093  44  SUM
094  03  3
095  14  D
096  76  2nd Lbl
097  15  E
098  01  1
099  44  SUM
100  05  5
101  14  D
102  76  2nd Lbl
103  35  1/X
104  43  RCL
105  05  5
106  35  1/X
107  42  STO
108  11  11
109  43  RCL
110  04  4
111  34  √X
112  35  1/X
113  42  STO
114  12  12
115  02  2
116  00  0
117  42  STO
118  08  8
119  43  RCL
120  12  12
121  33  X²
122  85  +
123  01  1
124  95  =
125  34  √X
126  85  +
127  43  RCL
128  12  12
129  95  =
130  42  STO
131  13  13
132  45  Yˣ
133  43  RCL
134  11  11
135  95  =
136  42  STO
137  14  14
138  35  1/X
139  42  STO
140  15  15
141  43  RCL
142  14  14
143  75  –
144  43  RCL
145  15  15
146  95  =
147  42  STO
148  16  16
149  43  RCL
150  14  14
151  85  +
152  43  RCL
153  15  15
154  95  =
155  42  STO
156  17  17
157  76  2nd Lbl
158  16  2nd A'
159  43  RCL
160  10  10
161  65  x
162  02  2
163  85  +
164  01  1
165  95  =
166  42  STO
167  18  18
168  77  2nd X≥t
169  18  2nd C'
170  17  2nd B'
171  76  2nd Lbl
172  18  2nd C'
173  67  2nd X=t
174  10  2nd E'
175  19  2nd D'
176  76  2nd Lbl
177  19  2nd D'
178  01  1
179  94  +/–
180  44  SUM
181  10  10
182  91  R/S
183  76  2nd Lbl
184  10  2nd E'
185  09  9
186  00  0
187  38  2ns sin
188  55  :
189  02  2
190  95  =
191  65  x
192  43  RCL
193  16  16
194  95  =
195  94  +/–
196  72  STO 2nd Ind
197  09  09
198  91  R/S
199  76  2nd Lbl
200  17  2nd B'
201  43  RCL
202  18  18
203  65  x
204  43  RCL
205  11  11
206  65  x
207  09  9
208  00  0
209  95  =
210  42  STO
211  19  19
212  38  2nd sin
213  65  x
214  43  RCL
215  16  16
216  55  :
217  02  2
218  95  =
219  94  +/–
220  72  STO 2nd Ind
221  09  09
222  01  1
223  44  SUM
224  10  10
225  44  SUM
226  09  9
227  43  RCL
228  19  19
229  39  2nd cos
230  55  :
231  02  2
232  65  x
233  43  RCL
234  17  17
235  95  =
236  72  STO 2nd Ind
237  08  08
238  01  1
239  44  SUM
240  08  8
241  16  2nd A'
242  92  INV SBR
243  91  R/S
244  LRN
```

Input:
Ω – STO 00
A_{min} – STO 03
ϵ^2 – STO 04
n=2 – STO 05
n=15 – STO 06
1 to X≷t

Program 2

```
LRN
000  43  RCL
001  01  1
002  65  x
003  93  .
004  01  1
005  95  =
006  22  INV
007  28  2nd log
008  75  –
009  01  1
010  95  =
011  42  STO
012  03  3
013  43  RCL
014  00  0
015  65  x
016  93  .
017  01  1
018  95  =
019  22  INV
020  28  2nd log
021  75  –
022  01  1
023  95  =
024  55  :
025  43  RCL
026  03  3
027  95  =
028  28  2nd log
029  42  STO
030  03  3
031  43  RCL
032  02  2
033  28  2nd log
034  65  x
035  02  2
036  95  =
037  55  :
038  43  RCL
039  03  3
040  95  =
041  35  1/X
042  85  +
043  93  .
044  04  4
045  05  5
046  95  =
047  59  2nd Int
048  42  STO
049  06  6
050  66  2nd Pause
051  66  2nd Pause
052  66  2nd Pause
053  13  C
054  76  2nd Lbl
055  13  C
056  93  .
057  01  1
058  32  X≷t
059  25  CLR
060  01  1
061  00  0
062  42  STO
063  03  3
064  25  CLR
065  02  2
066  00  0
067  42  STO
068  04  4
069  43  RCL
070  06  6
071  55  :
072  02  2
073  95  =
074  42  STO
075  07  7
076  59  2nd Int
077  75  –
078  43  RCL
079  07  7
080  95  =
081  50  2nd |X|
082  22  INV
083  77  2nd X≥t
084  19  2nd D'
085  14  D
086  76  2nd Lbl
087  14  D
088  43  RCL
089  06  6
090  42  STO
091  01  1
092  32  X≷t
093  01  1
094  42  STO
095  00  0
096  86  2nd St Flg
097  00  0
098  11  A
099  76  2nd Lbl
100  19  2nd D'
101  43  RCL
102  06  6
103  42  STO
104  01  1
105  32  X≷t
106  02  2
107  42  STO
108  00  0
109  22  INV
110  87  2nd If Flg
111  00  0
112  16  2nd A'
113  76  2nd Lbl
114  11  A
115  01  1
116  08  8
117  00  0
118  65  x
119  43  RCL
120  00  0
121  55  :
122  43  RCL
123  01  1
124  95  =
125  42  STO
126  02  2
127  39  2nd cos
128  50  2nd |X|
129  94  +/–
130  72  STO 2nd Ind
131  03  03
132  43  RCL
133  02  2
134  38  2nd sin
135  72  STO 2nd Ind
136  04  04
137  43  RCL
138  00  0
139  67  2nd X=t
140  91  R/S
141  12  B
142  76  2nd Lbl
143  12  B
144  02  2
145  44  SUM
146  00  0
147  25  CLR
148  01  1
149  44  SUM
150  03  3
151  44  SUM
152  04  4
153  87  2nd If Flg
154  00  0
155  11  A
156  16  2nd A'
157  76  2nd Lbl
158  16  2nd A'
159  43  RCL
160  00  0
161  65  x
162  02  2
163  75  –
164  01  1
165  95  =
166  42  STO
167  05  5
168  43  RCL
169  01  1
170  65  x
171  02  2
172  95  =
173  55  :
174  43  RCL
175  05  5
176  95  =
177  35  1/X
178  65  x
179  01  1
180  08  8
181  00  0
182  95  =
183  42  STO
184  06  6
185  39  2nd cos
186  50  2nd |X|
187  94  +/–
188  72  STO 2nd Ind
189  03  03
190  43  RCL
191  06  6
192  38  2nd sin
193  72  STO 2nd Ind
194  04  04
195  43  RCL
196  00  0
197  67  2nd X=t
198  91  R/S
199  12  B
200  92  INV SBR
201  91  R/S
202  00  LRN
```

Input:
A_{min} – STO 00
A_{max} – STO – 01
Ω – STO 02

Elliptic filter design using TI-59

Using this program the design of an elliptic low-pass filter takes only a few minutes

Many of programs concerning electronic filter design have been published and the calculation of Tschebycheff and Butterworth low-pass filters are in the subroutine to the TI-59, to my knowledge a simple program to solve a normalized elliptic low-pass hasn't yet been published. To overcome the rather difficult theory of elliptic integrals and elliptic functions little mathematics has been used to calculate the filter order, zeros and poles of the Tschebycheff rational function.

Program commentary

In designing an elliptic filter four values are given: A_{max} maximum passband loss, A_{min} minimum stopband attenuation, ω_B upper passband edge, ω_H upper stopband edge. These values enable zeros and poles of the Tschebycheff rational function $R_n(x,L)$ to be estimated. Calculate first

$$L^2=\frac{10^{0.1A_{min}}-1}{10^{0.1A_{max}}-1}\text{ and hence }\beta=\arcsin(1/L) \qquad (1)$$

then $$k=\sin\alpha=1/x_L=\frac{\omega_B}{\omega_H},$$

hence $$\alpha=\arcsin\left(\frac{\omega_B}{\omega_H}\right). \qquad (2)$$

With α and β the filter order n may be computed by means of complete elliptic integrals as functions of x_L^{-1} and L^{-1}. To overcome the difficulty of evaluating complete elliptic integrals the modular function as defined in Appendix by equation A1 is used. Supposing k is known, q can be computed by means of the Newton's approximation formula given by equation A2. Using the relation between q and complete elliptic integrals K together with the complementary integrals K′ the filter order n is given simply by equation A3. As the zeros of $R_n(x,L)$ are given by

$$x_{z\gamma}=\mathrm{sn}\,\frac{2\gamma K}{n}\quad\text{for n odd}$$

$$\text{and}\quad x_{z\gamma}=\mathrm{sn}\,\frac{(2\gamma-1)K}{n}\quad\text{for n even} \qquad (3)$$

the elliptic function sn u must be calculated. To simplify this task q_1' given by equation A4 has been introduced, which makes possible to express the competent elliptic function sn u′ by equation A5. Once zeros of $R_n(x,L)$ are known the poles may be computed by

$$x_{p\gamma}=\frac{x_L}{x_{z\gamma}}. \qquad (4)$$

by Kamil Kraus

Besides poles and zeros of $R_n(x,L)$, one might want to know where $R_n=\pm1$ or $R_n=\pm L$ as these points determine the location of the maximum passband or minimum stopband attenuation. The location of maxima x_m is

$$x_{m,\gamma}=\frac{(1+2\gamma)K}{n}\quad\text{for n odd}$$

$$\text{and}\quad x_m=\frac{2\gamma K}{n}\quad\text{for n even.} \qquad (5)$$

The location of minimum stopband attenuation is given by equation 4, where $x_{m\gamma}$ is inserted instead of $x_{z\gamma}$.

The program written for the TI59 follows the sequence of equations from equations A2 to A5. First, the program answers the question: is $k^2<0.5$ or $k^2>0.5$?, and then approximates q_1 and q_2 using A2. To get n as an integer the calculated value of n is rounded downwards and then 2 is added. In the final part of the program, the elliptic function according to A5 is computed. Here two cases are to be distinguished: n is even, zeros are stored in STO 11-20 and the maximas are stored in STO 21-29, when n is odd the location of zeros and maxima is interchanged!

To compare the results obtained using this program with the values calculated by another method the example given in ref. 1 is solved. Here, instead of $x_{z\gamma}$ and $x_{m\gamma}$ frequencies are given so we have to multiply the results by 20.

Program appears on page 59

Example. To find the zeros and maxima of normalized elliptic low-pass filter which has A_{max}=0.1dB, A_{min}=30dB, f_B=20 and f_H=26. First find x_L=1.3 and L=207.0952, hence α=50.28486277° and β=0.276664°. With these values calculate n=4.656928611 rounded to n=6.

Calculated zeros	ref. 1 zeros
STO11: 6.254545988	6.296
STO12: 15.72067887	15.622
STO13: 19.60740999	19.566
Calculated maxima	**ref. 1 maxima**
STO21: 11.67429795	11.66
STO22: 18.28716445	18.18
STO23: 20.0	20.0

A comparison shows that the results obtained are sufficiently accurate to be used in designs of elliptic low-pass filters.

Appendix

The modular function[2] is

$$k^2=16q-\frac{1+4q^2}{1+8q+24q^2}. \qquad \text{A1}$$

Newton's approximation formula is

$$q_{n+1}=q_n-\frac{f(q_n)}{f'(q_n)} \qquad \text{A2}$$

where $f(q)=64q^3-24k^2q^2+(16-8k^2)q-k^2$
$f'(q)=192q^2-48k^2q+(16-8k^2)$.

The relation between q and the complete elliptic integrals $K(1/x_L)$ and its complementary form $K'(1/x_L)$ by ref. 2, is

$$\frac{K_1'(1/x_L)}{K_1(1/x_L)}=\kappa_1,\quad q_1=e^{-\pi\kappa_1}\Rightarrow\frac{K_1'}{K_1}=-\frac{1}{\pi}\ln q_1$$

$$\frac{K_2'(1/L)}{K_2(1/L)}=\kappa_2,\quad q_2=e^{-\pi\kappa_2}\Rightarrow\frac{K_2'}{K_2}=-\frac{1}{\pi}\ln q_2$$

so that the filter order n is

$$n=\frac{1}{\pi^2}\ln q_1\cdot\ln q_2. \qquad \text{A3}$$

Introducing

$$q_1'=\exp\cdot(\pi^2/\ln q_1) \qquad \text{A4}$$

we have

$$\mathrm{sn}\,u'=\sin y(1+4q_1'\cos^2 y) \qquad \text{A5}$$

where $u'=u/K=2y/\pi$ and $u=2\gamma K/n$ for n odd, $u=(2\gamma-1)K/n$ for n even.

References

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continued from page 55

Example. Given A_{min}=28dB, A_{max}=3dB, Ω=2.2382, we obtain n=4 and

STO11 $\sigma_1=-0.3826834324$
STO12 $\sigma_2=-0.9238795325$
STO20 $\gamma_1=0.9238795325$
STO21 $\gamma_2=0.3826834324$

These values are in full agreement with those in reference 2.

References

1. Approximation Methods for Electronic Filter Design, by R. W. Daniels. McGraw Hill, New York, 1974.
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Compensated active summer

Adding two op-amps and six resistors to the basic summing amplifier can reduce phase and magnitude errors to negligible levels.

by A. M. Soliman

It is well known that the complex open-loop gain characteristics of operational amplifiers (op-amps) degrade significantly the performance of the weighted summing structures. With the introduction of low-cost dual and quad op-amps having closely matched characteristics which track with changes in temperature and voltage, active compensation techniques have proved very attractive. Recently several active phase-compensated weighted summers using two op-amps have been described[1]. It has been shown that for low frequencies the two op-amp compensated summer has phase and magnitude errors proportional to $(\omega/\omega_t)^3$ and $(\omega/\omega_t)^2$, where ω_t is the unity gain bandwidth of the op-amp. That is, the phase error of the two op-amp summer is reduced to a negligible level; whereas the magnitude error remains a second order term, as that of the uncompensated summer.

Most recently, active compensated amplifiers using three op-amps have been considered[2]; however, the reported are not suitable by their nature for realizing generalized weighted summers for both positive and negative gains.

With the circuit described here, at low frequencies the phase and the magnitude errors are proportional to $(\omega/\omega_t)^3$ and $(\omega/\omega_t)^4$ respectively. That is, both the phase and the magnitude errors are reduced to negligible levels. The design equations assume the use of mismatched op-amps, although the special case of matched op-amps will also be considered.

Compensated summer

The circuit is shown right. The voltage $V_{11}, V_{12}, \ldots, V_{1m}$ represent the m inverting inputs and the voltage $V_{21}, V_{22}, \ldots, V_{2n}$ are the n noninverting inputs. Let the open loop gain of each of the three op-amps be represented by the single pole model given by

$$A_i(s) \approx \frac{\omega_{ti}}{s} \text{ for } i=1,2,3 \qquad (1)$$

where ω_t is the unity gain bandwidth of the op-amp and is ideally infinity. By direct analysis of the circuit, the generalized expression of the output voltage V_0 is

$$V_o=\left[\frac{(K+1)}{G^+}\sum_{i=1}^{n}(V_{2i}G_{2i})-\frac{K}{G}\sum_{i=1}^{m}(V_{1i}G_{1i})\right]\left[\frac{K_1+1}{K_2+1}\right].\epsilon(s) \qquad (2)$$

where

$$G^+=\sum_{i=1}^{n}G_{2i},\ G_{2i}=\frac{1}{R_{2i}}(i=1,2,\ldots n) \qquad (3)$$

$$G=\frac{1}{R}=\sum_{i=1}^{m}G_{1i},\ G_{1i}=\frac{1}{R_{1i}}(i=1,2\ \ldots m) \qquad (4)$$

ϵ (s) is the remaining error function of the compensated circuit and is equal to

$$\frac{1+s\tau_2+s^2\tau_2\tau_3}{1+s\tau_3+\left(\frac{K+1}{K_2+1}\right)[s\tau_1+s^2\tau_1\tau_2+s^3\tau_1\tau_2\tau_3]} \qquad (5)$$

where $$\tau_i=\frac{K_i+1}{\omega_{ti}}(i=1,2,3) \qquad (6)$$

Choosing $K_2 = K$, equations (2) and (5) become

$$V_o=\left[\frac{(K_1+1)}{G^+}\sum_{i=1}^{n}(V_{2i}G_{2i})-\frac{K(K_1+1)}{(K+1)G}\sum_{i=1}^{m}(V_{1i}G_{1i})\right].\epsilon(s) \qquad (7)$$

$$\epsilon(s)=\frac{1+s\tau_2+s^2\tau_2\tau_3}{1+s(\tau_1+\tau_3)+s^2\tau_1\tau_2+s^3\tau_1\tau_2\tau_3} \qquad (8)$$

Examining the above equation for the remaining phase and magnitude errors, it is seen that by taking

$$\tau_1=\frac{\tau_2}{2}=\tau_3 \qquad (9)$$

will yield relatively negligible phase and magnitude errors over a prescribed frequency range. The compensated error function reduces to

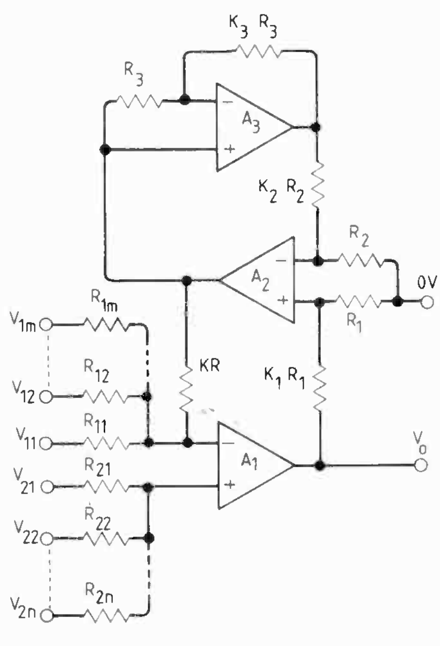
$$\epsilon_c(s)=\frac{1+2\tau_1 s+2\tau_1^2 s^2}{1+2\tau_1 s+2\tau_1^2 s^2+2\tau_1^3 s^3}$$

From the above equation, it is seen that the phase and the magnitude errors of the compensated circuit are given respectively by

$$\phi\equiv\arg.\ [\epsilon_c(j\omega)]\simeq 2\ (\tau_1\omega)^3$$

$$=2\left[(K_1+1)\ \frac{\omega}{\omega_{t1}}\right]^3$$

$$\gamma\equiv\ |\ \epsilon_c(j\omega)\ |\ -1\approx 4(\tau_1\omega)^4$$



Basic summing amplifier is A_1. Compensation of the summer is achieved by A_2 and A_3 and a few resistors: these reduce phase error to a third order term and magnitude error to a fourth order term.

Ahmed Soliman received the B.S. degree in electrical engineering from Cairo University, and the M.S. and Ph.D. degrees from the University of Pittsburgh. He is currently in the department of electronics and communications engineering at Cairo University.

$$=4\left[(K_1+1)\frac{\omega}{\omega_{t1}}\right]^4$$

where $\omega\tau_i<<1\ (i=1,2,3)$

Thus with the conditions of equation (9) being satisfied and at frequencies such that $\omega\tau_i \ll 1$ ($i = 1,2,3$), the phase error is reduced to a third order term and the magnitude error is reduced to a fourth order term.

The gain requirements are controlled by the parameter K. The compensation conditions can be satisfied by selecting the resistors K_1R_1, K_2R_2 and K_3R_3. The design equations for K_1, K_2 and K_3 are obtained from equations (6) and (9) and are

$$K=K_2=2(K_1+1)\left(\frac{\omega_{t2}}{\omega_{t1}}\right)-1$$

$$K_3=(K_1+1)\left(\frac{\omega_{t3}}{\omega_{t1}}\right)-1$$

It is not necessary to use matched op-amps with this generalized summer. If matched op-amps are used however, the design equations simplify to

$$K=K_2=2K_1+1$$

$$K_3=K_1$$

It should be noted that the above design is based on the choice $K = K_2$. Other choices for the parameter K are possible.

It is worth noting that the three port v.c.v.s. reported most recently[3] is a special case from this generalized summer by setting $m=n=1$ and $\tau_3=0$. WW

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Elliptic filter program

LRN			089	95	=	179	66	2nd Pause	269	35	1/X
000	76	2nd Lbl	090	44	SUM	180	66	2nd Pause	270	76	2nd Lbl
001	17	2nd B'	091	04	4	181	66	2nd Pause	271	19	2nd D'
002	43	RCL	092	43	RCL	182	66	2nd Pause	272	43	RCL
003	15	15	093	01	1	183	61	GTO	273	04	4
004	32	X≷t	094	33	x^2	184	34	√X	274	72	STO 2nd Ind
005	43	RCL	095	65	x	185	76	2nd Lbl	275	30	30
006	00	0	096	43	RCL	186	34	√X	276	25	CLR
007	38	2nd sin	097	00	0	187	43	RCL	277	01	1
008	33	X^2	098	65	x	188	08	8	278	44	SUM
009	77	2nd X≥t	099	02	2	189	59	2nd Int	279	30	30
010	13	C	100	04	4	190	85	+	280	25	CLR
011	14	D	101	95	=	191	02	2	281	02	2
012	76	2nd Lbl	102	94	+/−	192	95	=	282	44	SUM
013	13	C	103	44	SUM	193	42	STO	283	02	2
014	43	RCL	104	04	4	194	01	1	284	43	RCL
015	00	0	105	43	RCL	195	43	RCL	285	01	1
016	39	2nd cos	106	01	1	196	06	6	286	75	−
017	33	X^2	107	45	Y^x	197	35	1/X	287	43	RCL
018	42	STO	108	03	3	198	23	lnX	288	02	2
019	00	0	109	95	=	199	55	:	289	95	=
020	43	RCL	110	65	x	200	89	2nd π	290	22	INV
021	10	10	111	06	6	201	95	=	291	77	2nd X≥t
022	32	X≷t	112	04	4	202	35	1/X	292	18	2nd C'
023	11	A	113	95	=	203	65	x	293	10	2nd E'
024	76	2nd Lbl	114	44	SUM	204	89	2nd π	294	76	2nd Lbl
025	14	D	115	04	4	205	95	=	295	35	1/X
026	43	RCL	116	43	RCL	206	94	+/−	296	43	RCL
027	00	0	117	04	4	207	22	INV	297	04	4
028	38	2nd sin	118	55	:	208	23	lnX	298	72	STO 2nd Ind
029	33	X^2	119	43	RCL	209	42	STO	299	31	31
030	42	STO	120	03	3	210	00	0	300	25	CLR
031	00	0	121	95	=	211	25	CLR	301	01	1
032	43	RCL	122	94	+/−	212	01	1	302	44	SUM
033	10	10	123	85	+	213	42	STO	303	31	31
034	32	X≷t	124	43	RCL	214	02	2	304	25	CLR
035	11	A	125	01	1	215	25	CLR	305	02	2
036	76	2nd Lbl	126	95	=	216	00	0	306	44	SUM
037	11	A	127	48	2nd Exc	217	32	X≷t	307	02	2
038	08	8	128	01	1	218	86	2nd St Flg	308	43	RCL
039	65	x	129	95	=	219	02	2	309	01	1
040	43	RCL	130	75	−	220	10	2nd E'	310	75	−
041	00	0	131	43	RCL	221	76	2nd Lbl	311	43	RCL
042	95	=	132	01	1	222	18	2nd C'	312	02	2
043	75	−	133	95	=	223	02	2	313	95	=
044	01	1	134	50	2nd $\lvert X\rvert$	224	42	STO	314	22	INV
045	06	6	135	22	INV	225	02	2	315	77	2nd X≥t
046	95	=	136	77	2nd X≥t	226	25	CLR	316	91	R/S
047	94	+/−	137	12	B	227	22	INV	317	10	2nd E'
048	42	STO	138	11	A	228	86	2nd St Flg	318	92	INV SBR
049	03	3	139	76	2nd Lbl	229	02	2	319	91	R/S
050	43	RCL	140	12	B	230	10	2nd E'	320	00	LRN
051	00	0	141	43	RCL	231	76	2nd Lbl			
052	65	x	142	01	1	232	10	2nd E'			
053	43	RCL	143	72	STO 2nd Ind	233	43	RCL			
054	01	1	144	05	05	234	02	2			
055	65	x	145	87	2nd If Flg	235	65	x			
056	04	4	146	01	1	236	09	9			
057	08	8	147	15	E	237	00	0			
058	95	=	148	76	2nd Lbl	238	55	:			
059	94	+/−	149	16	2nd A'	239	43	RCL			
060	44	SUM	150	01	1	240	01	1			
061	03	3	151	44	SUM	241	95	=			
062	43	RCL	152	05	5	242	42	STO			
063	01	1	153	43	RCL	243	03	3			
064	33	X^2	154	09	9	244	39	2nd cos			
065	65	x	155	42	STO	245	33	X^2			
066	01	1	156	00	0	246	65	x			
067	09	9	157	86	2nd St Flg	247	04	4			
068	02	2	158	01	1	248	65	x			
069	95	=	159	17	2nd B'	249	43	RCL			
070	44	SUM	160	76	2nd Lbl	250	00	0			
071	03	3	161	15	E	251	85	+			
072	43	RCL	162	89	2nd π	252	01	1			
073	00	0	163	33	X^2	253	95	=			
074	94	+/−	164	42	STO	254	42	STO			
075	42	STO	165	08	8	255	04	4			
076	04	4	166	43	RCL	256	43	RCL			
077	43	RCL	167	06	6	257	03	3			
078	00	0	168	23	lnX	258	38	2nd sin			
079	65	x	169	65	x	259	65	x			
080	08	8	170	43	RCL	260	43	RCL			
081	75	−	171	07	7	261	04	4			
082	01	1	172	23	lnX	262	95	=			
083	06	6	173	55	:	263	42	STO			
084	95	=	174	43	RCL	264	04	4			
085	94	+/−	175	08	8	265	87	2nd If Flg			
086	65	x	176	95	=	266	02	2			
087	43	RCL	177	42	STO	267	19	2nd D'			
088	01	1	178	08	8	268	61	GTO			

Load:

α – STO 00
1 – STO 01
0.5 – STO 15
β – STO 09
0.000 000 1 – STO 10
6 – STO 05
11 – STO 30
21 – STO 31

Program to calculate the order n of a normalized elliptic low-pass: STO 08, zeros and maxima of Tschebycheff rational function: STO 11-STO 20, STO 21-STO 29 respectively.

Advanced IT and Alvey

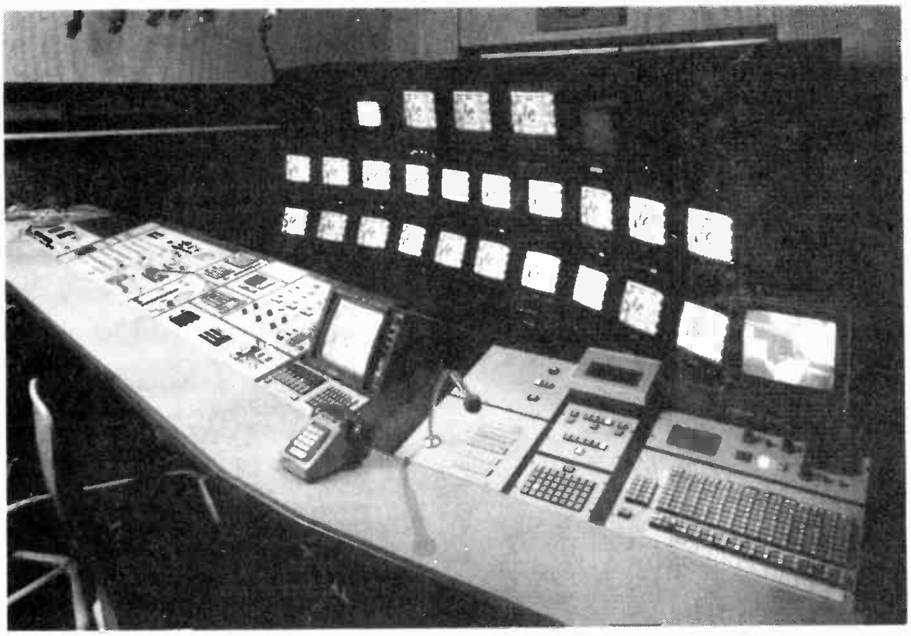
The first four definition studies for large-scale demonstrator projects under the Alvey programme for advanced information technology have now been started by ICL, GEC Electrical Projects, Racal Research and Marconi Avionics. A further six studies are to be commissioned, leading to the final selection of about five projects to be implemented over the five years of the programme.

GEC, working with the Artificial Intelligence Department of Edinburgh University and the National Engineering Laboratory, East Kilbride, are developing a 'Design to Product' system for a completely automated factory where design concepts are input at one end and the finished product, which includes maintenance data, will energe from the other. The system will automatically provide all the detailed design work, process planning, machining of parts and assembly all with a minimum of human intervention. The demonstrator will provide a skeleton system for the whole process.

An efficient service to the public in their contact with the complexities of the legislature system is the aim of ICL in partnership with the DHSS and Logica. This could be achieved by using knowledge-based decision systems and improved user-machine interfaces. Mobile information terminals could bring many new facilities to road users and business people on the move. Part of Racal's study is the development of terminals which will use all the other technologies developed through the Alvey programme to form the basis of multi-purpose data communications, processing and display console for mobile and portable use. Racal will be working with a consortium including SPRL, BL Technology, the Human Science and Advanced Technology Research Group, Loughborough University and the Transport and Road Research Laboratory.

'Replacement of man underwater' for the inspection and maintenance of installations in gas and oil fields is the goal of the project proposed by Marconi Avionics in association with Offshore Engineering Ltd.

The Alvey programme follows the Alvey Committee Report recommending a national research programme into advanced information technology costing $350M over five years. It aims to combine the strengths of industry, the academic sector, research organizations and the Government to work in four specific key technologies: very large scale integration, software engineering, user-machine interfaces and intelligent knowledge-based systems. The programme works in collabortion with ESPRIT, the European Strategic Programme for Research and Development in Information Technology.



Refurbishment of the complete vision system at Studio 4, BBC Television Centre, London, has been carried out by Link Electronics. The equipment includes six Link 125 colour cameras, a Grass Valley vision mixer, 13 colour monitors, 41 monochrome monitors and a complete package of distribution and interface systems as well as test equipment.

OU to study IT in education

Appropriately for a university that was founded on mass communication, the Open University has been commissioned by the EEC to study the future use of information technology in education and training. The outcome of the study will be recommendations, all financially valued, for action by the EEC to stimulate the appropriate use of IT-based educational technology in the member states. Eight researchers, under the direction of Dr Peter Zorkoczy, will take six months to look at media, educational technology, computing, electronics and communications.

The team is anxious to contact individuals and organizations who are considering the use of such technologies in their training programmes. They are the EEC Project Office, Block T12, The Open University, Walton Hall, Milton Keynes MK7 6AA.

Secondary radar will oust primary

Marconi Radar have introduced a monopulse secondary surveillance radar system that can provide greater directional accuracy, and which is capable of operating the proposed Mode S, where each aircraft can be individually 'interrogated' to establish a data link. New techologies being introduced into s.s.r. systems, Marconi say, mean that they are set to replace primary radar as the main source of air traffic control data. In secondary surveillance radar all aircraft within a specific distance from the airfield, fitted with a transponder, receive digital coded signals transmitted from the ground station and automatically transmit back details of the identity and height of the aircraft.

The first element in the system is a new, patented, large vertical-aperture antenna, specifically designed for monopulse working which can produce three azimuth patterns at both 1030 and 1090MHz. This forms the means of considerably improved sidelobe suppression and direction finding, and also reduces the 'clutter' caused by ground reflections and false targets, such as buildings or aircraft on the ground.

The transmitter/receiver, known in this context as an interrogator/responder, is completely solid-state including the final output power stage of 500W to 2kW. The monopulse receivers have parallel outputs from balanced channels to allow very accu-

Optical memory

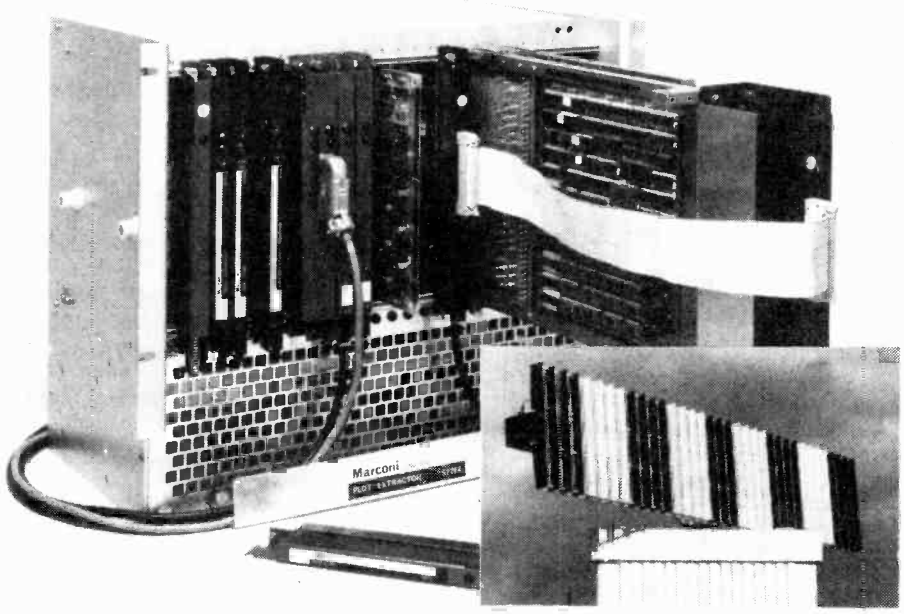
Another development in optical disc storage devices capable of holding vast amounts of memory has been announced in Japan by Hitachi. At the same time they have announced the development of an electronic filing system based on the optical discs. A 12in optical disc can store up to 1310Mbytes per side, the equivalent of 20000 A4 size pages. In addition images and illustrations can be included. The average access time is 250ms. Hitachi is making available an optical disc "library' which uses 16 discs with an average access time of 5s and another with twice the capacity, 32 discs, accessed within 6s. The discs are designed to work with Hitachi computers and work stations but are also available with GP1B interfaces for use with other computers.

The electronic document filing system, Hitfile 60, consists of a disc controller, a high-resolution display unit, keyboard, scanner, printer and facsimile adaptor with one or more optical discs. At the maximum configuration this system can hold 8640Mbytes of data, or about 1.3 million A4 documents. Documents are stored as facsimile images of the document produced by a scanner. Each document may be entered into up to eight different files and then can be retrieved from any of these. A document retrieved on a display can be magnified or reduced in size by simple control from the keyboard or a 'mouse' and for high-speed magnification and reduction, Hitachi offer an image processor as an option. The 15in monochrome display produces a high resolution picture composed of 1728 by 368 dots, enabling a user to read newspaper type characters with ease. Different models of document scanner and output printer depending on the degree of speed and resolution required.

rate direction finding on single inputs.

The decoding equipment includes special logic to ensure the retention of wanted data in poor or ambiguous signal conditions. A high-speed data bus is employed with bit-slice processing. Outputs to other circuits in the unit are used to form plotting data expressing the range, azimuth, identity and altitude of all s.s.r. targets within the radar cover. All formats for digital outputs are programmable and therefore may be reconfigured to take in any new standard.

Although Marconi admit that such equipment exists elsewhere and that there is an American rival, they feel that they have achieved the same objectives in a very efficient way with a system that is capable of many expansions and extensions to offer an air traffic control data system to last well into the 21st century. Marconi say they expect to capture a good proportion of the potential market of 1000 systems worldwide.



Decoding and plot extraction modules for the Marconi Messenger secondary surveillance radar use many processors interconnected by a high speed data bus. (Inset) The Large Vertical Aperture antenna used with the system.

Computer for railway signals . . .

A trial installation of a new computer system capable of automatically setting signalled routes for trains has been commissioned at the new Three Bridges signal box controlling the London-to-Brighton main line. The Automatic Route Setting system is superimposed on the signalling safety interlocking system and covers about 13km. It can cope automatically with substantial deviations from the timetable without the signal operator's intervention, though it may be manually over-ridden. The system uses two microcomputers. One is linked to the signalling train identifier and to the regional master timetable system; the other takes into account any deviations and routes the trains so as to minimize any aggregate delay. During development of the system at BR's R & D Division at Derby, considerable use was made of a large simulation package, or in everyday terms, a train set. This enabled engineers to produce a software package capable of general application throughout BR and assisted them in exploring the interactions and interfaces between the signalling system, the signal operators and the computer.

. . . and traffic signals

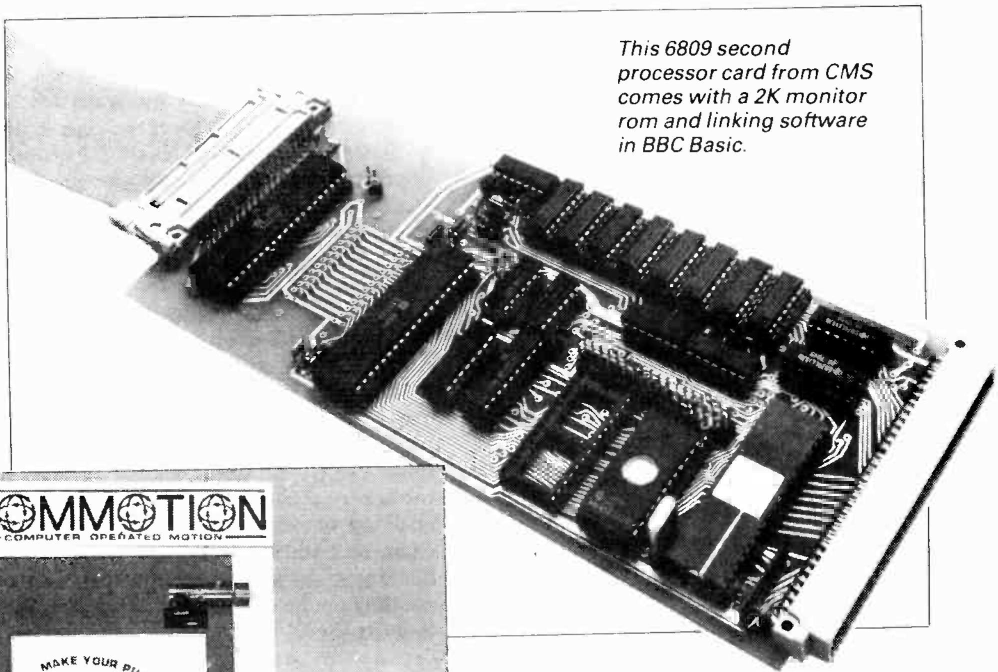
A remote monitoring and control system for traffic lights has been developed by Stonefield Electronics Ltd and Leicester County Council. The system, known as REMAC, can automatically call up a central control room if a fault develops at a set of signals. It also enables the control room operator to check the correct working of the signal lamps and vehicle detectors and to verify the timings of the signal sequences. It works equally well for light-controlled pedestrian crossings. Using normal telephone lines, through an integral modem, REMAC only calls if there is a fault, there is no need to keep the lines open. Provision is made for the system to contact a maintenance contractor or to dial more than one centre or a standby central co-ordinator. The system can work in conjunction with microprocessor-based traffic controllers.

Stonefield produce a self-contained computer to work the system. With a colour v.d.u. and a disc memory that stores the details of each junction so that if a call comes in the junction may be automatically displayed with symbols for lights, road markings, traffic sensors etc. There is also space to display the reported fault. The computer can also hold traffic flow information so that the gravity of a fault may be assessed. The first production model of REMAC has been installed at Slough, Berks with the central terminal at the Department of Transport South East Regional Office.

Micro User Show

The BBC Microcomputer continues to consolidate its reputation as a machine for the experimenter, and among the computer games at last December's Micro User Show in London some interesting new add-ons were visible.

A 6809-based second processor board from Cambridge Microprocessor Systems provides the basis of a versatile development system for industrial applications. The card, which can be fitted inside the computer or mounted in a rack externally, carries two 28-pin eprom sockets and 64K of ram with optional battery back-up. Software is available to allow standard FLEX discs to run on the BBC, giving access to a wide range of high-level languages including Pascal, Fortran, C, PL9, Forth and BCPL. Basic price is £249 and the system is available also as a single-board controller. C.M.S., 11 St Margaret's Road, Girton, Cambridge CB3 OLT, tel. 0223-276791.



This 6809 second processor card from CMS comes with a 2K monitor rom and linking software in BBC Basic.

Second processors were being shown by other exhibitors, including Acorn themselves (Z80 and 6502) with a 16032 promised, and Watford Electronics (Z80A). The Watford unit has 16K of rom space and 64K of ram, with room internally for a further 64K. Expansion options include a hard disc interface, additional serial channels, an IEEE488 interface, a real-time clock and a prototyping board. The operating system is CP/M 2.2 and the price £299. Watford Electronics, Cardiff Road, Watford, Herts, tel. 0923-40588.

◀ For the technocat who has everything: a servo control module which plugs in to the BBC Microcomputer.

Acorn also showed their IEEE488 instrument interface (described elsewhere in this issue, and featured on our cover); the unit, styled in a case to match the computer, costs £282.60.

One drawback of the standard BBC Micro is that high-resolution graphics are incompatible with long user programs, since in some display modes the operating system sequesters up to 20K of ram to store the screen display. A board from Cambridge Microcomputer Consultants, the Aries B20, provides a substitute for this lost memory. Paging is carried out automatically, allowing programs as long as 28K to run even in the highest resolution modes. The board, which costs £86.91, fits inside the computer case; and, for compatibility with software which makes direct acesses to the screen, it can be enabled or disabled from the keyboard.

The same company offered at the show yet another IEEE488 interface; its price, £195, includes software on disc or cassette. C.M.C. Ltd, Freepost, Cambridge CB1 1BR, tel. 0223-210677.

From SJ Research comes the Control Rom, a useful piece of firmware which its designers believe will do for control applications what high-level languages have done for computing in general. Plugged into one of the BBC Micro's paged rom sockets, it enables data to be written to or read from specific bits on the i/o ports as easily as loading or saving to disc or tape. Its commands are available to any language which can support filing systems. The rom can handle up to 32 channels at once, giving direct access to the computer's memory space, and it has two special channels suitable for communication with Control Universal's 8-bit and 12-bit analogue cards. As a bonus, the rom has a 'terminal' mode allowing communications via the RS423 port. The price is £39, and a version will be available for the Acorn Electron. S. J. Research, 108 Mill Road, Cambridge CB1 2BD, tel. 0223-69927.

Commotion Ltd, who were showing the Control Rom, also had an interesting miniature servo interface – the Beasty. Designed for uses in micro-robotics, this module makes it possible to control up to four servo mechanisms, including standard model aircraft servos, through software or directly from the computer keyboard. The Beasty is accessed via a single pin of the computer's user port. It costs £43.45 from Commotion, 241 Green Street, Enfield, Middlesex EN3 7SJ, tel. 01-804 1378.

Among many other new roms for the BBC Micro was a very flexible machine code data base program, Beebase-1, which enables the creation of files of up to 20,000 characters with potentially unlimited storage capacity on tape or disc. Up to 25 data fields are possible in each record, with a maximum of 250 characters per field. Beebase-1 is supplied with a Basic printer routine on cassette which could easily be adapted to print data in a variety of unconventional formats – including, for example, tables. GCC (Cambridge), 66 High Street, Sawston, Cambridge CB2 4BG, tel. 0223-835330.

For plotting graphs and charts, a graphics dump rom from D. A. Computers includes fast machine-code routines for several popular dot-matrix printers, including models by Epson, Seikosha and NEC. The rom can be called from software or from the keyboard and it offers a choice of print densities and magnifications. The screen can be printed complete or in part, in four or eight shades of grey or in plain black-and-white. The rom costs £15.66 from D. A. Computers, 104 London Road, Leicester, tel. 0533-549407.

Beebug Publications have added to their range of software a Basic programmer's aid in rom, to complement their Exmon machine code monitor. The Toolkit includes a powerful screen editor, an error trap, a 'bad program' recovery routine and many other utilities for manipulating Basic programmes. Toolkit and Exmon cost £23.48 each, or to Beebug subscribers £14.35. Beebugsoft, P.O. Box 109, High Wycombe, Buckinghamshire HP11 2TD.

Prices quoted do not include v.a.t. or delivery.

New frequencies for land mobiles

A technical specification for land mobile radio services operating in the frequency range 174 to 225MHz has been published by the Radio Regulatory Division of the DTI. The specification lays down the parameters and related methods of measurement for fm equipment including digital signalling techniques.

The method of measurement described in the specification have been aligned with CEPT recommendations to enable British manufacturers to compete in European markets.

This frequency band was released from 405-line tv service, due to close down at the end of this year. Among the user groups to be assigned channels in the new band will be the power industries who will be displaced from the 105 to 108MHz band when this is re-allocated to fm broadcasting services.

Cellular radio – first details

Plans for the implementation of a cellular radio system have been unveiled by Telecom Securicor Cellular Radio, the joint venture between BT and Securicor who were offered one of the two licences to start a cellular service. The switching system to be used is TACS (Total Access Communications System), which is a UK development of AMPS, the system which has had trial operation in Chicago. The heart of the system is a non-blocking, digital mobile switching exchange (EMX) that controls signalling and voice communication within the cell system as well as connecting with the public switched network. Each cell site contains a base site controller and multichannel transmit/receive equipment. Each unit may be expanded to handle up to 64 channels on a single antenna. EMX keeps track of caller and switches between base stations as the caller moves between cells, 'handing-off' the call to each new cell and switching to a free channel in that area. This process is unnoticed by the user and the channel previously occupied is free for re-use. There is to be a multi-layered hierarchy of areas; the base station comes within a location area, which is connected to an EMX, joined to others through a service network with an overall sytems area. All this is invisible to the user who needs only to dial a user's number to be connected anywhere in the country.

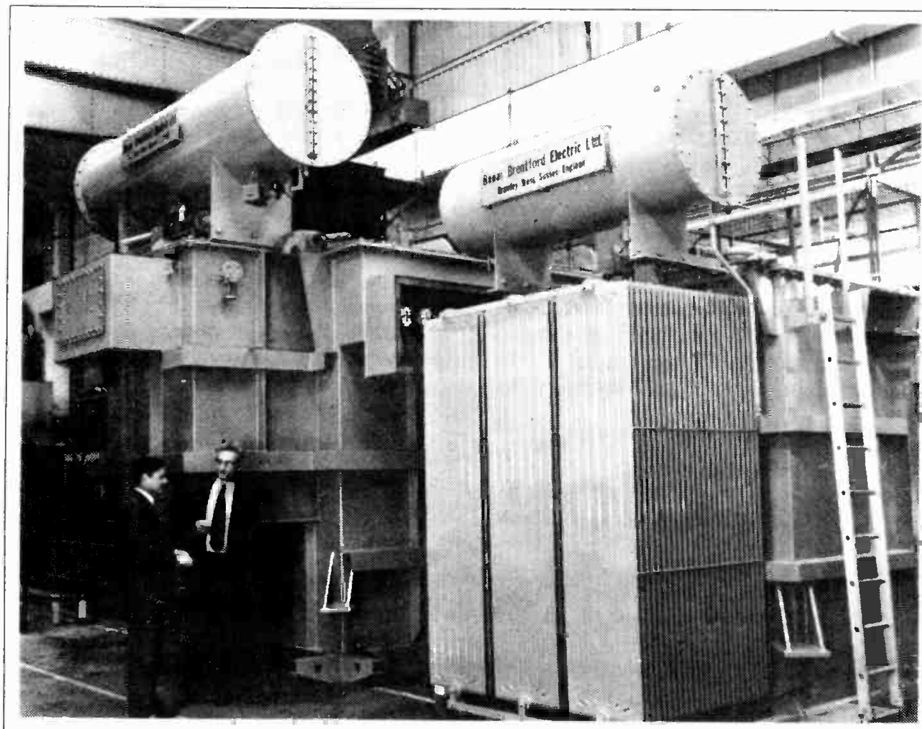
TACS includes a dedicated control channel, has allocated channels without hunting for a vacant channel; it uses 6kHz supervisory audio tones and offers good recovery and registration of signals. Data may be transmitted on the SKb/s "Manchester' signalling system which offers five repetitions of each block of data.

Capacity of the system may be expanded by reducing the size of each cell in heavily populated areas. The minimum size of a cell is about 1km radius around the transmitter. The system has 25kHz bandwidth and as there is no need for guard bands between adjacent channels broadband transmission is possible to reduce interference. Further noise reduction is achieved by using expansion and compression. In theory there could be as many users as now use conventional telephones, with no reduction in sound quality.

User equipment is not provided by TSCR but many manufacturers are said to be planning car-based and portable sets. These are likely to include many facilities associated with office telephones such as an internal memory for frequently dialled numbers, automatic re-call of engaged numbers, call transfer, conference calls and so on. Initially, a car-based set could cost as much as £2,500, but mass production and the use of very similar sets in the USA, could bring the price down considerably. Data facilities with the use of a modem and a portable computer could mean connection with electronic mailboxes, databases and word processors.

There is no attempt at co-operation between TSCR and their rival licencee, Racal-Milgo, and two independent parallel systems are to be developed. The only way that a caller on one system will be able to contact another on the rival will be through the public switched network.

TSCR expect to have an operational system in London by the beginning of 1985 and to cover 90% of the UK population by 1989, or sooner.



The power needed to accelerate particle beams in the Large Electron-Positron (LEP) storage ring, at CERN, Geneva, is provided by r.f. cavities fed by klystron tubes. There will be 96 1MW klystrons, with six feeding each r.f. station in the LEP to provide up to 86GeV per beam. The prototype transformer and rectification equipment, supplied by Bonat Brentford of Crawley, incorporates an input transformer and two high tension transformer rectifiers to provide the d.c. supply to the klystrons. The h.t. transformers step up the voltage to 100kV and the rectified, thyristor controlled supply can provide up to 36A d.c. This is sufficient to drive only two of the 1MW klystrons for experimental work.

Patented brainware

A solution to the problem of copyright and computer programs is suggested in a Government Green Paper. It proposes that in a sweeping reconstruction of the patent laws such works are 'intellectual property' and like other ideas or inventions they should be covered by patents. Because of current delays in the patenting system they also propose streamlining the Patent Office by making it a separate statutory body, independent of the Department of Trade and Industry, and breaking the monopoly of the Patent Agents.

One way of speeding up the system, the paper suggests, is to introduce a 'petty' patent which would have a ten-year life and provide the owner of an idea with a simpler form of protection, without the long and costly procedures of a full patent. Other forms of intellectual property, such as designs, would also be transferred from copyright to patent protection.

In the Green Paper, the academic world is castigated for freely exchanging information, nationally and internationally, without any attention to the possible commercial application of their ideas. On the other hand school pupils are encouraged to copy software without any thought to copyright. All fields, including small businesses, should be encouraged to look to the protection and commercial exploitation of their intellectual property. Employees who develop ideas should be given the right to take over their inventions if employers do not intend to exploit them.

Another new departure from existing procedures would be the right to challenge the validity of a patent even after it has been granted.

The paper proposes an Intellectual Property and Innovation Bill to bring together all these ideas.

More News appears on page 71.

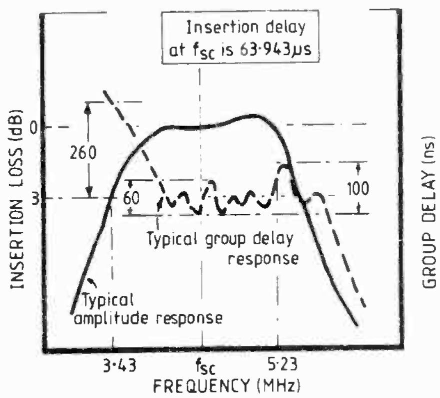
Improving colour television decoding

This third installment of David Read's decoder article continues the January discussion of a PAL modifier with adaptive notch and follows with colour tube problems.

by D. C. A. Read
B.Sc. (Eng), M.I.E.E.

Some of the colour prints in this article are referred to in previous instalments. Colour print 1 relates to the first part, in December, page 76 and prints 2-5 to the January article. Due to last-minute alteration of figure numbering, figure numbers in the last (January) paragraph did not match properly with the illustrations. This paragraph, repeated with correct numbering, precedes the concluding paragraphs of part 2, followed below by part 3 on tube problems.

Traces in Fig. 24 (January) show the inverting and non-inverting inputs; the output summing point is shown in the bottom trace of Fig. 25. The envelope timing is matched, i.e. the two traces of Fig. 24 are delay-adjusted to obtain the 64μs spacing, and the colour subcarrier phase and amplitude values are also balanced to achieve cancellation. In the top two traces of Fig. 25 the carrier frequency has been shifted slightly be removing the 25Hz term and changing ¼ to a ½ in the subcarrier expression, the result being that the subcarrier is now stationary with respect to line timing. You can now see that phase (group delay) in the gaussian chroma bandpass filter and the cheap DL60 chroma delay line, below, reduce the ability to obtain cancellation at the vertical colour transition where the sidebands gen-



erated are large. Residual error is shown in the bottom trace, Y-out, Fig. 25. Some is also due to the changed rise times of the subtracting chroma transitions due to the reduced bandwidth of the chrominance signal. Comparison of the two traces in Fig. 24 shows this rise-time difference. Colour print 5 shows the effect of the reduced rise time on the chroma-only display.

For the horizontal colour bars signal, however, where the combing action across the adjacent lines could make cancellation worse, the notch has to be switched back into circuit. (A mixed vertical and horizontal colour bars signal could be used, as in colour print 6, but the small areas detail would not show up in the colour printing when showing the whole screen. This test pattern is useful for showing defects in adaption switching, where vertical and horizontal transitions occur.) With the sort of notch indicated in Fig. 17 (a) (January) the picture is visibly softened, but with an electronically switched notch, as in the present application, the notch depth and

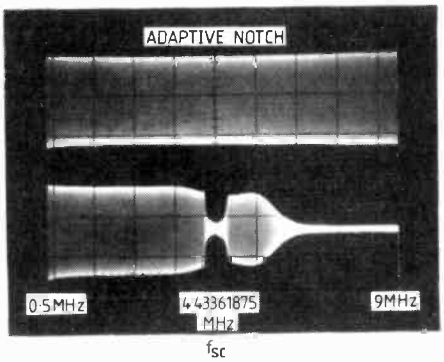


Fig. 26. *Line-rate sweep signal fed to the modifier comb circuit. (Tr_1 and Tr_2 bases). Lower trace shows adaptive notch 'snapping in' as explained in the text.*

width can be set according to the analysis. Fig. 26 shows the effect with the notch switched in and Fig. 27 with the notch out. The extra marker on Fig. 27 indicates the subcarrier frequency, the other markers are in 1MHz steps.

Comb decoding techniques reduce the moving dots on coloured edges, i.e. the cross-luminance, but they also increase the luminance bandwidth so that luminance detail can be displayed up to 5.5MHz. The last grating on test card F is at 5.25MHz and if the main criterion is to have a better luminance resolution then it must be considered whether the display tube is capable of displaying the higher frequencies and, if not, whether application of high frequency luminance to the tube could result in a worse picture. Moiré beat patterns might occur due to the structure of the tube and the luminance highband detail. The high frequencies may not be usefully displayed,

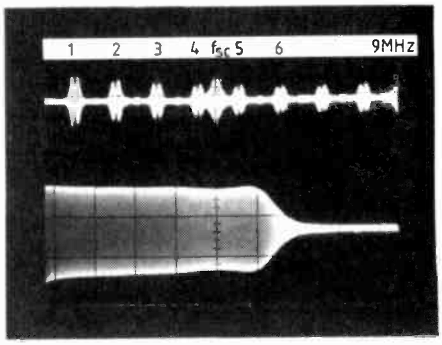


Fig. 27. *Trace of the ouput of the modifier comb circuit with the adaptive notch non-operative, (gate of f.e.t. is at OV and is thus switched off).*

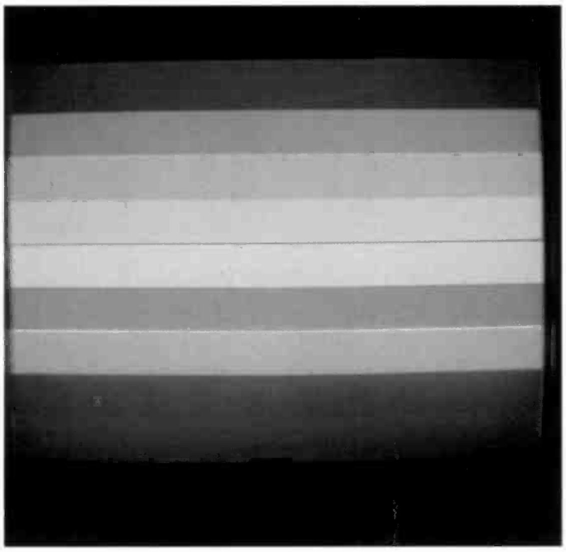
and the beat pattern could degrade the picture. Slow panning of the camera could also result in high frequency components producing additional moving beats and twitter.

Colour tube limitations

Part 3 – Inability of the modern colour tube to display full bandwidth liminance

New colour tubes, such as the Philips 30AX self-aligning 110% in-line gun, have fully interchangeable picture tube and deflection yokes that are truly self-aligning and self-converging. When these tubes are replaced it is merely a matter of the deflection unit being pushed against the tube neck onto registering lugs. In such in-line tube arrangements the corrections normally achieved by external magnet sets are carried out in the neck of the tube by two, four and six-pole fields, produced by thin magnetic wire rings within the electron gun and which correct all that was previously carried out externally on the tube neck.

Other advantages are that the phosphor has an improved pigmentation providing



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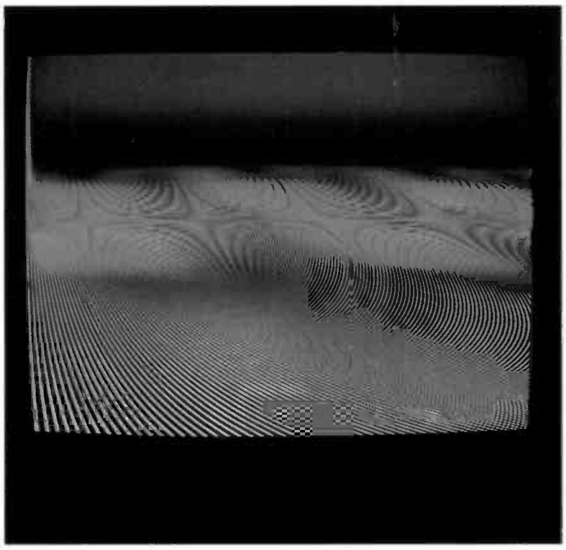

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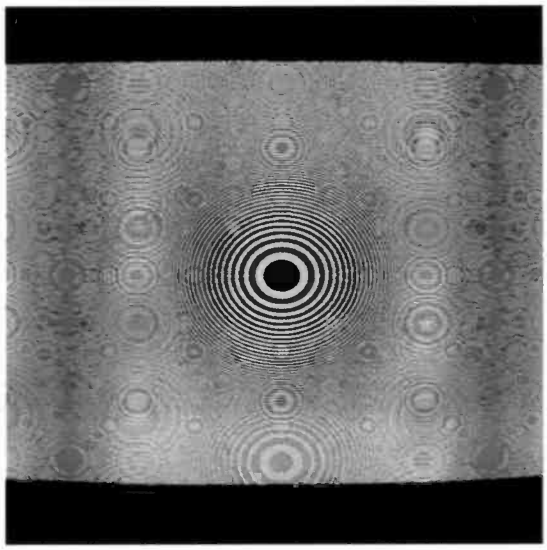

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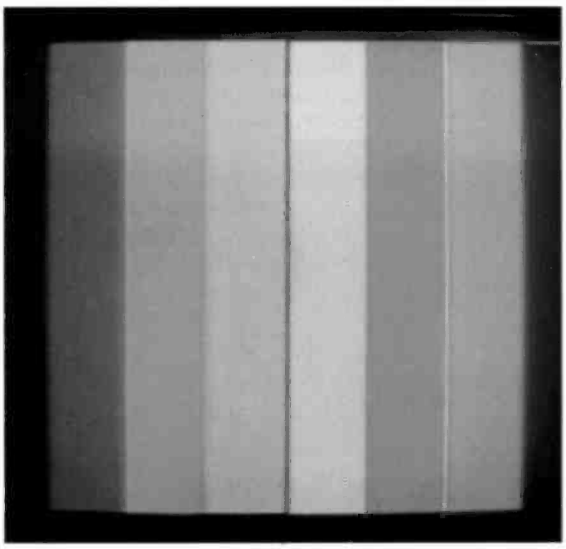

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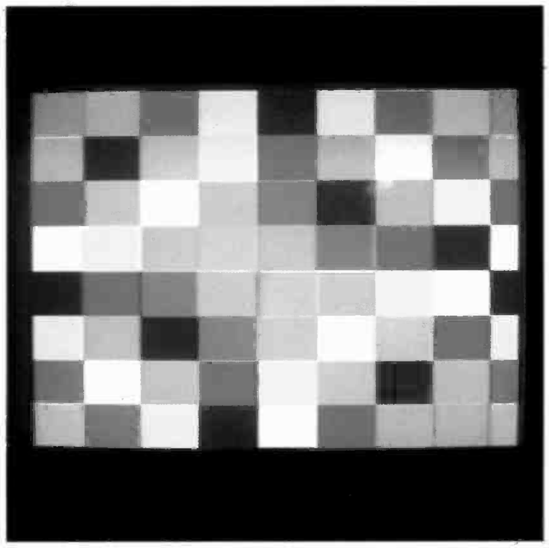

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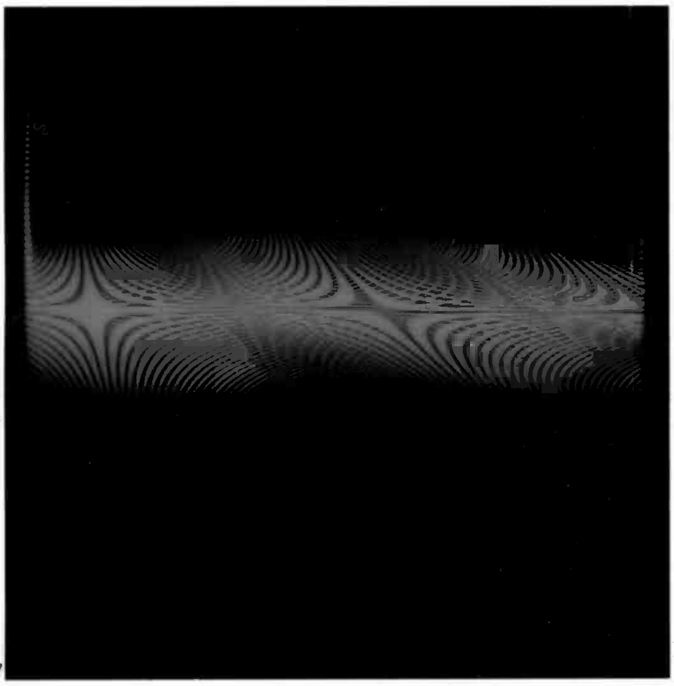
1. Three-line chroma decoding, no luminance. Colour print forms Fig.12(b), referred to in Fig.12 caption, part one, December 1983 issue, page 78.
2. Line sweep skew with PAL modifier in the luminance signal, as per page 53 January 1984 issue. (Two-line chroma decoding, one narrow line delay.)
3. Result of comb filtering across three lines with wideband 64μs delays, as in Fig.12(a) and 12(c) block diagram. See page 78 December 1983 issue.
4. Non-linearity is evident when the signal overloads in processin stages, producing indecipherable patterning due to harmonic generation.
5. Effect of reduced rise-time due to gaussian bandpass filter and narrow chroma delay line, on chroma-only display with two-line chroma decoding. See Fig.24 page 56 January 1984 issue. (No luminance.)
6. Displayed signal is a mix of vertical and horizontal colour bars. The decoding effects are not clear as detail would not show up in the colour printing. This test pattern is useful for showing up defects in adaptive switching where vertical and horizontal transitions occur.



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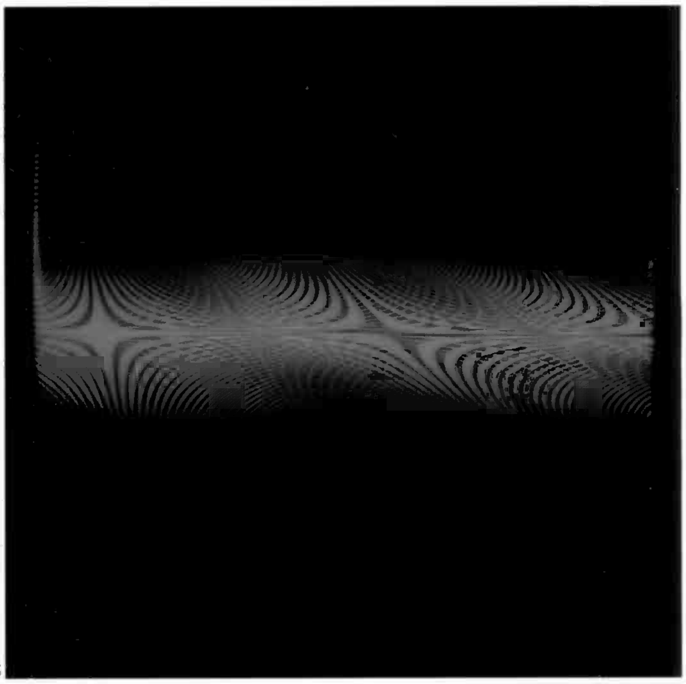

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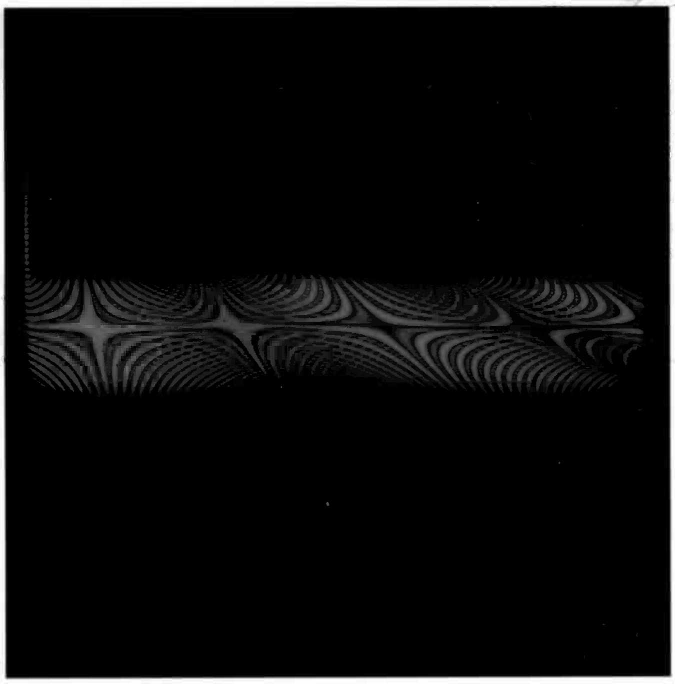

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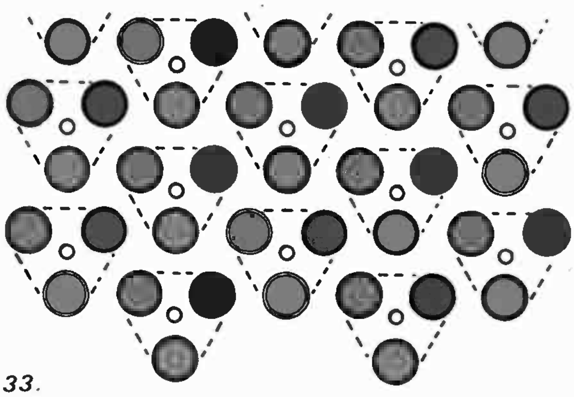


Fig. 33.

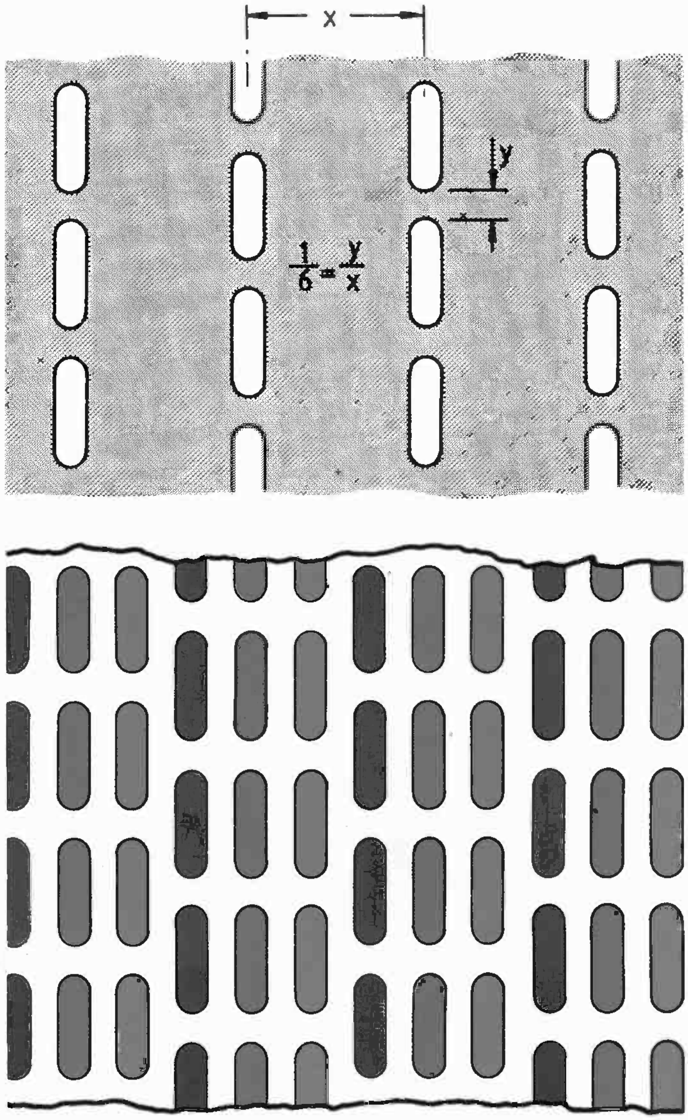


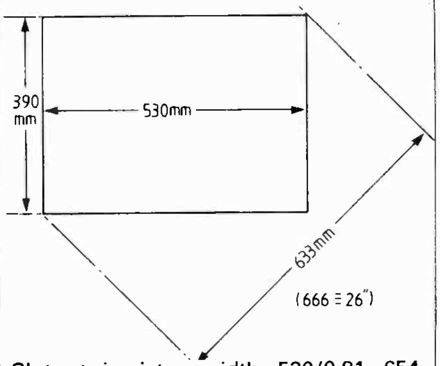
Fig. 28.

7. Line sweep skew with one-line chroma decoding (no luminance).
8. Line sweep skew with two-line chroma decoding (no luminance).

9. Line sweep skew with three-line chroma decoding (no luminance, two wideband delay lines used.) See also Fig. 12, page 78, December 1983 issue.

Fig. 28. Typical slot shadow-mask tube with its phosphor faceplate.
Fig. 33. Triad tube face structure, as used on earlier and some current high resolution c.r.ts. Centre circle is shadow mask hole.

Effective sampling frequency



Slot sets in picture width = 530/0.81 = 654
To display a black-to-white cycle two shadow-mask slots will be required. Therefore the number of cycles per active picture width is 654/2 = 327. Time of active picture width is 64μs (line length) − 12μs (line blanking) = 52μs so period for one cycle = 52/327 = 159ns ≡ 6.3MHz. This is the nominal cut-off frequency, which is half the sampling frequency. Note also that fs/3 = 12.6/3 = 4.2MHz where width modulation starts.

Fig. 29. Derivation of effective sampling frequency for 26in 30AX in a TX10 receiver.

greater light output and the tube guns have quick-heating cathodes, giving a picture 5-10 seconds after switch-on, also the spot defocusing with high beam current and deflection defocusing in the corners is very much reduced by what the Mullard manufacturer describes as a quadrapole lens. The tube doesn't require adjustment for convergence, colour purity or raster orientation, and together with its reduced deflection energy, improved raster shape, general sharpening up of the spot, and soft flash on the e.h.t., it seems a very attractive component.

Sampling properties of the tube face

Figure 28 shows a typical shadow-mask tube with its phosphor faceplate. The upper section illustrates how the slots in the metal shadow mask are stood back from the glass screen to ensure that the electron beams from three guns in the tube neck only reach the appropriate phosphor stripes. The spacing of these stripes determines the subjective performance of the tube with high frequency luminance.

Considering the green gun, which produces the images that the eye is most sensitive to as far as revolving detail is concerned, the video signal is effectively sampled by the spacing of the green vertical stripes illuminated by the gun as it scans across the screen. The Nyquist theorem states that the sampling frequency must be at least twice that of the highest signal frequency. Any higher frequencies would reappear in a lower frequency spectrum; this is called an aliasing component. The pitch of the stripes can be 0.83 to 0.795mm, but for calculation an average figure of 0.81mm spacing is used.

As an example of the effect of stripe spacing, consider the dimensions of a 26in 30AX tube in a Ferguson TX10 receiver. The measured screen diagonal is 633mm and as 660mm is the metric equivalent of 26in, this must therefore be presumed to be an interpreted or a projected dimension of an ideal display tube that is considered square. Progressing from this slight deceit, more significant for displaying pictures is the usable width of the tube, which is 530mm (17in). Dividing 530mm by the 0.81mm stripe spacing gives a total of 654 RGB stripe sets in the picture width. From this, Fig. 29 derives an equivalent half sampling frequency of 6.3MHz.

The structure of the stripes is clearly visible in Fig. 30 on the left-hand side of the screen. The tube, as used on a JVC 6in 12-volt portable receiver, is typical of the coarse slot type. In the displayed line sweep, the frequency of the video signal increases to the right of the screen, and you can see that at one-third of the frequency the spacing is beginning to be width-modulated, and at half the sampling frequency it is not displaying anything useful at all. Therefore accurate representation of horizontal luminance detail is prevented in the 26in 30AX tube because luminance bandwidth is reduced to

On page 79 of the December issue David Read suggested a novel method of decoding. Perfect still picture decoding with reduced impairment with movement could be achieved by reducing subcarrier frequency by 6.25Hz. Both U and V signals are in antiphase over one picture period, as the lower part of Fig 14 showed; unfortunately the caption incorrectly referred to raising the subcarrier. The upper part, which should have shown 90° of f_{sc} as 56.39ns, not ms, related to the decoding arrangement of Fig.13(b).

Apologies for numerical slips in the captions; in Fig. 9 which gave 6 instead of 64μs, Fig. 10 which gave 54 and not 56ns, and in Fig. 13 (b) the subcarrier is of course 4.433 . . . not 4.422 . . . MHz.

4.2MHz, as derived in Fig. 29. Applying text card F directly from a slide scanner and with no PAL coding or decoding, luminance resolution was of display value up to 4.5MHz. At 5.25MHz it was clear that some vertical lines were displayed but their spacing was modulated. With a line sweep test signal the Moiré patterning was pronounced. So in spite of the improved bandwidth from the comb, the final video

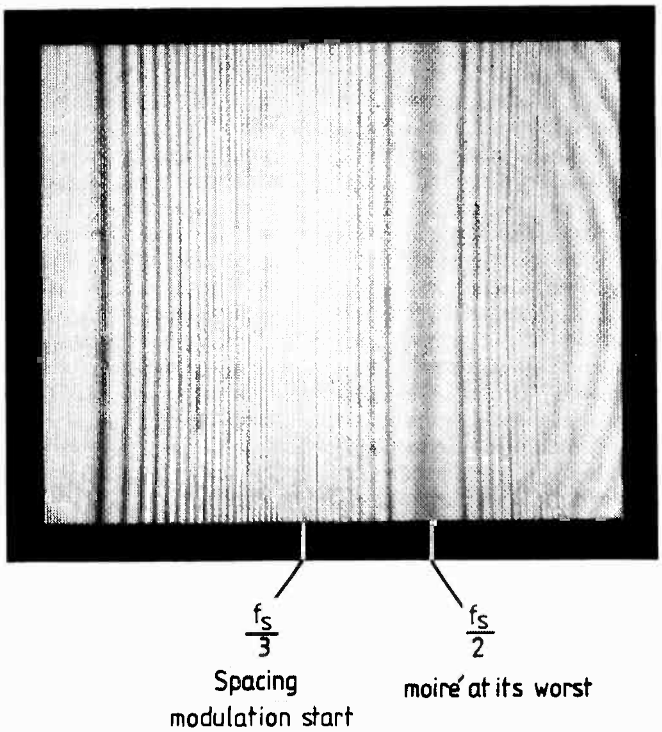
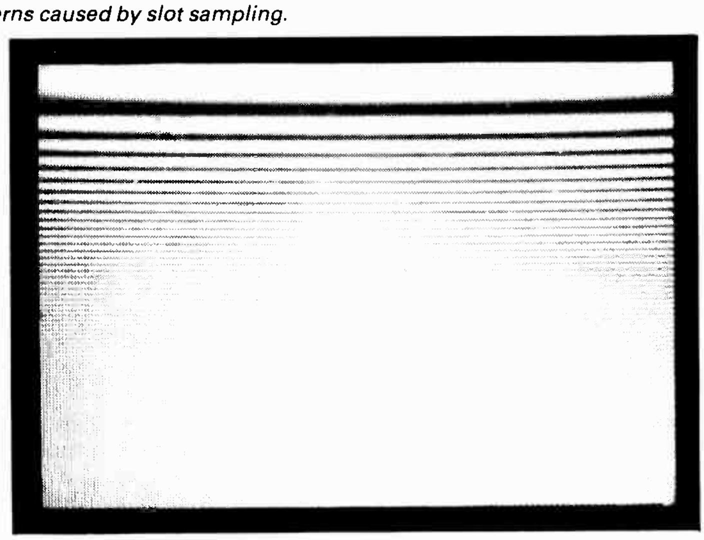


Fig. 30. Photograph of video line sweep applied to slotted shadow-mask tube shows patterns caused by slot sampling.

Fig. 31. Vertical sweep on the slot tube.



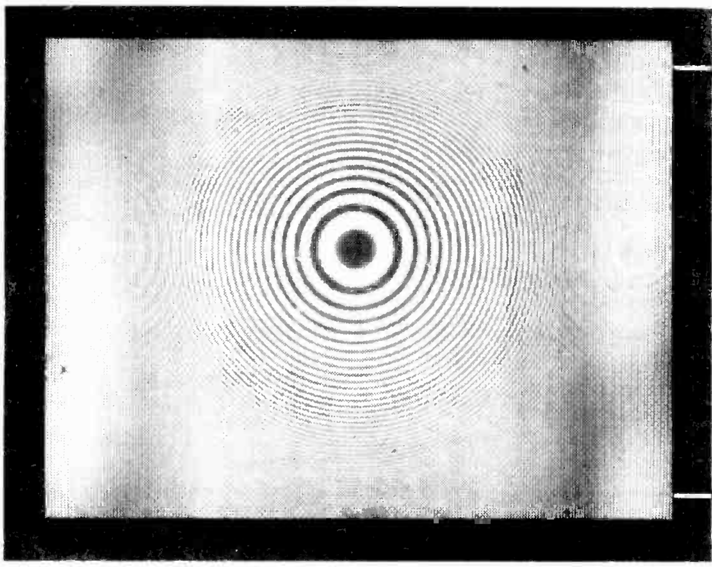


Fig. 32. Circular zone plate on the slot tube.

drive to the tubes was allowed to roll-off, typically 1 to 2dB down at 4.5MHz, and 3 to 4dB at 5.5MHz.

Observing Fig. 28, it seems possible that there would be a display problem due to the horizontal bridges supporting the structure of the shadow mask. For a 26in tube the horizontal spacing between the vertical stripes is 0.759mm. The vertical spacing is 0.810mm, so there could be difficulty in sampling on a vertical sweep. In Fig. 31 the Moiré patterning is not apparent, but there is a significant interference in the 625-line sampling structure beating with the vertically increasing frequency, i.e. the number of cycles per increment of picture height beating with the 625 line raster. This produces a very prominent horizontal 'twitter'. The evidence therefore shows that the problem due to the line structure interfering with vertical video detail is far greater than that of the shadow mask. Looking closely at the picture on Fig. 31, the only effect of the shadow mask structure is that some lines appear to be straight and others appear as a row of white dots. At normal viewing distance this is not apparent and the horizontal twitter is the dominating effect.

The vertical stripes have a different effect on diagonal luminance information as might be expected, shown in Fig. 32, along a diagonal luminance line the vertical stripes generate a castellation of 'knotted rope' effect. Radially (from the centre) the zone-plate test pattern represents increasing spatial frequency. The fundamental television system gives a square display of detail, so that fine luminance information will be in the corners, although the slot shadow-mask structure tends to prevent this being displayed. In the horizontal direction width modulation is clearly visible before the Moiré patterning builds up.

Vertically, there seems to be more resolution available. This is because the bridges supporting the shadow mask are small in area compared to the horizontal spacing between individual slots. This spacing is typically ⅙ of the vertical slot spacing, as shown on Fig. 28. On the new higher resolution tubes, which use 0.6mm spacing between the vertical slots, the horizontal support distance is only 0.1mm. For the more common 22in colour tube, the spacing between the vertical slots measured with a travelling microscope, is about 0.8mm. Usable screen width is 444mm and from these figures the sampling frequency is calculated to be approximately 10.6MHz. Maximum display frequency is now limited to 5.3MHz but as the Moiré patterning clearly starts at a lower frequency, the 26in tube with similar slot spacing is evidently the minimum tube size for which it is worth trying to improve the luminance resolution. On a smaller tube, improved luminance resolution would only make this Moiré patterning more visible without fine detail being effectively displayed.

When viewing closely these types of slot tubes, the structure of the shadow mask is certainly discernable, as seen on all three photographs, Figs. 30, 31 and 32.

Colour tube using triad hole spacing

In most high resolution tubes using the triad spacing and the dot structure is not particularly discernable. They also use lower spacing, a typical figure being 0.68mm compared with 0.83mm for some of the slot tubes. The equivalent half sampling frequency for 0.68mm is 7.4MHz (22in tube). Fig. 33 shows a triad phosphor screen where the interaction between the shadow mask structure and the video information is less noticeable. Also, low frequency Moiré patterning occurs at a later point as a result of the higher half sampling frequency. With the triad structure, the step effect on luminance diagonals is again not apparent. Viewing both a slot tube and a triad tube side-by-side the convergence drift on the triad tube causes an effective reduction of resolution, and on balance the slot tube is more stable. To take advantage of the increasing display resolution from higher luminance bandwidth it is certainly necessary to use either a 26-in slot tube or the triad structure.

With microprocessors in the home and the greater uses of electronic graphics there are now available higher resolution (slot spacing 0.4 to 0.6mm) RGB monitors capable of displaying up to 80 characters per line; but although greater detail can be displayed their screen sizes seem to be limited to 20in at the moment. The electronics driving the new tubes are also much improved. Supply rail regulation on the Ferguson TX10 receiver for example is excellent, with a switched-mode power supply stabilizing all rails; with the e.h.t. supply separate from the line scanning, an extremely stable picture is obtained even in the presents of widely varying picture level. Overall, this enables the receiver to be set up with no overscan, so that the transmitted pictured can be visible to the full width of the screen (as paid for in the licence fee).

If the stability is not good, the 'cover-up' method is to deliberately overscan the picture. This can have some advantage, in that a small amount of overscan causes the sampling frequency to be effectively increased e.g. by about 0.3MHz for 5% overscan. Most sets sold in the shops have 7-10% overscan. So, if a 22 or 26in set appears to be extremely stable on picture size with brightness changes, it is certainly worth reducing any excessive overscan.

Competition news

Twelve entries have been selected for the finals of our competition, which are to take place on January 30th. There are six prizes to be won and the winners will receive their awards from Princess Anne. The list of finalists is:

– David Battison of Cambridge, whose Miaphone provides a speak-back facility for blind disabled typists. With the help of this device, the young user for whom it was designed is now able to type and prepare non-braille correspondence.

– Chris Batchelor of Stockport, designer of the Speakeasy. About the same size as a portable radio, this incorporates a keyboard and an allophone-type speech synthesizer.

– Michael Bolton and Alastair Taylor of Aberdeen: their entry is a computer inferface using a pneumatic suck-puff transducer.

– T. G. Clarkson of London SE13, whose eye-controlled communicator allows a severely disabled person to select data presented on a television screen, using eye-movements to direct a cursor.

– Ian Dilworth and David Boley of the University of Essex, who have entered a v.h.f. wireless alarm system for use in hospitals or old people's flats.

– Tony Heyes of Nottingham University, whose entry is a microprocessor-based sonar aid for the blind.

– S. Ishiguro of Guildford, whose Touchvision enables the blind reader to follow ordinary printed text.

– William McCarthy, who lives in Edinburgh. His entry is an audible electronic depth gauge for the visually handicapped.

– Ian Mitchell of Hull, designer of another speech device, the TAB or Talking Box, produed as a communication aid for a group of children with speech difficulties.

– Henry Myatt of Harrow, who has designed a braille printer. This reproduces ASCII text from a microcomputer as braille characters on thin card.

– Phil Pickersgill and N. J. Stewart, who lives in Wokingham: their entry is the Frenchay speech-slowing aid, a device to help stammerers control and so improve their delivery.

– J. W. Smith of Haverhill, Suffolk, whose infra-red remote control device allows a user to switch up to 30 electrical appliances.

Inductance measurement

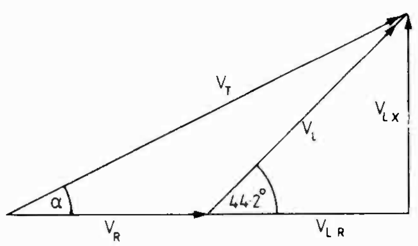
Simple practical method, hard to find in the textbooks

by D. R. Fownes

The inspiration for writing this article arose recently when I found myself in the radio shack looking for a coil of specific inductance. I had gone to a good deal of trouble to calculate the value of inductance required for this particular function and was now faced with the daunting job of going through my box of inductors, trying various coils until one worked satisfactorily. After ten minutes of trial and error and getting nowhere I came to the conclusion that there must be an easier way.

I began thinking of ideas for measuring the values of pre-wound inductances using basic test equipment which most enthusiasts have available in their radio shack. The method of measurement I eventually decided on is an application of two mathematical rules, the "cosine rule" and the "sine rule".

Looking at the phasor diagram of Fig. 1, if the frequency applied to the circuit shown is changed, then X_L will change in direct proportion thus the phase angle α will also change.

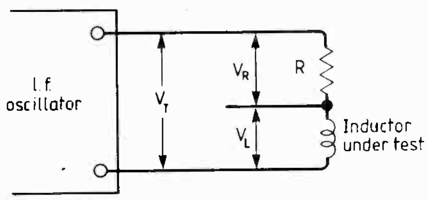


V_T applied voltage
V_R voltage developed across R
V_{LR} voltage developed across the resistive component of the inductor
V_L voltage developed across the inductor
V_{Lx} voltage developed across the reactive component of the inductor

For the purpose of inductance measurement, this phenomenon can be ignored as it is allowed for within the calculations. This can be verified by measuring the voltages at a number of different frequencies and repeating the calculations. As will be shown, once this phase angle has been calculated the value of inductance can be derived.

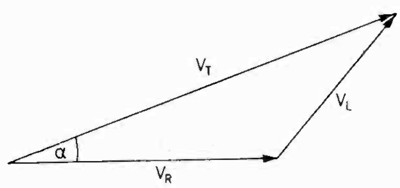
The test equipment required for this inductance measurement are

- low frequency oscillator with variable frequency and amplitude
- alternating voltmeter
- resistor whose value is known accurately and measures about one quarter of the d.c. resistance of the coil whose inductance is to be measured (perhaps a decade resistor).



The frequency generator should be set to oscillate at about 100Hz to 500Hz as long as it is known. It will be apparent when the frequency is sufficient as the algebraic sum of V_R+V_L will be greater than the applied voltage, V_T. Output amplitude is not critical as it is measured as part of the test.

When the oscillator is running voltages V_R, V_L and V_T as shown the circuit must be measured as accurately as possible. Once these values are established, the inductance is simply calculated by substituting them into the formulae below.



From the diagram

$$\cos\alpha=\frac{V_R^2+V_T^2-V_L^2}{2V_RV_T}$$

And as $\sin\alpha=\sqrt{1-\cos^2\alpha}$, inductance can be calculated from

$$L=\left(\frac{V_T}{V_R}\right)\left(\frac{R}{2\pi f}\right)\sin\alpha.$$

Example. To test the method I used a low-frequency oscillator set to 100Hz with an output amplitude of 2V r.m.s., laboratory-type inductor with an inductance of 1 henry, decade resistor set to 200 ohms, and a d.m.m. set to measure 10V a.c. full scale, all connected as in Fig. 2 to measure the voltages: $V_T=2.000$V, $V_R=0.373$V and $V_L=1.714$V. This gave $\cos\alpha=0.804$ and therefore $\sin\alpha=\sqrt{1-\cos^2\alpha}=0.594$, hence $L=1.01$H.

Check. $V_{XL}=V_L\sin 44.2=1.194$V

$$V_{LR}=\sqrt{V_{XL}^2-V_L^2}=1.229\text{V}$$

$$\therefore V_T=\sqrt{(V_R+V_{LR})^2+V_{XL}^2}=1.998\text{V}.$$

Since 1979 David Fownes has been employed as an electronics technician by a company producing aircraft power controls for both ministry and civil aircraft, and which currently has a world lead in fly-by-wire technology. He gained City and Guilds full technological certificate in power engineering and O.N.C. in electronics at technical college during his apprenticeship. Mr Fownes believes that due to new technological advances in powered flight we are now witnessing the most exciting developments in aviation history since the Wright Brothers' first flight.

Morse code on a ZX81

This Morse code system enables the computer to be used as an electronic Morse keyboard and runs on a 16K ZX81 under Basic.

by D. Ibrahim

This article is in two parts: the first describes the hardware necessary to make a ZX81 microcomputer function as a Morse code keyboard. The second part describes system operation in detail and includes a listing of the software. Sending Morse code with this system is very much like typing.

The hardware is a simple interface to an existing ZX81 and provides a single bit (serial) output port. All the hardware is external and it is not required to make any internal hardware modifications to the ZX81.

Address decoding is provided by the two chips 74LS32 and 74LS00, Fig. 1. The single-bit output port is designed from a 74LS74 D-type flip-flop and is enabled in the address range decimal 8192 to 16383 inclusive. Data to the D-type is derived from the least significant bit of the data bus. Three types of outputs are provided. Output OP_1 drives an l.e.d. which is lit according to the transmitted code. Output OP_2 drives a c.m.o.s. tone generator and a speaker. This output is useful in practising Morse code or for listening to the code during transmission. Output OP_3 is intended for switching a c.w. transmitter for Morse code transmission.

The hardware can be built on a small piece of stripboard, interfacing to the ZX81 via a 23-way edge connector. The hardware requires no setting up.

Software

Special care has been taken to ensure a fast execution speed. A message (upto a carriage return) is read from the user's terminal. The length of a message can be as long as you like, limited only by memory size. Once a message is received from the keyboard, it is converted to Morse code, with the proper inter-letter and inter-character spacings. The complete message is then sent to the output port. It is important to realise that a character is not sent as soon as it is received; a complete message is first received and decoded and then sent to the output. With this approach it is possible to achieve a fast execution time.

In the software listing lines 100 to 198 convert the input characters to Morse code. Only the letters A-Z, numerals 0-9 and the space key are included in the program, though it is possible to extend the list to include other characters e.g. period, comma, question-mark, etc. The decoding is

- each dot is converted to a "0"
- each dash is converted to a "1"
- individual elements of a character are separated by a "2"
- individual words are separated by a "3".

Fig. 2 In decoding, for example, the message "MORSE TX", each dot is converted to '0', each dash to '3', characters are separated by '2', and words are separated by '3'.

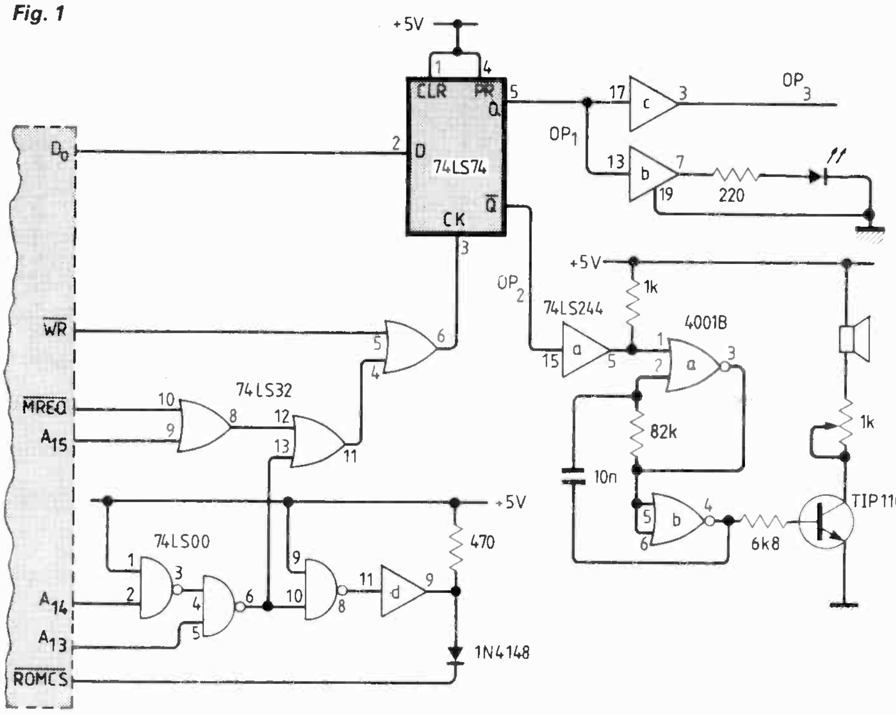
Fig. 2 shows how the message "MORSE TX" is decoded. Line 205 calculates the transmission speed and stores it as variable "T". The input message is stored in the string variable "L". The command input "END" transfers commands back to the ZX81 operating system.

Lines 500 to 510 call the appropriate output subroutines to drive the serial output port. The program runs in fast mode and the usual Morse code timing rules apply:

- a dot ("0") is one unit-time
- a dash ("1") is three unit-times
- characters are separated ("2") by three unit-times
- words are separated ("3") by seven unit-times.

Sending Morse code with the system described is very much like typing. Transmission speeds of over 30 word/min can easily be achieved. Line 205 has been adjusted to provide a correct speed in the range of about 1-20 word/min. For higher speeds there is a non-linear relationship between the speed and the delay generated by the pause statement of the ZX81. It should therefore be necessary to scale up the required speed appropriately before entering to the computer.

Fig. 1



Program appears on page 73

LETTERS

PROBLEMS IN SPECIAL RELATIVITY

Recent issues of *Wireless World* have seen writings by many people who feel disenchanted with the Special Theory, but whose case has been put in such a way as to cause further polarization of respective camps.

As a student, I was privileged to be lectured by Dr G. J. Whitrow, then Reader in Mathematics at Imperial College, who was then, and still is, one of the world's foremost authorities on this subject. I vividly remember the model posed by Whitrow in which the time-travellers would be taken round a circle at infinity, thus avoiding the problems of accelerated frames of reference. As a mere student, my protestations at the physical unreality of this model were, I feel, looked on as based on youthful inexperience. Many years later during the course of one of my many public lectures in an unrelated field I was charmed by the attendance of Otto Frisch, the pioneer of nuclear fission, himself a considerable mathematical physicist. In conversation we lightly stepped on the territory of Special Relativity and I found that the same feelings were aroused in me as to the response of what I might call the hierarchy of the world's physicists. I found again the attitude of the master talking to the schoolboy.

Undoubtedly, there may be many of us who are intellectually ill-equipped to appreciate the foundations of something as profound as the Special Theory, but I must stick to my feelings that the application of theoretical structures in those areas in which their approximations are so clearly invalid is extremely dangerous. Furthermore, the "instantaneous" light signals which formed a key element of teaching in my days as a student of this subject seem to me to be totally divorced from physical common sense.

Surely, if signals are to be sent, reflected from a moving body and then received by a detector in the frame of the sender, the entire mathematical problem must be worked out clearly and with great attention to a "feet on the ground" approach. Without labouring the point we should have to ask when is a signal regarded as being received by the detector (how much of it do we have to perceive before we draw useful conclusions)?

Overall, as an average mathematical physicist, I still feel as unconvinced by the use of Special Theory in conditions of accelerated frames of reference as I did as a student some 25 years ago. It is, therefore, a great pleasure to see a level-headed article such as this essentially reiterating those doubts I have as a non-member of the family of scientists who are brow-beaten into believing in the general applicability of a theory in those areas in which its validity is in doubt. At the same time, I have sufficient humility to accept that there are many people of greater intellect than myself but, sad to say, that large body has been incapable of presenting its case to me in a convincing fashion.

N. J. Phillips
University of Technology
Loughborough

Before worrying too much about 'Problems in Special Relativity' (Prof. I. McCauseland, October issue) it would be as well to find out just what the relevant predictions of Special Relativity really are. Suppose that one has a set of observers at rest with respect to one another and spaced out along a line, that they synchronise their clocks according to conventional procedures, and that another observer B is in motion relative to them along the same line. Then Special Relativity predicts that each time he encounters a new member of the initial set of observers he will find that observer's clock registering a time further in advance of his own. From the way this statement is framed it evidently doesn't matter whether B is considered to be moving relative to the other obsevers, or to be at rest while they move relative to him.

The key point here is that one observer is encountering a sequence of observers. The situation can be reversed by associating B with another string of observers moving along the same line, but this time at rest relative to him and with their clocks synchronised with his. Then each observer of the first set will have the same kind of experiences as B as he encounters in succession the observers of B's set. This seems thoroughly paradoxical until one realises that simultanetaneity does not transfer between inertial frames, i.e. that when the first set of observers synchronise their clocks B's set claim that they have made systematic errors in the synchronisation, and conversely when B's set synchronise theirs. This appears to be the situation envisaged by McCrea (M12), where the M denotes a McCausland reference. Dingle never did catch on to the failure of simultaneity, and some of his most impressive paradoxes result from ignoring it[1].

The second prediction involves introducing a kinetic assumption to the effect that at any instant an accelerated clock keeps the same time as the clocks in the frame in which it is instantaneously at rest (see Hill[2]). Originally Einstein appears to have made this assumption implicitly rather than explicitly, since it follows naturally from the idea that world lines in Minkowski space must be continuous. It then becomes possible (*pace* G. Stadlen (M11)) for Special Relativity to deal with accelerated clocks, including a polar clock and a clock located at the equator, provided that one ignores gravitation effects. As a result two or more encounters between two clocks may occur, and one is faced with the phenomenon of differential ageing, as in the so-called twin paradox. These are the conditions Einstein had in mind in making the statement about an equatorial clock losing time with respect to a clock at one of the poles. Professor McCausland didn't try very hard to arrange a meeting of clocks: a clock carried by a jet aircraft flying round the equator in the opposite direction to the earth's equatorial motion at appropriate speed would have done very nicely. This is essentially G. J. Whitrow's response (M7) to Dingle's supplementary question.

Dingle's original question is paradoxical from the beginning, it does not correspond to any specific prediction of Special Relativity, and therefore it cannot be answered without making some guess as to what he might have had in mind. J. M. Ziman's response, with a clear indication in the quotes round "Dingle's 'question' " that he thought the 'question' should be rephrased (M5), was the General Relativity answer to the question of which clock registers the greatest time between any two events at which it is present when there are gravitational fields to consider.

Finally Professor McCausland might have mentioned why Einstein excluded pendulum clocks from his observation about the timekeeping of equatorial clocks. The reason is that a pendulum does not in itself constitute a clock; the clock consists of the pendulum together with the earth.

C. F. Coleman

1. H. Dingle, *Nature* Vol. 197 1963, 1248.
2. E. L. Hill, 'The Theory of Relativity', Handbook of Physics, ed E. U. Condon and H. Odishaw (McCraw Hill, 1967).

The theories of relativity and quantum mechanics are the two major leaps forward in physics this century, and they appear to have attracted more than their fair share of controversy. One reason for this may be that most of our everyday experience of physical phenomena happens to be in the area where both theories agree with Newtonian mechanics.

As far as we know, neither relativity nor quantum mechanics contain any inconsistencies – and this is despite the effort put in to trying to discover them, by people of Einstein's calibre. Special Relativity is so well established among physicists that attempts to discredit it tend not to be taken seriously. However, a theory as rich as Special Relativity cannot be demonstrated to be consistent – just as we know that arithmetic cannot be shown to be consistent.

There are problems with both theories, and these arise from the fact that while the assumptions on which they are based are simple, the application of the theories contains subtleties. These subtleties lead exponents and opponents of the theories to make slips of thought which lead them to the conclusion they require.

For example, people often claim that they have found an inconsistency in Special Relativity by applying it to a physical example. They claim that when they attempt to do this, they obtain a result which is clearly false.

$$\text{Problem} \xrightarrow[\text{+ Newtonian Mechanics}]{\text{Special Relativity}} \text{falsity}$$

In fact, they have inadvertently added some Newtonian idea (which is inconsistent with Special Relativity). It is this combination of theories which produces the false result.

$$\text{Problem} \xrightarrow[\text{Relativity}]{\text{Special}} \text{falsity}$$

It is this slip which Dingle makes. Although (as I pointed out earlier) we cannot prove that Special Relativity is consistent, we can at least conclude that as there are mistakes in Dingle's argument, his case is not proven.

To turn to the specific example of the two clocks, Special Relativity does not say that one *is* faster than the other – in fact it denies the existence of absolute speed both of objects and of clocks. Special Relativity is a theory of measurement denying the existence of absolute space and time against which to measure the speed of material particles and clocks.

In McCausland's reference 10 Einstein is writing many years before formulating his general theory of relativity, and is using a very simplified model of two clocks. One is at a pole (i.e. stationary with respect to the fixed stars), the other is moving with the equator. He concludes that an observer who is stationary with respect to the fixed stars measures the clock on the equator as going more slowly than that situated at a pole. His argument here avoids the complication of gravitation, except in so far as it is the mechanism by which the moving clock traces its path. He excludes pendulum clocks from the argument, not through oversight, but because he realised that to include them he would have to include the effects of gravity. This would have complicated the argument unnecessarily.

A. D. Vella
Oxford Polytechnic

The author replies

Mr Coleman raises several interesting points. Referring to my statement that Ziman's answer

LETTERS

does not apply to the polar and equatorial clocks because they do not meet, he says that I didn't try very hard to arrange a meeting of clocks. I had thought that it was Ziman's responsibility to show how his answer applied to that case, not mine. However, let us consider Coleman's suggested clock carried by a jet aircraft flying round the equator in the opposite direction to the earth's equatorial motion at appropriate speed. I assume that by "appropriate speed" he means a speed equal to the earth's peripheral velocity at the equator; such a clock would be stationary relative to the polar clock, and would presumably work at the same rate. In that case, Einstein's prediction corresponds to a prediction that the airborne clock would work faster than the earthbound equatorial one. Now, if Ziman's answer is applicable to the comparison of those two clocks, as Coleman implies it is, then in order to deduce Einstein's result using Ziman's answer one would first have to show that the airborne clock was in free fall between the two meetings of the clocks, or for one full circuit of the earth. It is fairly obvious that the clock in question does not travel between the two meetings by free fall, but could perhaps be made to do so if one made the small extra step of removing the earth; however, Coleman does not seem to have that possibility in mind, since he stipulates that the clock is to be carried by a jet aircraft. It is also unclear how he uses this example to justify Whitrow's answer, since what he says does not alter the fact that the earthbound equatorial clock is not in an inertial frame.

Coleman also tells us that Ziman's response shows a "clear indication" that Ziman thought Dingle's question should be rephrased. But Ziman did not say it should be rephrased; he said it was "a perfectly reasonable question to which science should indeed given an answer". Professor Ziman is a prolific writer who may be assumed to have sufficient command of the language to be able to say what he means without requiring readers to indulge in mind-reading. If he believes that Dingle's question ought to have been rephrased, he should tell us so himself.

Coleman goes on to say that Ziman's response was the General Relativity answer to the question. But the whole point of Dingle's question was to find out what justification was given *by the Special Theory* for one clock to work faster than the other. So Coleman is supporting the view that Dingle's perfectly reasonable question has not been answered.

Finally, let us consider one of the most important topics of all – the synchronization of clocks. Coleman mentions synchronization and then goes on to say that Dingle never did catch on to the failure of simultaneity. Let us consider this problem in more detail.

First of all, Dingle was careful to distinguish between simultaneity of events and synchronization of clocks; see, for example, his letter in *The Listener* dated 30 December 1971. He also pointed out, in *Science at the Crossroads*, that when a pair of relatively stationary clocks are synchronized they are synchronized for all observers. Although this is a crucial part of Dingle's argument, I can recall only one review of his book that discusses synchronization, and it *agrees* with Dingle that synchronization is independent of the observer; that review is Stadlen's, which was cited in my article.

Since Einstein argued, in his original paper on Special Rrelativity, that observers moving relative to the pair of synchronized clocks would find that they were not synchronized, let us now consider Einstein's original definition and argument.

Einstein gave a definition of synchronization in the following way. Two clocks A and B are at rest relative to one another, and a flash of light is emitted from A and reflected back from B to A. If the reading on B at the moment of reflection is halfway between the readings of A at emission and return of the flash, the clocks are synchronized. Any observer, in any state of motion, would see the same set of three readings, and woud reach the correct conclusion about the synchronization of the clocks. (If desired, the experiment could be done in darkness, and the only three clock readings seen by anyone would be the readings illuminated by the flashes; the observer need not consult his own clock, nor indeed need he posses one.)

Now consider the argument by which Einstein concluded that observers moving relative to a pair of clocks would find that they were not synchronized. The argument involves a rigid rod aligned with the x axis of a stationary reference frame, and moving longitudinally along the x axis; at its ends A and B are two clocks, and along the x axis arc several stationary clocks which are synchronized with one another. A flash of light is emitted from A and reflected back from B to A to test for synchronization.

The crucial fact about this experiment is that each of the clocks at A and B is constrained to give the same reading as the stationary clock that happens to be adjacent to it at any instant. I say "constrained" deliberately, because it turns out from results derived later in the theory that the clocks at A and B, if they were running freely, would *not* continue to give the same readings as the stationary clock adjacent to them as they move along, but would fall further and further behind the stationary clocks. To make them continue to show the same readings as their stationary neighbours they would have to be continually readjusted, in which case they would not be regularly-running clocks. To put it more bluntly, they would not be clocks at all, for their clock works could be removed and their readings adjusted by demons to correspond to the readings of the adjacent stationary clocks. Even more simply, the "clocks" could be removed altogether and replaced by mirrors which would simply *reflect* the appropriate readings.

In the experiment, the flash of light reflected from B arrives back at A, the end of the rod from which the flash was emitted. Since A has by then moved on, relative to the stationary row of clocks, the clock then opposite A is not the same one as the one that was opposite A when the flash was emitted; the reading at B is therefore not halfway between the two clock readings at end A of the rod. Therefore, according to Einstein "observers moving with the moving rod would thus find that the two clocks were not synchronous".

But Einstein is not using his definition of synchronization in reaching that conclusion. The "clocks" at the ends A and B of the rods are not regularly-running clocks, but merely objects which reflect the readings of the stationary clocks beside them. Since the definition requires the reflected flash of light to return to the regularly-running clock from which the original flash was emitted, and since it does not do so until after it has passed the new position of end A of the moving rod, it is not valid to make any inference about synchronization of clocks from the reading of the clock at the new position of A. Einstein's conclusion is therefore unjustified.

Reply to A. D. Vella

Dr Vella states that Dingle made an error, but does not identify a specific error. He goes on to say, referring to the two clocks, that "Special Relativity does not say that one *is* faster than the other – in fact it denies the existence of absolute speed both of objects and of clocks." I do not hink that a statement that one clock works faster than another is a claim about absolute rates of clocks, but in any case it was Einstein himself who stated explicitly that the equatorial clock must work slower than the polar one.

Vella goes on to say that the polar clock is stationary with respect to the fixed stars, which is not true. He then says, referring to Einstein: "He concludes that an observer who is stationary with respect to the fixed stars measures the clock on the equator as going more slowly than that situated at a pole." Vella implies that it is the state of motion of the observer that determines which clock is measured as the slower one, but this is not what Einstein said; he stated that the equatorial clock must work more slowly than the polar one.

In view of the two statements that I have quoted from Dr Vella's letter, I would ask him to answer, with a simple yes or no, the following question: Would an observer on the equator measure the clock at the pole as going more slowly than that situated on the equator?

Reply to J. C. Laine

After a fairly obscure derivation, Mr Laine concludes that "it is the *travelling clock* which runs *slower* than the stationary clock". Exactly. But the theory says that either clock can be taken to be the stationary one (as Laine seems to agree when he says that "stationary" is a relative expression), so Laine's statement supports Dingle's claim that the theory requires each clock to work slower than the other.

Laine then goes on to talk about observation, in an apparent attempt to avoid the obviius result of the statement quoted above. But that does not remove the problem. As I pointed out in *Wireless World* in October 1980, Professor P. C. W. Davies, in his book *Space and Time in the Modern Universe*, makes the following statement about two clock-carrying observers in uniform relative motion: "It is not that each observer merely *sees* the other clock running slow, it actually is running slow – a real physical effect." [Emphasis in the original.] In any case, the observer is not an essential part of the special theory, as has been pointed out by H. Reichenbach, one of the contributors to the book *Albert Einstein: Philosopher-Scientist*, edited by P. A. Schilpp, who wrote that "In a logical exposition of the theory of relativity, the observer can be completely eliminated".

General comments

Without exception, critics of my article have failed to answer my main point, which is that defenders of the theory have published arguments which are inconsistent with one another and/or with Einstein's own statements. Clear evidence that there are problems in tthe theory is provided by the fact that these inconsistent statements remain uncorrected. The alternatives are clear: either some of those scientists' statements are wrong, or the theory from which those scientists claim to have deduced their statements is internally inconsistent. Therefore, unless the defenders of the theory can remove the inconsistencies by showing that some of their statements are wrong, they have themselves proved that the special theory is untenable.

Program allows ZX81 keyboard to generate Morse code

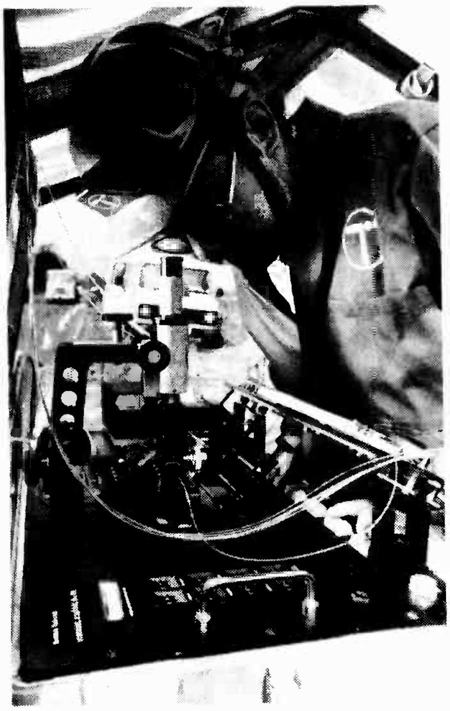
```
1     REM "MORSETX"
7     REM *(C) COPYRIGHT D. IBRAHIM*
10    POKE 8192,0
20    GOTO 200
50    POKE 8192,1
52    PAUSE T
53    POKE 16437,255
54    POKE 8192,0
55    PAUSE T
56    POKE 16437,255
57    RETURN
60    POKE 8192,1
62    PAUSE X
63    POKE 16437,255
64    POKE 8192,0
65    PAUSE T
66    POKE 16437,255
67    RETURN
70    PAUSE Y
71    POKE  16437,255
72    RETURN
80    PAUSE Z
81    POKE 16437 255
82    RETURN
100   REM "CODE DECODING"
110   FOR I = 1 TO LENGTH
111   IF L$(I) ="A" THEN LET P$="01"
112   IF L$(I) ="B" THEN LET P$="1000"
113   IF L$(I) ="C" THEN LET P$="1010"
114   IF L$(I) ="D" THEN LET P$="100"
115   IF L$(I) ="E" THEN LET P$="0"
116   IF L$(I) ="F" THEN LET P$="0010"
117   IF L$(I) ="G" THEN LET P$="110"
118   IF L$(I) ="H" THEN LET P$="0000"
119   IF LS(I) ="I" THEN LET P$="00"
120   IF LS(I) ="J" THEN LET P$="0111"
121   IF L$(I) ="K" THEN LET P$="101"
122   IF L$(I) ="L" THEN LET P$="0100"
123   IF L$(I) ="M" THEN LET P$="11"
124   IF L$(I) ="N" THEN LET P$="10"
125   IF L$(I) ="O" THEN LET P$="111"
126   IF L$(I) ="P" THEN LET P$="0110"
127   IF L$(I) ="Q" THEN LET P$="1101"
128   IF L$(I) ="R" THEN LET P$="010"
129   IF L$(I) ="S" THEN LET P$="000"
130   IF L$(I) ="T" THEN LET P$="1"
131   IF L$(I) ="U" THEN LET P$="001"
132   IF L$(I) ="V" THEN LET P$="0001"
133   IF L$(I) ="W" THEN LET P$="011"
134   IF L$(I) ="X" THEN LET P$="1001"
135   IF L$(I) ="Y" THEN LET P$="1011"
136   IF L$(I) ="Z" THEN LET P$="1100"
137   IF L$(I) ="1" THEN LET P$="01111"
138   IF L$(I) ="2" THEN LET P$="00111"
139   IF L$(I) ="3" THEN LET P$="00011"
140   IF L$(I) ="4" THEN LET P$="00001"
141   IF L$(I) ="5" THEN LET P$="00000"
142   IF L$(I) ="6" THEN LET P$="10000"
143   IF L$(I) ="7" THEN LET P$="11000"
144   IF L$(I) ="8" THEN LET P$="11100"
145   IF L$(I) ="9" THEN LET P$="11110"
146   IF L$(I) ="0" THEN LET P$="11111"
190   IF L$(I) =" " THEN LET R$=R$ + "3"
191   IF L$(I) < >  " " THEN LET R$ = R$ + P$
192   IF L$(I+1) < > " " AND L$(I) < > " "
      THEN LET R$ = R$ + "2"
193   NEXT I
198   RETURN
200   PRINT " "
202   PRINT "ENTER THE TRANSMIT SPEED (WPM):"
203   INPUT WPM
204   PRINT WPM
205   LET T = 50/(2.08*ABS (WPM - 2.4))
206   LET X = 3*T
207   LET Y = 2*T
208   LET Z = 6*T
210   LET R$ = ""
211   PRINT ""
213   PRINT "ENTER THE MESSAGE:"
215   INPUT L$
217   PRINT L$
219   IF L$="END" THEN STOP
221   LET LENGTH = LEN L$
222   LET L$ = L$ + " "
223   FAST
225   GOSUB 110
229   PRINT ""
230   PRINT  "START OF TRANSMISSION"
500   FOR I=1 TO LEN R$
502   IF R$(I)="0" THEN GOSUB 50
504   IF R$(I)="1" THEN GOSUB 60
506   IF R$(I)="2" THEN GOSUB 70
508   IF R$(I)="3" THEN GOSUB 80
510   NEXT I
511   CLS
512   PRINT "END OF TRANSMISSION"
513   SLOW
514   GOTO 210
```

News starts on page 60

How reliable is Cruise?

A study of the technical aspects of the ground-launched Cruise missile has cast doubts on the system's reliability. An engineering critique of the system says that on purely technical grounds, there are good reasons for not deploying it. *The Ground Launched Cruise Missile, A Technical Assessment*, written by electronics design engineer, Tim Williams, and published by Electronics for Peace, concludes that the system as been insufficiently tested, and has been rushed into production for political reasons; it has not been designed or built to the standards required for deployment in Europe. Particular areas for concern are pinpointing; the over-hasty system software testing; inadequate manufacturing quality control; the use of unproven systems concepts could lead to long-term unreliability; the competence and training of maintenance personnel and operators is below the standard necessary.

The report, which took a year to prepare, draws on a number of sources including Congressional hearings, technical articles and the manufacturers' own material. In the pamphlet, Tim Williams states: "the hazard posed by a system which involves transportable nuclear warheads is greater than for any other currently deployed nuclear weapon. Acceptance of deployment is an offer of hospitality to an untested, unreliable, bug-ridden system that could turn out to be fatal to its hosts." History has overtaken Mr Williams, the system is already here.



Optical fibre cables have been laid by BT between Luton and Milton Keynes along the A5 trunk road. Joining successive lengths of the fibres must be carried out so that they are lined up to within 0.05 microns on a fibre 8 microns thick. Alignment and electric fusion are carried out on this automatic machine, developed by BT, shown here operated on site by technician John Guile. A pair of cables use a multiplexed monomode transmission system to carry up to 2,000 phone calls at once.

Electronic scrap recycled

The first refinery in the world designed and built specifically for electronic scrap has been opened by Engelhard Industries. A wide range of precious metal bearing materials have hitherto been too expensive to recover, but the new Cinderford plant built at a cost of £2.2M uses a combination of processes, equipment and computer control to optimize the recovery efficiency. Electronic scrap amounts to thousands of tonnes a year in Europe alone, and locked within it lies a potential fortune in precious metal.

The process involves calcination, burning at very high temperature to burn off the plastic and to reduce the raw metallic scrap to an ash. The ash is pulverized in a vibratory crusher and then separated into different sized particles by a series of sieves where an electro-magnet sorts out the ferrous scrap. These and the non magnetic fractions are taken to a melt shop for separate refining. Computer analysis of the 'fines' determines the precise type and quantity of flux to be added to optimize melting. The powdered mixture is rolled into pellets for the furnace.

Nine induction melting furnaces are used in the melting process and the hot impure metal is cast into bars which consist of mixtures of silver, gold and platinum-group metals in a greatly enriched form suitable for processing in a conventional refinery. Particular care has been taken to keep air and noise pollution to an absolute minimum.

Another dish in the Docks

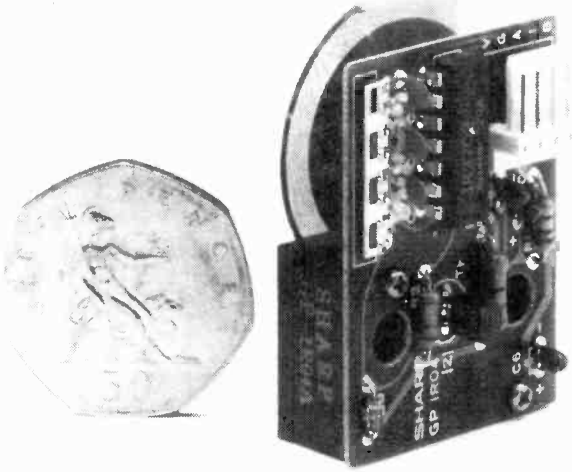
Following the announcement of BT's satellite earth station in London's dockland, Mercury Communications have received outline planning permission for the use of East Wood Wharf on the Isle of Dogs, London for a satellite station of their own. Two dishes are to be installed: an eight-metre dish providing tv distribution within the UK, to be operational in March. A 13m unit for transatlantic television and digital telecommunications should enter service in May. Both systems are supplied in containerized form by Marconi Communication Systems. In summer an 18m dish will come into operation for further communications with North America. This is to be sited in Tackley, Oxfordshire at a disused quarry within 400m of a railway line and BR's wayleaves, used by Mercury. Like BT, Mercury have an eye on providing programmes via satellite to cable operators as well as communications to remote and offshore sites.

NEW PRODUCTS

Rotary encoder

A compact, lightweight photointerruptor type of rotary encoder is shown in the photograph of the Sharp GP-IR04. This uses an infra red led and an integrated photodiode to provide three types of two-phase output; a sinewave, a cosine wave and an index output. Different slotted discs are used in the five models to give resolutions of 96, 100, 192, 200 or 360 pulses per revolution. Besides their compact and lightweight design, the encoders feature high accuracy through the laser trimming of the circuitry and a high frequency respose because of the use of a laser diode with very good thermal characteristics. The encoder can detect arc angles, count revolutions, measure rotational speed and indicate rotational direction. It has applications in a variety of tools and instruments including micrometers and vernier calipers but the small size suggests that it would be highly suitable for robotics. Available through Hero Electronic Ltd, Dunstable Street, Ampthill, Beds MK45 2JS.
WW 301

WW 301

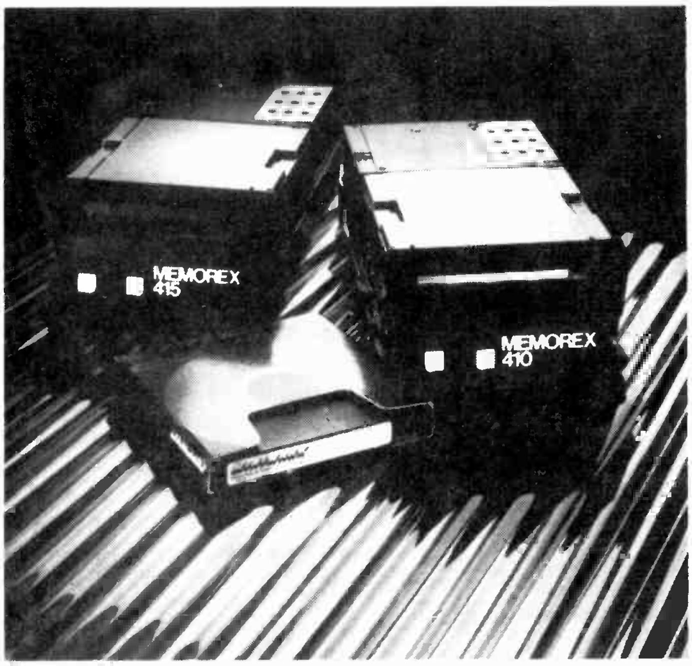


5Mbyte disk with back-up

The availability of the Memorex 410 series of hard discs with removeable disc back-up storage has been announced. Each disc has 5.2Mb formatted capacity and are packed together in a standard 5.25in disc housing. The removeable cartridge disc has been designed in the style proposed as an ANSI standard. The next drive in the range, the 415, available soon, will offer a main disc storage capacity of 10.48Mb witn the same 5.24Mb disc fitting into the slot for back-up. A range of controllers and the drives themselves are from Craft Data Ltd, M and M House, Frogmore Road, Hemel Hempstead, Herts HP3 9RW.
WW 302

Low-cost eraser

It has always surprised us that something as simple as a light-proof box and an ultraviolet lamp should cost as much as many available on the market. A more realistic price of £19.95 is asked for the Uvipac eprom eraser which can operate on up to three eproms at once in a unit only 90 by 80mm. Erasure time varies from 5 to 20 minutes depending on the device. A built-in 15-minute timer costs £5 more (prices inclusive of v.a.t.) Ground Control, Alfreda Avenue, Hullbridge, Essex SS5 6LT.
WW 303



Bespoke firmware

A number of utility programs are available as listings or programmed roms with user guides. They include m/c monitors for the 8080, 8085 and Z80 processors; Tiny Basic, Contol Basic, floating-point mathematics packages, serial communications interface; an eprom programmer which includes verification before 'burning'; and a number of system simulation packages. Isis for example is an interactive computer program which enables the user to solve non-linear differential equations and may be used as a replacement for an analogue computer to solve problems in dynamics and transient behaviour of continuous systems, such as servo systems or automatic control systems. Most of these are designed to run on 8080, 8085 or Z80-based microcomputers, and some may be run through CP/M. The manufacturers say that they may make the programmes available for use on other computers. Simulaton Systems Ltd, The Gables, North End, Yatton, Bristol BS19 4AS.
WW 000

Mike power

A battery unit to provide power for condenser microphones where no power feed is otherwise available, is provided by the AKG B18. Running off two PP3-type batteries, the unit may be connected to balanced and unbalanced amplifier, mixer or tape recorder inputs. The compact casing is provided with a swivel clip for attaching to the user's belt and a led indicates the battery status. Weighing only 130g, the unit provides opportunities to use condenser mikes when it would otherwise be impossible. AKG Acoustics Ltd, 191 The Vale, London W3 7QS.
WW 305

Real-time analyser for PC

An add-on 1/3-octave real-time analyser board uses the processing and display facilities of the IBM Personal Computer. RTA 331 consists of 31 two-pole filters from 20 to 20kHz and has a package of assembly-language routines called from Basic. It features instantaneous display, variable decay rates and averaging periods, peak hold and weighting functions, display of two independant bar graphs. It includes a pink noise generator which may be controlled through the program as may the input gain. Eight-bit sampling at 20kHz means that it can store up to 22 seconds of input in 128Kbytes of memory. Similar systems are available for use on Apple, TRS80 and Commodore computers. Marquee Electronics Ltd, 90 Wardour Street, London W1V 3LE.
WW 306

Hand-held dmm

A three-and-a-half digit, l.c.d. multimeter comes from Keithley in their model 130A. This model claims a 0.25% accuracy on the direct voltage range and has current measurement up to 10A on both a.c. and d.c. The sensitivity is 100ΩV, 1ΩA and 100mΩ in the

respective ranges and the meter can also be used for diode checks. It is protected against overloads and has indicators for polarity and if the battery voltage drops. The meter is warranted for two years and needs to be recalibrated after about the same period. Battery and fuse may be replaced without taking the meter apart. Keithley Instruments Ltd, 1 Boulton Road, Reading, Berks RG2 0NL.
WW 307

Image store/processor

By using the latest processors and dynamic read/write memory, Cambridge Research say that they can produce Alphascan, an image frame store and processing system, for a fraction of the cost of any (Far East) rival. The system has a wide range of applications in scanning microscopy, medical scanning instruments, data transmission, image processing, ultrasound imaging, and displays for non-destructive testing, amongst many. Signal collection at slow scan rates and c.r.t. presentation of the final image is standard and a number of software extensions permit digital processing, quantification, image analysis, two and three-dimensional measurement, disc storage and printer options. Cambridge Research Instruments, Chesterton Mill, French's Road, Cambridge CB4 3NP.
WW 308

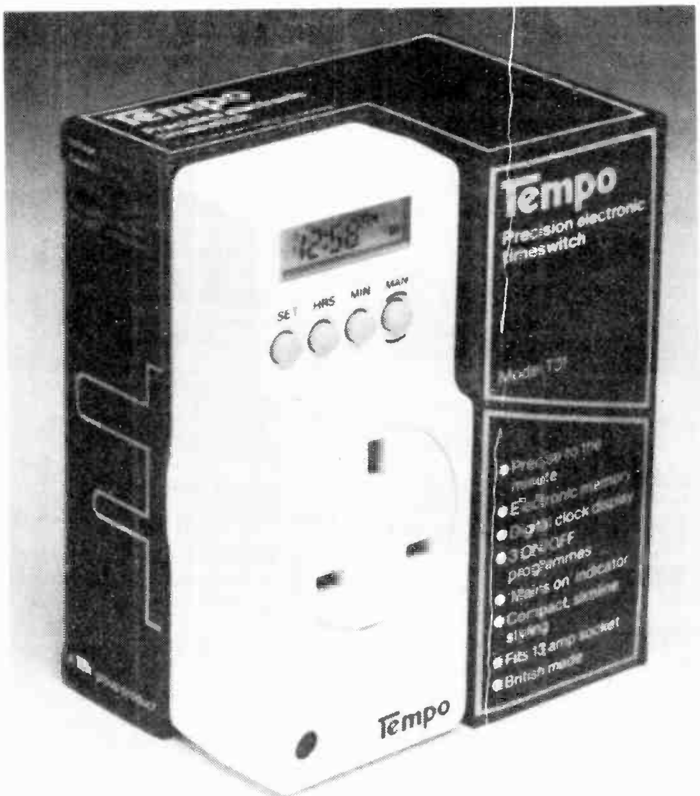
Domestic timer

A plug-in time switch for home or business use provides the accuracy of digital quartz timing with a neat compact case and a number of useful features. It is accurate to the minute, unlike most mechanical time switches and it can remember up to three on/off times which are protected in the memory against power failure by an internal battery. Any setting may be overridden by a touch of a button and programs may be suspended whenever the normal routine is not required, for example, at weekends. The unit, called Tempo, displays the time and the display is also used when setting the switch times and for checking them. Because of its accuracy, the time switch may be used to control remotely the recording of radio programmes, for alarm calls or for setting security systems. It may also be used to turn lights on and off around the house to deter burglars. Tempo, at £19.95 inclusive + £1.95 postage and packing is available by post from Tek Marketing, Burrel Road, St Ives, Huntingdon, Cambs PE17 4LE.
WW 309

PCB CAD

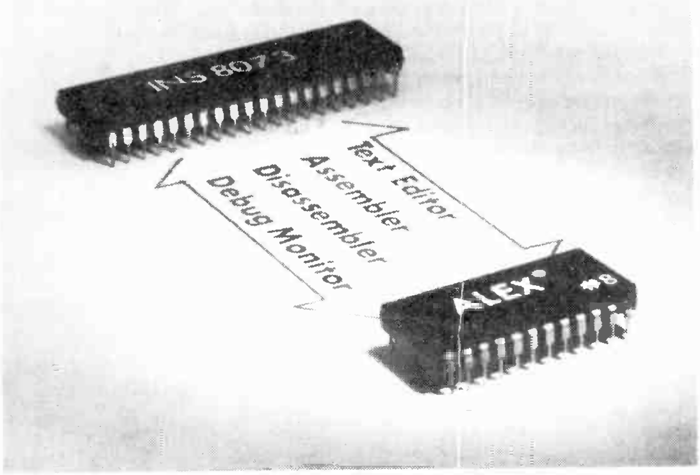
A computer-aided design system for p.c.bs has been developed by Dyad. The Chroma-cad system includes a high-resolution colour monitor with a second monochrome monitor displaying numerical information simultaneously. There is a dedicated keyboard and a

WW 308



WW 309

WW 311



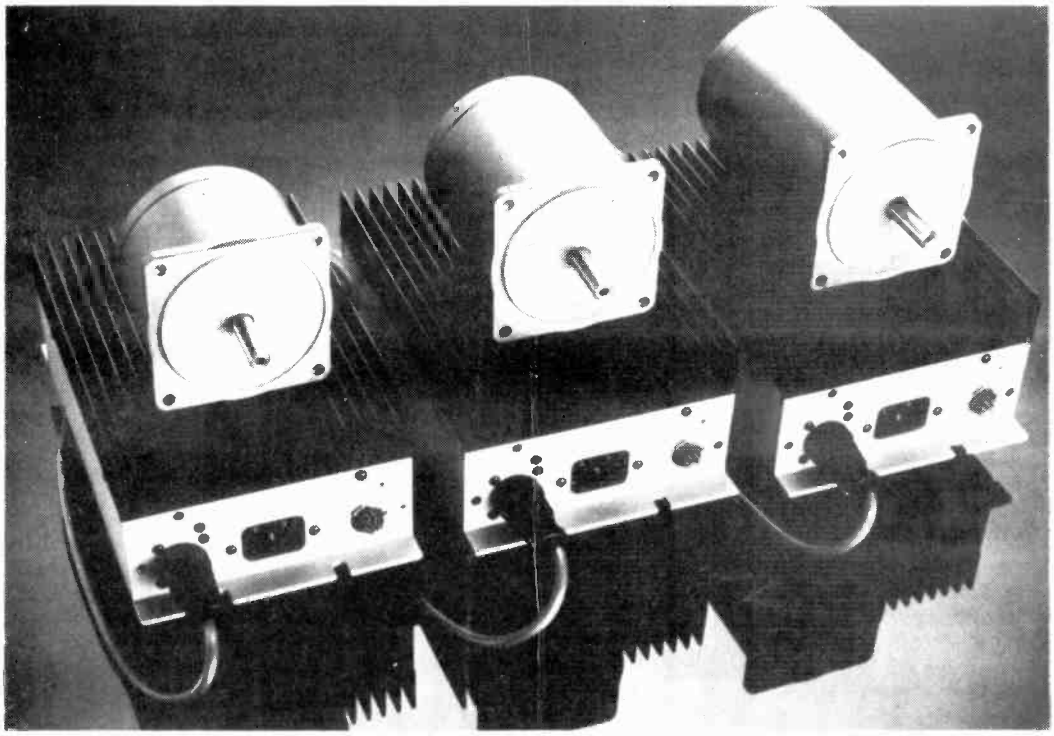
trackerball for rapid cursor movement. Developed for the creation of multi-layered designs, a complete board can be output to a plotter to produce camera-ready masters; or transmitted to a bureau for the production of higher-standard masters. The system uses two processors (Z80 and 8088) with the Z80 acting as a systems organiser while the 8088 is solely concerned with controlling the colour display. Drawings for p.c.bs up to 32m each side, working to a tolerance of 0.001m, is possible while up to 80 i.cs or their equivalents may be handled on the standard system. With memory expansion boards, the capacity can be increased. Component layout, or whole sub-circuits may be stored to and recalled from a library held in disc memory. Different layers of a board are displayed in different colours. Images may be selected for displaying together and the image may be 'panned' across or 'zoomed' into for a closer look. A variety of plotters, including photoplotters may be used and the system may be optimized to find the best combination of pad size and track width for particular pens, inks or paper. The makers point out that DoI grants are available for those companies purchasing CAD equipment. Dyad Developments, The Priory, Great Milton, Oxon OX9 7PB.
WW 310

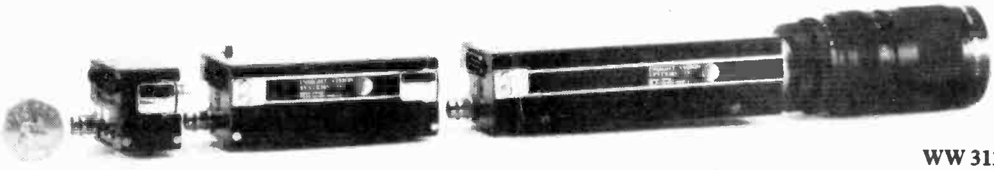
Tiny support package

A useful addition to the Essex Tiny Basic single-board computer is Alex. Intended for developing machine-code routines on the INS 8073-based system, it includes an assembler, enabling source code to be entered at a terminal; a disassembler for examining code already in memory; a text editor to allow lines to be altered without rewriting it all and a monitor routine which allows memory to be examined, copied, modified, compared and tested with a debugging program. Alex is supplied on a 4K eprom with a comprehensive users' manual. Essex Electronics Centre, University of Essex, Colchester, CO4 3SQ.
WW 311

If you would like more information on any of the items featured here, enter the appropriate WW reference number(s) on the mauve reply-paid card bound in this issue. Overseas cards require a stamp.

NEW PRODUCTS





WW 313

How pure are your sines?

A quick visual check on sinewave purity is provided by a pair of oscilloscope graticules which incorporate accurate sinewave traces printed on them permanently. The regular graticule is removed from the oscilloscope and the Sinecheck may be attached to the face of the c.r.t, alignment marks are provided. According to the designer, it is possible to monitor sinewave purity with a precision limited only by the fineness of the trace. Graticule 1 has a complete sinewave and may be used for initial setting up. It is itself adequate for most purposes, but for the more demanding occasion, graticule 2 may be used for further testing. This latter has two traces; a positive and negative half cycle. The graticules are available to fit up to a 100 by 80mm working area. Other sizes may become available if there is sufficient demand. The pair of graticules are available for £2. Enquirers should include screen working dimensions and a stamped addressed envelope to Sinecheck Graticules, Freepost, Watford, Herts WD1 8FP.
WW 315

Compumotor

Advantages over both stepper motors and d.c. servo motors are claimed for the Compumotor motor-and-control combination. Smooth linear acceleration over intermediate incremental positions compares with the stop/start magnetic detents of the stepper motor. This means that much less high frequency energy is transferred to the driven system so mechanical damping and dissipation can be greatly reduced. It provides high torque over a wide speed range and is claimed to have a much better slow-speed control combined with high resolution. Similar comparisons may be made with the d.c. servo motor system. With an increase in low speed torque while "the elegant simplicity and completeness of the Compumotor packages mean shorter design, specification, procurement and check-out times". Open and closed-loop configurations are available and the accuracy at slow speed frees the system from hunting the final position, as is common with many servo systems. The Compumotor is available with a variety of resolutions, up to 50 000 steps per revolution with a maximum step rate of 50 000 steps/s. Output power is from 0.001 to 2.5 horsepower. Unimatic Engineers Ltd, 122 Granville Road, London NW2.
WW 312

Miniature cctv

What is claimed to be the smallest available self-contained monochrome tv camera with broadcast-standard picture quality, the Insight 75 includes ×10 automatic gain, edge enhancement, automatic black level, motorised vidicon racking, built-in iris drive servo and an external lock. All this is in a package which fits into the palm of a hand and yet provides a resolution of 600 lines, a 56dB signal/noise ratio and a power consumption of 1.6W. A socket is provided for clip-on modules including a battery pack and a remote control unit. Applications include robotics, scientific research and surveillance. The system has been successfully used in surveying sewers and drains, boreholes, ducts and pipelines, for which purposes the manufacturers have devised and patented lighting and contro systems. Insight Vision Systems Ltd, Unit 1, Merebrook Industrial Units, Hanley Road, Danemoor, Malvern, Worce WR13 6NP.
WW 313

Inter-pcb connections

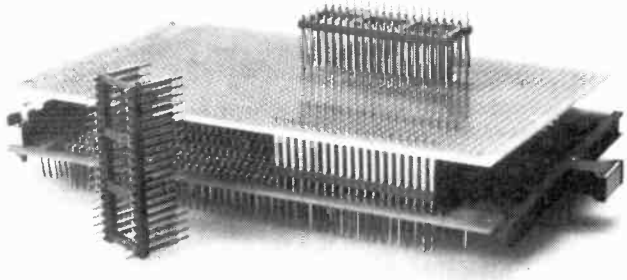
A double-decker p.c.b. connector obviates the need to use multi-layer boards. Using 0.1in pitch dual-in-line socket frames incorporting special stepped stand-offs with pin ends compatible with standard p.c.b. holes, collar supports ensure that the p.c.bs are held rigidly at 15mm parallel spacing. 17 options cover six to 64-pin d.i.l. packages which may be used with extender boards to add, e.g. more memory to a computer board. Test facilities may be added to a board using this system. Scott Electronics Ltd, 50 London Road, Sevenoaks, Kent TN13 1AS.
WW 314

In brief . . .

Three-stage power darlington transistors made by TI can switch voltages up to 1150V and currents up to 20A. They can withstand overload conditions up to 33kV. Available from VSI Electronics (UK) Ltd, Raydonbury Industrial Park, Harlow, Essex CM19 9BY.
WW 316

Two variations of Mains input filters are stocked in 1, 3, and 6A versions. The standard version (WF100) meets the 0.5mA leakage current standard for digital equipment while the WF100B meets the need for less than 5uA for medical applications Comway Ltd, Market Street, Bracknell, Berks RG12 1QP.
WW 317

WW 314



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The units have a 14" screen and are suitable for the BBC Micro, Lynx, Oric, Apple, IBM and most other leading micros.

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MODEL REFERENCE	1302-1 Medium Resolution	1302-2 High Resolution
RESOLUTION	370 x 470 Pixels	580 x 470 Pixels
C.R.T.	14"	14"
SUPPLY	220/240v. 50/60Hz.	220/240v. 50/60Hz.
E.H.T.	Minimum 19.5kv Maximum 22.5kv	Minimum 19.5kv Maximum 22.5kv
VIDEO BAND WIDTH	6MHz.	10MHz.
DISPLAY	80 characters by 25 lines	80 characters by 25 lines
SLOT PITCH	0.63mm	0.41mm
INPUT: VIDEO	R.G.B. Analogue/ TTL Input	R.G.B. Analogue/ TTL Input
SYNC	Separate Sync on R.G.B. Positive or Negative	Separate Sync on R.G.B. Positive or Negative
EXTERNAL CONTROLS	On/off switch and brightness control	On/off switch and brightness control

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I understand carriage per monitor will cost an extra £7.00.

(N.B. A Medium Resolution Monitor including VAT, lead, and carriage costs £187.39. A High Resolution Monitor including VAT, lead, and carriage costs £279.39.)

I enclose a cheque for £ ______ Or please debit my credit card account with the amount of £ ______ My Access/Barclaycard (please tick) no. is ______

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WW6

WW – 051 FOR FURTHER DETAILS

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TF2002A/S (illustrated) 10kHz-72MHz. AM/FM. **£750**
TF2002. As above but AM only. **£450**
MARCONI TF1066B. AM/FM Generator. 10-470MHz. 0.2uV-200mV output. FM Deviation up to ±100kHz.
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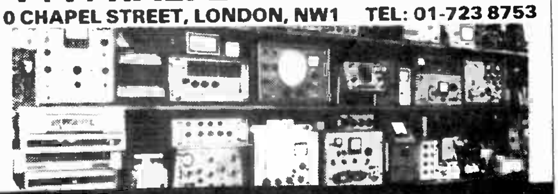

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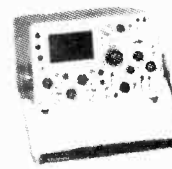

TEKTRONIX 453. Dual-trace 50MHz.
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SOLARTRON CD1740. 50MHz sweep-delay **£350.**
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MADE IN ENGLAND BY DOWTY UECL

SPECIFICATION: Designed to BS9525 and DIN 41612. Flame retardant polyester moulding. Twin cantilever socket contacts. Current rating per contact: 2A at 20°C. Working Voltage 350V D.C./A.C. Other Terminal Styles and Configurations in stock. Please phone for full stock list.
All below types available ex-stock.

Connector	No. of Contacts	Termination	Pitch	Moulding Size	Contact Rows used	Order Code	Price ea. 10-99 pcs	Price ea. 100-499 pcs*
PLUG	32	90° SPILL	2.54mm	2 ROW	A	20100	£0.60	£0.51
PLUG	64	90° SPILL	2.54mm	2 ROW	A+B	20500	£0.85	£0.72
PLUG	64	90° SPILL	2.54mm	2 ROW	A+C	20900	£0.85	£0.72
PLUG	96	90° SPILL	2.54mm	3 ROW	A+B+C	21100	£1.20	£1.00
SOCKET	32	4mm STRAIGHT SPILL	2.54mm	2 ROW	A	20202	£0.75	£0.63
SOCKET	32	13mm WIRE WRAP	2.54mm	2 ROW	A	20206	£0.75	£0.63
SOCKET	64	4mm STRAIGHT SPILL	2.54mm	2 ROW	A+B	20602	£1.20	£1.00
SOCKET	64	13mm WIRE WRAP	2.54mm	2 ROW	A+B	20606	£1.20	£1.00
SOCKET	64	4mm STRAIGHT SPILL	2.54mm	3 ROW	A+C	21002	£1.20	£1.00
SOCKET	64	13mm WIRE WRAP	2.54mm	3 ROW	A+C	21006	£1.30	£1.10
SOCKET	96	13mm WIRE WRAP	2.54mm	3 ROW	A+B+C	21206	£1.80	£1.53

*** Further quantity discounts on application ***

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TRANSFORMERS EX-STOCK

MAINS ISOLATORS
Pri/Sec 0-120V×2

VA	Price	P&P
*20	5.82	1.60
60	9.49	1.80
100	11.08	2.00
200	15.69	2.25
250	18.97	2.64
350	23.47	2.70
500	29.23	2.95
750	41.28	3.70
1000	53.00	4.00
1500	68.37	4.70
2000	82.27	5.10
3000	115.35	OA
6000	203.65	OA

*115 or 240V only. Pri 240V.

400/440V ISOLATORS
400/440 to 200/240V

VA	Price	P&P
60	9.50	1.80
100	11.08	2.00
200	15.68	2.25
250	18.97	2.40
350	23.47	2.70
500	29.23	2.95
1000	52.98	4.00
2000	82.27	5.00
3000	115.37	OA
6000	228.75	OA

12/24V or 12-0-12V
2×12V Secs. Pri. 220-240V

12V	24V	Price	P&P
.3	.15	2.41	.90
1	.5	3.19	1.20
2	1	4.25	1.20
4	2	4.91	1.60
6	3	7.69	1.60
8	4	8.98	1.60
10	5	9.82	1.80
12	6	10.89	1.90
16	8	12.97	2.12
20	10	17.46	2.44
30	15	21.69	2.64
60	30	44.45	OA

96/48V. Pri 2×120V
Secs 2×36/48V

72/96	36/48	Price	P&P
.5	1	5.37	1.20
2	4	14.69	2.20
3	6	17.79	2.40
5	10	32.23	3.20
6	12	40.36	3.50
8	16	44.03	3.75

50/25V or 25-0-25V
2×25V tapped secs. Volts out 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40, 20-0-20 or 25-0-25V

50V	25V	Price	P&P
.5	1	4.13	1.40
2	4	8.69	1.84
3	6	10.36	1.90
4	8	14.10	2.12
6	12	18.01	2.20
8	16	24.52	2.70
10	20	30.23	3.00
12	24	36.18	3.20

60/30V or 30-0-30V
Pri 2x120V. 2×30V tap secs Volts out 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60, 24-0-24 or 30-0-30V.

60V	30V	Price	P&P
.5	1	4.70	1.50
1	2	7.15	1.50
2	4	9.20	1.90
3	6	13.31	2.00
4	8	15.15	2.20
5	10	19.16	2.20
6	12	21.86	2.65
8	16	30.72	3.00
10	20	35.76	3.30
12	24	41.22	3.50

CASING SERVICE
Transformers can be cased in sturdy metal ventilated boxes. Cable in/out; USA 3 pin skts. or 13A to order. Phone/Write for quotes.

MINIATURES (SCR)
Pri. 240V

Sec V	A	Pri	P&P
3-0-3	.2A	3.11	.90
6×2	1A×2	3.45	1.20
9-0-9	.1	2.59	.90
9×2	.33×2	2.41	.90
8,9×2	.5×2	3.36	1.20
8,9×2	1A×2	4.27	1.40
15×2	.2A×2	2.41	.90
12-0-12	.05	3.11	.90
20×2	.3×2	3.39	1.20
20,12,0			
12,20	.7(DC)	4.13	1.20
15,20-2	1A×2	5.60	1.60
15,27×2	.5×2	4.83	1.40
15,27×2	1A×2	7.30	1.60

30/15V or 15-0-15V
2×15V tap Sec. Volts 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30 or 15-0-15V

30V	15V	Price	P&P
.5	1	3.19	1.20
1	2	4.32	1.40
2	4	6.99	1.60
3	6	8.10	1.85
4	8	9.67	1.90
5	10	11.95	2.00
6	12	13.52	2.00
8	16	18.10	2.26
10	20	20.88	2.26
12	24	23.20	2.50
15	30	26.60	3.00
20	40	35.64	4.83

AUTOS
Volts available 105, 115, 190, 220, 230, 240V
For step-up or down

VA	Price	P&P
80	4.84	1.40
150	6.48	1.60
350	11.84	2.00
500	13.30	2.24
1000	22.70	2.80
1500	28.17	3.20
2000	42.14	4.00
3000	71.64	4.80
5000	108.30	OA

CASED AUTOS
240V cable in. USA skts. out

VA	Price	P&P
20	7.21	1.50
80	9.35	1.60
150	12.10	1.90
250	14.73	2.00
500	22.14	2.20
1000	33.74	2.80
2000	60.47	4.50

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TV Style 20" MONITOR Black & White. Video In.................£30 each
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29 H.P. CALCULATOR PLOTTER 9125A with Extended Memory 9101A and Cal Buffer 9102A.................£250
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AN240P	2.80	MC1496	1.25	TA7146	2.95	TBA651	1.75	TDA2530	1.95
AN612	2.15	MC14011BCP	0.32	TA7176AP	2.95	TBA651R	2.50	TDA2532	1.95
AN7140	3.50	MC145106P	7.95	TA7203	2.95	TBA720A	2.45	TDA2540	1.25
AN7145	3.50	MC1723	0.50	TA7204P	2.15	TBA750Q	2.65	TDA2541	2.15
AN7150	2.95	MC3357	2.75	TA7205AP	1.50	TBA800	0.89	TDA2560	2.15
BA521	3.35	ML231B	1.75	TA7222AP	1.80	TBA810AS	1.65	TDA2571	£1.95
CA1352E	1.75	ML232B	2.50	TA7227P	4.25	TBA810P	1.65	TDA2581	2.25
CA3086	0.46	MSM5807	6.75	TA7310P	1.80	TBA820M	0.75	TDA2593	2.95
ETT6016	2.50	PLL02A	5.75	TA7313AP	2.95	TBA820Q	1.45	TDA2600	5.50
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LA4400	4.15	SL901B	5.50	TAA661B	1.20	TBA990Q	1.49	UPC566H	2.95
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LC7120	3.25	SL1310	1.80	TBA120B	0.95	TCA270	1.10	UPC1025H	2.50
LC7130	3.50	SL1327	1.10	TBA120C	1.15	TCA270SQ	1.10	UPC1028H	1.95
LC7131	5.50	SL1327Q	1.10	TBA120T	1.05	TCA650	2.50	UPC1032H	1.50
LC7137	5.50	SN76003N	1.95	TBA120U	1.00	TCA800	2.15	UPC1156H	2.75
LM324N	0.45	SN76013N	1.95	TBA231	1.25	TCA940	1.65	UPC1158H	0.75
LM380N	0.95	SN76023N	1.95	TBA395	1.50	TDA440	2.20	UPC1167C2	1.15
LM383T	2.95	SN76033N	1.95	TBA396	0.75	TDA1001	1.95	UPC1181H	1.25
M51513L	2.30	SN76110N	0.89	TBA440N	2.55	TDA1004A	2.20	UPC1182H	2.95
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MC1310P	1.50	SN76533N	1.65	TBA520Q	1.10	TDA1170	1.95	UPC1365C	3.95
MC1327	0.95	SN76544N	1.95	TBA530	1.10	TDA1170S	1.95	UPC2002H	1.95
MC1327Q	0.95	SN76570N	1.00	TBA530Q	1.10	TDA1190	2.15	555	0.35
MC1330P	0.76	SN76650N	1.15	TBA540	1.25	TDA1270Q	3.95	556	0.42
MC1349P	1.20	SN76660N	0.80	TBA540Q	1.35	TDA1327	1.70	723	0.50
MC1350P	0.95	TA7061AP	3.95	TBA550Q	1.45	TDA2002	1.95	741	0.35
MC1351P	1.50	TA7108P	1.00	TBA560C	1.45	TDA2020	2.45	747	0.50
MC1352P	1.25			TBA560CQ	1.45	TDA2030	2.80	748	0.35
MC1357	2.35			TBA570	1.00	TDA2522	1.95	7805	0.60

SEMICONDUCTORS

AAY12	0.25	BC173B	0.10	BD166	0.55	BF362	0.38	R2008B	1.70
AC126	0.22	BC174	0.09	BD179	0.72	BF363	0.38	R2010B	1.70
AC127	0.20	BC174A	0.09	BD182	0.70	BF371	0.20	R2322	0.58
AC128	0.28	BC177	0.15	BD201	0.83	BF394	0.19	R2323	0.66
AC128K	0.32	BC178	0.15	BD202	0.65	BF422	0.32	R2540	2.48
AC141	0.28	BC182	0.10	BD203	0.78	BF457	0.32	RCA16334	0.90
AC141K	0.34	BC182LB	0.10	BD204	0.70	BF458	0.36	RCA16335	0.80
AC142K	0.30	BC183	0.10	BD222	0.46	BF459	0.36	SKE5F	1.45
AC176	0.22	BC183L	0.09	BD223	0.48	BF595	0.23	TIP29	0.40
AC176K	0.31	BC184LB	0.09	BD225	0.48	BF597	0.25	TIP29C	0.42
AC178	0.28	BC204	0.10	BC232	0.35	BFR39	0.23	TIP30C	0.43
AC187	0.25	BC207B	0.13	BD233	0.35	BFR40	0.23	TIP31C	0.42
AC187K	0.28	BC208B	0.13	BD234	0.35	BFR41	0.28	TIP32C	0.42
AC188	0.25	BC212	0.09	BD236	0.45	BFR81	0.25	TIP33B	0.75
AC188K	0.37	BC212L	0.09	BD237	0.40	BFR88	0.30	TIP34B	0.75
AD142	0.79	BC212LA	0.09	BD238	0.40	BFR90	1.50	TIP41A	0.45
AD143	0.82	BC213	0.09	BD241	0.40	BFR91	1.75	TIP41C	0.45
AD149	0.70	BC213L	0.09	BD242	0.50	BFT42	0.28	TIP42C	0.47
AD161	0.39	BC214	0.09	BD246	0.60	BFT43	0.28	TIP47	0.65
AD162	0.39	BC214C	0.09	BD376	0.32	BFW92	0.85	TIP120	0.60
AD161/2	0.90	BC214L	0.09	BD410	0.55	BFX29	0.30	TIP125	0.65
AF114	1.50	BC237	0.10	BD434	0.55	BFX84	0.26	TIP142	1.75
AF124	0.34	BC237A	0.09	BD437	0.50	BFX85	0.32	TIP146	2.75
AF125	0.35	BC237B	0.09	BD438	0.80	BFX86	0.30	TIP161	2.95
AF126	0.32	BC238	0.09	BD506	0.50	BFX88	0.25	TIP2955	0.80
AF127	0.32	BC239	0.12	BD508	0.40	BFY50	0.21	TIP3055	0.55
AF139	0.40	BC251A	0.12	BD520	0.65	BFY51	0.21	TIS91	0.20
AF178	1.95	BC252A	0.15	BD538	0.65	BFY52	0.25	TV106/2	1.50
AF239	0.42	BC258	0.25	BD597	0.75	BFY90	0.77	2N2219	0.28
AU106	2.00	BC258A	0.39	BD697	1.10	BLY48	1.75	2N2905	0.40
AU107	1.75	BC284	0.30	BD698	1.10	BR100	0.26	2N3053	0.40
AU110	2.00	BC300	0.30	BD707	0.80	BR101	0.30	2N3054	0.59
AU113	2.95	BC301	0.30	BDX32	1.50	BRC4443	0.85	2N3055	0.52
BC107A	0.11	BC303	0.26	BDY57	1.66	BT106	1.49	2N3702	0.12
BC107B	0.11	BC307	0.09	BF115	0.35	BT108	1.89	2N3703	0.12
BC108	0.10	BC307A	0.09	BF127	0.24	BT116	1.20	2N3704	0.12
BC108A	0.11	BC307B	0.09	BF154	0.12	BT119	1.65	2N3705	0.12
BC108B	0.12	BC327	0.10	BF158	0.22	BT120	1.65	2N3706	0.12
BC109	0.10	BC328	0.10	BF160	0.27	BU105	1.22	2N3708	0.12
BC109B	0.12	BC337	0.10	BF167	0.24	BU108	1.69	2N3773	1.95
BC109C	0.12	BC338	0.09	BF173	0.22	BU124	1.25	2N3792	1.35
BC114	0.11	BC347A	0.13	BF177	0.38	BU125	£1.25	2N4427	1.50
BC116A	0.15	BC461	0.35	BF178	0.26	BU126	1.60	2N4444	1.15
BC117	0.19	BC478	0.20	BF179	0.34	BU204	1.55	2N5294	0.42
BC119	0.24	BC527	0.20	BF180	0.29	BU205	1.30	2N5296	0.48
BC125	0.25	BC547	0.10	BF181	0.29	BU208	1.39	2N5298	0.60
BC139	0.20	BC548	0.10	BF182	0.29	BU208A	1.52	2N5496	0.65
BC140	0.31	BC549A	0.08	BF183	0.29	BU326	1.20	2SA715	0.60
BC141	0.25	BC550	0.08	BF184	0.28	BU407	1.24	2SC495	0.80
BC142	0.21	BC557	0.08	BF185	0.28	BU500	2.25	2SC496	0.80
BC143	0.24	BC557A	0.08	BF194	0.11	BU526	1.90	2SC1096	0.80
BC147	0.09	BC557B	0.08	BF195	0.11	BUY69B	1.70	2SC1172Y	2.20
BC147B	0.09	BC558	0.10	BF196	0.11	MJ3000	1.98	2SC1173	1.15
BC148A	0.09	BCY33A	1.60	BF197	0.11	MJE340	0.40	2SC1306	1.00
BC148B	0.09	BD115	0.30	BF198	0.16	MJE520	0.48	2SC1307	1.50
BC149	0.09	BD116	0.60	BF199	0.14	MPSA12	0.20	2SC1449	0.80
BC157	0.12	BD124P	0.59	BF200	0.40	MPSA13	0.20	2SC1678	1.25
BC158	0.09	BD131	0.32	BF241	0.15	MPSA92	0.30	2SC1945	2.10
BC159	0.09	BD132	0.35	BF245	0.30	MRF450A	12.50	2SC1953	0.95
BC160	0.28	BD133	0.40	BF246	0.28	MRF453	17.50	2SC1957	0.80
BC161	0.28	BD135	0.30	BF256/LC	0.28	MRF454	23.50	2SC1969	1.95
BC170B	0.15	BD136	0.30	BF257	0.28	MRF475	2.50	2SC2028	1.15
BC171	0.09	BD137	0.32	BF258	0.28	MRF477	10.00	2SC2029	1.95
BC171A	0.10	BD138	0.30	BF259	0.28	OC23	1.50	2SC2078	1.45
BC171B	0.10	BD139	0.32	BF271	0.26	OC42	0.55	2SC2091	0.85
BC172	0.10	BD140	0.30	BF273	0.13	OC44	0.75	2SC2166	1.95
BC172B	0.10	BD144	1.10	BF336	0.34	OC45	0.55	2SC2314	0.80
BC172C	0.10	BD159	0.65	BF337	0.29	OC70	0.45	2SD234	0.50
				BF338	0.32	OC71	0.40	3N211	1.95
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BA145	0.16	BY210-800	0.33	IN4007	0.06
BA148	0.17	BY223	0.90	IN4148	0.02
BA154	0.06	BY298-400	0.22	IN4448	0.10
BA155	0.13	BY299-800	0.22	IN5401	0.12
BA156	0.15	BYX10	0.20	IN5402	0.14
BA157	0.30	BYX36-150R	0.20	IN5403	0.12
BAX13	0.04	BYX38-600R	0.60	IN5404	0.12
BAX16	0.06	BYX55-600	0.30	IN5405	0.13
BB105B	0.30	BYX71-600	0.60	IN5406	0.13
BT151	0.79	BZY95C30	0.35	IN5407	0.16
BY126	0.10	OA47	0.09	IN5408	0.16
BY127	0.11	OA90	0.05	ITT44	0.04
BY133	0.15	OA91	0.06	ITT923	0.15
BY164	0.45	OA95	0.06	ITT2002	0.10
BY176	1.20	OA202	0.10		
BY179	0.63	IN914	0.04		
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ECH83	0.78
ECH84	0.69
ECH2000	1.50
ECL80	0.60
ECL82	0.65
ECL83	2.50
ECL84	0.74
ECL85	0.69
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EF94	0.85
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EF97	0.90
EF98	0.90
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EF184	0.65
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EL82	0.58
EL84	0.75
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PC97	1.10
PC800	1.10
PC900	1.25
PCC84	0.40
PCC85	0.54
PCC88	0.70
PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	0.40
PCF200	1.80
PCF201	1.80
PCF800	0.40
PCF801	1.35
PCF802	0.60
PCF805	1.25
PCF806	1.00
PCF808	1.25
PCH200	1.50
PCL82	0.80
PCL83	2.50
PCL84	0.85

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PCL86	0.85
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U54	4.50
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U191	0.70
U192	1.00
U193	0.65
U251	1.00
U291	0.60
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	1.75
UBC81	1.50
UBF89	0.60
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	1.20
UCH42	1.35
UCH81	0.65
UF85	1.20
UF41	1.15
UF42	1.15
UF80	0.80
UF89	2.50
UL41	3.50
UL84	0.85
UU5	2.50
UU7	8.00
UU8	9.00
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1L6	1.50
1LA6	1.00
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6F25	1.25
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6H6	1.35
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6J4WA	3.15
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6J5GT	1.50
6J6	0.65
6JB6A	3.95
6JE6C	3.95
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6KD6	5.50
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6L6GC	2.95
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6P25	4.00
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6Q7GT	1.20
6S4A	1.50
6S7	1.10
6SA7GT	1.00
6SC7	1.50
6SG7	1.20
6SH7	1.20
6SJ7GT	1.20
6SK7	0.80
6SK7GT	1.20
6SL7GT	0.85
6SN7GT	0.69
6SQ7	0.80
6SS7	1.95
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6U5G	1.50
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6U8A	1.50
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6X4	0.96
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12SA7GT	1.00
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12SN7GT	1.85
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18D3	1.60
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19G3	17.00
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19Q6	9.00
20A2	10.50
20D1	0.70
20D4	1.75
20LF6	3.50
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.05
20P5	1.15
21LU8	2.50
25L6GT	1.75
25BQ6	1.75
29C1	19.50
30	2.85
30C1	0.70
30C15	0.40
30C17	0.40
30C18	1.48
30F5	0.95
30FL1	1.00
30FL2	1.35
30FL12	0.95
30FL13	1.10
30FL14	1.25
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30PL1	2.50
30PL13	0.60
30PL14	1.75
31JS6A	4.15
35A5	4.50
35L6GT	2.00
35W4	0.70
35Z3	1.85
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40KD6	5.50
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50B5	1.50
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85A1	6.50
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1625	3.00
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5840	3.50
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6072	4.20
6080	5.75
6080WA	8.50
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6132	10.00
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6201	6.95
6211	2.50
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WW-2

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B7G Skirted	0.30
B8G	0.70
B9A	0.20
B9A Skirted	0.30
B10B	0.16
B13B	0.50
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14 Pin DIL	0.15
14 Pin DIL/Q	0.30
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OCTAL	0.35
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6V2 7V5 8V2 9V1 10V 11V 12V 13V 15V 16V 18V 20V 22V 24V 27V 30V 33V 36V 39V 47V 51V 56V 68V 75V

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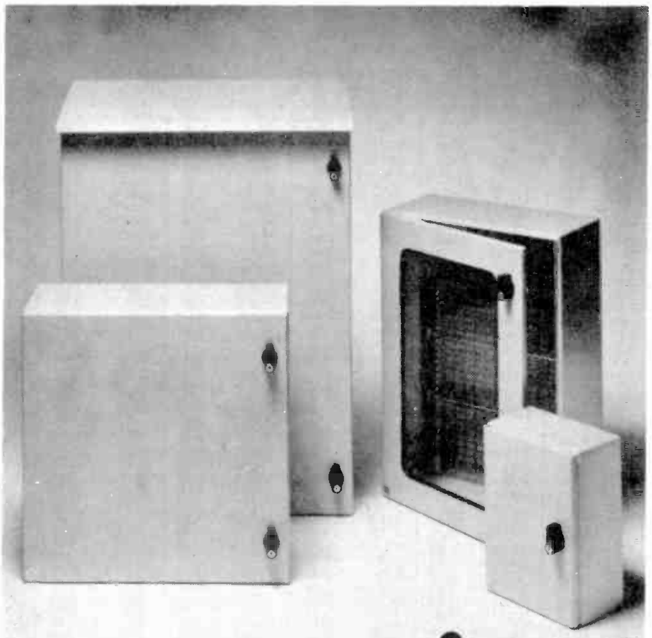

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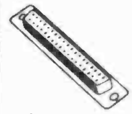

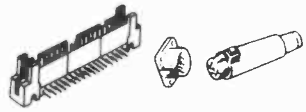

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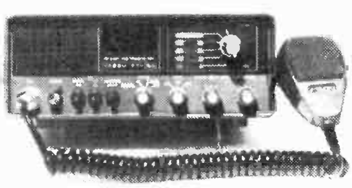

TM180 "PIONEER" HF SSB TRANSCEIVER. 1.8-18MHz, 6 channels 100 watts RF output measuring only 95(H) x 240(W) x 310(D)mm and weighing 6kg. May be operated as a base or mobile transceiver, complementing our trap dipole and HW4 mobile aerials. **Prices start** at £700, making this unit not only very attractive but highly competitive.

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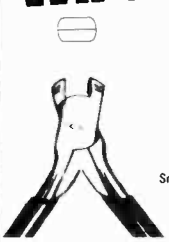
These precision box jointed pliers and cutters are manufactured in West Germany and are of extremely high quality. They are supplied to and used by the electronics industry. They all have double leaf springs, moulded-on PVC grips and polished heads. The cutters have induction hardened cutting edges.

As a little test of the quality and the squareness and fit of the jaws we tried holding pieces of paper with the pliers and cutting the paper with the cutters – we were extremely impressed. Naturally we also tested them with wire and were equally pleased with the results.

We decided to offer readers the alternative of a set of the three most vital tools, comprising top cutters, side cutters and snipe nose pliers (smooth inside jaws). All are approximately 4¾" long. In shops this set (Set A) would cost about £29.70, but our price to readers is **£19.50** incl VAT and UK p&p.

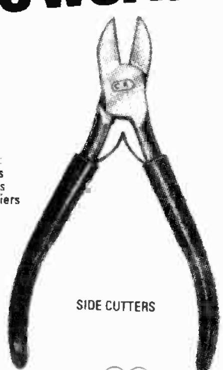
Our alternative choice is the above set plus a pair of round nose pliers which are extremely useful for shaping wires, etc. This set (Set B) comprising the four tools would normally cost £38 but we are offering it at only **£24.75** incl VAT and UK p&p.

We regret the tools are not available separately – only the sets as offered.

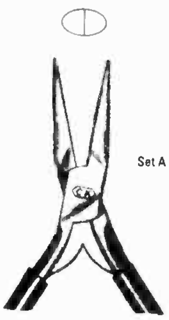


TOP CUTTERS flush cutting

SET A comprises: Top Cutters Side Cutters Snipe Nose Pliers

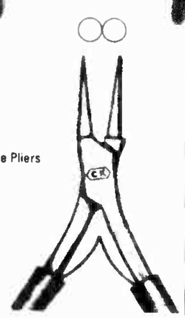


SIDE CUTTERS



SNIPE NOSE PLIERS

SET B comprises of: Set A plus Round Nose Pliers



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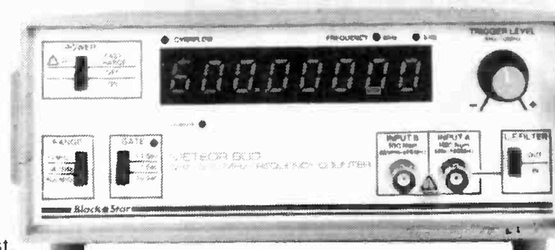

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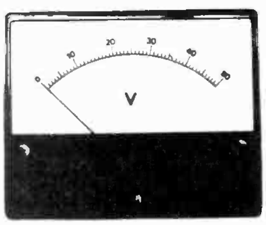

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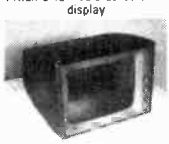

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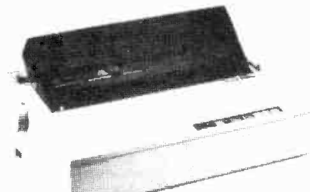

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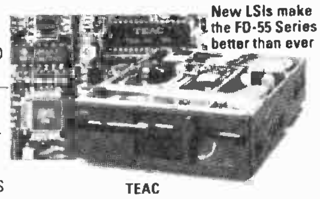

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2.5	360v	£1.50	6	300v	£2.00
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(1926)

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Name ....

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(861)

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The Industrial Electronics Group in the Department of Electronic and Electrical Engineering at the University of Surrey has vacancies for Technicians (Engineers) who are keen to further their experience in a wide range of electronic fields and are qualified to ONC level or higher

The work will involve operating on a project basis, covering all phases of prototype equipment manufacture, development and documentation.

The Group at present consists of a small team of Professional Engineers and Technicians who liaise closely with academic staff in problem solving for industry. Projects usually entail the development of novel instrumentation covering communication, non-destructive testing and signal processing fields with increasing emphasis on microprocessor based systems.

The commencing salary will be within the range of £5,151 to £7,332 on Grade 3, 4 or 5 technician salary scale (according to age, qualifications and experience) for a 36½ hour week). Excellent working conditions including the possibility of day-release study for higher qualifications.

For further information or to arrage a visit contact the Staff Officer, University of Surrey, Guildford GU2 5XH (Guildford (0483) 571281, extension 776) to whom completed application forms must be returned by 31st January 1984

Career Opportunities in the High Technology Broadcast Industry

Located in Hampshire, Sony Broadcast is an internationally renowned world leader in the professional broadcast television industry. Our extensive product range includes cameras, VTR's/VCR's, sophisticated editing control systems and now the exciting new range of Betacam equipment. Applications are now invited from experienced engineers who feel they have the potential to develop with the Company.

Field Service Engineer
The successful candidate will be engaged in the service, repair and commissioning of our extensive range of equipment. This will involve travel throughout our marketing territory of Europe, the Middle East and Africa. Full product training will be given where necessary. Applicants should have several years experience gained in the broadcast television industry, either in operations or allied manufacturing industries, and up-to-cate knowledge of VTR's and cameras is essential.

Senior Project Engineer – Systems
To co-ordinate a small team responsible for the manufacture and commissioning of complex static and mobile television systems including dubbing and editing systems, full production studios and EFP packages. This is a challenging and responsible position and candidates should have direct experience of sound and television principles. A background in project management together with the ability to plan and meet deadlines is also required.

Engineer – Customer Acceptance
To join a department responsible for the evaluation of product performance. Key activities will include conducting customer acceptance tests, the provision of engineering support to our inspectorate and an involvement in the establishment and maintenance of ATE. There will be a significant involvement with customers. Candidates aged 25 plus should possess HNC electronics or equivalent together with 5+ years experience in a high technology electronics environment.

Lecturer
To conduct theoretical and practical courses on our range of equipment. The department boasts excellent lecturing facilities together with a technical publications department and library. Applicants, educated to at least honours degree level electronics, should be able to present ideas clearly and have the ability to assimilate state of the art broadcast technology. Previous lecturing experience would be an advantage, although training in teaching skills and on our product range will be given where appropriate.

Product Engineer
We are looking for a professional electronics engineer to join our Product Management team. The person appointed will provide technical support to the Marketing and Engineering divisions of Sony Broadcast. This position combines in-depth technical involvement with interdepartmental and customer liaison, and there will be an opportunity for overseas travel. Applicants should be honours graduate electronics engineers, preferably experienced in the electronics industry. Full product training will be given where necessary.

If you like the thought of enjoying the success of world leadership together with a highly attractive salary and benefits package, write with details of career to date and present salary to David Parry, Personnel Department, Sony Broadcast Ltd, City Wall House, Basing View, Basingstoke, Hants RG21 2LA. Telephone (0256) 55011

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Sony Broadcast Ltd.
City Wall House
Basing View, Basingstoke
Hampshire RG21 2LA
United Kingdom

(2425)

SYSTEM PROJECT ENGINEERS

The Ampex Broadcast Systems Group based in Reading, Berkshire, supplies complete television studio and mobile systems to broadcast installations worldwide.

Owing to expansion of the group's activities, we are now looking for Systems Project Engineers to join our innovative project teams involved in the design installation and commissioning of television studio and outside broadcast vehicle projects.

These appointments involve occasional overseas travel for on-site commissioning.

Key requirements are:

* Thorough knowledge of video and audio principles – HNC/Degree in Electronics preferred.
* Experience in broadcast television industry.
* Previous knowledge of TV systems an advantage.

Attractive salaries and benefits, which include pension, life assurance, permanent health scheme, Bupacare option, product training, overseas allowances and relocation expenses where appropriate.

AMPEX

Please contact Maureen Brake for an application form:

AMPEX GREAT BRITAIN LIMITED
ACRE ROAD
READING RG2 0QR
TEL. READING (0734) 875200

(2447)

VIDEO ENGINEERS

Rediffusion Consumer Manufacturing Ltd is seeking an intermediate and a senior video engineer with OND, HND or similar qualifications, together with a knowledge of modern consumer electronics circuitry techniques, to join a small team looking after Rediffusion's mammoth investment in domestic video recorders and video disc players.

In addition to analysis of performance and long term reliability factors, assessment reporting is an important part of the team's function and the ability to express oneself verbally and in writing is essential. Our laboratories are situated at Chessington within easy commuting distance of the Surrey countryside. Attractive salaries and the usual big company benefits, which include assistance with relocation expenses, are offered to suitably qualified and experienced engineers. If you believe you can make a significant contribution to our video projects please write to or phone:–

Harry Brearley,
Rediffusion Consumer Manufacturing Ltd.,
Fullers Way South,
Chessington, Surrey. KT9 1HJ.
Telephone: 01-397-5411.

REDIFFUSION

(2407)

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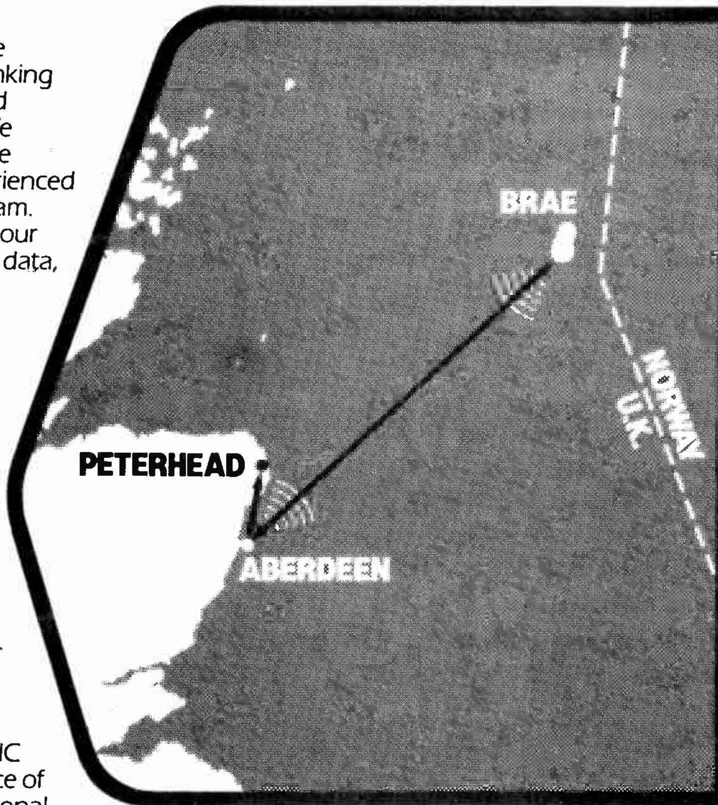
David Marsh, Customer Service Manager
DATRON INSTRUMENTS LIMITED
Hurricane Way, Norwich Airport
Norwich NR6 6JB

(2365)

Telecommunications



Marathon's Aberdeen office is the nerve centre of a private wire system linking the Aberdeen office with the Peterhead Shore Base and the Brae-A platform. We currently have two vacancies within the Telecommunications function for experienced individuals to become part of a small team. This group has overall responsibility for our communications networks, comprising data, telex, facsimile and all voice equipment.

Telecommunications Analyst - Onshore

Working at Marathon's Aberdeen office you will be responsible for the efficient day-to-day running of the network. You will be required to provide technical support to users and to produce clear and concise progress reports on system development and maintenance. There will be some opportunities to be involved in the specification of various systems.

Candidates will be qualified to HNC level with at least three years' experience of speech systems, data lines and international circuits; you should also have some relevant practical experience. Relocation assistance, as appropriate, is available for this position.

Telecommunications Technician - Offshore

Working offshore on a 2-week rotation you will be responsible for all telecommunication and radio equipment on the platform. As an experienced technician, your main functions will be to undertake repair work, preventive maintenance and fault-finding. You will form part of the offshore maintenance group and report directly to the Topsides Maintenance Supervisor.

A City & Guilds or ONC qualification is required for this position and your three years' experience should include some time offshore.

For both positions, we are offering competitive salaries supported by an attractive range of benefits including non-contributory pension scheme, subsidised BUPA and generous offshore allowances where appropriate.

Please write or telephone for an application form to:

Ian M Drysdale, Employee Relations Representative, Marathon Oil U.K., Ltd., Marathon House, Rubislaw Hill, Anderson Drive, Aberdeen AB2 4AZ. Tel: (0224) 576133.

MARATHON

(2438)

Radio Systems Planning Engineers
Middlesex

Over the past 35 years IAL has been involved in almost all areas of communication technology and has developed an expertise for which demand continues to expand worldwide. Consequently we now need additional Engineers to join the Telecommunications Engineering Department at our Headquarters near Heathrow.

These appointments represent excellent career moves for Engineers with varying levels of qualifications and experience and offer complete involvement in a planning and consultancy role on modern radio communications systems. These systems will be in the HF to SHF bands and range from point to point links through mobile area coverage schemes to broadband microwave links.

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For further details phone the Technical Recruitment Officer, on 01-574 5134 or write to him at Recruitment Services Division, IAL, Aeradio House, Hayes Road, Southall, Middlesex, UB2 5NJ. Please quote Ref. K004.

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(1640)

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(2417)

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Sound knowledge of business administration will be expected. Excellent promotional prospects.
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Applicants write with full C.V. to:

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Block D, Metropolitan Wharf
Wapping High Street, London, E.1
Telephone: **01-265 0722** (24-hour phone)
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(2418)

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Application forms and further details obtainable from the **Personnel Officer, Preston Polytechnic, Corporation Street, Preston, PR1 2TQ. Telephone: Preston 262027.**

Reference No: NT/83/84/49.

Closing Date: February 17th, 1984.

(2422)

Trainee Broadcast Engineers

We are responsible for broadcasting the programmes of Independent Television, Channel Four and Independent Local Radio. The continued growth of our broadcasting services means we have a number of vacancies for Trainee Broadcast Engineers who, on completion of their training, will work in a challenging and secure environment.

The selected candidates will embark on our 18-month residential training course which commences in June 1984. It will be conducted at our Training College, in Devon, and also at the Newcastle Polytechnic. The course is designed to give you a training in Broadcast Transmission Engineering that is second to none. It demands a high standard of understanding and personal commitment from those selected to undertake it. During the course we will pay you a salary and in addition, all your fees, accommodation and meals.

Applications are invited from men and women who hold an HND/HNC/HTEC in Electrical or Electronic Engineering or the City and Guilds Telecommunication Technicians Full Technological Certificate with some appropriate experience; or who are qualified or about to qualify to First Degree level in Electrical/Electronic Engineering or related disciplines.

Your salary while training will be £6,652 per annum. On the satisfactory completion of training, your salary will be £8,421 and will rise by annual increments to £10,461 per annum; further progression to £12,966 per annum is possible.

Employment benefits include a free life assurance and personal accident scheme, a contributory pension scheme, generous relocation expenses and subsidised mortgage facilities.

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(2370)

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(2433)

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(2403)

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Application forms and further details available from the **Personnel Officer, Brighton Polytechnic, Mithras House, Moulsecoomb, Brighton BN2 4AT. Telephone (0273) 693655, ext. 2536.** Closing date: February 18th, 1984.

BOX NOs.

Box number replies should be addressed to:

Box No...................
c/o Wireless World, Quadrant House
The Quadrant, Sutton, Surrey SM2 5AS

TVS, the young and forward-looking ITV programme company serving the South and South-East, requires a

Project & Installation Engineer

The position is based in the Southampton studios, but the successful applicant will be responsible for the design and development of electronic projects for all the Company's studio centres, and will be required to liaise with and, where necessary, advise the Project and Installation Department on all aspects of electronics.

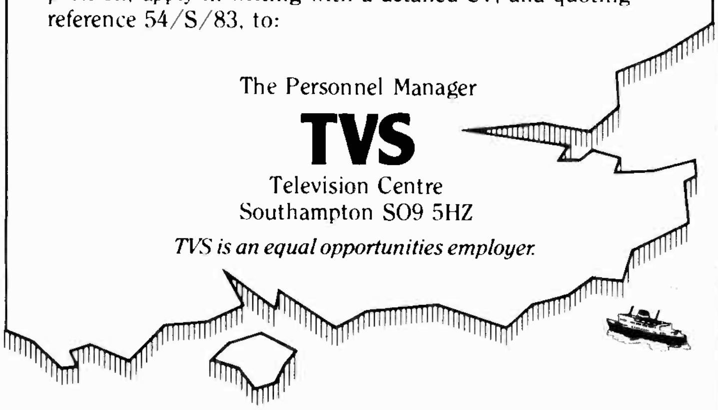
Candidates should have a thorough knowledge of current electronic devices and circuit design, and ideally a background of digital techniques. Where possible, he/she should be able to write and amend computer software. A basic knowledge of television techniques and practice would be an advantage.

ACTT terms and conditions apply.

If you feel you have the qualifications to fill this demanding position, apply in writing with a detailed CV, and quoting reference 54/S/83, to:

The Personnel Manager
TVS
Television Centre
Southampton SO9 5HZ

TVS is an equal opportunities employer.



the best view of the South

(2446)

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Included in the total package of company benefits are competitive salary, contributory pension scheme and good working conditions. Applicants should realise that relocation to the Aberdeen area is essential. Removal assistance will be provided.

Interested applicants should write enclosing a C.V. stating salary requirements for the attention of:—

Miss F. Skinner, Personnel Co-ordinator
TELECO OILFIELD SERVICES LTD.
Barclayhill Place, Portlethen, Aberdeen AB1 4PF

TELECO

Agency enquiries are not requested.

(2445)

LABORATORY ENGINEERS

BBC Engineering Research Department
Kingswood Warren, Tadworth, Surrey

Research Department has vacancies for Laboratory Engineers in two separate areas of work.

1) Duties include work with mobile units which are concerned with investigations into aspects of UHF and VHF transmitter propagation and reception, and with the development of new broadcasting services. Although based at Kingswood Warren, Laboratory Engineers must be prepared to travel and work for periods anywhere in the U.K., this includes some week-end working. Candidates must be able to drive.
2) Duties include the construction and testing of experimental equipment and some design and investigation work concerned with one or more of the following areas of research: video, sound and data origination, processing, recording, distribution, transmitting and receiving equipment using analogue and digital techniques. The work may also involve the use of microprocessors and the manipulation of associated software.

Please indicate any preference for either of the two areas of work.

Applicants should possess a degree in Electrical Engineering, Electronics or Physics; HNC/HND (Electrical); Higher T.E.C.; or City and Guilds Full Technological Certificate in Telecomms, and have a good knowledge of electronic technology. An interest in broadcasting engineering and computer techniques is desirable.

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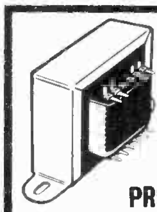

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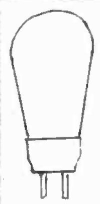

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