FOR EVERYTHING IN ELECTRONICS

Wireless world

JULY 1983

80p

Design competition - 5th month

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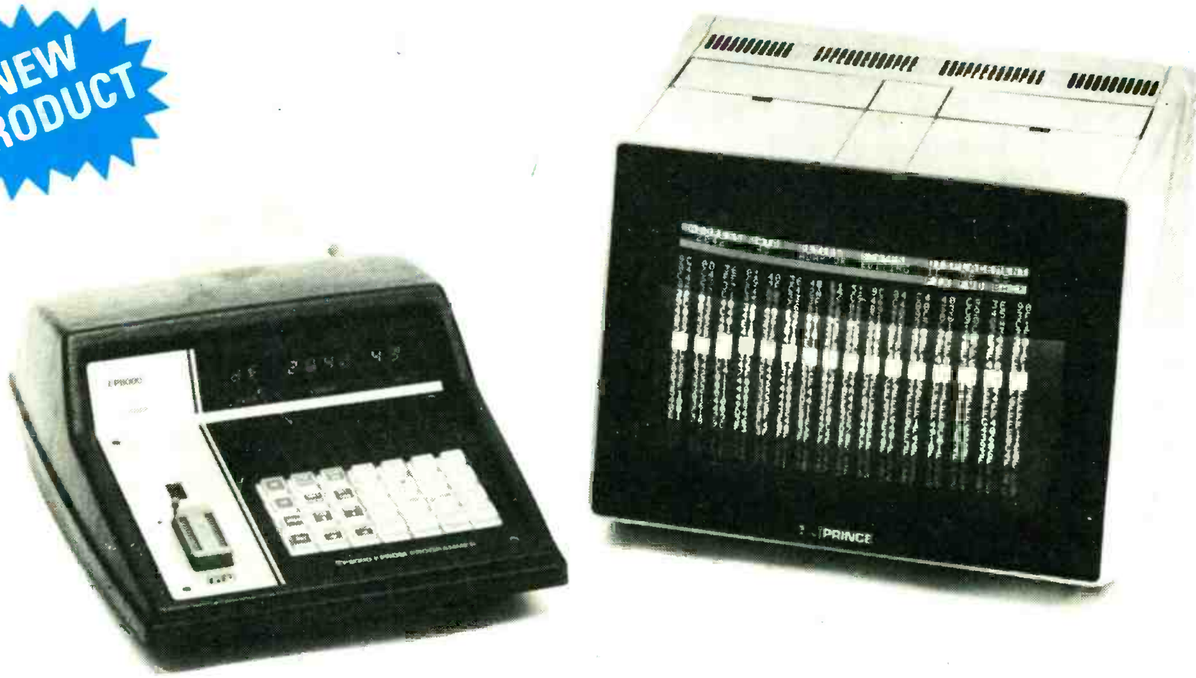
EP8000 EPROM EMULATOR PROGRAMMER

NEW PRODUCT



The new microprocessor controlled EP8000 Emulator Programmer will program and emulate all EPROMs up to 8k x 8 sizes, and can be extended to program other devices such as 16k x 8 EPROMs, Bipolar PROMs, single chip microprocessors with external modules.

Personality cards and hardware changes are not required as the machine configures itself for the different devices.

The EP4000 with 4k x 8 static RAM is still available with EPROM programming and emulation capacity up to 4k x 8 sizes.

FEATURES

- Software personality programming/emulation of all EPROMs up to 8k x 8 bytes including 2704, 2708, 2716(3), 2508, 2758A, 2758B, 2516, 2716, 2532, 2732, 2732A, 68732-0, 68732-1, 68766, 68764, 2564, 2764. Programs 25128, 27128 with adaptors.
- No personality cards/characterisers required.
- Use as stand alone programmer, slave programmer, or EPROM development system.
- Checks for misplaced and reversed insertion, and shorts on data lines.
- Memory mapped video output allows full use of powerful editing facilities.
- Built-in LED display for field use.
- Powerful editing facilities include: Block/Byte move, insert, delete, match, highlight, etc.
- Comprehensive input/output – RS232C serial port, parallel port, cassette, printer O/P, DMA.
- Extra 1k x 8 scratchpad RAM for block moving.

● EP8000 8k x 8 Emulator Programmer – £695 + £12 delivery ● BSC8 Buffered emulation cable – £49 ● SA27128 Programming adaptor – £69 ● SA25128 Programming adaptor – £69 ● EP4000 4k x 8 Emulator Programmer – £545 + £12 delivery ● BSC4 Buffered emulation cable – £39 ● BP4 (TEXAS) Bipolar PROM Module – £190 ● Prinz video monitor – £99 ● UV141 EPROM Eraser with timer – £78 ● GP100A 80 column printer – £225 ● GR1 Centronics interface – £65

VAT should be added to all prices

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Rather than try to show how electronics could help disabled people this month's cover by Geoff Harrold depicts the things you might choose to surround yourself with in entering our design competition.

NEXT MONTH

Compact electronic typewriter can be equipped with an RS232 interface to enable it to be used as a printer for computer output at a total cost for both typewriter and interface of just over half that of the lowest price commercial alternatives.

Loudspeaker measurement techniques designed to avoid the vagaries of personal prejudice and room acoustics normally require a calibrated microphone. But using the principle of reciprocity Peter Dobbins shows how three transducers can be calibrated with no specialized equipment.

Simple ultrasonic transmitters and receivers with appropriate control by 6502 or Z80 can give a robot distance-measuring capability, even in a noisy environment.

Current issue price 80p, back issues (if available) £1, at Retail and Trade Counter, Units 1 & 2, Bankside Industrial Centre, Hopton Street, London SE1. Available on microfilm; please contact editor.
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FOR EVERYTHING IN ELECTRONICS

Wireless world

JULY 1983 VOL 89 NO 1570

Philips Fluke

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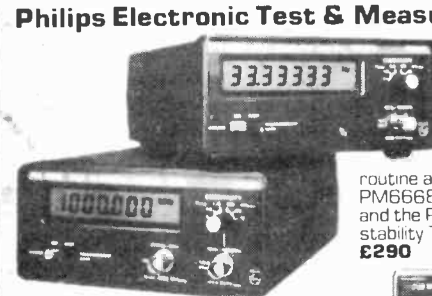

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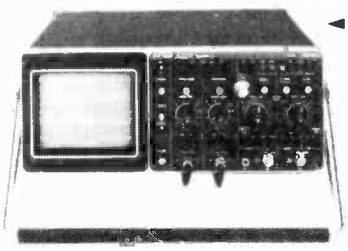

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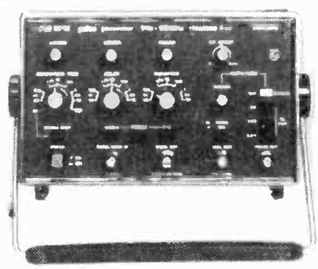

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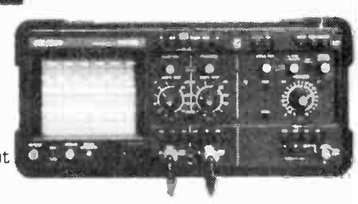

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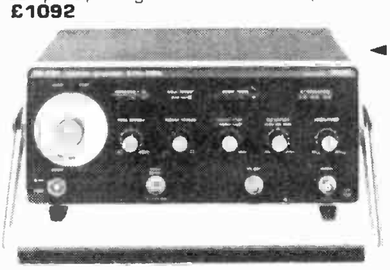

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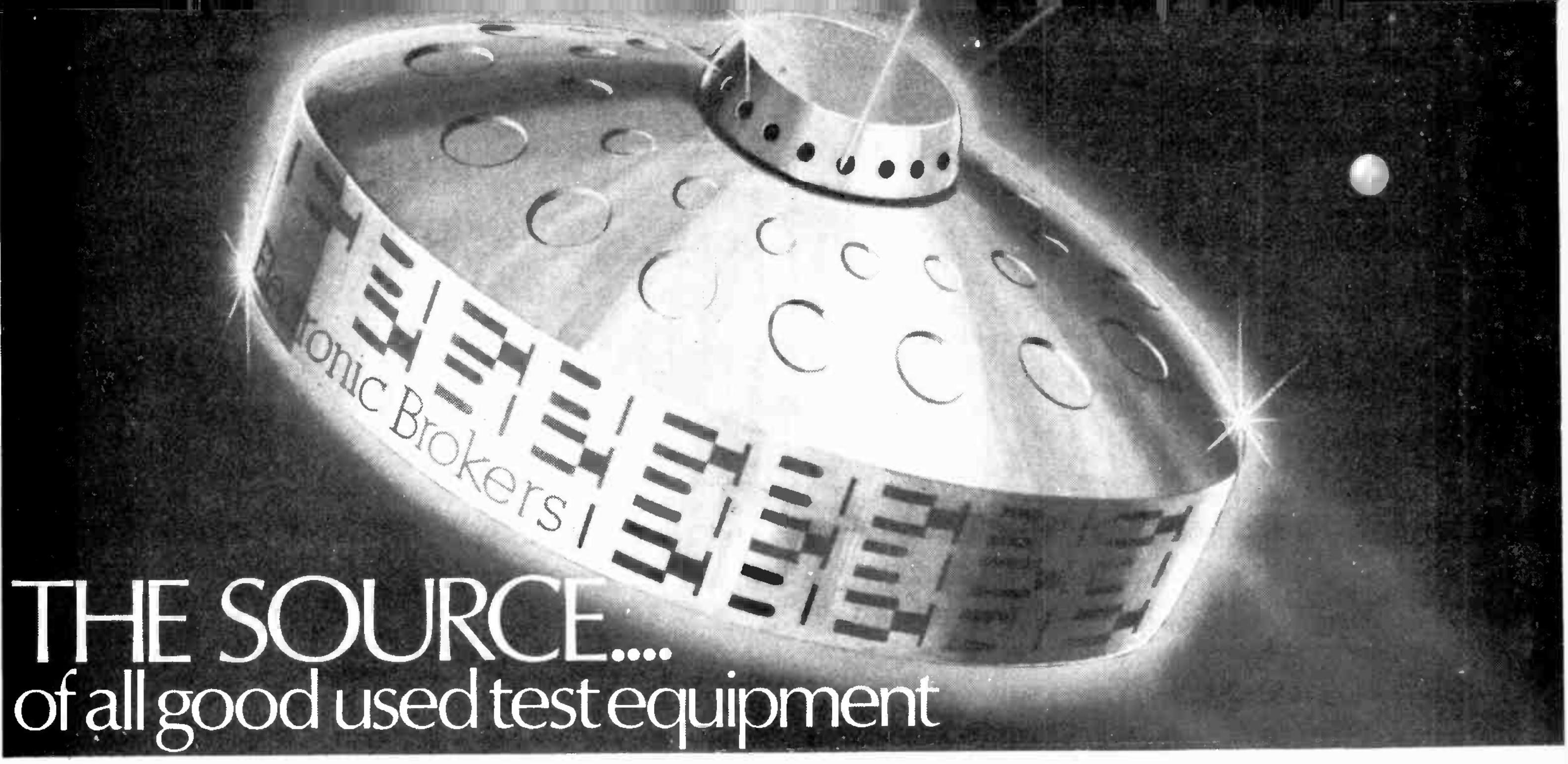

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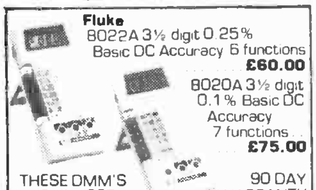

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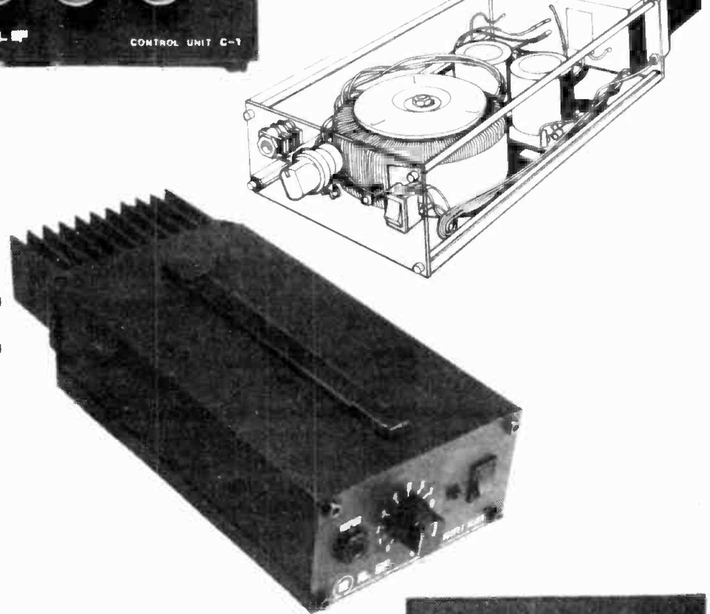

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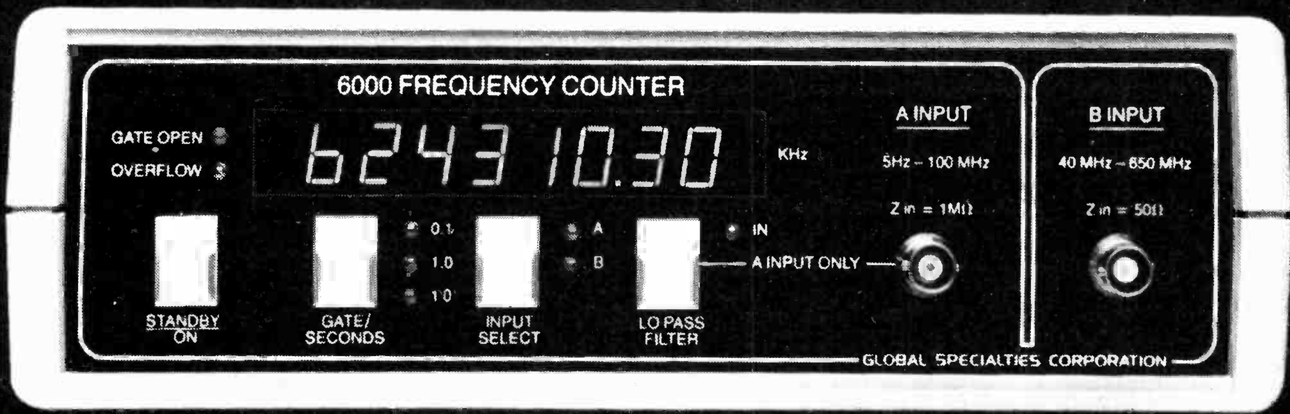
THE NEW GSC 6000 FREQUENCY COUNTER



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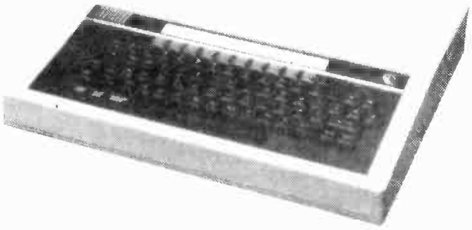

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4044 40p
4045 105p
4046 50p
4047 45p
4048 50p
4049 24p
4050 24p
4051 45p
4052 60p
4053 50p
4054 90p
4055 90p
4046 90p
4059 450p
4060 55p
4063 90p
4066 27p
4067 225p
4068 14p
4069 14p
4070 14p
4071 14p
4072 14p
4073 14p
4075 14p
4076 48p
4077 16p
4078 16p
4081 14p
4082 15p
4086 55p
4089 125p
4093 24p
4094 90p
4095 75p
4096 70p
4097 290p
4098 90p
4099 100p
4500 575p
4502 60p
4503 45p
4504 75p
4505 400p
4506 35p
4507 35p
4508 130p
4510 45p
4511 45p
4512 48p
4514 120p
4515 110p
4516 55p
4518 40p
4520 50p
4521 90p
4522 120p
4526 60p
4527 60p
4528 50p
4532 70p
4534 400p
4536 270p
4538 90p
4539 70p
4543 75p
4553 245p
4555 35p
4556 35p
4557 300p
4560 120p
4566 160p
4568 250p
4569 170p
4572 30p
4583 90p
4584 40p
4585 75p
40014 40p
40085 90p
40097 45p
40102 140p
40103 170p
40105 110p
40106 40p
40109 100p
40110 275p
40163 60p
40174 50p
40175 75p
40193 75p
40244 160p
40245 180p
40257 160p
40373 160p
40374 160p
14495 300p
14500 700p
14599 290p

COUNTERS

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

DIL SWITCHES

4-way 90p
8-way 120p
6-way 105p
10-way 150p
4116-20 80p

Most items despatched by return of post

Ask for our detailed price list

LINEAR ICs

AD7581 £14
ADC0808 990p
AN103 200p
AY1-5050 99p
AY3-1270 750p
AY3-1350 350p
AY3-8910 350p
AY3-8912 525p
AY5-3600 600p
AY5-4007D £6
CA3028A 120p
CA3019 80p
CA3046 70p
CA3048 220p
CA3059 285p
CA3060 350p
CA3080E 70p
CA3086 48p
CA3089E 200p
CA3090AQ £4
CA3130E 90p
CA3130T 110p
CA3140E 50p
CA3140T 90p
CA3160E 100p
CA3161E 150p
CA3162E 450p
CA3189E 300p
CA3240E 110p
CA3280G 200p
D7002C 420p
DAC0800 £2
DAC0808 £2
DG308 300p
HA1366 195p
HA1388 270p
ICL7106 700p
ICL7650 400p
ICL7660 250p
ICL7611 95p
ICL8038 300p
ICM7217 750p
ICM7555 80p
LC7120 300p
LC7130 325p
LC7137 270p
LF347 150p
LF351 48p
LF353 95p
LF356P 95p
LF357 110p
LF13331 100p
LM10C 325p
LM1011 480p
LM301A 25p
LM308N 75p
LM310 120p
LM311 70p
LM318 150p
LM319 215p
LM324 30p
LM334Z 90p
LM335Z 140p
LM339 50p
LM348 65p
LM358P 60p
LM377 175p
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
LM725 300p
LM733 60p
LM741 18p
LM747 70p
LM748 35p
LM1014 150p
LM1801 300p
LM1830 250p
LM1871 450p
LM1872 450p
LM1886 £5
LM1889 350p
LM2917 200p
LM3302 75p
LM3900 50p
LM3909 85p
LM3911 125p
LM3914 200p
LM3915 200p
LM3916 225p
LM13600 110p
M51513L 230p
M51516L 500p
MB3712 200p
MB3730 400p
MC1310P 150p
MC1413 75p
MC1445 250p
MC1458 36p
MC1493 100p
MC1495L 350p
MC1496 70p
MC3340P 120p
MC3401 50p
MC3403 75p
MF10 250p
MK50240 900p
MK50398 700p
ML920 800p
MM57160 620p
MN6221A 600p
NE531 140p
NE544 150p
NE555 16p
NE556 45p
NE564 420p
NE565 120p
NE566 155p
NE567 140p
NE570 410p
NE571 400p
NE592 60p
NE5532 130p
NE5533 140p
NE5534P 110p
NE5534AP 120p
PLL02A 500p
RC4136 60p
S566B 225p
SAA1900 £16
SAD1024A £9
SFF96364 800p
SN76131 125p
SN76477 450p
SN76488 450p
SN76660 120p
SN87489 400p
SN76495 400p
SP0256AL2 £12
TA7120 150p
TA7130 160p
TA7204 200p
TA7205 90p
TA7222 150p
TA7310 150p
TBA641BX1 £4
TBA800 80p
TBA810 100p
TBA820 80p
TBA950 225p
TC9109 900p
TCA210 350p
TCA220 350p
TCA270 350p
TCA940 175p
TCA965 120p
TDA1004A £3
TDA1008 320p
TDA1010 200p
TDA1022 500p
TDA1024 120p
TDA1170 300p
TDA2003 325p
TDA2006 325p
TDA2020 320p
TL064 100p
TL071/81 25p
TL072/82 45p
TL074 100p
TL083 75p
TL084 90p
TL094 200p
TL170 50p
TL430C 70p
UA1003-3 935p
UA2240 150p
UAA170 170p
ULN2003A 75p
ULN2004 75p
ULN2068 290p
ULN2802 200p
ULN2804 150p
UPC575 275p
UPC592H 200p
UPC1156H £3
UPC1185H £5
XR210 400p
XR2206 300p
XR2211 575p
XR2240 120p
ZN414 80p
ZN419C 180p
ZN423E 130p
ZN424E 130p
ZN425E 350p
ZN426E 300p
ZN427E 590p
ZN428E 490p
ZN429E 210p
ZN450E 790p
ZN459 600p
ZN1034E 200p
ZN1040E 670p
ZNA134 £23
ZNA234 850p

VOLTAGE REGULATORS

FIXED PLASTIC

1A	+ve		-ve	
5V	7805	40p	7905	45p
6V	7806	40p	7906	45p
8V	7808	40p	7908	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
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 £3
78S40 225p
78P05 900p
78H12 650p
78HGKC 600p
78HO5KC 550p
78GUIC 200p
79GUIC 225p
79HGKC 700p
ICL7660 200p
LM305AH 250p
SG3524 300p

OPTO-ELECTRONICS

2N5777 40p
OCP71 180p
ORP12 120p
ORP60 120p
ORP61 120p
TIL32 55p
TIL78 55p
TIL31A 120p
TIL81 90p
TIL100 75p

OPTO-ISOLATORS

ILD74 130p
MCT26 100p
MCS2400 190p
MOC3020 150p
ILQ74 180p
TIL111 70p
TIL112 70p
TIL113 70p
TIL116 70p

LEDS

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 90p
FND507 90p
MAN4640 200p
MAN8910 250p
NSB5881 570p
TIL311 600p
TIL312/3 110p
TIL321/3 130p
TIL330 140p
7750/60 200p
Bargraph 225p

DISPLAYS

DL704 140p
DL707 Red 140p

DRIVERS

9368 250p
9370 300p

TRANSISTORS

AD161/2 45p
BC107/8 13p
BC109C 14p
BC117 20p
BC147/8 9p
BC149 10p
BC157/8 10p
BC159 11p
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
BC337 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 24p
BFY51/2 24p
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 600p
BUY69C 350p
E310 50p
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 56p
TIP42A 60p
TIP42C 65p
TIP54 160p
TIP120 75p
TIP121 75p
TIP122 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 25p
2N3054 55p
2N3055 35p
2N3442 140p
2N3553 240p
2N3584 250p
2N3643/4 48p
2N3702/3 10p
2N3704/5 10p
2N3706/7 10p
2N3708 10p
2N3773 200p
2N3819 20p
2N3820 40p
2N3823 30p
2N3866 90p
2N3902 700p
2N3904 15p
2N3906 18p
2N4037 65p
2N4056 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 150p
2SC2335 200p
2SC2612 200p
3N128 120p
3N140 120p
3N141 110p
3N201 110p
3N204 200p
40290 250p
40361/2 75p
40408 90p
40409 100p
40410 100p
40594 120p
40595 120p
40673 75p
40871/2 100p

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CPUs

1802CE 650p
2650A £12
6502 350p
6502A 500p
6800 225p
6802 250p
6805E2L £18
6809 650p
68B09 £12
6809E £12
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 320p
Z80B £9

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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 850p
8251 250p
8253 390p
8255 250p
8256 £36
8257 400p
8259 400p
8271 £36
8279 440p
8284 350p
8288 £11
8755 £16
9901 £10
9902 £3
TMS4500 £14
Z80P10 250p
Z80AP10 280p
Z80CTC 250p
Z80ACTC 280p
Z80ADART 700p
Z80ADMA £9
Z80SI0/1/2 £9

MEMORIES

2101-4A 400p
2102-3L 120p
2107B 500p
2111A 300p
2112-A 300p
2114-2L 100p
2147 450p
4027-3 300p
4116-15 120p
4116-20 90p
4118-3 450p
4164-2 400p
4164-15 450p
4416-20 500p
4532-20 300p
4552-2 350p
4816AP-3 270p
5101 300p
5516 750p
6116-3 420p
6116LP-3 550p
6514-45 200p
6810 120p
74S189 150p
74S201 350p
74S289 150p
93415 600p
93425 600p
93L422 950p

ROMs/PROMs

74S188 325p
74S287 350p
74S288 225p
74S387 325p
74S471 650p
74S473 850p
74S474 650p

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2532 350p
2532-30 700p
2564 £6
2708 300p
2716(+5v) 250p
2732 350p
2764-25 £11
27128-25 £25
TMS2716 £7

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CRT6545 900p
CRT5027 £18
CRT5037 £18
EF9365 £36
EF9366 £36
MC6845 650p
MC6845SP £12
MC6847 650p
SFF96364 £8
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TMS9927 £18
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AD561J £14
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DS3691 300p
DS8830 140p
DS8831 140p
DS8832 250p
DS8833 225p
DS8836 150p
DS8838 225p
LF13201 450p
MC1488 55p
MC1489 55p
MC3418 950p
MC3446 250p
MC3480 850p
MC3486 550p
MC3487 300p
MC4024 325p
MC4044 325p
MC14411 675p
MC14412 750p
75107 90p
75110/12 160p
75114/15 160p
75121/22 140p
75150P 120p
75154 140p
75159 220p
75365 150p
75451/2 72p
75453/4 72p
75491/2 65p
8T26 120p
8T28 120p
8T95/96 90p
8T97/98 90p
81LS95/96 80p
81LS97/98 80p
88LS120 350p
9602 220p
9637AP 160p
ZN425E-8 350p
ZN426E-8 350p
ZN427E £6
ZN428E-8 450p

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8272 £20
FD1771 £20
FD1791 £22
FD1793 £23
FD1795 £28
FD1797 £28
FD2793 £42
FD2797 £42
WD1691 £15
WD2143 550p

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L.C. 700p
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SN74S262AN £10

KEYBOARD ENCODER

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74C922 500p
74C923N 500p

BAUD RATE GENERATORS

MC14411 700p
COM8116 800p
4702B 750p

UARTs

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AY-5-1013P 300p
COM8017 300p
IM6402 380p
TR1602 300p

ZIF SKTS

(TEX TOOL)
24 pin 575p
28 pin 800p
40 pin 975p

MODULATORS

6MHz UHF 375p
8MHz UHF 450p

CRYSTALS

32.768KHz 100p
100KHz 250p
200KHz 280p

Freq in MHz
1.0 290p
1.008 275p
1.8432 210p
2.00 225p
2.45760 210p
2.5 250p
2.662 250p
3.276 150p
3.5795 100p
3.686 300p
4.00 150p
4.194 200p
4.43 110p
4.608 250p
4.915 250p
5.0 175p
5.068 £2
6.0 150p
6.144 150p
7.0 150p
7.168 175p
8.00 150p
8.86 175p
10.00 175p
10.5 250p
10.7 250p
12.00 150p
14.318 175p
14.756 250p
15.00 200p
16.00 200p
17.7 200p
18.00 200p
18.432 150p
19.968 150p
20.00 200p
24.00 £2
26.690 150p
27.145 200p
38.6667 175p
48.0 175p
55.5 400p
116 300p
145.80 250p

REAL TIME CLOCK

MK3805 £TBA
MM58174 700p
MSM5832 500p

TELETEXT DECODER

SAA5020 600p
SAA5030 700p
SAA5041 £16
SAA5050 900p

LOW PROFILE SOCKETS BY TI

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	18p	28 pin	26p
16 pin	11p	22 pin	22p	40 pin	30p

WIRE WRAP SOCKETS BY TI

8 pin	25p	18 pin	50p	24 pin	70p
14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

DIODES

BY127 12p
BYX36300 20p
OA47 8p
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
1N5404/5 14p
1N5404/7 19p
IS920 9p

BRIDGE RECTIFIERS

1A 50V 19p
1A 100V 20p
1A 400V 25p
1A 600V 35p
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 100p
8A 600V 140p
12A 400V 160p
16A 100V 180p
16A 400V 180p
C106D 45p
MCR101 36p
TIC44 27p
2N3525 130p
2N4444 180p
2N5060 30p
2N5061 00p
2N5064 35p

PCB MOUNTING RELAYS

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

ZENERS

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

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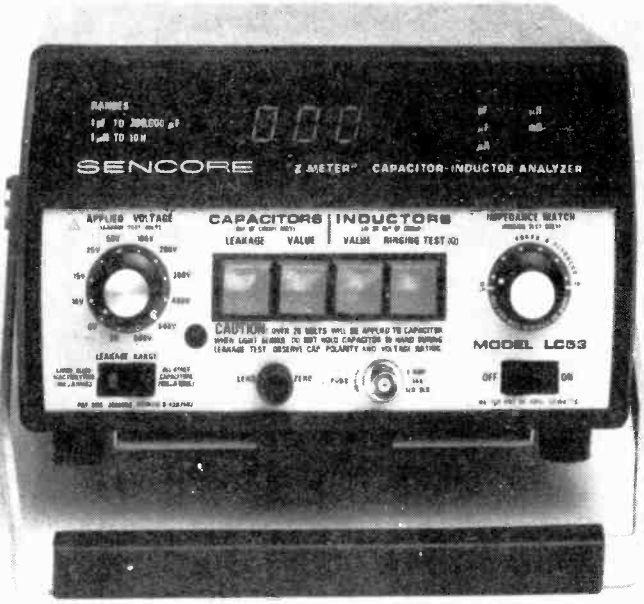
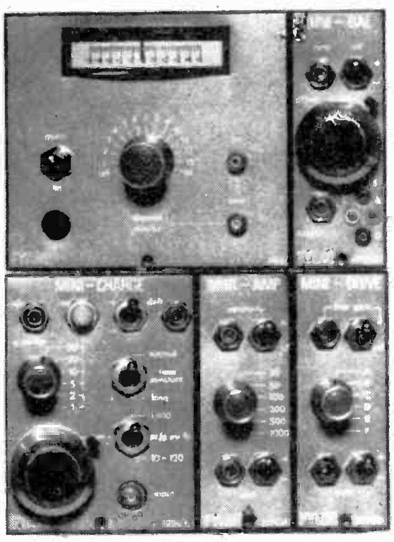


WW – 057 FOR FURTHER DETAILS



WW – 018 FOR FURTHER DETAILS

WW – 022 FOR FURTHER DETAILS

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Design competition

Although it is too early yet to know whether the outcome of our design competition will be successful, it is at least possible to say that the number of entries and variety of devices under development give grounds for encouragement.

From boxes intended to identify the contents of tins of food to quite exotic equipment concerned with cars, a great deal of imagination is being demonstrated by those who have registered their intention of entering the competition: there are more examples on page 67. It is possible, of course, that some of the ideas will remain exactly that – ideas. But the spur of a rather large money prize and the somewhat more intangible satisfaction of making people's lives more convenient and pleasurable will, without doubt, convert a significant number of nebulous notions into hardware.

It is not going to be easy. One of the hardest parts of a wide-open competition of this kind is to decide exactly what to design. Many needs can be better satisfied by a simple mechanical device than by a complicated piece of electronics: good judgement in this decision can be the most telling aspect of an entry. The next hurdle comes when it is discovered that the realization of an idea is not as straightforward as it was at first imagined, and the temptation to change one's mind appears. There is nothing wrong with that, if there is still time before October to complete the work, but it is often the case that this approach leaves one with two half-baked projects instead of one well-done one. It is surprising how a little gentle research in the literature can straighten one out, when to all intents and purposes stuck fast.

The last date for registration is June 30. You do not have to present entries at that time: simply register your intention to do so before October. A panel of judges experienced in both engineering and user aspects of devices to assist handicapped people will take some time to arrive at their decisions, during which some entrants will be asked to come to London to discuss their designs and perhaps take part in a prize-giving ceremony, which may well be televised.

There are six prizes, but we expect to describe many more entries than the winning six during the subsequent year, so that even one of the designs not chosen as a winner could attract attention and may be adopted as a commercial proposition.

This is an interesting, socially valuable and possibly profitable competition. A large number of readers have already entered: there is still time for a great many more. You have a couple of weeks left to make up your mind.

COMMUNICATIONS

Spectrum battles

Although the US Congress agreed late last year to the ratification of the WARC 1979 "Radio Regulations", many influential American groups continue to express disenchantment with the whole process of international frequency allocation and ITU procedures. Among the critics have been members of FCC who were most unhappy at the proceedings at the ITU Plenipotentiary Conference at Nairobi in Autumn 1982, and the "needless politicization" of the decision making. Although it is being suggested that the US should remain in the ITU it is being urged that, if "politicization" continues, the US should have available "a fully developed and workable alternative organization". However Kalmann Schafer, international affairs adviser to the FCC, believes that few important US interests have been surrendered and that "the day will come when the Third World realizes that disruption of ITU conferences will be against their own best interests".

The sort of problems that face the forthcoming ITU Conference on DBS planning for Region 2 is shown by the fact that both the UK and Argentina have listed the Falkland Islands – with 1800 residents and a lot of sheep – as an area they intend to serve by DBS. One suspects it might be less costly to provide every home with a v.c.r. and a large number of cassettes, or cable every habitation! Meanwhile the mere idea of having two different international spectrum regulatory bodies would seem the sure path to chaos.

World television?

That chaos is already close on h.f. was emphasised recently by Douglas Muggeridge, m.d. of BBC External Services when he delivered a blistering attack on the jamming of the broadcast bands by the Soviet Union and Eastern Bloc countries. He claimed that up to 80 per cent of usable frequencies are currently affected during peak listening hours and warned of an imminent breakdown of "law and order on the airwaves". Root of the trouble, of course, is broadcasting across frontiers without the agreement of the target country.

By 1986 the question of "world television" whereby direct broadcast satellites will send pictures across frontiers will be of practical concern: and despite what is sometimes suggested deliberate jamming of DBS transmissions *is* possible and would affect viewers in the whole of the coverage area. For years, international organizations have been discussing questions of "cultural or economic imperialism" and the potential cultural damage and loss of the "unique identity of a population after exposure to outside ideas and lifestyles". On the other hand Article 10 of the European Convention states: "Everyone has the right to freedom to hold opinions and to receive and impart ideas without interference by public authority and regardless of frontiers". But what is a right to free speech to some, is malevolent propaganda to others!

In reality, of course, international regulation of the radio spectrum and the use of the airwaves to broadcast to other than your own people have been inconclusively debated for over 50 years. Did not the old International Broadcasting Union in May 1933 – on the initiative of a BBC plagued by Radio Luxembourg and Captain L. F. Plugge's Radio Normandie – resolve that the systematic diffusion of programmes or messages specifically intended for listeners in another country should be considered an "inadmissible act" – though such a resolution must have seemed a poor breakwater against the rising flood of transmissions from Zeesen, Radio Roma and Radio Moscow. It was not long before the UK was plunging into foreign-language broadcasting. Even today some countries argue that there should be no transmissions of "politically subversive or culturally disruptive material" across frontiers "without the prior consent of the receiving State", and defend their right to jam transmissions they find offensive while themselves engaging in massive external broadcasting. The USSR has ground-wave jammers in all Soviet cities of more than 200,000 people and rather less effective skywave jamming in rural areas. The Western Nations, it would seem, are attempting to counter jamming by engaging in the power race and multiple-frequency techniques that in themselves contribute to the destruction of orderly spectrum planning. The BBC, for example, is currently seeking planning permission to install at the former Post Office receiving station at Bearley, Warwickshire six 300kW h.f. transmitters primarily for serving Eastern Europe. Today few people distinguish between h.f. and/or m.f. broadcasting in your own language (e.g. BBC World Service), surely a laudable service, and the one-time "inadmissible" practice of foreign-language broadcasting!

Black broadcasting

Governments are not always content even with straight-forward external broadcasting, as witness the take-over of one of the 250kW transmitters on Ascension Island last year and similar action during the Suez affair in 1956. A detailed study of radio skulduggery has recently been published by Ellic Howe, an eminent typographer whose special skills were used in World War 2 to forge leaflets and other printed material on behalf of the Political Warfare Executive. His book "The Black Game" (Michael Joseph, 1982) provides much new information on P.W.E.'s many "black" radio services and the building in 1942 of the 600kW "Aspidistra" m.f. transmitter at Crowborough, a transmitter that was finally retired last year. Much of the technical detail has been provided by Harold Robin who for many years was chief engineer of the Diplomatic Wireless Service but who previously worked for Sir Richard Gambier-Parry's wartime "Special Communications".

Ellic Howe lists no less than 48 different P.W.E. "black" services directed at 15 different enemy or enemy-occupied countries. Many of the programmes were recorded at "Simpon's" (Wavendon Towers) and later Milton Bryant. Transmissions were made over four RCA 7.5kW h.f. transmitters at Gawcott and Potsgrove, near Bletchley. In "black" broadcasting it is made to appear that the station is located in the target country. In the early days some French scripts were written by Lisa Towse, G-P's personal secretary and future wife. GP himself, moved out of Whaddon Hall into Wavendon Towers. "Aspidistra" was a 500kW RCA transmitter that had been built for WJZ, New Jersey but refused an FCC licence under the 50kW maximum-power rule. Harold Robin managed to get it up to 600kW and it was installed at a 70-acre site high in the Ashdown Forest, in an underground building. A Canadian Army road-building unit, kept going by copious supplies of beer, with six bulldozers and a lot of explosives, made the necessary "very big hole" in the ground. Elsewhere Aspidistra proved a constant source of inter-departmental squabbles, not least with the BBC who wanted to run it.

G-P, ex-BBC, ex-Philco, supported by Harold Robin, who had been endeavouring immediately pre-war to set up a commercial station in Liechenstein directed at English audiences, were not disposed to hand over their "raiding Dreadnought of the Ether" to the Corporation's engineers – and indeed Aspidistra remained in the control of the FCO for its 40 years of operational use, though much of the time carrying the BBC External Service programmes.

E.m.p. bomb?

In the December 1981 issue of *WW* Kenneth Cook of the M-O Valve Co. Ltd drew attention to his company' gas-filled protection devices that operate in less than one nanosecond. Such devices he claimed "will protect solid-state receivers and telephone equipment in a simulated e.m.p. (electromagnetic pulse) environment". E.m.p. is the massive pulse that follows the explosion of a nuclear device high above ground.

Despite this assurance that effective protection against e.m.p. is available, there can be little doubt that the potential threat to radio communications, computer installations and telecommunications posed by

COMMENTARY

high-altitude (40 to 400km) nuclear explosions is still being taken very seriously in many parts of the world. Even if military installations can be effectively "hardened" there remains the problem of the enormous number of civilian installations.

Now, according to recent press reports from Washington, the US Government is investigating the possibility of developing an atomic weapon designed specifically to provide enhanced e.m.p. as "a defensive system that would hurt the enemy without necessarily hurting his people". E.m.p.-bombs could be launched to black-out enemy communications; the Americans are also reported to be currently providing additional shielding against e.m.p. on their B-52 long-range bombers. Similarly scientists at the University of Minnesota are reported to be working on techniques that would not only counter the effects of e.m.p. but could also reduce the effects of solar flares, which can cause radio blackouts, auroral propagation etc, particularly in northern latitudes.

AMATEUR RADIO

DX-disaster

For several decades, there have been an increasing number of "DX-peditions" mounted by radio amateurs in remote and out-of-the-way places. The object has been to permit a well-equipped team of operators to activate one of the rare country callsigns and then make thousands of brief contacts with amateurs all over the world. Funds for such expeditions are often donated by amateurs eager to increase their "countries worked" totals, although there has always been opposition to the technique of making a charge for QSL cards.

Since there is "resident" amateur radio operation in most countries of the world, DX-peditions have increasingly been directed towards smaller, more remote islands some of which are little more than reefs.

In mid-April a German DX-expedition to Spratly Islands, a group of small islands in the China Sea between West Malaysia (Borneo) and Vietnam, ran into problems that caused the death of at least two members of the party. The islands are territories politically in dispute by several countries and appear to be under military occupation by more than one country. As the German vessel approached the islands it was fired on with fatal consequences, and sank, although some survivors were later picked up about 100 miles away in a small boat by a Panamanian ship.

New callsigns

Before long the Home Office expect to be issuing callsigns in the G0, GM0 etc sequences for Class A, and G1, GM1 etc sequences for Class B. The figures 0,1 are the only remaining unused digits since G7, G9 are used for commercial "test and development" licences. The present G6 class B sequence is already up to "W" and G4 class A to "T". When the 0 and 1 sequences are used up it would be possible for the Home Office to issue British amateurs calls with an M-prefix. Both GAA to GZZ and MAA to MZZ are internationally allocated to the UK.

One internationally-recognized radio amateur, Ray Cracknell, Z22JV of Zimbabwe (formerly G2AHU) would welcome either a G or an M callsign when he returns soon to the UK. Ray Cracknell has been, over several decades, one of the most successful pioneers of transequatorial propagation (t.e.p.) and has been responsible for uncovering, with the help of his equipment and a series of "beacons" which he has built, a wealth of information about the tropical inonosphere, much of it previously unknown and unsuspected by both professional and amateur researchers. Yet recently when he sought to renew his British licence it was indicated, presumably as the result of a dispute over reciprocal licensing with Zimbabwe, that he would be required to sit an RAE and take a Morse test. One can think of few people deserving of an unhindered re-issue of a licence than Ray Cracknell. Let us hope by the time these notes appear the Home Office will have graciously rescinded such an apparently bureaucratic ruling.

Ionospheric focusing

Although it is now generally accepted that many low-power h.f. transmissions travel long-distances without intermediate ground-reflection by what is termed chordal hop propagation, amateur operators have paid less attention to antipodal-type mechanisms that result in enhanced signals at a point precisely on the opposite side of the globe. Signals travelling along great circle paths all converge on the antipodal point. Amateurs in the UK have no exact antipodal point with which to exchange signals, since this point is in the Pacific Ocean, although UK amateurs have long recognised the consistency of the long-distance paths to Australia and New Zealand, the nearest land-mass to the antipodal point.

Brian Austin, ZS6BKW, writing from the University of the Witwatersrand, Johannesburg notes that South Africans are more fortunate in that they have Hawaii as the antipodal point. He comments: "Over many years I have listened, on and off, to WWVH mainly on 15 MHz. What has struck me lately is that the Fort Collins, Colorado station, WWV, runs the same power (10kW) and I assume uses similar antennas. Yet WWVH is by far the stronger signal of the two in this country. Could it be because of antipodal focusing or would the fact that Hawaii is a relatively small land mass, and hence the signals may be launched more effectively over the sea water "groundplane" be the reason? "He believes there is still much to be finally discovered about h.f. ionospheric propagation.

Code-free in USA?

Although in late 1982, the president of ARRL, Vic Clark, W4KFC, asked FCC to defer for at least 18 months any action that might lead to a class of amateur licence not requiring a test in the international Morse code, the FCC has subsequently issued a "notice of proposed rule making" for two forms of code-free licence. The first would eliminate the 5wpm test for existing "Technician" licences (above 50 MHz). The second would be an "Experimenter class" licence rather akin to the Canadian "Digital Amateur Class Certificate" but conveying all normal operating priviledges on frequencies above 144 MHZ. There are no proposals for any form of code-free h.f. licence. Comments on the FCC proposals were due by April 29.

In brief

Harold Ling, G4CCH has made several e.m.e. ("moonbounce") contacts on 1.3GHz using only an 8ft aerial dish and 100 watts of transmitter output. . . . In *CQ-TV*, R. Platts, G8JZP comments on the "anti-social and selfish" behaviour of some amateur television enthusiasts who make broadband transmissions on 430MHz "in excess of two hours duration". He feels no transmission should last more than 15-20 minutes. . . . John Wood, G3YQC of Rugby, in association with G8VBC, has succeeded in exchanging pictures on 1255MHz with F1EDM at Le Havre, a distance of about 200 miles. . . . The paid-up membership of AMSAT-UK increased from about 1300 to 1700 during 1982. . . . Launching of the Phase IIIB Oscar amateur satellite, set for June 3, has been delayed. . . . Amateurs in north-west England have been experiencing considerable interference on 432 MHz from Syledis. . . . Forthcoming mobile rallies: June 26 Longleat Park, Warminster; July 10 Droitwich High School, Ombersley Road, Droitwich; July 17 RAIBC Picnic at The Fairground, Broadlands Estate, Romsey, Hants, and Camborne Technical College, Camborne, Cornwall; July 24 Anglian rally, Stanway School, Colchester, Essex and McMichael rally, Bells Hill, Stoke Poges, near Slough; July 31 Rolls-Royce Sports & Social Club, Barnoldswick; August 7 RSGB National rally at Woburn.

PAT HAWKER, G3VA

Planning for plenty

Objections to the introduction of new "community" radio services have included claims that such stations will place excessive demands on frequency space. Norman McLeod – one of the few engineers involved in the campaign for new stations outside the BBC and IBA – puts forward suggestions for accommodating new services, with an account of currrent technical thinking on the subject.

by Norman McLeod

It is three years since I last looked at some of the technical questions surrounding community radio in this journal[1]. Since then, the idea that radio broadcasting in this country offers an incomplete service – which could usefully and practically be extended by new and different stations – has gained wide acceptance.

Indeed the Home Office has received to date over a hundred applications from various organisations requesting licences to operate broadcast services. And as a scan across broadcast wavebands in many cities will show, many enthusiasts are prepared to offer new services to the public without bothering with the paperwork to HQ. It's not hard to see why pirate stations do not wait for the formalities: the Home Secretary recently annouced that there would be no further progress on the question of licencing community radio until 1985[2]. And there is no guarantee of licences being forthcoming even then.

There have been attempts by what one observer has called "an uneasy hotchpotch of pragmatists, careerists, reformists, radicals, commercial interests and radio enthusiasts" to form campaigns to press the case for more stations and to promote community radio ideas and ideals. But there is still no effective central organisation, no public relations budget, no full-time workers striving to bring people and ideas together. Such progress as has been made has come not from marching forward in unison, but from various small independent initiatives – not least from the hundred organisations who have been applying to the Home Office.

One such initiative came just before Christmas last year, when the Greater London Council commissioned a report from Wireless Workshop – a small firm in Brighton in which I am a partner – to examine the question of frequency resources for community radio in London. This provided a welcome promise of funds to sit down and work through proposals for new radio services in more detail than had previously been possible. But we were left with the problem of deciding just what sort of services we were supposed to be finding frequencies for. There were two general ideas circulating in community radio circles: one was "neighbourhood radio" and the other "community of interest" services.

Briefly, neighbourhood radio would be intended to provide a more localised service than is available at present. In the case of London, each so-called "local" radio service, provided by the BBC or the IBA, broadcasts to a potential audience of over 10 million people. There is clearly some scope for splitting this vast audience up to provide services more local and distinctive in character – Radio Brixton may be expected to sound quite different from Radio Hampstead, for example.

The other idea was that across the whole of London there are various subdivisions of the public who would be interested in listening to a service directed specifically at their interests and aspirations. These minority audiences – ethnic groups, fans of particular types of music, students, the elderly, media radicals etc. – are not necessarily concentrated in any particular part of London and therefore require a transmission system which will reach a city-wide audience. It has been suggested that these are the sort of programmes BBC Radio London should be doing instead of tagging along behind Capital Radio with the likes of the Tony Blackburn show[3] but this is not a question we can dwell on here.

Armed with these basic ideas, we proceeded to take a look at some of the possibilities for broadcasting to London.

Transmission systems and technology

With the prospect of wideband cable services looming ever closer, we examined briefly whether new technology might have any relevance for the development of community radio services. But the only advantages we could see arising from the new cable technology were that it might provide – eventually – a lower cost method of networking various small transmitters across the city, by establishing point-to-point links more cheaply and flexibly than the present British Telecom landlines.

The advantages of using existing broadcasting bands and receivers were overwhelming: compared to any high-technology systems, sending radio programmes out from conventional transmitters to conventional receivers represents the cheapest, easiest and most flexible way of establishing new services. In discussions held between the GLC and various interest groups and consultants, it was suggested that the "pay-as-you-listen" programme scrambling techniques might be applied to broadcast radio. We did not think there was any mileage in this idea: a radio service costing more than a few pounds per listener per year would be very expensive indeed, and the hardware involved in coding and decoding the signals would cost far more than the revenue it would generate. In any case, using the public broadcast band for "privatized" signals like these would set a dubious precedent.

Previous plans

In November 1979, a report[4] entitled "The Technical Feasibility of Community Radio in London" was produced by a team of consultants headed by former IBA engineer Fred Wise for the Community Communications Group. It addressed itself to some possibilities for new radio services operating in the v.h.f. band – m.f. channels were not explored.

Wise envisaged three categories of community station: category A, with a service radius of three to four kilometres, was the smallest. Category B described medium-sized stations covering a sector of the city, and category C covered larger stations aimed at specialist interests and covering the whole city.

In the spectrum below 97.6 MHz, Wise concluded:

". . . presently available channels could be used to provide about a dozen category A stations and one category B station, or, alternatively, about fourteen category A stations."

He also said that none of the channels which he discovered were suitable for the high power needed for an all-London station. Looking at the upper section of the band (above 97.6MHz), Wise said that:

". . . If it could be agreed . . . that community services could operate on the basis of provisionally assigned frequencies, which may subsequently need to be changed, then a number of additional community stations could be authorised at an early date . . ."

But Wise warned that the number of additional stations likely to be possible in this part of the band was very much dependent on BBC and IBA plans. At the time these were not known, but the Home Secretary's statement[2] sheds some light on the matter:

". . . frequencies for (two) national networks should be used to provide an independent national radio service. The Government finds this proposal attractive . . . I propose to allocate the other new network to the BBC so that there can be separate v.h.f. networks for Radios 1 & 2 . . ."

So the frequencies between 97.6 and 102MHz – which the Home Office has promised to clear by 1990 – will be used by two new national networks. This leaves 102.1 to 104.6MHz as a new local radio sub-band. Frequencies in this sub-band are going to be employed for some of the new BBC and commercial local radio services around the periphery of London, but at present there are no official plans from the BBC or the IBA to establish more radio services in London itself. Our own proposals do not include this sub-band because at the time it was not clear what the future of the spectrum above 97.6MHz was likely to be.

Official comment

The Third Report of the Home Office Local Radio Working Party (HOLRWP)[5] was published at the end of 1980 and remains the last official report which took note of community radio aspirations. The working party itself was set up by the Labour Home Secretary Merlyn Rees, and was retained by William Whitelaw to prepare proposals for the long-term expansion of local radio. It has twelve members, four from the BBC, four from the IBA, and four from the Home Office. The secretary of the Working Party is a Home Office civil servant.

Although no community radio groups were themselves represented on the working party, a substantial section of the report addressed itself to the question of community radio. This section began by stating that there were no commonly accepted guidelines as to what constitutes a community radio station, although the authors did recognise the distinction between "neighbourhood" radio and "community of interest" services, which I outlined earlier.

On the question of frequency planning the working party was far from enthusiastic:

". . . it would be wrong . . . to allocate frequencies to small community stations at the expense of the expansion of BBC and independent local radio . . . there may be some scope for additional very low power stations at both v.h.f. and m.f., but there are a number of important reservations . . . the number of stations which could be accommodated in this way would be small and is likely to prove least in areas such as London where the demand is likely to be greatest . . ."

The Working Party also cast doubt on whether the higher-power "community of interest" stations would be technically possible at all, and they also suggested that a more flexible approach to planning standards would almost certainly be necessary.

Fred Wise – author of the earlier plan for community radio services on v.h.f. – prepared some comments in response to this report [6]. He did not share the pessimistic attitude of the HOLRWP towards fitting new low-power services within the existing spectrum. He said that this seemed at least to provide a realistic approach for an experiment.

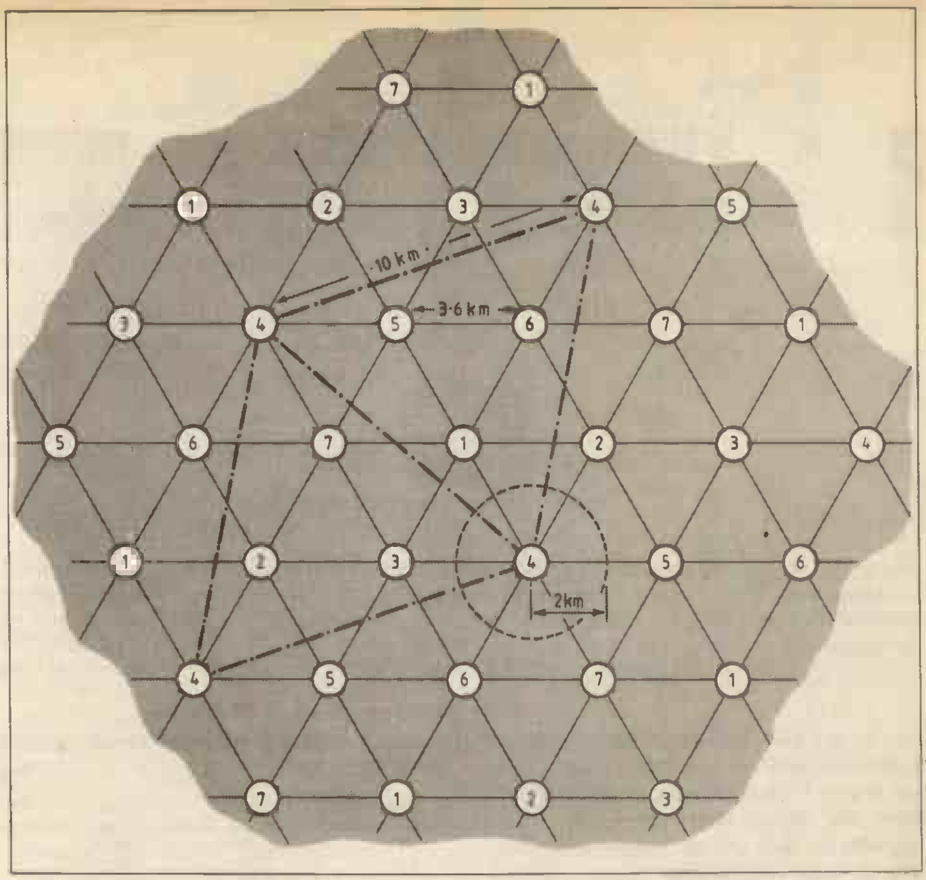


Fig. 1. Planning lattice for v.h.f. 'neighbourhood' stations. Each frequency used is represented by a number in a circle chosen so as to be at least 600kHz away from existing services and from each other and also free from strong 'out of area' transmissions. Adjacent transmitters are 3.6km apart and stations using the same frequency are 10km apart. The approximate service radius of each station is 2km, though this will vary with the effect of geographical factors as will the siting of the transmitters.

HOLRWP had suggested that the sharing of frequency bands between the BBC and the IBA on the one hand and other, community broadcasters on the other would require strict control of technical standards. Wise dismissed this, saying:

". . . it does not seem obvious . . . why this sharing of the band with the present broadcast services should pose great difficulties in the control of technical standards. The principle seems already to have been established in the television bands where authorised privately-operated self-help transmitters may be used . . ."

A further objection to new radio services was raised by HOLRWP. They claimed that a very small station could represent a major constraint on frequency planning, because of the need to protect it from interference from other services, thereby preventing the re-use of the same or closely adjacent frequencies for high-powered stations nearby. It missed the point that the order of planning is all-important. As Wise put it:

". . . the practical reality is that, in accordance with established practice, the larger stations would be planned first and the very small stations fitted in later. In this way the very small stations would not impose constraints on the larger stations . . ."

The latest report

Our own report[7] dealt with only two of the three segments of radio spectrum available for broadcasting to ordinary receivers – the m.f. (medium-wave) band and the lower part of Band II (88 to 97.6MHz). On v.h.f., our proposals differ from the earlier Wise stations in that the stations envisaged on v.h.f. are much smaller – only 2km service radius instead of 3-4km, but a much greater number of them were considered to be practicable – up to 160 instead of a dozen or so (Fig. 1).

Each transmitter would cover between 25,000 and 100,000 people, depending on the population density surrounding the transmitting site. If this is thought to be too small, we suggest that stations use more than one transmitter linked by landline or re-broadcast links to the studio. Since transmitters are likely to be much cheaper than studios this would appear to be an attractive proposition financially. We suggested that transmitters should be sited in such a way that their "impact area" – where signal strength is not strong enough to provide useful reception but still strong enough to cause interference to other services – is minimised. This would seem to suggest that conventional techniques of v.h.f. transmitter siting should be turned on their head. Rather than siting the transmitting aerial on a tall mast, or on top of a block of flats, such that the optical horizon may be twenty or thirty miles away, we suggested that aerials should be located near the lowest part of

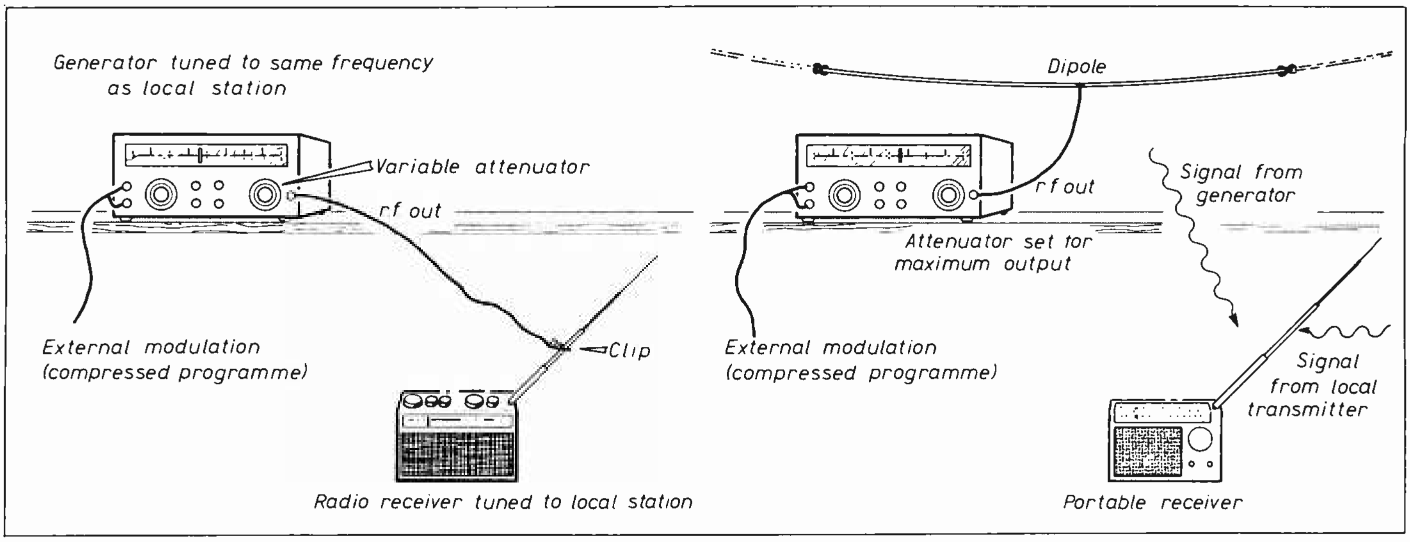


Fig. 2. Experiments to determine the degree of protection needed to separate signals transmitted on the same frequency. The first connects a generator, tuned to the same frequency as a local station, directly to the aerial of a receiver tuned to the same station. It is possible to adjust the level of the generator signal so that the received broadcast signal is heard with little or no interference from the generator. The second experiment is similar but the generator is connected to a transmitting dipole. Orientation of the receiver's aerial can find positions where the generator signal does not interfere with the received signal even with the generator at full power.

the target area, and that their maximum height should be restricted to no more than, say, 15 metres above ground level. In this way, geographical screening outside the service area will be maximised, while the service within the designated area should be adequate in most locations.

We considered that with careful siting of transmitting aerials along these lines, it should be possible to re-use any frequency successfully at a distance of just five times the service radius – i.e. 10km should separate adjacent neighbourhood stations on the same frequency. This is backed up by two very simple but useful experiments which we carried out into practical levels of co-channel interference.

Table 1. Vital statistics of various low-powered m.f. stations operating in London.

TX power	70dBμ radius	70dBμ area	Population '000s inner city	Population '000s suburbs	40dBμ radius	sky wave 100-400km
1W	2.5km	20km²	155	70	20km	21dBμ
2W	3.3km	34km²	260	114	23km	24dBμ
4W	4.0km	50km²	400	170	28km	27dBμ
8W	5.0km	79km²	620	260	33km	30dBμ
16W	6.0km	112km²	870	375	38km	33dBμ
32W	7.2km	162km²	1260	542	44km	36dBμ
64W	9.0km	254km²	1970	850	50km	39dBμ
128W	11.0km	380km²	2960	1270	61km	42dBμ

Co-channel protection ratios

The first experiment involves hooking the output of an f.m. signal generator via a crocodile clip to the telescopic aerial of a portable v.h.f. receiver (Fig. 2). The receiver should then be tuned to a local programme, and the generator tuned to the same frequency, and modulated with an alternative programme (or tone). With the radio operating in mono, adjust the level of signal emitted from the generator while listening to the output from the radio. The object of the experiment is to determine the degree of co-channel protection needed to obtain subjectively satisfactory suppression of the weaker signal.

One assumption may be made about the programme content: it may be taken that the modulation is compressed or otherwise kept reasonably constant in depth (such as the signals from Radio 2 or commercial radio). Under these circumstances, we consider that acceptable levels of unwanted interference can be obtained with a co-channel protection ratio of as little as 20dB. The total range covered on the generator's attenuator, between virtual inaudibility and almost complete 'capture' of the frequency, is never much more than 40dB, in our experience.

A development of this experiment is shown in Fig. 2. Here, instead of having the generator connected directly to the receiver, it is connected instead to a dipole aerial of appropriate length (about 1.5m). The attenuator of the signal generator should be set for maximum output, and the receiver moved away from the dipole aerial until a point is reached where the signals from the local generator and the more distant broadcast transmitter are competing – in space – for its attention.

You should find that very minor movements of the receiver and/or its aerial will produce nearly complete elimination of one signal or the other, as far as the audible output from the receiver is concerned.

The conclusions which we draw from these two experiments are: (a) that 20dB co-channel protection ratio is just adequate for mono reception; (b) that where two or more signals are present, moving the receiver and/or its aerial very slightly has a marked effect on the relative signal strengths picked up from the melange.

In the case of our idealised lattice (Fig. 1), free-space attenuation alone will provide a 12dB ratio between a transmitter 2km distant and one 8km away. We then have geographical screening *and* receiver positioning available as factors to ensure that at least a further 8dB difference is introduced between the wanted and the total unwanted signals. On the face of it, this does not seem too implausible, though practical tests would be interesting to carry out.

We suggest that the total power radiated by each transmitter should be of the order of 2 to 10W e.r.p. – the idea being to ensure that 2km distant the service is limited more by co-channel interference than by failing signal strength. The unattenuated field 2km away at this level of power is several millivolts per metre, but we are assuming that we ought to be reaching portable receivers in less-than-advantageous domestic locations.

Medium wave

We also looked at medium-wave, and carried out a number of exploratory calculations to see what would happen when the medium-wave transmitters of various powers were operated. The first step towards performing these calculations is to draw up a mean propagation curve from published data[8]. This curve is shown in Fig. 3, and is compiled from the average of two CCIR recommendations for signals at 1500kHz – one for a ground conductivity of 3mS/m, and the other for a ground conductivity of 10mS/m. This curve may be taken to be valid, within a few dB either way, for frequencies between 1251 and 1602 kHz and for the range of ground conductivities present in and around London.

We restricted our calculations to the high-frequency end of the m.f. band because it seemed that this was the most fruitful place to search for relatively quiet channels – in daytime at least – and also because fairly efficient aerials can be constructed on these frequencies without the need for great height.

If the signal strength 1km from the

Norman McLeod (28) splits his time between designing equipment for small broadcasting stations, and writing about developments in broadcasting for technical and consumer publications. At the moment he is a partner in Wireless Workshop – a small firm dealing in hospital and student radio transmitters and studio equipment. He has also been technical consultant to the National Association of Student Broadcasters since 1978. When not immersed in some radio-related activity, he enjoys cycling, travelling and listening to music.

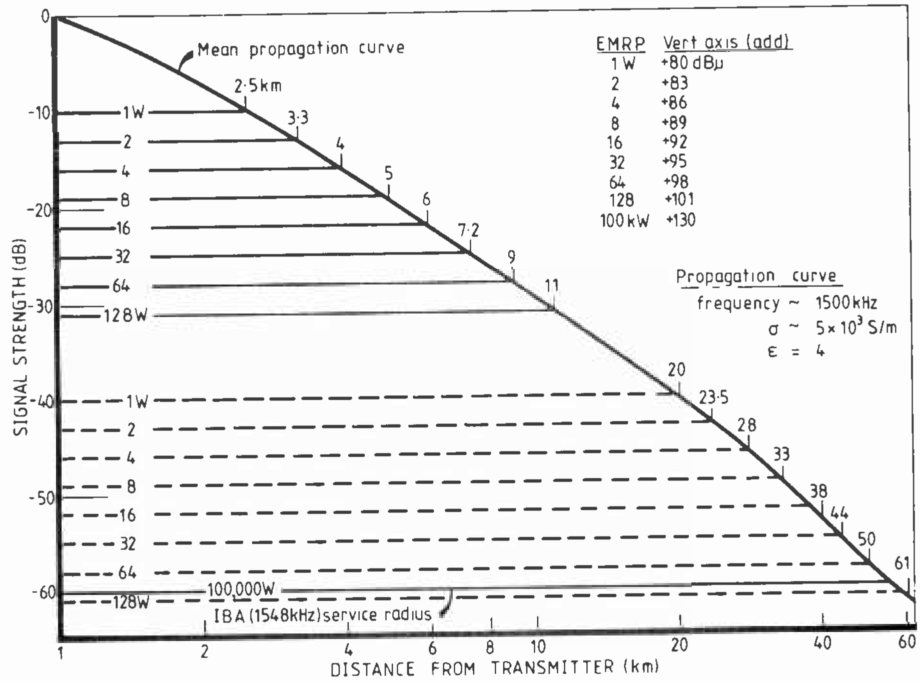


Fig. 3. Curve of the mean propogation taken from the average of two CCIR recommendations for m.f. signals at 1500kHz, for ground conductivities of 3 and 10mS/m. The service (70dBμ) radii of a number of low-powered transmitters are shown with continuous lines while the broken lines represent the 'impact' radii, defined by the 40dBμ contour, representing the minimum distance at which an occupied frequency could be re-used.

transmitter is known (and this can be inferred from the effective monopole radiated power) then the predicted signal strength at any distance up to 60km from the transmitter can simply be read off the graph. The vertical axis of Figure 3 is scaled in decibels relative to the signal strength at 1km.

Figure 3 shows how this curve is used to predict the 'service' (70dBμ) radii of transmitters using various amounts of power. Also shown on this curve is the 'impact' radius – defined by the 40dBμ contour, and representing the minimum radius, at which the occupied frequency could be re-used.

The IBA transmitter on 1548kHz is also shown on the diagram to provide a sense of perspective. All three London 'local' radio stations use high-power channels – channels which could (and in the view of the author should) be used for network levels of power and coverage. Our proposals cannot run to the tens of kilowatts used by the BBC and the IBA because international clearance for such powers would not be forthcoming. Indeed, after contemplating 'impact' radii and sky-wave propagation estimates (Table 1), we decided that we could keep effective monopole radiated power down to a few hundred watts on any frequency, while providing London-wide coverage on a pair of channels.

We take the view that new community radio services should take the lead in applying an approach to broadcast engineering which seeks to maximise the efficiency with which every watt or radiated power is used. It is clear from the data which we have generated from our exploratory calculations that using a large number of smaller transmitters is much more effective than using one large one with the same total power. For instance, eight two-watt transmitters will cover an area of 272km^2 with a field strength of 70dBμ or more; one sixteen-watt transmitter covers just 112km^2 to the same effect. Clearly, there are economic imperatives which ultimately point us in the other direction. But maximising the number of listeners per watt is probably the most important task facing broadcast engineers in the all-too-crowded spectrum.

The hypothetical m.f. transmitters which we have analysed may either be used independently, or as part of a network of fully-synchronous transmitters using two frequencies per service – in much the same way as Radio 1 and Radio 2 already cover the country. We suggested that between eight to ten transmitters, each with an effective monopole radiated power of about 50 to 80W, should be assigned to the two frequencies in such a way that good reception on one channel co-incided with poor reception (due to multiple signals) on the other. The problem of cyclic fading, due to imperfect synchronisation between carriers, and of modulation distortion due to unequal time-delays in the distribution network are both easier to solve on this smaller scale. Cyclic fading can be tacked by locking each transmitter to a common frequency source (such as one of the Brookman's Park m.f. transmitters), while the time dealys in any distribution circuit are sufficiently small for correction circuits to be easy and practical.

We did suggest (perhaps rather optimistically) that frequencies at v.h.f. or u.h.f. (possibly old broadcasting frequencies released by the Merriman Spectrum Review Committee) should be made available for point-to-point links across the city, thus saving the expense and bother associated with land-lines.

Conclusions

For the moment, all this can be dismissed as just an amusing piece of speculation.
Continued on page 44

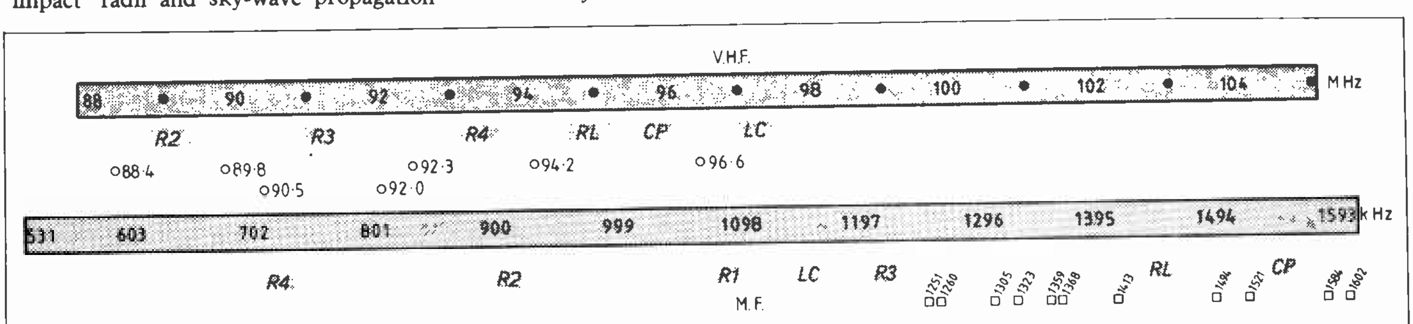


Fig. 4. Frequencies for the v.h.f. lattice plan (above) and possible low-power m.f. operation (below). Outside London the frequencies used may differ particularly on v.h.f. but the number of channels available for low-powered use should be about the same.

Mixed logic

First came nand and nor, their functions being a product of the technology of the time. Circuit synthesis procedures evolved which regarded these devices as actually performing nand/nor logic functions. We now inherit a system which automatically generates obscurely-intentioned circuit schematics. But all is not lost . . .

by M. B. Butler

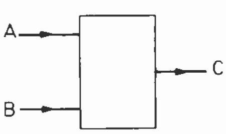
A circuit diagram is a medium of communication and is one of the most important items of documentation linking the designer with the user.

The circuit diagram of a digital system should convey the original logic intentions of the designer of the circuit. It should do this directly, with no requirement for elaborate transformations.

- Circuit symbols should represent combinational logic directly in and-or-not terms.
- Correspondence between logic value (true and false) and physical voltage counterpart (high and low) should be evident at any point in the circuit.
- Notation should clearly indicate type of physical device used at any point in diagram.

The reality

A manufacturer produces a device with the following response to applied input voltage signals



A	B	C
L	L	H
H	L	H
L	H	H
H	H	L

Fig. 1

Using positive logic convention, the manufacturer suggests a logic truth table for this device

A	B	C	
0	0	1	
1	0	1	
0	1	1	
1	1	0	$A.B=\bar{C}$ $(\overline{A.B}=C)$

Fig. 2

And assigns a symbol to the device . . .

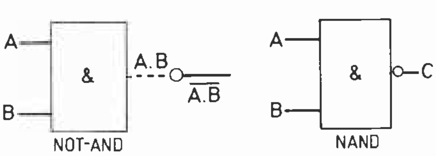


Fig. 3

Highlighted sector of Fig. 2 is the only region that most customers consider. As a result, a whole tradition of logic synthesis has evolved which concerns itself with forcing reduced expressions into a fixed format (network of nand gates) by tortuous manipulation, De Morgan's rule being constantly invoked.

Examination of Fig. 2 however reveals that it conceals another logic identity . . .

A	B	C	
0	0	1	$\bar{A}+\bar{B}=C$
1	0	1	
0	1	1	
1	1	0	

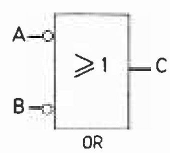
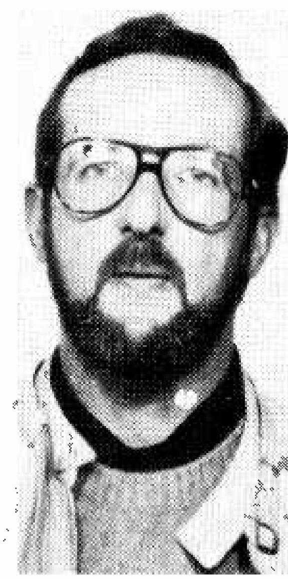


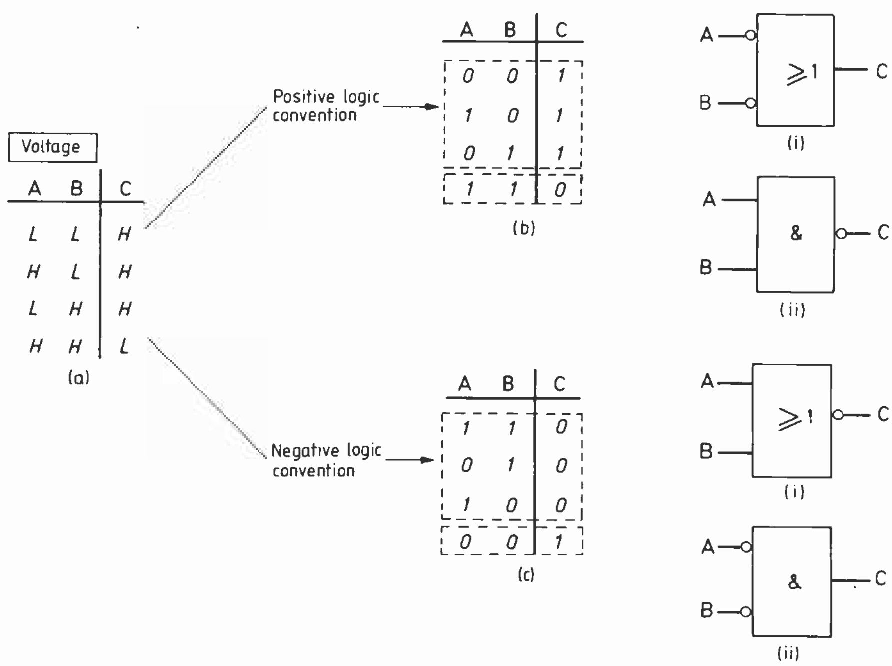
Fig. 4

Now make a full analysis with the aid of Fig. 5.

"**Duality.** – Given a physical device characterised by a table of combinations, the logic function performed by the device is determined by the specific choices of the 1-state at its inputs and outputs . . ."



Mike Butler, M.S.E.R.T., joined Marconi International Marine Co. as a Radio Officer in 1961. After 6½ years he went ashore to head office in Chelmsford as a test engineer. Work in the engineering division led to his current position as a radar development engineer in the company's laboratories.



(a) Voltage

A	B	C
L	L	H
H	L	H
L	H	H
H	H	L

(b) Positive logic convention

A	B	C
0	0	1
1	0	1
0	1	1
1	1	0

(c) Negative logic convention

A	B	C
1	1	0
0	1	0
1	0	0
0	0	1

Fig. 5

Definition extracted from BS3939, section 21. In Fig. 5, left, we may recognize two pairs of 'duals', i.e. (b) i &·ii and (c) i & ii. Examine another physical device:

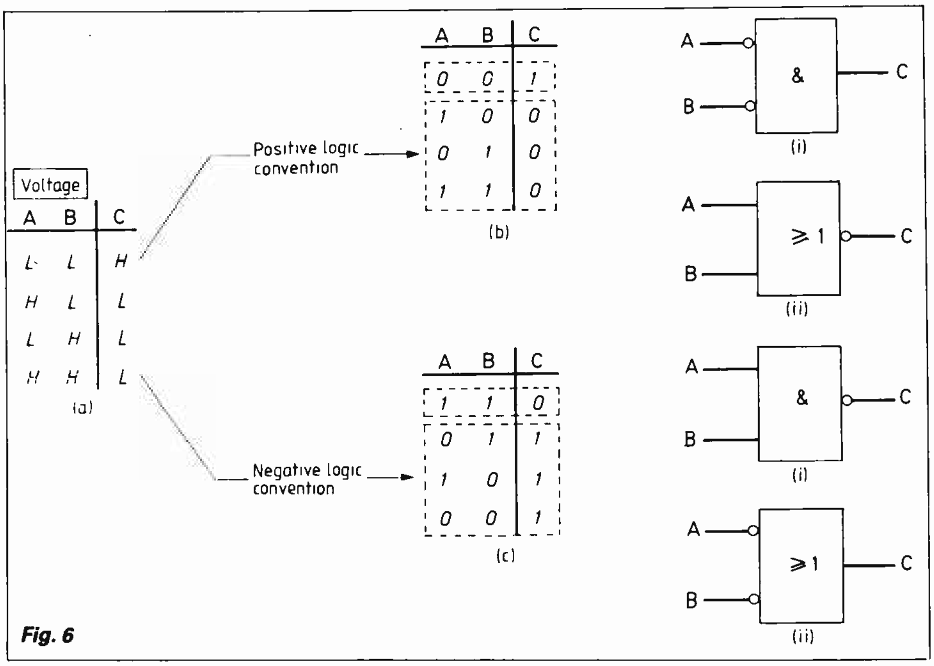


Fig. 6

It is evident from Figs 5 and 6 that one physical device may have its logic function interpreted in four ways, i.e. two pairs of logic duals.

We must regard an example to reinforce our bewilderment.

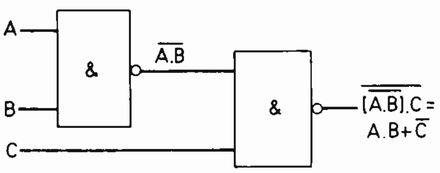


Fig. 7

Fig. 7 above illustrates a standard schematic representation of a logic function. Without the transformation shown, it is not possible to directly interpret its function. Re-draw the circuit, using the logic dual concept (intentional logic):

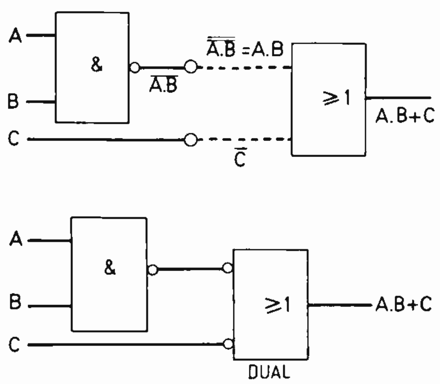


Fig. 8

From Fig. 8

– the 'negation indicator' (circle at input/output) may be regarded as a DeMorgan operator

– two negation indicators at each end of a connective line, cancel the effect of each other

– use of the logic dual clarifies interpretation of a schematic representation.

The above illustration does however raise a nasty doubt in the mind! Are the two gates in the example, physical nor gates using negative logic representation Fig. 6 (c)? And are the two gates in the example, physical nand gates using positive logic representation Fig. 5 (b)?

We are left with the problem of identifying the physical implementation of the above circuit, with no clues to conjure with!

Summary so far

- Classical logic synthesis procedures tend to generate unreadable circuit schematics.
- A logic function may be synthesized directly in and-or terms using logic duals (intentional logic).
- The 'not' function may be implemented easily by manipulation of the negation indicator on connectives.
- Logic diagrams below do not directly relate logic state to voltage level at each node in the circuit, a factor which can be of extreme significance in field servicing.

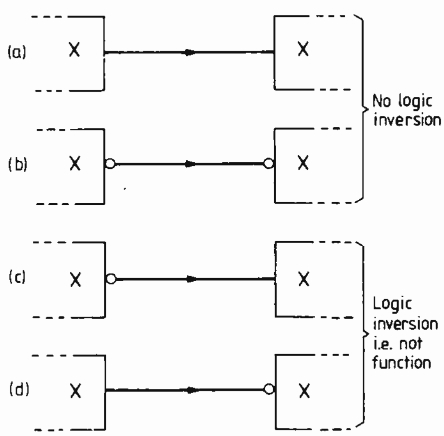


Fig. 9

Mixed logic

We must abandon the **fixed** convention of positive and negative logic and ***mix them!*** Conventional methods emphasize close parallel between logic and voltage; mixed logic will emphasize the *distinction* between the two, eliminating the confusion introduced by forcing a fixed relationship between logic and voltage.

Back to basics

The functions 'and' and 'or' are represented by the customary symbols BS3939.

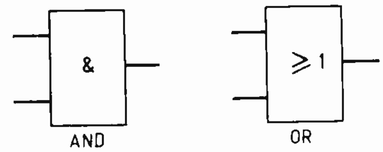


Fig. 10

Following conventions are stated

Logic validity defined as true symbolized by 1 or false symbolized by 0

Voltage level is described as high symbolised by H or low symbolised by L

A new symbol is introduced to indicate application of a convention: the 'flag' or polarity indicator.

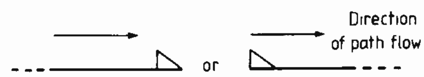


Fig. 11

This is applied as shown below.

logic		voltage
1	equivalent to	H
0	equivalent to	L
(no polarity indicator)		
1	equivalent to	L
0	equivalent to	H
(polarity indicator used)		

For example

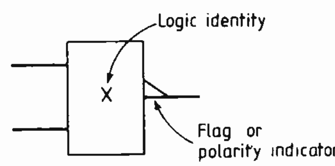


Fig. 12

Presence or absence of polarity indicator serves only to define which *voltage* convention in force at interconnection input or output interface of basic logic symbol, and does not indicate reversal of logic state.

To reinforce this concept, study the following examples. Note that they include two truth tables to emphasize the *crucial* distinction between logic and voltage.

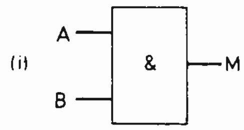
From Fig. 13, over,

Logic truth table remains same for each basic identity, whether flagged or unflagged.

Relevant section of voltage truth table modified where flag is applied.

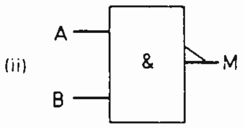
The voltage truth tables above can be taken to describe the action of a physical device which would be used to implement

(i)



Logic			Voltage		
A	B	M	A	B	M
0	0	0	L	L	L
1	0	0	H	L	L
0	1	0	L	H	L
1	1	1	H	H	H

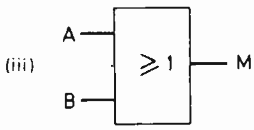
(ii)



A	B	M	A	B	M
0	0	0	L	L	H
1	0	0	H	L	H
0	1	0	L	H	H
1	1	1	H	H	L

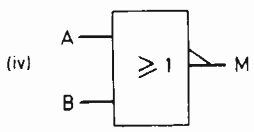
Flag alters convention i.e. 0 ≡ H 1 ≡ L

(iii)



A	B	M	A	B	M
0	0	0	L	L	L
1	0	1	H	L	H
0	1	1	L	H	H
1	1	1	H	H	H

(iv)



A	B	M	A	B	M
0	0	0	L	L	H
1	0	1	H	L	L
0	1	1	L	H	L
1	1	1	H	H	L

Flag alters convention i.e. 0 ≡ H 1 ≡ L

Fig. 13

the function. The voltage truth table of (ii) describes a t.t.l. 7400 nand gate, while the voltage truth table of (iv) describes a t.t.l. 7402 nor gate.

Two more examples are shown in Fig. 14.

Logic duality

If you now compare the voltage truth tables in Fig. 14 with the voltage truth tables of the previous four examples in Fig. 13, you should come to a startling conclusion, Fig. 15, right.

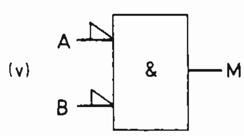
The same physical gate may perform an 'or' or an 'and' logic function under certain conditions, a physical nand gate may perform a logic 'or' function, and a physical nor gate may perform a logic 'and' function. This is the law of Logic Duality.

We now introduce the non-equivalence and equivalence logic functions. Figure 16 shows the gate symbols and truth tables for these two functions.

You are now left to prove the Fig. 17 duals, using the procedure outlined earlier.

Figure 18 summarizes logic duals.

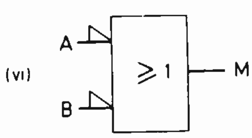
(v)



Logic			Voltage		
A	B	M	A	B	M
0	0	0	H	H	L
1	0	0	L	H	L
0	1	0	H	L	L
1	1	1	L	L	H

Flag alters convention i.e. 0 ≡ H 1 ≡ L

(vi)



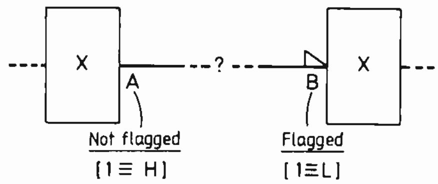
A	B	M	A	B	M
0	0	0	H	H	L
1	0	1	L	H	H
0	1	1	H	L	H
1	1	1	L	L	H

Flag alters convention i.e. 0 ≡ H 1 ≡ L

Fig. 14

Voltage level changing

Given the following problem, what do we do?



Required

Logic		Voltage	
A	B	A	B
1	1	H	L
0	0	L	H

Fig. 19

To validate the voltage truth table in physical terms, we require of course a physical device called a voltage inverter, symbolized below.

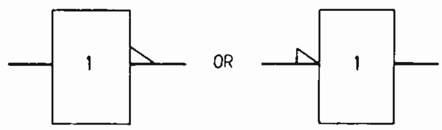


Fig. 20

Our solution to the above problem is therefore

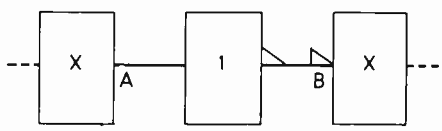


Fig. 21

Note carefully that no logic change has occurred; the same logic signal is present on both sides of the voltage inverter. Sole function of the voltage inverter is to change *voltage* representations for logic truth.

As further example for emphasis, consider implementation of equation M = A + B, where

input A is flagged ('1' ≡ L)
input B is un-flagged ('1' ≡ H)
output M is flagged ('1' ≡ L).

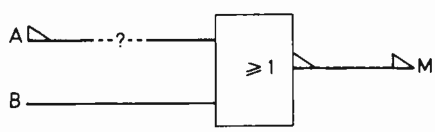


Fig. 22

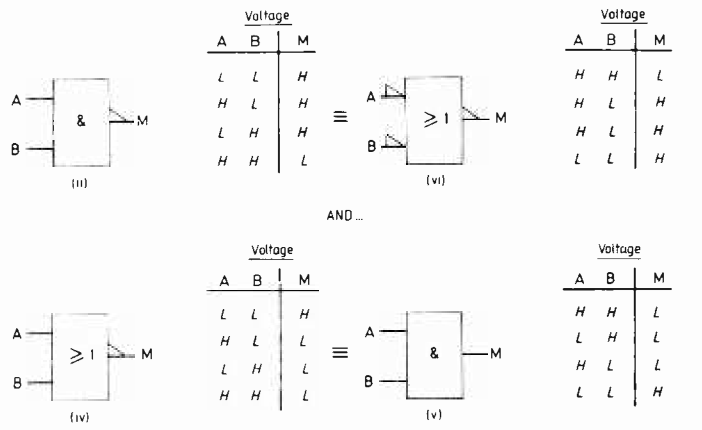


Fig. 15

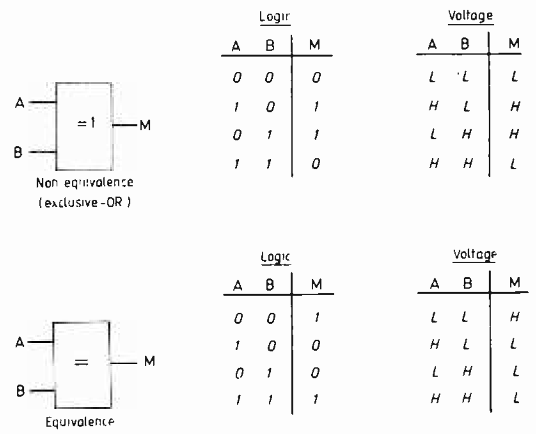


Fig. 16

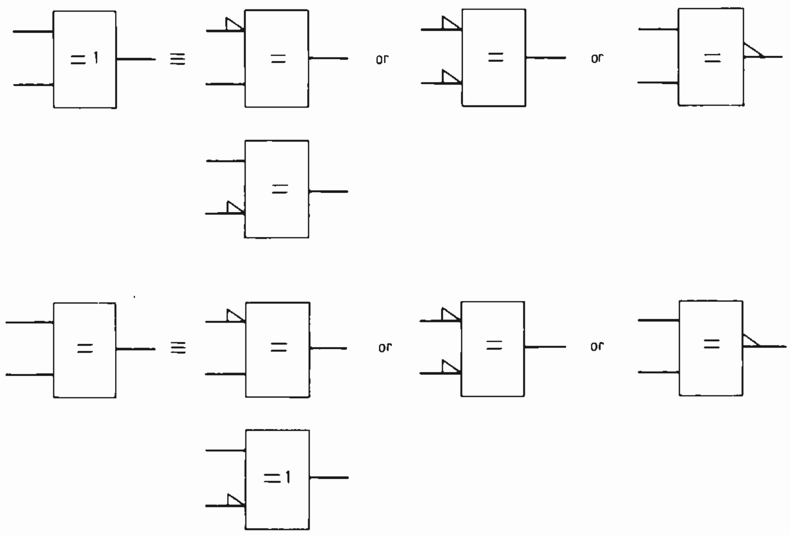


Fig. 17

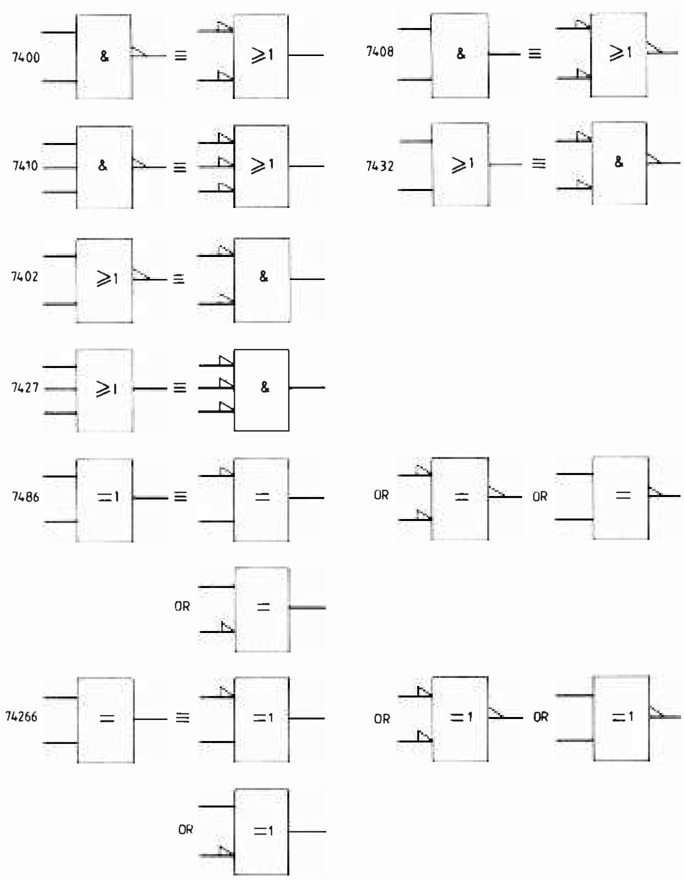


Fig. 18

We obviously require a voltage inverter at the A input.

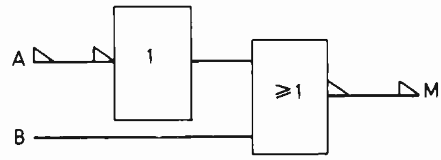
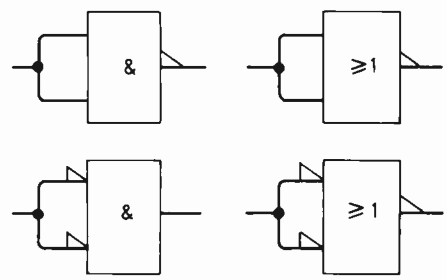


Fig. 23

The same logic signal is present on both sides of voltage inverter on A line. The voltage inverter may be implemented in a variety of other ways.



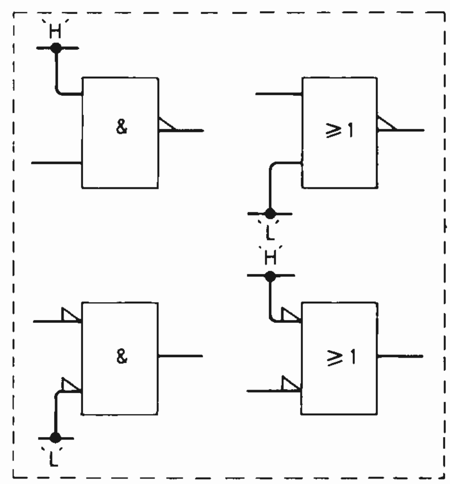


Fig. 24

All of these variants will be encountered in practical circuits.

Logic inversion

What is the physical implementation of logic 'not'? Consider the circuits of Fig. 25.

Logic variables A and B are being physically implemented by the *same* voltage on wire. The logic tables above are derived

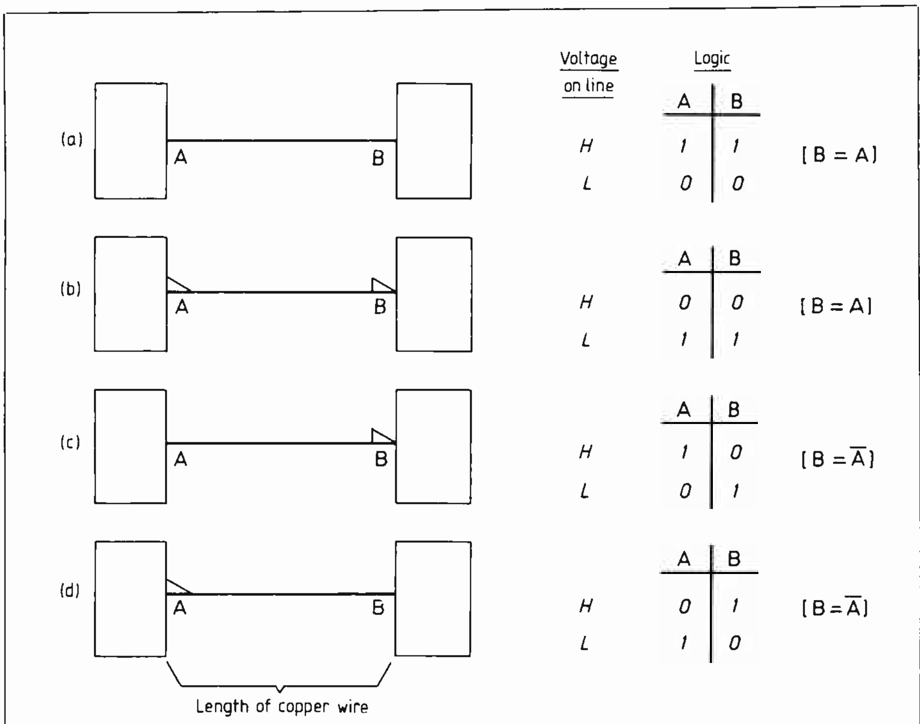


Fig. 25

from voltage on line (H or L), logic states depending on the presence or absence of flags at A and B. In cases (a) and (b) no inversion occurs. However, in cases (c) and (d) the logic truth table indicates logic inversion (logical not).

To summarize: logical not operation occurs over a piece of wire on which voltage convention is 'switched'.

To guard against any tendency to wonder about an error in the circuit diagram, an oblique 'slash' . . .

is placed across any line over which logical not operation has occurred.

The logical not operation is thus clearly identified on the diagram, and shows that voltage convention has been switched:

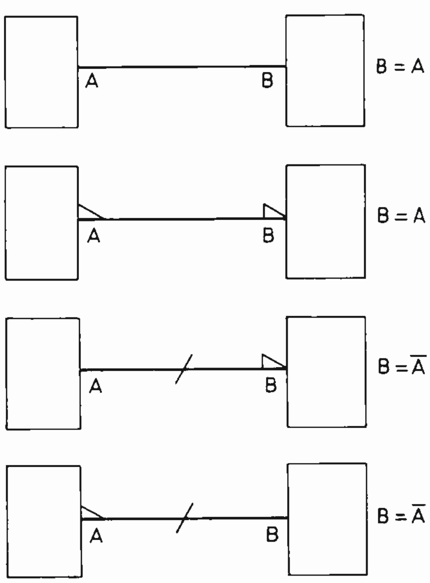


Fig. 26

The presence or absence of a 'polarity indicator' also serves to define voltage convention in force at a 'labelled' input or output to combinational logic network, and is associated with validity of 'label' at these points, Fig. 27.

Last words

Adoption of the system presented means total reversal of an outlook drilled into a generation of students by basic classic textbooks, and I confess to performing many mental gymnastics in the process of re-conditioning my thinking. During this procedure however, many nasty rule-of-thumb habits were discarded.

With regard to design of combinational logic circuits, the technique is very powerful and results in economical design. Greatest advantage lies in the fact that the designer works in pure logic and only reverts to the physical world when choosing devices to implement the design; at which point a few voltage inverters transform the circuit into the real world.

Use of duals in circuit diagrams appears to upset users who encounter this representation for the first time, and the response is very typical: "This is all very nice and academic of course, but how will the p.c.b. layout draughtsman and service technician be able to identify the physical type of, say, IC_{30} and IC_{31}?"

The answer lies of course in the fact that manufactured devices are always in 'and', 'or' nand or nor form, i.e. they don't have flagged *inputs*. Therefore on encountering a gate with flagged inputs a mental dual transformation is all that is necessary, Fig. 28.

Continued on page 35

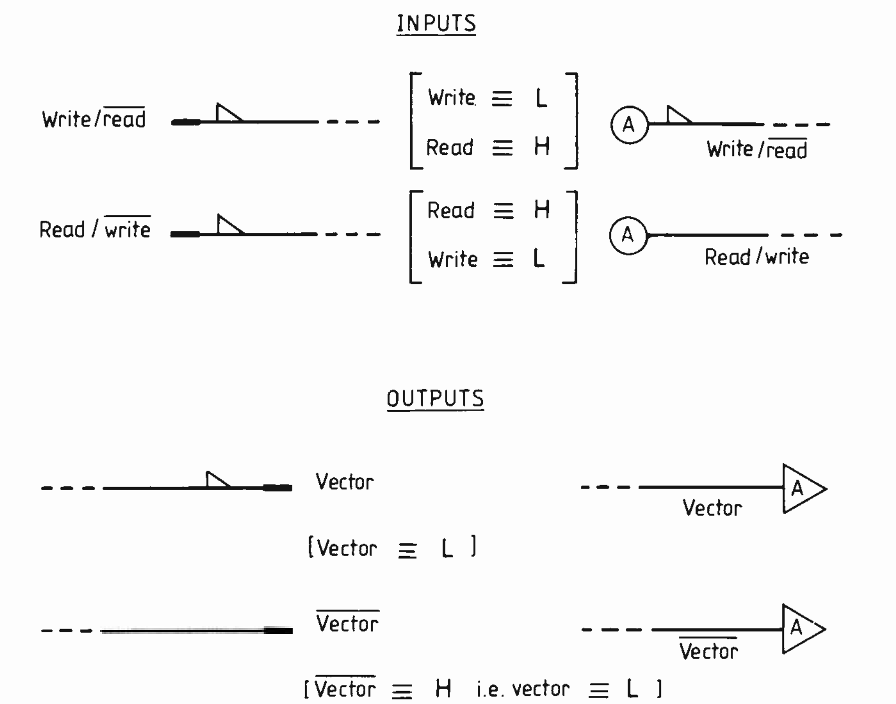


Fig. 27

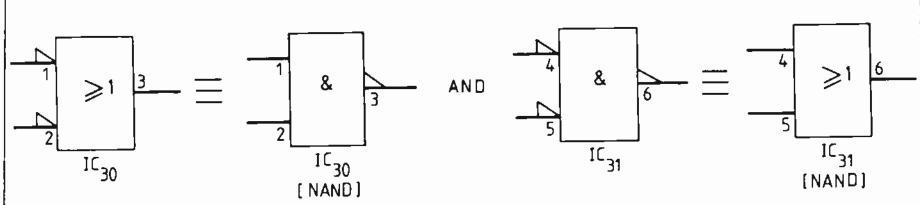


Fig. 28

300baud full-duplex modem

Most designs featured in magazine articles have been acoustically coupled and have not met any previously adopted standard for frequencies. This design directly couples to the telephone line, giving better security and lower error rates, and uses standard data channel frequencies

by Des Richards

The unit has been designed to meet British Telecom specifications but as these include the standard of construction and layout it cannot therefore be said to be BT approved. But if all the layout instructions are followed the unit should meet with BT approval. This can be done locally through the Transmission Efficiency Officer or by submitting an application to

Telecom HQ
Marketing Executive
R.C.S.D.
Tenter House
45 Moorfields
London EC2Y 9TH

The modem offers the facility to originate or answer the call manually, or by using the auto answer unit it can be used as an auto-answer modem. The unit is designed to be compatible with the BT Datel 200 service to give data rates of up to 300 bit/s. Duplex transmission over two wire circuits is achieved by using frequency-division techniques, as shown in the table. Two channels are used with the following frequencies

Channel 1	980Hz–binary 1
	1180Hz–binary 0
Channel 2	1650Hz–binary 1
	1850Hz–binary 0

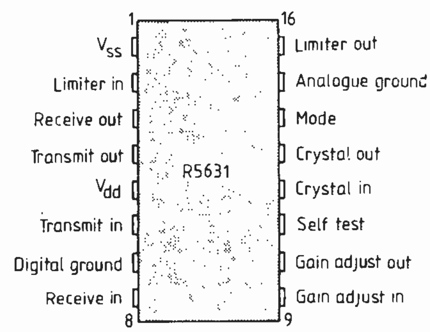
A protocol must be established so that one channel is used in one direction of transmission and *vice versa*, by creating call and answer modes of operation.

Call mode	Frequency designation	Answer mode
	980Hz–binary 1	
Transmit	Channel 1	Receive
	1180Hz–binary 0	
	1650Hz–binary 1	
Receive	Channel 2	Transmit
	1850Hz–binary 0	

Using this convention the contention of two modems trying to transmit to one another on the same frequencies will not arise provided that each modem is in the complementary mode.

To enable duplex transmission over a two-wire circuit the transmit and recieve signals must be separated by the use of a hybrid transformer and transmit and receive filters. The hybrid transformer also provides a d.c. loop on the telephone circuit to hold the call. This is required on both the originating call and the answering call to indicate to the exchange equipment that the line is in use. The transformer must be able to carry a primary direct current of up to 120mA and not saturate, thus enabling a.c. signals to be sent and received through the transformer without attenuation. Both the transmit and receive signals are buffered by zero-gain amplifiers to give a stable impedance of 600 ohms to the hybrid and they also provide a degree of protection to the filter against high voltage transients which could be induced into the transformer from the telephone circuit.

The filter consists of a single integrated circuit specifically designed for modem use. It is the Reticon R5631, a monolithic i.c. containing two ten-pole switched-capacitor band-pass filters fabricated in n-mos technology with a 16 pin dual in-line package (see below for pin connections).



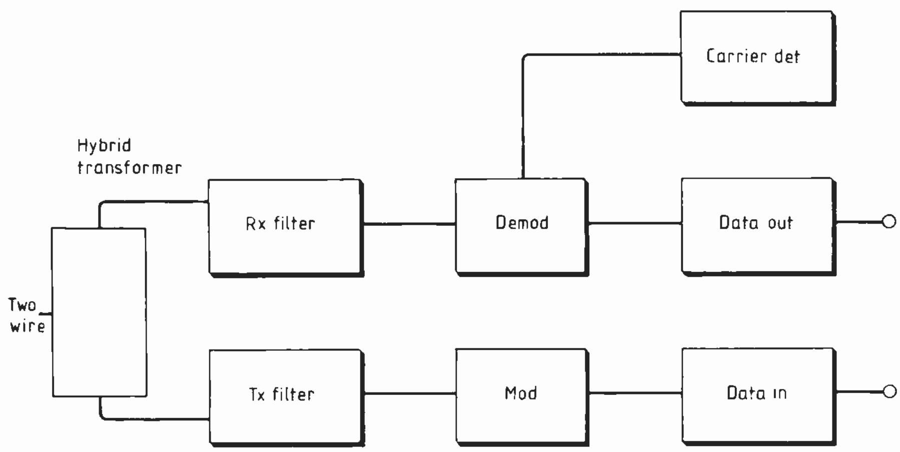
Included in the chip is a receiver gain-control stage which is externally variable from 0 to 20dB, a separate limiter for use with the receive output, a clock oscillator and t.t.l.-compatible switch inputs for self-test and mode selection, Fig. 3. The self-test mode gives the ability to loop the modulator and demodulator together via the filter and thereby enable local testing to be carried out.

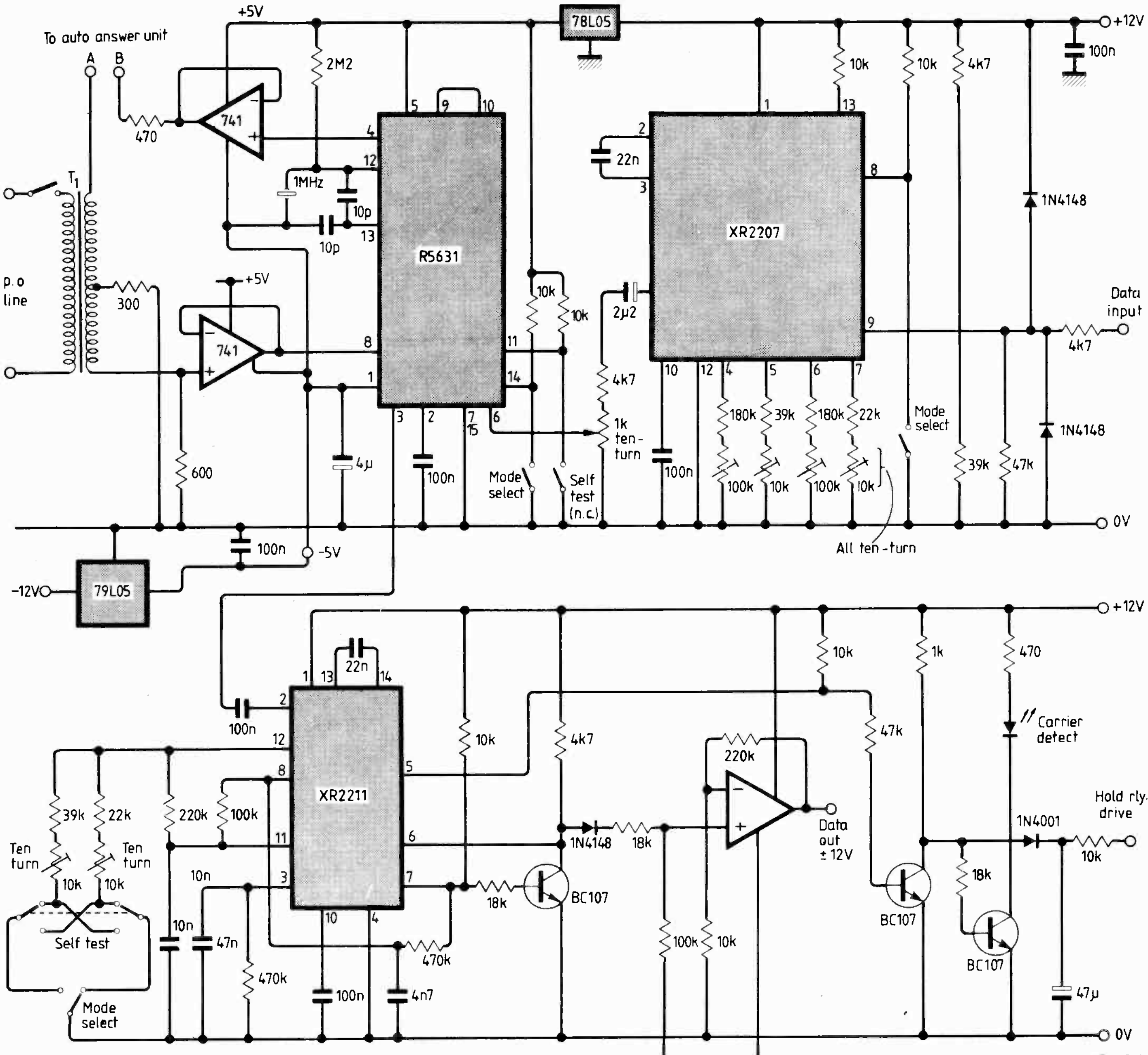
The mode select and self-test gives the following combination of filters.

Modulator

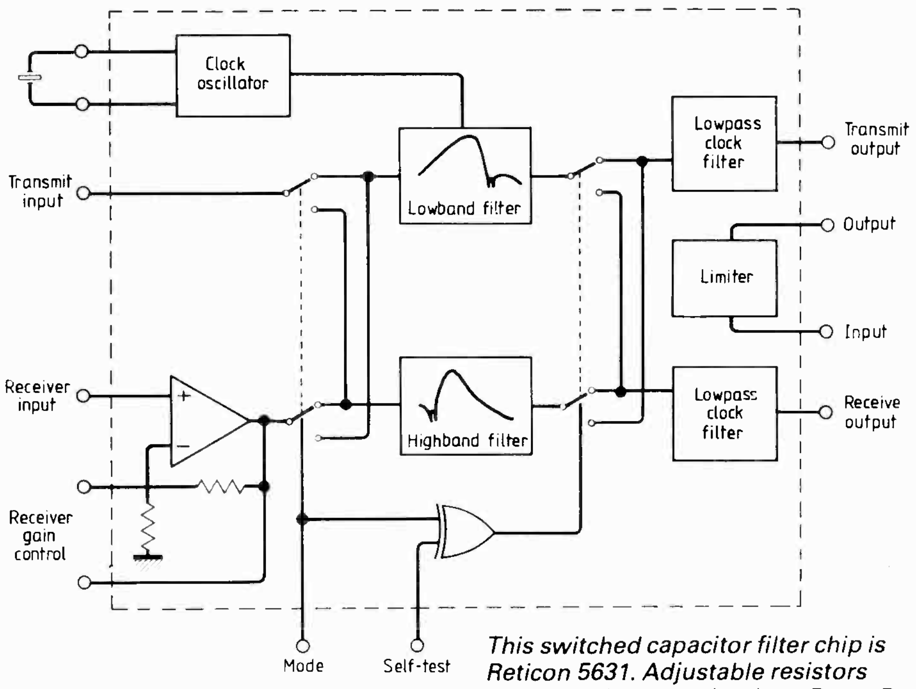
The modulator is built using the XR2207 f.s.k. modulator i.c. which gives phase continuous output, the frequency of which is determined by C_f and the resistors R_1-R_4 selected by the logic combinations on pins 8 and 9.

The XR2207 provides two outputs, one a square wave on pin 13 and the one used in this application is a triangular waveform on pin 14. Use of the channel-select input on pin 8 gives the ability to change channel when the modem is switched between the





All switches shown in answer mode (high band Tx, low band Rx)

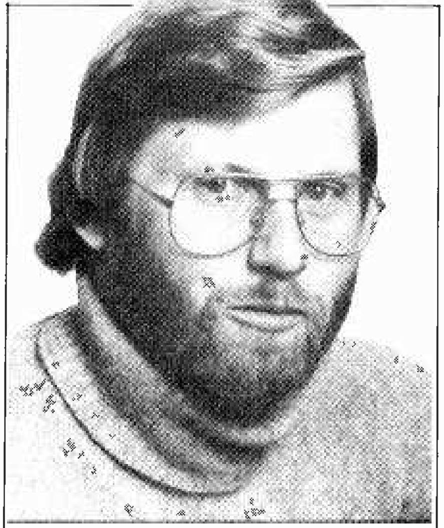


This switched capacitor filter chip is Reticon 5631. Adjustable resistors around 2207 circuit (top) are R_{V1} to R_{V4} in text.

call and answer modes.

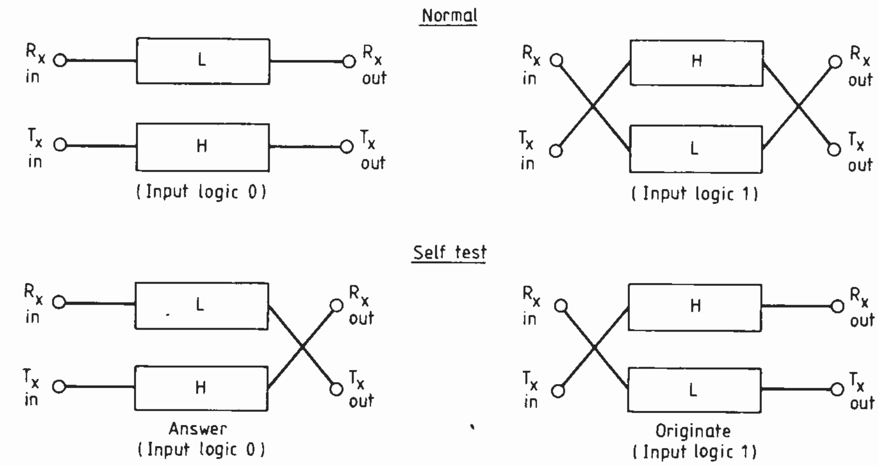
To set the frequencies of the modulator follow this procedure. Apply a logic 1 to the data input and select channel one by applying a logic 0 to pin 8, this can be done by switching to originate mode. Adjust R_{V1} to give an output frequency of 980Hz. Then apply a logic 0 to the data input and adjust R_{V2} to give 1180Hz at the output. The adjustments must be done in this order as R_{V1} affects both the low and the high frequency whereas R_{V2} only affects the high frequency.

The same procedure applies to set channel 2 frequencies. This is done by selecting the answer mode and applying logic 1 to the data input. Resistor R_{V3} is then adjusted to give a frequency of 1650Hz. The data input is then set to logic 0 and R_{V4} adjusted to give an output frequency of 1850Hz. The output level is adjusted to give −10dB into 600ohms at the two-wire line side of the hybrid transformer. This completes the alignment procedure for the modulator.



Since he qualified in communications in 1972, Des Richards has been an engineer on a local radio station. He also runs a small business designing and supplying specialist equipment, and finds time to build model steam engines and fly light aircraft.

Logic-level pin 8	pin 9	Active timing Resistor	Output Freq. (f)
L	L	pin 6	$\frac{1}{C_fR_1}$
L	H	pin 6 and 7	$\frac{1}{C_fR_1}+\frac{1}{C_fR_2}$
H	L	pin 5	$\frac{1}{C_fR_3}$
H	H	pin 5 and 4	$\frac{1}{C_fR_3}+\frac{1}{C_fR_4}$



Self-test mode allows modulator and demodulator to be looped together through the filter for local testing. Diagram shows mode and self-test filter combinations.

Demodulator

The demodulator is built using another Exar circuit, the XR2211 which is a monolithic phase-locked loop device. It consists of a basic phase-locked loop for tracking a signal within the passband, a quadrature phase detector that provides carrier detection, and an f.s.k. voltage comparator circuit that provides f.s.k. demodulation. It will detect a signal between 2mV and 3V and has a built in a.g.c. preamplifier. The centre frequency, bandwidth and output delay are set by external components, centre frequency being determined by C_f and R_f. Adjustment of R_f is as follows.

Open R_5 and monitor pin 13 or 14 with a high impedance probe. Don't try to adjust the centre frequency by monitoring C_f with everything connected and no input signal applied.

The two centre frequencies are adjusted in the same way. Select call mode and adjust the frequency to 1750Hz and then select the answer mode and adjust the frequency to 1080Hz. This completes the alignment of the demodulator.

The carrier detect output drives the hold relay on the auto-answer board, and also gives a status indication of carrier being present on the circuit. The complementary output to this is connected to the data output circuit to hold the output to a logic 1 (−12V) when no carrier is present. This prevents spurious data from appearing on the output when no carrier is present. The output of the demodulator is unipolar and is converted to RS232 by an op-amp buffer to give ±12 volts.

To be continued

Continued from page 32

With regard to servicing, one is only concerned with reading the logic action and checking voltage levels at specifically numbered pins on labelled i.c. packages (assuming a silk-screened p.c.b., and suitable documentation). It is only when replacing a defective package that one must identify its physical type, and this information should be present in the documentation.

Example

With (a), (b) and (c) representing spare gates, which two of three shown can be connected to fulfill the function of the network illustrated?

How will the network be represented in mixed logic notation? (For maximum clarity of operation.) WW

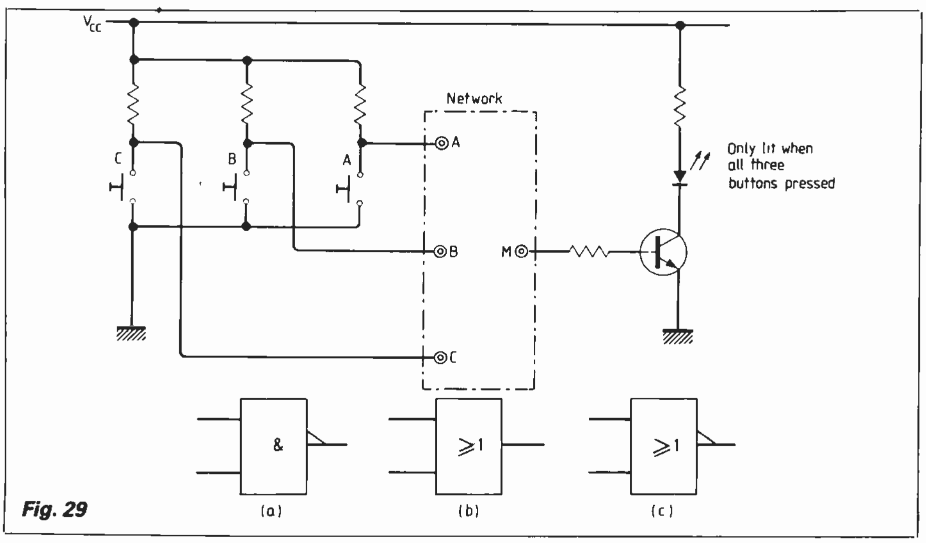
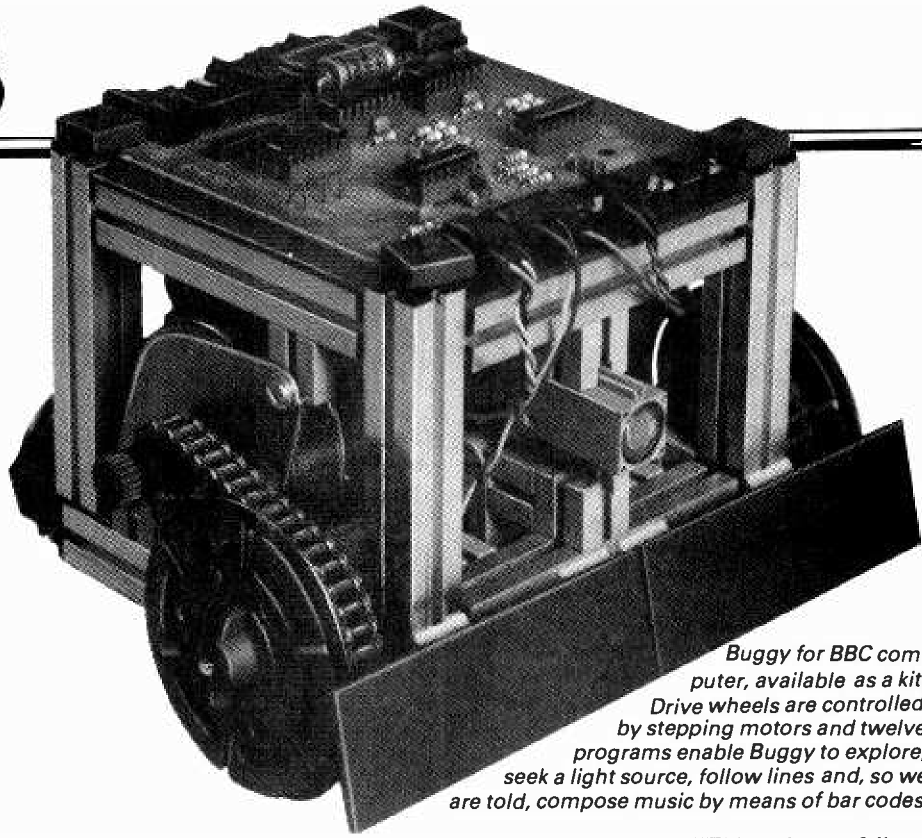


Fig. 29

NEWS

More micros for minors



Buggy for BBC computer, available as a kit. Drive wheels are controlled by stepping motors and twelve programs enable Buggy to explore, seek a light source, follow lines and, so we are told, compose music by means of bar codes.

Eight million pounds of Government money is to go toward new computing equipment and up-grading existing computers in schools and colleges of further education.

The extension to the Micros in Schools Scheme consists of 50% funding to allow RM380Z and BBC Model A computers to be converted. The Research Machines computer will be provided with 56K of memory (formerly 32K) and the graphics board with software, while the BBC design in its Model B form is to have disc drives and an Econet interface. Both computers can be supplied with a Microvitec colour monitor and a Walters printer. As an extra to the computers, the Government will also assist schools to buy a Buggy, which is a three-wheeled robotic device by Economatics, controlled by the computer, which will adaptively follow set paths, detect and delineate objects, operate a pen and find its way towards a given point. There is also Vela, which is effectively a multipurpose measuring instrument for voltage, frequency, waveform generation, transient capture and data analysis, being a central-hardware, programmmable-function device.

A further scheme – CNC Machine Tools in Further Education – has as its aim the equipping of colleges with computer numerically controlled tools of various types, again on a 50% basis.

Announcing the CNC programme, Kenneth Baker MP, Minister for Information Technology, said "This scheme follows the enormously successful micros for school schemes, as a result of which the UK has achieved the greatest progress of any country in technological education for young people."

More than 6500 secondary schools have already received microcomputers under the scheme.

934MHz changed to meet European plans ...

UK 934 MHz citizens' band is to be moved downward by 12½kHz following a Home Office decision to fall in line with a recent international channelling agreement for Europe reached by the Conference of European Posts and Telecommunications Authority, CEPT. Other technical requirements for 934MHz remain unchanged and existing sets may be used for the present. Dates by which existing sets must be modified and sets being manufactured must conform to the new channel requirements have yet to be fixed. Amendments to Home Office performance specification MPT1321 are being made to reflect the new channel plan.

... for whom?

Currently only one UK manufacturer, Reftec, makes sets for 934MHz and according to the company's main distributor, 934 Communications, some 500 transceivers have been sold since Reftec first started manufacturing some 15 months ago. But a second company, Beeware of Harrogate, is about to break the monopoly by selling a 934MHz transverter that can be used with existing 27MHz sets. Beeware expects to sell around 1800 transverters in the first 12-18 months, a figure representing 2½% of the existing 75 000 official and unofficial c.b. operators.

Prices of a basic Reftec transceiver and a Beeware transverter with a 27MHz set are almost the same, working out at around £250, but the second option is more attractive to those who already have 27MHz sets and to those who want to operate on both bands. But according to Don Lane, a spokesman for 934 Communications, "Beeware cannot be serious. Japanese companies need an order of 10 000 before they will manufacture anything and there just isn't the market for that number of sets." Technical Director of Beeware, Bill Dewhurst replied "Of course we are serious. We have carried out a feasibility study, spent money and liased with the Home Office on the specifications – had it not been for the recent changes, our product would be on the market now." Sanwa make the company's 27MHz set but Mr Dewhurst could not tell us who was manufacturing the Grandstand transverter expected to be available by the end of July.

Sets conforming to a European standard can potentially be exported. When approached on this subject, Dewhurst said "the snag is that the Japanese like to do things their own way. Exporting Japanese sets from the UK would not be easy but we have plans to manufacture in the UK, in which case we would be looking into exports. We have a design for a complete 934MHz transceiver and are looking into other fields of communications like marine and land-mobile radio and satellite tv."

Lasers and radiation safety

Rapid increase in the use of lasers in both industrial and commercial has led to a complete revision of the BSI standard on laser radiation safety which has been in effect since 1972. Radiation safety of laser products and systems, BS 4083, has been published in advance of an international standard, which is an infrequent occurrence, and it could be that ISO in Geneva will base their standard on its content.

BSI says "It is impossible to regard laser products and systems as a single group since hazards vary according to factors such as wavelength, power and energy of the beam and duration of the emission. Eyes are the organs most at risk because the incoming visible or near infrared beam may be focussed on the retina to a 10 to 200μm spot which raises energy density by up to half a million times. High irradiance, either direct or reflected, may cause skin damage. Other potentially dangerous sources are power supplies and cooling agents sometimes used." The standard is in three parts, one covering determination of maximum permissible exposure levels in a summary of biological considerations, one specifying manufacturing requirements, and a user's guide covering safe operation, maintenance and servicing of lasers.

NRPB, who are more concerned with biological effects of lasers rather than with mechanical construction which is BSI's main concern, plan to publish a review of maximum permissible limits for exposure to laser radiation in about six months at the request of the Health and Safety Executive. This information is used by BSI as a basis for its standard. A further consultative document on laser radiation hazards from NRPB is due in about a year.

● Finalization of the consultative document concerning non-ionizing radiation limits summarized in *Wireless World*, April 1983 has been delayed "slightly" due to an unexpected influx of comments and questions at the NRPB, particularly concerning e.l.f. radiation.

Racal gets 25 years in cells

Racal Millicom has received a 25-year licence to run a mobile telephone service based on cellular-radio technology but according to the DoI, the competing licence to be held by the BT/Securicor consortium "is still to be issued." The licence requires that the service must start no later than 31 March 1985 – unless the holder has a good excuse – and that 95% of the population must be served by 1989.

When asked why BT hadn't got its licence yet, a spokesman said: "We are working toward providing a cellular radio service in early 1985 – the licence is incidental, and there's no need to have it immediately." On the other hand, Racal could not tell us anything more than what is in the licence and how much it costs (£1,000 initially then £1,000 p.a.). When asked when production of equipment might start – or indeed when anything concerned with cellular radio might start – Racal replied "we'll let you know." But as we write, the election looms and one can say that it is likely to be more embarrassing for a Government to retract a licence than it would be to refuse to issue one in the first place.

In brief

An agreement to support European Computer Manufacturers' Association work towards proposed CCITT electronic mail standards was signed on 29 April by seven companies – ICL, Rank Zerox, Ferranti, CII Honeywell Bull, Olivetti, ITL and Logica.

City & Guilds Radio Amateur course 765 starts at Oak Farm centre, Chaucer Road, Farnborough, Hants on 22 September. For further details telephone 0252 540084.

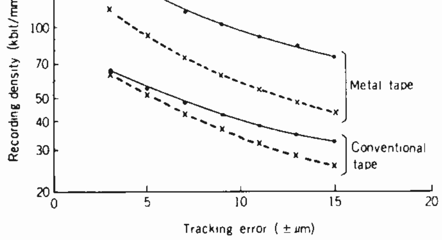
Incorporated Practitioners in Radio and Electronics, IPRE, is reborn under the wing of the Society of Electronic and Radio Technicians. Providing professional services to engineers involved in domestic and industrial electronics servicing, IPRE bases its entry levels on City and Guilds courses and is the only institution open to the many service technicians whose study is not normally recognized because of its practical nature.

Infrared astronomical satellite IRAS spotted a comet approaching us at 28km/s on 11 April and estimated that it would miss Earth by 4.5 million kilometres on 11 May, appearing faint but several times the size of the moon.

Digital v.c.r. with metal powder tape

Using recently developed metal-powder coated tape and a modified domestic video cassette recorder, researchers at NHK laboratories have demonstrated that high-density digital recording can give better results than conventional analogue v.c.rs. The researchers say that given some improvement in head sensitivity and tracking accuracy, the digital v.c.r. will consume less tape than its analogue counterpart and produce good picture quality.

Digital circuits used are the same as those developed for NHK's 1979 digital v.t.r. experiments but using trial samples of Fuji's metal powder tape has allowed recording density to be more than doubled, to 3kbit/mm. With the same tape consumption as a conventional recorder, digital rates of 216Mb/s were achieved. This experiment is outlined in NHK Laboratories Note No 218.



Calculated results of recording density for metal powder vs conventional tape. With good head sensitivity and tracking accuracy, recording density for metal tape is 5.5µm²/bit.

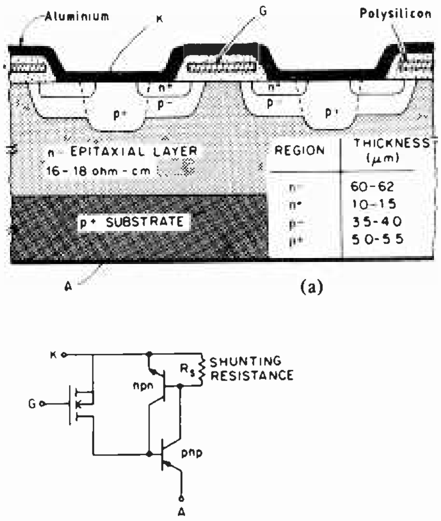
General specifications for NHK's experiments in high-density digital recording for video signals. Digital circuits for both experiments are the same but using metal powder tape has double recording capacity. Characteristics of reproduced digital video signal are also given. "There were many dropouts because a trial production metal-powder tape was used, but error rate could be reduced to one tenth of this value by using a mass-production coater in the tape manufacturing process."

	High-density recording experiment, 1982	**Experimental v.t.r., 1979**
Tape	Fe metal-powder coated (trial product)	Cobalt iron oxide, $CoFe_2O_3$
Head	Sendust metal head	Ferrite, single crystal MnZn
Recorder	Domestic VHS cassette video recorder	One inch helical v.t.r. (SMPTE C)
Tape-to-head relative speed	11.6m/s	25.6m/s
Bit interval	0.33µm	0.73µm
Density	3kbit/mm	1.4kbit/mm
Track width	45µm	40µm
Track pitch	58µm	60µm
P.c.m. coding	$3\times f_{sc}$, 6bit/sample	$3\times f_{sc}$, 8bit/sample
Recording	2 channel	3 channel
Reproduced signal s/n ratio	35dB	31dB
Bit error rate	2.5×10^{-4}	1×10^{-6}
Block error rate	3×10^{-3}	3×10^{-4}
Remaining errors	2 blocks/min	no error

MOS power device with thyristor on resistance

A mos gate-controlled power switch with an on resistance comparable to that of a thyristor has been developed by RCA. On resistance of v-mos power devices rises with increasing drain-source voltage capability, limiting their high-voltage applications, but the newly structured device exhibits an on resistance ten times lower than standard state-of-the-art mosfets with the same size and voltage rating. RCA scientists have manufactured several hundred of the devices, called Comfets (conductivity-modulated fet), some 1.5mm^2 and some 3mm^2, and nearly all of the larger chips had on resistances of less than 0.1Ω at 20A.

Typical experimental Comfets with 8A anode current took 1μs to turn on but between five and 20μs to turn off, which is relatively slow. The n-p-n-p structure of the device is similar to that of a thyristor and it can be made to latch using high drive currents. In the larger devices latching occurred at between 10 and 30A, depending as one would expect on temperature and anode voltage. But an interesting feature of the device is that latching current is also strongly influenced by gate turn-off time. Slow gate turn offs of around 10μs permit anode currents up to 30A without latching but a rapid gate turn off of less than 1μs leads to latching at much lower anode-current levels in the region of 10A. The Comfet is detailed by J. P. Russel, A. M. Goodman, L. A. Goodman and J. M. Nielson in *IEEE Electron Device Letters*, vol. EDL4, no 3, March 1983.



Comfet – a new mos gate controlled power switch with an on resistance comparable to that of a thyristor. Experimental devices produced by RCA researchers have on resistances lower than 0.1Ω at 20A.

4Mbyte micro-floppy

Using a different approach to perpendicular magnetic recording, Sony claims to have produced the highest density magnetic recording ever, with a linear density of 2.58kbit/mm. This represents an improvement of 31 times that of a 51/4in floppy disc or eight times that of a high-density microfloppy. Toward the end of last year Toshiba claimed a 27-fold improvement over conventional floppy discs for their p.m.r. technique (February News) and although this figure is lower than the latest claim, Toshiba indicated their disc and drive was ready for manufacture whereas Sony's development is still in the experimental stage.

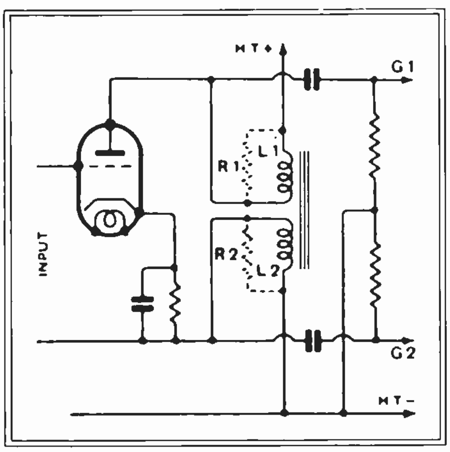
Effects of magnetic properties and thickness of single-layer cobalt-chromium media on perpendicular recording with a ring-shaped head are discussed in *IEEE Transactions on Magnetics*, vol. Mag-18, no. 6, November 1982. In this experiment Sony researchers achieved a recording density of 4.5kbit/mm using a ring-shaped head but the disc drive more recently described uses a w-shaped head to give a recording density of 2.58kbit/mm. Toshiba uses a ring-shaped head in its drive.

Obituary

Lawrence Henry Hewes Cooper, 'Dick' Cooper to his many friends and associates, died in hospital last February following an operation.

Born in 1912 and educated at Dulwich College, he spent a lifetime in electronic engineering. In his early career he worked with P.G.H. Voight at the Edison Bell Company, where he was involved in sound recording and reproduction. In 1933 he joined British Acoustic Films and worked on the design and installation of recording equipment at the Gaumont British Studios in Shepherds Bush. By 1935 he was working independently on the design of battery charging equipment using wet tantalum rectifiers, work which, coupled with other developments, led to the formation of Correx Communications and Correx Amplifiers. During this period he took out a patent for a modified form of push-pull drive circuit using a double-wound choke in place of the resistance or transformer feed circuit then in current use.

In June 1948, Transformer Equipment Ltd was founded and was soon serving many of the best known names in the electrical engineering industry. In addition to a wide range of other transformers, from 1958 the company made well known and widely used ultra-linear output transformer designed by J. Somerset-Murray.



Lawrence Cooper's phase-splitting circuit was the subject of an article in the 22 October 1937 issue of *Wireless World*. At that time, centre-tapped inter-valve transformers had been widely used for driving push-pull output stages but the demand for high-fidelity reproduction had led to resistive phase splitting circuits being introduced which became inefficient with low h.t. supplies. Mr Cooper's solution was to use a double-wound choke in place of the phase-splitting resistors to give a greater anode voltage with a lower potential difference between heater and cathode at low h.t. supplies.

Corrections

High-impedance electronics. In the first paragraph of this article, which appeared in the April issue, a line was dropped. The relevant section, nine lines into the paragraph, should read "... it saturates at 500 to 600mV as the junction becomes forward biased (Fig. 2). If the diode is connected between 'real' earth and the virtual earth ...".

Domestic alarm system. Several errors occurred in this article, published in the March issue. In Fig. 1, V+ should go to the right of the fuse, and C_2 (unlabelled) is connected to pin 4 of gate A. The Disarm-in line should continue to the disarm switch, bypassing pin 5 of IC_2, and the 1μF capacitor across IC_2 should still go to pin 5. Diodes across the relays are 1N4001, and the resistor on pin 4 of $IC_{7(a)}$ is 680k not 220kΩ. The caption to Fig. 2 shows a 25s delay, not 20s.

In Fig. 3, the capacitor on pin 4 of $IC_{7(a)}$ is 47μF, 16V and IC_{10} is a 7555. The switches should be S_3 and S_4, not S_1 and S_2, which are fire and disarm in Fig. 1. Capacitor C_x is on pin 2 of $IC_{7(a)}$. Lines 14 and 15 of the first paragraph of page 30 should refer to FIRE, not $\overline{FIRE}$, and line 2 of this page should say "IC_2 input".

The third line of paragraph two of the section headed 'Control unit' should refer to a 30s delay.

Organ interface for microcomputer

Principles used for each section of the software for the Nascom 2 organ interface and music editor, described in the June Issue, with source code listings for the critical elements.

By R. D. Easson

The software is described in four sections, see panel. The first enables the microcomputer to repeat a performance made on the organ, with variation of speed, whilst the second provides the edit functions. The third section allows music to be typed into the microcomputer, and the fourth (in Forth) provides simple polyphonic extemporization.

The first section comprises only about 150 instructions. Only the first two sections were conceived when the interface was originally designed but to date the software has obstinately refused to stop growing.

Read and play routines

The system now has 24 register pairs. Two groups of 24 bytes of ram are designated console fields 1 and 2. When the read and play modes are entered, the console fields are set to represent the console switches with all keys off (status 0) and all stops cancelled (status 1). The PIO is then set up to mode 01 (input) and the interrupts are enabled, as described by the source listings given in List 1. It is worth commenting that four levels of interrupt have to be set: c.p.u. interrupt mode 2, PIO port B interrupt, c.p.u. enable interrupt, and pending interrupt disable. The last of these was particularly vexing: even Mostek did not seem to know about it when they wrote the provisional data sheet on the MK3881 PIO. It was finally laid to rest on page 109 of the Mostek 1979 Microcomputer Components Data Book. The address of the routine which services the interrupt is kept at the vector address.

Once the PIO and c.p.u. are ready to accept an interrupt, the microcomputer enters a wait loop which includes a scan of its own keyboard for the read-mode direct commands. On the Nascom 2 with NAS-SYS 3 this is accomplished very simply with the routine "in" (DF62H) which transfers the ASCII code for any character typed to the A register. When the interrupt arrives from the interface hardware, operation moves to the interrupt service routine (List 1) and the first byte is read in through port A to console field 2. The remaining 23 bytes follow at about 20μs intervals. Operation relies on the hardware working slightly faster than the software (which necessitates a short wait loop if the c.p.u. is running at 4MHz) but the hardware and software are re-synchronized after each byte because the hardware has to wait for the c.p.u. to raise the ready line.

Thus the status of each register is read into the appropriate place in console field 2 once per frame. Before operation returns to the wait loop for the next frame (i.e. as part of the interrupt service routine), the new console field is compared byte by byte with the previous one. If there has been no change, the null frame counter (n.f.c., a two-byte variable) is incremented. If something has changed, the contents of the n.f.c. and the number and revised status of the register or registers which have changed are read to the data field (which normally starts at 1340H) and the data field packed data pointer is incremented accordingly to the start of the next frame. Thus a frame comprises 3+2n bytes including the frame byte when n is the number of registers whose status has changed. The packed data and other pointers are sometimes parked in a scratchpad area of ram but where speed is important they are kept in register pairs of the Z80 or where necessary on the stack. Both sets of registers are used to provide sufficient pointers for comparing console fields 1 and 2, which is probably faster than using the index registers would be. The source code for this part of the interrupt service routine is given in List 2. Once the information has been extracted from console field 2 it is transferred to the console field 1 position so that console field 2 becomes free for the next frame.

Operation in play mode is simpler than in read mode because comparisons are not required. As before, a console field is initiated and the PIO and interrupts are enabled in the same way, except that different vector and interrupt service routine addresses are used and that the PIO is set to mode 00 (output) via port B. The wait loop is then entered and includes the checks for the play mode direct commands. When the interrupt arrives, the console field is trundled out through port B into the 4094 latches and the n.f.c. is decremented.

Operation then returns to the wait loop, which includes a check of the n.f.c. When it reaches zero, control passes to the update console field routine, which takes less than one frame period. This routine inspects the next byte in the date field. If it is a frame byte, the next value of n.f.c. is taken and the process continues, but if it is a register number the revised status of that register (the following byte) is read to the appropriate position in the console field and so on until the frame byte is reached (software couplings can be introduced at this stage). Operation then returns to the wait loop so that when the next interrupt arrives the revised console field is read to the console latches.

Console field 2 (read mode) or the console latches (play mode) are reset for every frame whether or not anything has changed. Should an error occur due to triggering of the interface hardware by a noise spike (a rare event) it will quickly be corrected, normally within one or two frames. Similarly, the synchronization of hardware and software is achieved one or two frames after the execution of the play mode and read mode routines.

Software breaks down into . . .

1. The read and play mode routines for transferring the data between the microcomputer and the organ, interrupt-driven via the PIO, and for converting this to and from data format.
2. The edit routines, based on a scan of the microcomputer keyboard in play mode and block transfers of sections of data in data format.
3. The translate mode routines for translating music typed into the microcomputer from entry format into data format, mainly by means of look-up tables.
4. A vocabulary of some 60 words in Forth (about 4K of compiled Forth code) which operates on both the duration and event components of themes in data format to produce some simple polyphonic extemporizations, including some basic harmonization rules, which could quite easily be extended.

Edit routines

The principal edit routines are effected by the play mode direct commands J (join) and E (edit) once the edit points have been selected. The principle is directly analogous to splicing tape recordings in that the Z80 block transfer routines (LDIR and LDDR) are used to move sections of a recording in data format from one part of the ram to another, with frame bytes overlaid. The lowest and highest source and destination addresses, as appropriate, are kept in a scratchpad area of ram for loading to the HL, DE and BC registers when everything is ready. Join throws away the intervening section (unless it has been kept by K (keep)) whilst edit inserts a new section as stored by keep. The edit routine needs to check whether the new section is longer, shorter or the same length as the old one using the length of the block from the highest edit point to an arbitrary upper limit, normally set to C000H. The lowest address for K is D000H; it can therefore store about five minutes of music (below F600H), whilst edit can accept an extra two minutes or so without interfereing with what has been stored by K. Clearly the limits can be changed if this is not adequate.

Most of the remaining play mode direct commands either are simple conditional branches or cause modifications to fragments of code. For example, P (pause) in read mode merely removes the enable interrupt in the wait loop. Short cuts of this kind may not be good practice, but they are very convenient for a relatively simple control program written in machine code rather than assembler, whilst being fast and compact. The two things to remember are firstly to keep a note in the source or reference listing of what is changed and of everything that changes it and secondly to remember to restore the program eventually. Entry points should also be clearly marked as a precaution against later changes to the code being entered, and one needs to be mindful of the branching protocol.

Early during the development of this system, the p.d.p. was parked in video ram between active frames to provide an indication of operation. It was soon found convenient when editing to decode the resulting hieroglyphics into a four-character address in hexadecimal.

Translate mode

The principles of operation are:

> that the note values (durations) are translated directly into values of the null frame counter, incremented or decremented for each following + or − respectively;
>
> the stop key codes are first translated into the appropriate register number and status by means of a look-up table. The register status is then added or subtracted from the current status in the console field.

In each code group, the first character is one of the eight directory characters H, R, P, S, T, L, ; and : . For H, R, P and T the next two characters are converted to look-up table addresses. For S, there is a further directory of three characters (H, R and P) which enable the same two-character stop codes which follow it to be used on each division of the organ.

Some care was needed over the construction of the look-up table. There is a trade-off between the complexity of the conversion process and the size of the table, which ended up with 384 bytes spread over 2.5K of memory (F600H to FFFCH). The interstices are not wasted: they gradually filled with various subroutines and other scraps of program.

The first step in constructing the look-up table was to provide a complete set of addresses for the notes C1 to C5 (or C6) including "black" notes. Then two more such sets for the other two divisions are required, plus three further sets for stops and one for pistons.

To make it easier to avoid clashes, the table was divided exclusively by the second least significant half-byte of the 16 digit code, as follows:

Hauptwerk stops	0, 1 and 2
Natural keys and pedals	3 and 5
"Black" keys and pedals	4 and 6
Pedal stops	7, 8 and 9
Rugpositiv stops	A, B and C
Thumbpistons	D and E

```
ZEAP Z80 Assembler - Source Listing

1200            SETIO   ORG  1200H ; AP 37:  SET PIO & WAIT
1200                    ENT
1200 3EB2               LD   A £B2     ;) Set vector address to
1202 D306               OUT  (6) A     ;) 10B2 (see 120A)
1204 3E4F               LD   A 4FH
1206 D306               OUT  (6) A     ; Set PIO mode 01 (input)
1208 ED5E               IM   2         ; Set CPU Interrupt Mode 2
120A 3E10               LD   A 10H     ;)
120C ED47               LD   I A       ;) Set I Register
120E 116000             LD   DE 60H    ; Set Frame Count for test
1211 C600               ADD  A 0       ; Set Flags
1213 3E07               LD   A 7H      ;) Disable PIO Port B
1215 D307               OUT  (7) A     ;) interrupt (Control 7)
1217 DB04               IN   A (4)     ; Initiate Port A RDY
1219 3E87               LD   A 87H     ;) Enable PIO Port A
121B D306               OUT  (6) A     ;) interrupt (Control 6)
121D FB                 EI   ;           Enable CPU Interrupt
121E 00                 NOP
121F F3                 DI   ;           Disable CPU Interrupt
1220 3E07               LD   A 7H      ;) Disable PIO Port A
1222 D306               OUT  (6) A     ;) Interrupt
1224 DB62               DEFW 62DFH     ; IN (scan keyboard once)
1226 FE30               CP   30H       ; 0?
1228 CA3010             JP   Z 1030H   ; If 0, goto Play Mode
122B FE52               CP   52H       ; R?
122D CAB011             JP   Z 11B0H   ; If R, Restart
1230 FE2E               CP   2EH       ; .?   (etc.)
1232 CA27F6             JP   Z £F627   ; If ., Reset PDP & return
                        ;                to NAS-SYS monitor
1235 C31912             JP   1219H     ; Loop, wait for interrupt
1238 0000               DEFB 0 0
                        ;           INTERRUPT SERVICE ROUTINE
123A F3                 DI   ;           Disable CPU interrupt
123B F5                 PUSH AF
123C C5                 PUSH BC
123D 00                 NOP  ;           ( DEC DE for testing)
123E 010419             LD   BC 1904H ;) Set byte count & Port A
                        ;              ) data address
1241 21180D             LD   HL 0D18H ; Set start of CF2 address
1244 3E17               LD   A 17H     ;) Disable PIO
1246 D306               OUT  (6) A     ;) pending interrupt
1248 CD4011             CALL 1140H     ; Call "DELAY FOR 4MHZ"
124B EDA2               INI  ;           Input from Port A
124D 20F5               JR   NZ -09H   ; Loop until done
                        ;          (Contd. on Fig. 2)
```

▲
List 1. PIO and interrupts are enabled for read mode. First part of the interrupt service routine reads in one frame from the console registers.

```
ZEAP Z80 Assembler - Source Listing

1252            RMISR   ORG  1252H ; AP38 :  READ MODE
1252                    ENT  ;          INTERRUPT SERVICE (contd.)
1252 21180D             LD   HL 0D18H  ; Init. 2nd frame pointer
1255 D9                 EXX
1256 0618               LD   B' 18H    ; Number of frames
1258 11000D             LD   DE' 0D00H ; Init. 1st frame pointer
125B 000000             DEFB 0 0 0
125E 0E00               LD   C' 0      ; Null Frame Detector = 0
1260 1A                 LD   A (DE')   ; 1st frame byte to A
1261 D9                 EXX
1262 96                 SUB  (HL)      ;) Compare bytes from 1st &
1263 CA6E12             JP   Z 126EH   ;) 2nd frames, hop if same
1266 7E                 LD   A (HL)    ;) 2nd frame byte to A if
1267 D9                 EXX  ;          ) it was different
1268 0C                 INC  C'        ; Inc. NFD
1269 73                 LD   (HL') E'  ; PDP puts regno. to DF
126A 23                 INC  HL'       ; Inc. PDP
126B 77                 LD   (HL') A   ; PDP puts reg. status to DF
126C 23                 INC  HL'       ; Inc. PDP
126D D9                 EXX
126E 23                 INC  HL        ; Inc. 2nd frame pointer
126F D9                 EXX
1270 13                 INC  DE'       ; Inc. 1st frame pointer
1271 10ED               DJNZ -11H      ; Loop if B.0
1273 0000               DEFB 0 0
1275 D9                 EXX
1276 C1                 POP  BC        ;) Return Null Frame
1277 D9                 EXX  ;          )    Counter (NFC)
1278 79                 LD   A C'      ; Prepare to test NFD
1279 C600               ADD  A 0
127B D9                 EXX
127C C28712             JP   NZ 1287H  ; Hop if last frame active
127F 00                 NOP
1280 03                 INC  BC        ; Inc. NFC
1281 C3B512             JP   12B5H     ; End if it was not active
1284 000000             DEFB 0 0 0     ; NOP
1287 2AA908             LD   HL (08A9H) ;) HL as PDP at NFC
128A 70                 LD   (HL) B    ;) position & store NFC in
128B 23                 INC  HL        ;) DF with it, MSB first
128C 71                 LD   (HL) C
128D 010000             LD   BC 0      ; Reset NFC
1290 3EFF               LD   A £FF     ;) Frame byte to DF
1292 D9                 EXX  ;          ) and inc. PDP
1293 77                 LD   (HL') A   ;)
1294 23                 INC  HL'       ;)
1295 0000               DEFB 0 0       ; NOP
1297 22A908             LD   (08A9H) HL' ; PDP to scratchpad
129A 21180D             LD   HL' 0D18H ;) Frame 2 to
129D 11000D             LD   DE' 0D00H ;)  frame 1 position,
12A0 011800             LD   BC' 0018H ;)  ready for
12A3 EDB0               LDIR ;          )  new frame 2
12A5 2A0908             LD   HL' (0809H) ; Reload PDP
12A8 CD6011             CALL 1160H     ; Call "PDP DECODE"
12AB 3EAA               LD   A £AA     ;) Temporary value of
12AD 77                 LD   (HL') A   ;)  NFC to DF, as at
12AE 23                 INC  HL'       ;)  end of DF, and inc.
12AF 77                 LD   (HL') A   ;)  PDP to next regno.
12B0 23                 INC  HL'       ;)  address
12B1 22310D             LD   (0D31H) HL' ;) PDP to tabulate
12B4 D9                 EXX  ;          ) position above CF2
12B5 F1                 POP  AF
12B6 ED4D               RETI ;           Return to wait loop
```

List 2. Second part of the read mode interrupt service ▶ routine compares two successive console fields and transfers information on differences to the packed data field.

Furthermore, the key codes for the three divisions were divided exclusively by the least significant half-byte. From then on, things fell into place quite easily. For example, the address of the first byte in the table for any of the 49 Hauptwerk keys is found by adding B800H. Thus the register number for C3 (4333H in ASCII) is stored at FB33H, whilst its status is stored at FB53H. The Z (for #) adds a further 10H to give the corresponding table addresses for HC3#: FB43H and FB63H. At a later stage, extra routines were added to convert flats (indicated by]) to the corresponding sharps. The same conversion process works for all notes except A♭ for which an extra test is required, as shown in List 3. Again to keep the table reasonably compact the stop codes (e.g. P8 for Prinzipal 8') are divided into two groups: the first group having initial character P, Q, R, S, T, U, V, or W with all others in the second group.

The thumbpistons on the instrument in question are divided into five groups designated A1 to E3, plus four "disables". These codes are converted in a similar manner. The complete table of conversion factors (apart from those for the thumbpistons which are specific to the instrument) is shown at the foot of this column.

Some rearrangement might be required for different stop lists. The stop names and codes used on the instrument to which the interface is connected are shown in Table 2.

The directory character L (lift) causes a search through the 16 bytes of the console field which represent keys and pedals. If the status of any of these is non-zero, their register numbers are read to the data field with status zero. The console field is also reset to zero. Later keying entries in the same frame might cause a further change of status, but the final status is left in the console field when the data field is unpacked by operation in play mode.

When the translate routine is operated, up to eleven lines of 48 characters in video ram are scanned directly, one or two characters at a time, by the video ram pointer according to the video ram line and column count (VRLC and VRCC). Scanning ceases at ":". Spaces are ignored, except for the ones which define the ends of Duration definitions. Following any space, any character apart from the eight directory characters is treated as an error.

The knottiest part of this section is the part which sorts out the natural, sharp and flat notes and the keyings from releases. One way of doing this is shown in list 3, in which the two-character key codes as typed are designated VRNC (video ram note code) whilst the contents of the look-up table (LUT) are designated ORN and ORS (organ register number and organ register status).

List 3. In translate mode, each key code can have one or two following characters to indicate sharp, flat and/or release. This routine determines the appropriate conversion factors.

```
ZEAP Z80 Assembler - Source Listing

0E29           TSTNC  ORG  0E29H ; MC4, 9 & 10 : TEST VRNC
0E29                  ENT  ;           & CONVERT IT TO LUT ADDRESS
0E29 22590E           LD   (0E59H) HL ; Ready VRP
0E2C 23  .            INC  HL          ;) Inc. twice to after
0E2D 23               INC  HL          ;) VRNC
0E2E C3700F           JP   0F70H       ; Goto flat routine
0E31 FE5A             CP   5AH         ; Z? (sharp test)
0E33 2811             JR   Z 13H       ; Hop if sharp & load store
0E35 3E00             LD   A 0         ;) Load "black" note store
0E37 32AB10           LD   (10ABH) A   ;) inactive
0E3A 7E               LD   A (HL)      ; Reload same character
0E3B FE2D             CP   2DH         ; -?
0E3D 2811             JR   Z 13H       ; If -, goto load - store
0E3F 3E00             LD   A 0         ;) Load - store inactive
0E41 32AE10           LD   (10AEH) A   ;)
0E44 1811             JR   13H         ; Goto VRNC routine
0E46 3E10             LD   A 10H       ;) Load "black" store
0E48 32AB10           LD   (10ABH) A   ;) active
0E4B 23               INC  HL          ; Inc. VRP
0E4C 05               DEC  B           ; Dec. VRCC
0E4D 7E               LD   A (HL)      ; If "black" note,
                      ;                  load - or space
0E4E 18EB             JR   -13H        ; Goto - test
0E50 3E01             LD   A 1         ;) Load - store active
0E52 32AE10           LD   (10AEH) A   ;)
0E55 23               INC  HL          ; Inc. VRP
0E56 05               DEC  B           ; Dec. VRCC
0E57 E5               PUSH HL          ; Save VRP
0E58 2A590E           LD   HL (0E59H) ; VRNC to HL (see 0E29)
0E5B 54               LD   D H         ;) Um, turn it right
0E5C 5D               LD   E L         ;) way round
0E5D 63               LD   H E         ;)
0E5E 6A               LD   L D         ;)
0E5F CD900F           CALL 0F90H       ;) Call "A IF FLAT AND
0E62 010E             DEFS 10EH        ;) CONVERT VRNC"
                      ;            FLAT ROUTINE
0F70 3E00             LD   A 0         ;) Flat and A flat stores
0F72 32A110           LD   (10A1H) A   ;) reset (inactive)
0F75 32A310           LD   (10A3H) A   ;)
0F78 05               DEC  B           ; Dec. VRCC
0F79 05               DEC  B           ; Dec. VRCC
0F7A 7E               LD   A (HL)      ; Fetch next character
0F7B FE5D             CP   5DH         ; ]? (flat)
0F7D 2804             JR   Z 6         ; If flat, deal with it
0F7F 7E               LD   A (HL)      ; Reload same character
0F80 C3310E           JP   0E31H       ; Goto sharp test
0F83 3E01             LD   A 1         ;) Set flat store active
0F85 32A110           LD   (10A1H) A   ;)
0F88 3E10             LD   A 10H       ;) Set "black" note
0F8A 32AB10           LD   (10ABH) A   ;) store active
0F8D C34B0E           JP   0E4BH       ; Go back for next chrctr.
                      ;      "A IF FLAT AND CONVERT VRNC"
0F90 3AA110           LD   A (10A1H)   ; Flat store contents to A
0F93 FE00             CP   0           ; Inactive?
0F95 280A             JR   Z 0CH       ; Hop if inactive
0F97 7C               LD   A H         ; Note letter code to A
0F98 FE41             CP   41H         ; A?
0F9A 2005             JR   NZ 7        ; Hop if not A
0F9C 3E07             LD   A 7         ;) Load A flat store
0F9E 32A310           LD   (10A3H) A   ;) active (reset at 0F75)
0FA1 ED5BA610         LD   DE (10A6H) ; MSB       ) Convert
0FA5 19               ADD  HL DE       ;           ) VRNC
0FA6 ED5BAB10         LD   DE (10ABH) ; "Black"   ) to table
0FAA 19               ADD  HL DE       ;           ) address of
0FAB ED5BA010         LD   DE (10A0H) ; Flat      ) ORN
0FAF ED52             SBC  HL DE       ;           ) by adding
0FB1 ED5BA210         LD   DE (10A2H) ; A flat    ) conversion
0FB5 19               ADD  HL DE       ;           ) factors
0FB6 C9               RET  ;             Return & continue
```

Additional characters could be added to the main directory. For example, "," instead of ";" indicating a bar line before the next duration, using a different frame byte; would enable the microcomputer to vary rhythm and tempo. "X" might be used for expression (swell pedal) followed by a number in the range say 0 to 1FH to indicate degree of opening. This information could also probably be stored in the frame byte.

Usually it is not necessary to type everything in. Most music contains sequences (phrases repeated at a different pitch) and echo passages. When this occurs the first phrase can be edited for the second or subsequent phrases.

Polyphonic extemporization

By this time, the original 150 instructions had grown to some 5K bytes of code, documented in about 60 pages of minute manuscript, some of which had been rewritten several times. Things were getting unwieldly and an alternative approach to programming seemed to be required. Forth came to the rescue. Using 'character fetch' and 'character store', together with four machine-code Forth words mainly extracted from the earlier programs, communication was soon established between the console field, the data field and the Forth stack. New console fields quickly blossomed, each one having its start address defined by a Forth constant, with

Continued on page 53

	Manuals		Pedals	Stops					
				First group			Second group		
Initial or second character	H	R	P	H	R	P	H	R	P
For m.s.b. address, add	B800	B805*	B80A*	A7D0	A870	A840	AFDO	B070	B040
To convert to l.s.b. address, add	0020	0020	0020	0001	0001	0001	0001	0001	0001
To convert to second group address, add							0800	0800	0800

*OK for keyboard compass to B5. Use B806 and B30C if C6 is needed. Additional conversion factors are used for "black" notes (0010), flats (0100) and A♭ (0700).

Digital filter design procedure

These examples of the design of a simple digital filter (June issue) and that of a fourth-order Butterworth filter show how laborious maths may be simplified and the recurrence formula written without having to solve a fourth-order equation.

by J. T. R. Sylvester Bradley

Many digital filter requirements can be met without any more algebra than as shown. It remains a problem, however, to design a low-pass filter with anything approaching an ideal characteristic, just as it does in the analogue world. The well-known Butterworth filter has a flat characteristic in the pass band and a steep roll-off depending on the filter order. In the example, a digital equivalent to a Butterworth filter is designed, and rather laborious algebra is involved. So far as is possible, this is worked in general form so that it can be applied to other filters with different cut-off frequencies, and one or two short cuts are pointed out.

To obtain a steep roll-off a high order is required, but this would need many terms in the recurrence formula, resulting in a time delay that would probably be too great for the filter to operate in real time. The order must be chosen with the ability of the hardware in mind. With this in view a fourth-order filter is worked as an example, as this is the minimum order which shows the Butterworth characteristic clearly.

Cut-off frequency is a function of the sampling frequency. Suppose a 4kHz base-band slot were sampled at the Nyquist rate (8kHz), with the requirement to filter the input so that there is no distortion in the pass band and a sharp cut-off at 3kHz. Then the required cut-off frequency is 3/8 of the sampling frequency: $f_c=3f_s/8$.

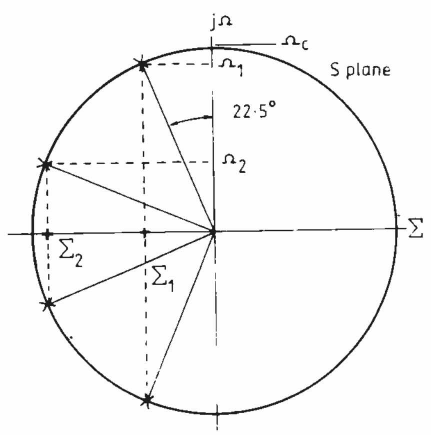


***Fig. 9.** S-plane diagram of a fourth-order (analogue) Butterworth filter.*

Bilinear transformation. The analogue Butterworth filter has a transfer function with a flat characteristic at low frequencies, rolls off sharply at the cut-off frequency and falls to zero at an infinite frequency. The digital version must follow the analogue characteristic as closely as possible, with a flat characteristic in the pass band, roll-off sharply at cut-off, and then fall to zero at f_{max} (not infinity, as for an analogue filter; f_{max} is half the sampling frequency and is the maximum frequency that can be processed by the digital filter). We have to make the frequencies on the z-plane correspond with those on the s-plane of the analogue equivalent. One way to make the frequencies correspond is use the mapping*

$$s=\frac{2(z-1)}{z+1}.$$

It follows that the frequencies on the z-plane are represented by angles (ωT) so

$$\omega T=2\tan^{-1}\omega/2.$$

T is the sampling period. Thus the z-plane maximum frequency is ω_{max} corresponds to an analogue frequency given by

$$\tan\frac{\omega_{max}T}{2}=\tan 90=\text{infinity}.$$

So having chosen the cut-off frequency ω_c as 3/8 sampling frequency on the z-plane the equivalent analogue cut-off frequency Ω_c is

$$\Omega_c=2\tan\frac{\omega_c T}{2}.$$

In general, for a nth-order filter H(s)=

$$\frac{\Omega_c{}^n}{(s+\Sigma_1\pm j\Omega_1)(s+\Sigma_2\pm j\Omega_2)\ldots(s+\Sigma_{n/2}\pm j\Omega_{n/2})}$$

*See page 207 of Digital Signal Processing by Oppheim and Schafer.

There are poles on the s-plane where $s+\Sigma_i\pm j\Omega_i=0$ (i=1 to n/2). Using the transformation given, the poles on the z-plane are where

$$\frac{2(z-1)}{z+1}+\Sigma_i\pm j\Omega_i=0.$$

$$\therefore \text{For}+j\Omega_1,\ 2-2z=\Sigma_1 z+j\Omega_1 z+j\Omega_1+\Sigma_1.$$

$$\therefore \text{For pole 1, } z_1=\frac{2-\Sigma_1-j\Omega_1}{2+\Sigma_1+j\Omega_1}.$$

Design method

- Filter data: f_c 3kHz, f_s8kHz, $\therefore f_{max}$ =4kHz and

$$\omega_c T=\frac{2\times 3000}{8000}=2.356.$$

- Pre-warp the cut-off frequency to obtain the equivalent analogue cut-off frequency

$$\Omega_c=2\tan\frac{\omega_c T}{2}=2\tan 1.178=4.828.$$

- Draw the s-plane diagram for the equivalent analogue Butterworth filter. This has poles distributed equally round the left-hand side of a circle (the Butterworth circle) of radius Ω_c, Fig. 9. The positions of the poles are given in terms of $\Sigma+j\Omega$ as

p_1 $\quad\Sigma_1=\Omega_c\sin 22.5=1.848$
$\quad\Omega_1=\Omega_c\cos 22.5=4.460$
p_2 $\quad\Sigma_2=\Omega_c\cos 22.5=4.460$
$\quad\Omega_2=\Omega_2\sin 22.5=1.848.$

Similarly for p_3 and p_4 in conjugate positions.

- Find the positions of the corresponding poles on the z-plane.

For p_1 $\quad Z_1=\dfrac{2-\Sigma_1 j-\Omega_1}{2+\Sigma_1+j\Omega_1}$

$$=\frac{2-1.848-j4.460}{2+1.848+j4.460}=0.758\angle-137.2°$$

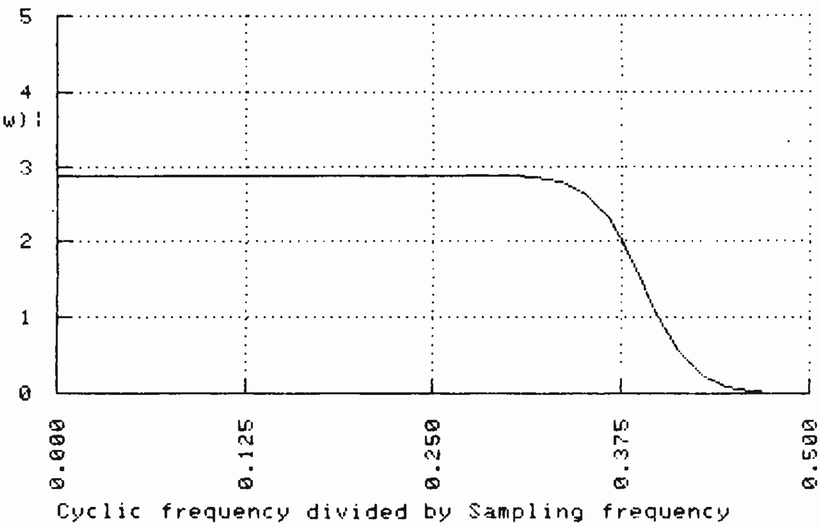
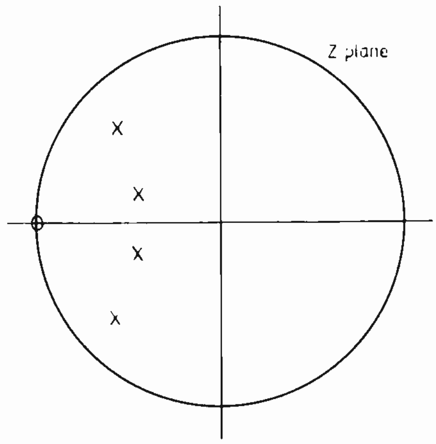


Fig. 10. Z-plane diagram and $|H(j\omega)|$ frequency spectrum of the fourth-order digital Butterworth filter showing a typical flat response up to the cut-off frequency.



for p_2

$$Z_2=\frac{2-4.460-j1.848}{2+4.460+j4.460}=0.458\angle 159.1°$$

with P_3 and P_4 as their conjugates.

● Draw the z-plane diagram and hence the $|j\omega|$ spectrum of the filter, Fig. 10.

● Find the z-transfer function H(z) from H(s). In general form first,

$$H(z)=\frac{G(z+1)^4}{z+a_1.z^4+a_2.z^3+a_3.z^2+a_4}$$

where a_1 to a_4 are the pole parameters, and G is a gain factor. The zero parameters are the coefficients of z in the numerator, which could be found by multiplying out. But this is not necessary as the coefficients are simply the binomial coefficients, which for the fourth-order expression are 1, 4, 6, 4, 1 (b_0, b_1, b_2, b_3 and b_4). Now in general

$$H(s)=\frac{\Omega_c^4}{(2+\Sigma_1\pm j\Omega_1)(s+\Sigma_2\pm j\Omega_2)}$$

$$=\frac{\Omega_c^4}{As^4+Bs^3+Cs^2+Ds+E}$$

where $A=1$

$B=2\Sigma_1+2\Sigma_2$

$C=\Sigma_1^2+\Omega_1^2+\Sigma_2^2+\Omega_2^2+4\Sigma_1\Sigma_2$

$D=2(\Sigma_1^2\Sigma_2+\Omega_1^2\Sigma_2+\Sigma_1\Sigma_2^2+\Omega_2^2\Sigma_1)$

$E=\Sigma_1^2\Sigma_2^2+\Omega_1^2\Omega_2^2+\Omega_1^2\Sigma_2^2+\Sigma_1^2\Omega_2^2.$

To find H(z) use the bilinear transformation and substitute $s=2(z-1)/(z+1)$, whence

$$H(z)=\frac{G}{16A\left(\frac{z-1}{z+1}\right)^4+8B\left(\frac{z-1}{z+1}\right)^3+4C\left(\frac{z-1}{z+1}\right)^2+2D\left(\frac{z-1}{z+1}\right)+E}$$

The denominator multiplied out and with like terms collected is

$(16A+8B+4C+2D+E)z^4+$
$(-64A-16B+4D+4E)z^3+$
$(96A-8C+6E)z^2+$
$(-64A+16B-4D+4E)z+$
$(16A-8B+4C-2D+E)$

Now obtain the coefficients of z in the H(z) transfer function equation by evaluating A, B, C, D and E from the values for Σ_1, Ω_1, Σ_2, Ω_2 given earlier ($\Sigma_1=\Omega_2=1.848$, $\Sigma_2=\Omega_1=4.46$). Then

$A=1$
$B=2\Sigma_1+2\Sigma_2=12.616$
$C=\Sigma_1^2+\Omega_1^2+\Omega_1^2+\Sigma_2^2\Omega_2^2+4\Sigma_1\Sigma_2=79.58$
$D=2(\Sigma_1^2\Sigma_2+\Omega_1^3\Sigma_1\Sigma_1^2+\Omega_2^3)=294.04$
$E=\Sigma_1^2\Sigma_2^2\Omega_1^2\Omega_2^2+\Omega_1^2\Sigma_2^2+\Omega_2^2\Sigma_1^2=543.2$

The parameters of z in the denominator are conveniently evaluated using the tabular form shown on the next page (top). Totals are normalized to a_0. This only affects G, which can be made any convenient value in a digital filter, so dividing both numerator and denominator of the general H(z) by a_0 yields

$a_0=1$
$a_1=1.968$ $\quad a_3=0.7242$
$a_2=1.734$ $\quad a_4=0.1203$

and substituting these values in H(z) gives the transfer function H(z)=

$$\frac{G(z+1)^4}{z^4+1.968z^3+1.734z^2+0.7242z+0.1203}=\frac{Y(z)}{X(z)}$$

The coefficients of x and y in the recurrence formula can be read directly from the transfer function in this form

y coefficients	x coefficients
$a_1=-1.968$	$b_0=1$
$a_2=-1.734$	$b_1=4$
$a_3=-0.7242$	$b_2=6$
$a_4=-0.1203$	$b_3=4$
	$b_4=1$

The b coefficients in the recurrence formula are simply the fourth-order binomial coefficients. Cross-multiplying gives

$$Y(z).z^4+1.968Y(z).z^3+1.734Y(z).z^2+0.7242Y(z).z+0.1203Y(z)$$
$$=GX(z).(z+1)^4X(z)$$
$$=GX(z).(z^4+4z^3+6z^2+4z+1).$$

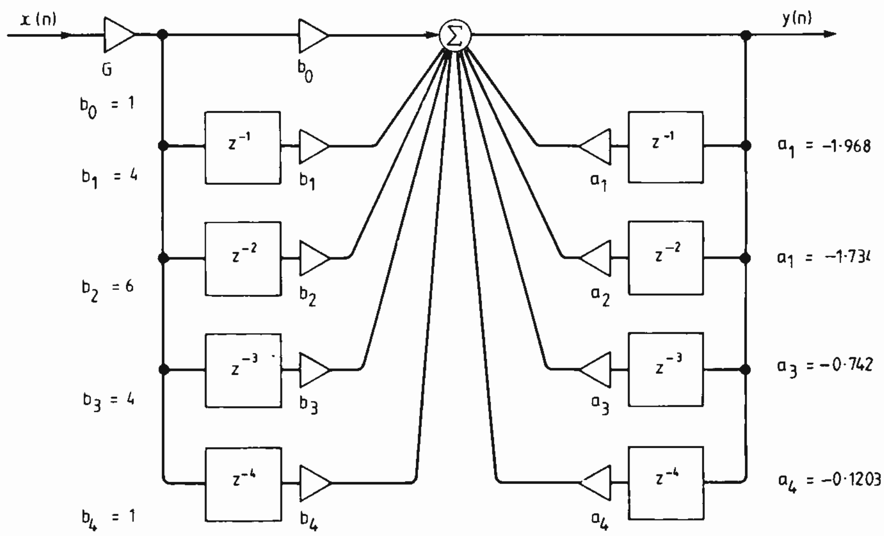


Fig. 11. Realization diagram for the fourth-order digital Butterworth filter.

	z^4 a^0	z^3 a^1	z^2 a^2	z^1 a^3	z^0 a^4
A	16A=16	−64	94	−64	16
B	8B=8×12.62	−16×12.62		16×12.62	−8×12.62
C	4C=4×79.58		−8×79.58		4×79.58
D	2D=2×294.04	4×294.04		−4×294.04	−2×294.04
E	E=543.2	4×543.2	6×543.2	4×543.2	543.2
Totals	1566.6	3083.1	2716.6	1134.5	188.5

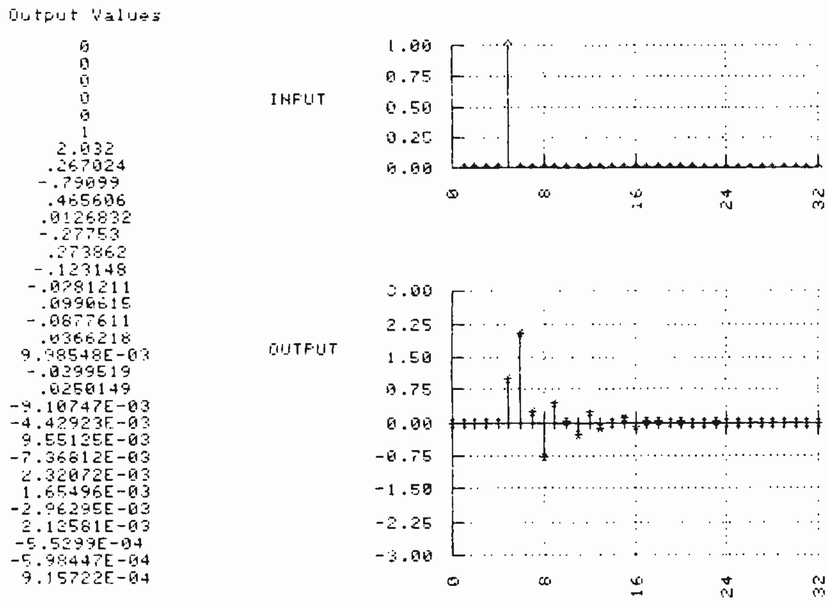


Fig. 12. Fourth-order Butterworth filter in action, showing impulse response with the filter "ringing" at ⅜ of the sampling frequency, as expected.

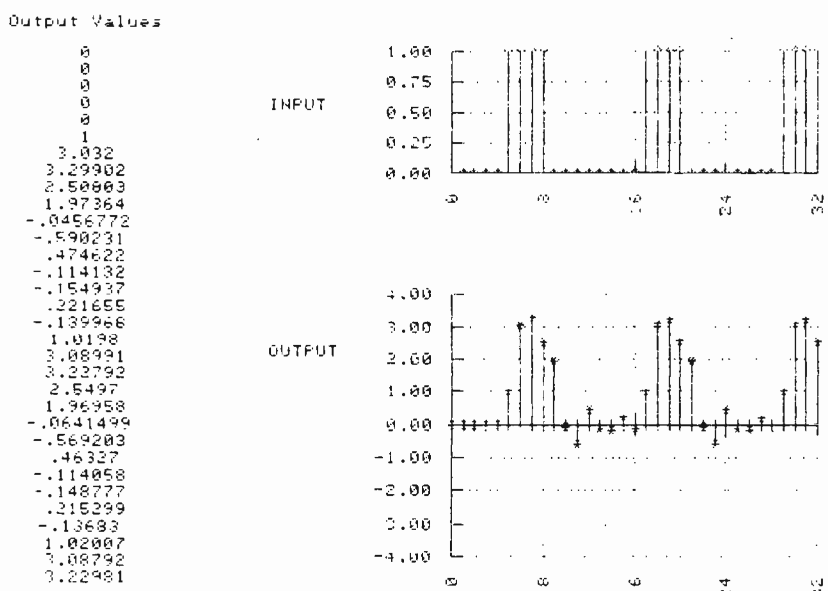


Fig. 13. Filter processing a series of four-sample pulses.

Dividing by z^4 gives

$$Y(z) = -1.968Y(z).z^{-1} - 1.734Y(z).z^{-2} - 0.7242Y(z).z^{-3} - 0.1203Y(z).z^{-4} + G\{X(z) + 4X(z).z^{-1} + 6X(z).z^{-2} + 4X(z).z^{-3} + z^{-4}\}$$

The gain G can be put external to the filter and can therefore be assumed equal to unity. The recurrence form is therefore and the realization diagram is drawn at Fig. 11. The recurrence formula can be

$$y(n) = -1.968y(n-1) - 1.734y(n-2) - 0.742y(n-3) - 0.1203y(n-4) + x(n) + 4x(n-1) + 6x(n-2) + 4x(n-3) + x(n-4)$$

written directly into a computer to realize the filter. Impulse response is shown at Fig. 12, from which it can be seen that the filter rings at ⅜ of the sampling frequency f_s, as expected. WW

Planning for plenty

continued from page 27

The Government shows no sign of being on the brink of licencing new radio services, perhaps because so far attempts to press it to do so have been ill-organised and incoherent. But it is important that engineers – without whom no radio services can ever be possible – become involved in the discussion about future directions for our radio services. Perhaps they can bring to it some clarity, cohesion – and common sense!

Further reading

Partridge, S. "Not the BBC/IBA: The Case For Community Radio" Comedia Publishing Group ISBN 0 906890 18 7 (9 Poland Street, London W1V 3DG)

Relay – the other magazine of the airwaves available quarterly from Box 12, 2A St Paul's Road, London N1 – annual subscription £2 for individuals

References

1. McLeod, N. "Community Radio" *Wireless World* vol 86 June/July 1980
2. *Commons written answers* no.59 and no.60 29 March 1983. Speaking specifically about community radio, Mr Whitelaw said: "... given the resource demands of other developments in the broadcasting field, and since the spectrum available in the longer term is not yet known, I have concluded that it would not be right to take matters further at present. However, in the preparation of UK proposals for the v.h.f. Band II Broadcasting Planning Conference next year, account will be taken of the possible needs of community radio with the aim of reducing the spectrum constraints which could otherwise apply in the future; and further consideration will be given to the possible development of community radio when the outcome of the Conference is known ..."
3. Local Radio Workshop Ltd. "Local Radio in London" ISBN 0-950-8114-0-8 (12 Praed Mews, London W2 1QY)
4. Sarah Clay & Partners, Report F19 "The Technical Feasibility of Community Radio in London" November 1979 (77 Park Road, Teddington, Middlesex TW11 0AW)
5. Home Office Local Radio Working Party – Third Report (50 Queen Anne's Gate, London SW1H 9AT)
6. Sarah Clay & Partners, Report F29 "Comments of the Third Report of the Local Radio Working Party" April 1981
7. Wireless Workshop "New Radio Services in London" January 1983 (25 Ditchling Rise, Brighton East Sussex BN1 4QL)
8. CCIR recommendation 368-2, XIIIth Plenary Assembly, Geneva, 1974 WW

Checking op-amps

Checking first-order integrity of op-amps with a transistor curve-tracer needs only simple interpretation, lending itself to "goods inward" testing.

by B. L. Hart

In analogue circuit development work involving the popular 741 operational amplifier it is useful to have available a simple, independent method of checking what might be termed the first-order integrity of the device, i.e. its capability of behaving as a direct-coupled differential gain block. There is certainly little point in making more detailed tests on parameters such as input offset voltage and common-mode rejection ratio until this has been established. This article describes the basis of a simple check that is applicable if a transistor curve tracer is available. The method has two major merits – first, no auxiliary power supplies are required, and second, no detailed interpretation of the display is necessary so the check can be performed by unskilled personnel, e.g. at a "goods-in" test stage.

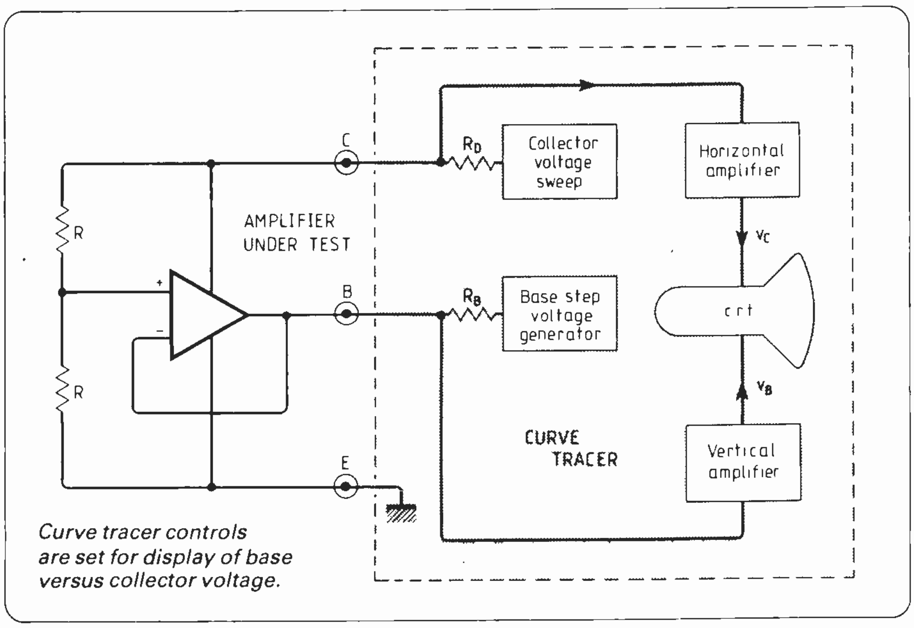
Terminals C,B,E are collector, base, emitter terminals of the transistor curve tracer the relevant parts of which are shown in block form inside the box. The positive collector voltage sweep of the curve tracer is applied, via the dissipation-limiting resistor R_D to the positive rail supply of the amplifier under test: the negative rail supply is earthed. The amplifier is connected for 100% d.c. negative feedback and an attenuated version of the collector sweep is applied to its non-inverting input terminal.

The controls of the curve tracer are set for display of base voltage *vs* collector voltage. The base step voltage generator cannot normally be switched off – a desirable condition for the check being performed – but its effect can be reduced by arranging for the display of the fewest small amplitude positive-going steps (e.g. four steps with step amplitude 10 mV) and using the maximum value of base drive resistor R_B.

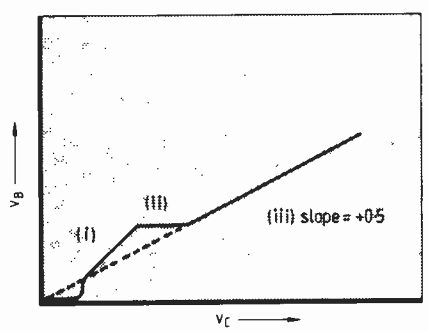
Circuit operation can be understood by reference to the signature of a good 741, sketched below. The characteristic has three parts: (i) $v_B=0$ initially because $v_C=0$ and R_B is effectively connected to earth, but when v_C starts to increase v_B rises to the lower saturation level of the amplifier; (ii) v_B remains almost constant at its saturation value as v_C increases because v_C is insufficient for all the bipolar devices comprising the amplifier to operate in the forward-active mode; (iii) v_B increases linearly with v_C. In this operating condition all the transistors of the amplifier operate in the forward-active mode and the feedback is operative. The circuit behaves as a unity-gain voltage-follower. As there is insignificant potential difference between the inverting and non-inverting terminals, $v_B - v_C/2$, so that the characteristic has a slope of +0.5 and when extrapolated back appears to pass through the origin of coordinates.

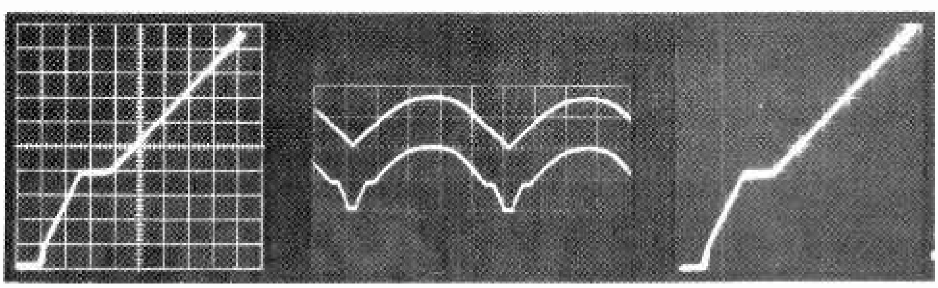
The precise location of (i) and (ii) of the characteristic might depend slightly on the particular amplifier but the location of (iii) should be independent of the specific parameters. It is this feature that forms the basis of the check of amplifier integrity. In (iii) there are large changes in the open-loop voltage gain A_V of the amplifier because A_V is a function of the rail supply. However, there is no significant effect on the slope of the characteristic as this is dependent on the expression $A_V(1+A_V)$ and $A_V \gg 1$ throughout region (iii). For practical convenience the curve tracer controls can be set so that the horizontal scale (V/cm) is twice that of the vertical scale. Then (iii) has an easily-recognized slope of unity.

The sweep test technique can obviously be adapted for use with an oscilloscope providing it has a time-base sweep voltage output socket and an x-y display facility. WW



Curve tracer controls are set for display of base versus collector voltage.





Characteristic of op-amp chosen from 75 amplifiers by several manufacturers (left) with circuit waveforms (centre). Double-exposure photo (right) shows coincident characteristics from two randomly chosen op-amps. Scales: 1V/cm horiz., 0.5V/cm vertical except for centre traces which are 5 ms/cm horiz., 5V/cm for V_C(top), 2V/cm for V_B (bottom). Curve tracer: Tektronix 575 (R_D=2k, R_B=22k, R = 10kΩ).

Bryan Hart B.Sc. M.I.E.R.E. is senior lecturer in electronics at North East London Polytechnic, Dagenham.

Resistance measuring unit

Designed as an optional extra for the precision voltmeter described in the June issue, but suitable for any high-impedance voltmeter having a 10mV range.

by W. J. Hornsby, M.I.E.R.E.

Obtaining quick and accurate measurements of resistance has long been a problem for designers and equipment users alike. There are two problems: one is the wide range of magnitudes required (10^{-7} or 10^{-8} to one) and the other is the fact that any moving-coil meter is current-driven and so the resistance-to-current relationship is reciprocal. The scale calibration of the meter will therefore not be linear.

In the average moving-coil test meter, even with a low current meter movement, we are restricted to two or at the best three highly non-linear resistance scales. In addition it is usually necessary to provide two power sources if the higher scales are to be useful.

A more accurate method but one far more tedious to operate is the Wheatstone bridge. This requires a galvanometer delicate enough to detect a fine balance yet robust enough to withstand the full out-of-balance current. The basic unit can be expensive and even more so if a two or three-coil galvanometer is employed.

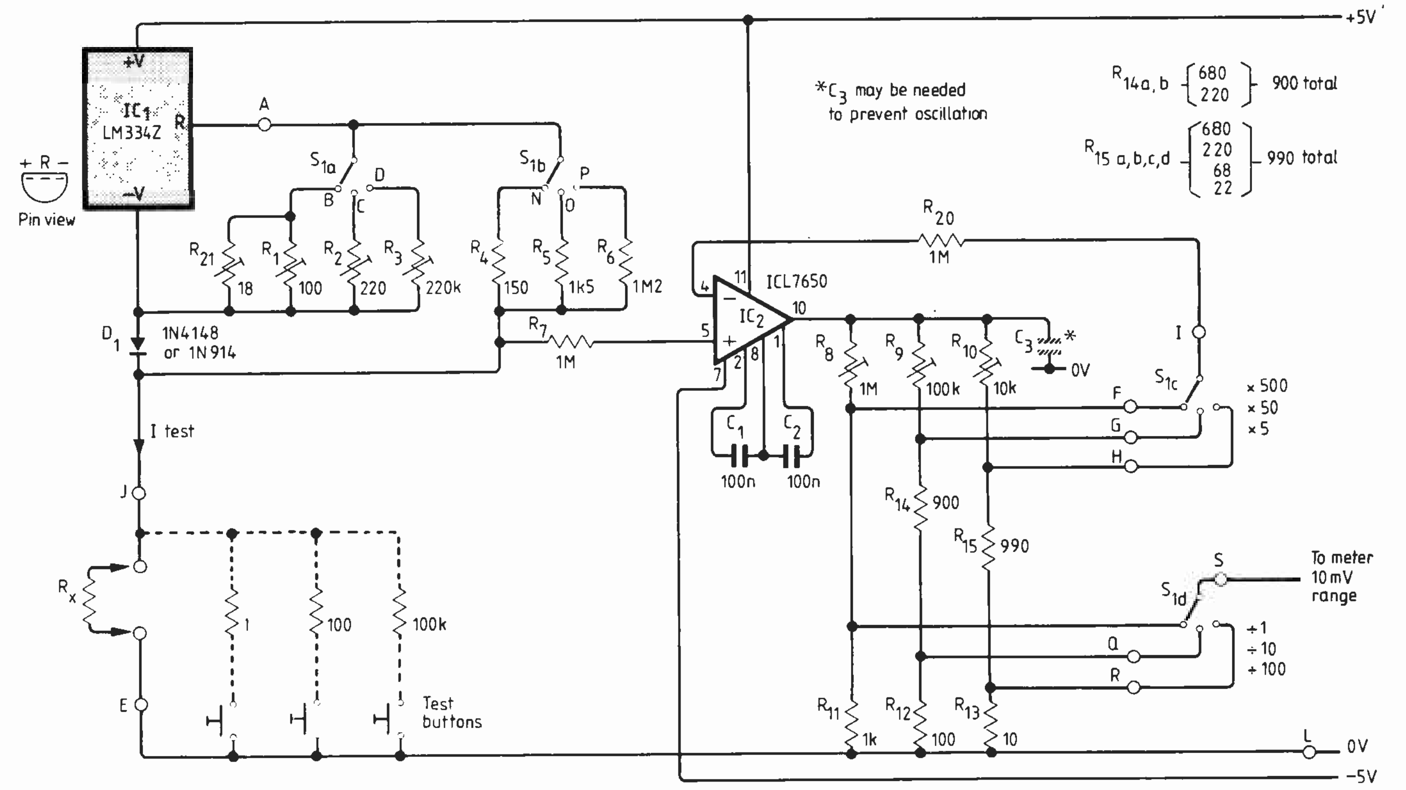
In more recent times the advent of the semiconductor and in particular the highly predictable operational amplifier has allowed the exploitation of two methods of resistance measurement long known but little used.

The first is the ratiometric method. In this case a current is passed through a known resistance and the unknown resistance in series. The voltage across each resistance is measured simultaneously and the value of the unknown resistance is then calculated as the value of the known resistor multiplied by the voltage ratio.

This method can be easily implemented by using the 7106/7107 type of digital voltmeter i.c. Reliable measurement can be made from tenths of an ohm (limited by lead and circuit resistance) to megohms (limited by resistor and circuit noise). The difficulty comes when the behaviour of a *changing* resistance is important: for instance, when moving a cable form looking for an intermittent short-circuit or earth connection an operator would not find it easy to cope with a continually changing set of numbers.

This article therefore concentrates on the second approach. In this method a specific current is passed through the unknown resistance and the voltage across the resistance is measured. If the current is constant then the voltage to resistance relationship is linear, resulting in linear scales (although one scale per decade is then required). However, if low voltage supplies are chosen, then very low currents with high stability will be required when high values of resistance are to be measured; and if a constant current circuit is used then when there is no load the voltage across the measuring terminals will rise very close to the supply. The following

Fig. 1. *In this complete circuit of the unit, IC_1 is a programmable constant-current source supplying a known current to the resistor to be tested. IC_2 protects the meter against overloading when the test terminals are open-circuit. ICL7650 is a chopper-stabilized operational amplifier – ordinary op-amps are not suitable. R_{14} and R_{15} may be assembled from standard-value resistors in series, as shown.*



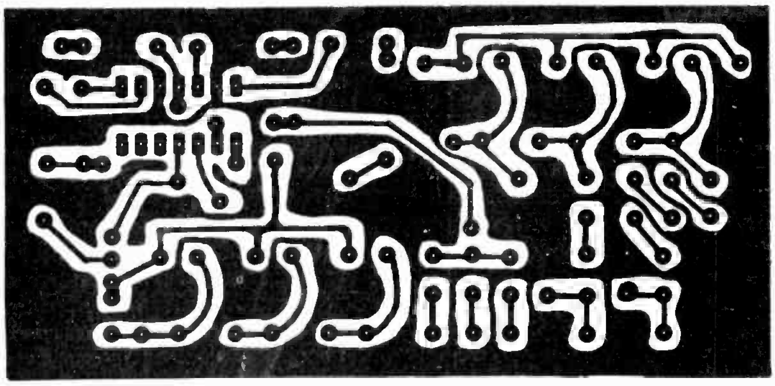


Fig. 2. Printed circuit board for the unit, shown full-size.

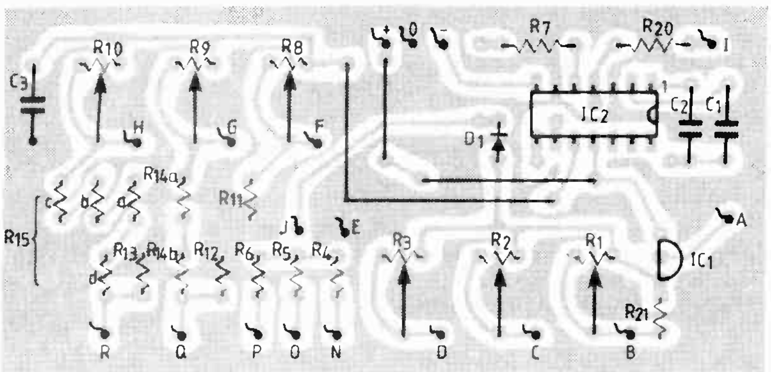


Fig. 3. Component plan for the printed circuit board.

voltmeter will then get a nasty surprise every time the resistance terminals become open circuit!

The constant current source can be provided using a purpose-made integrated circuit, but protection for the meter is more of a problem. All the i.cs used in the voltmeter described last month are capable of withstanding the full supply voltage at their input terminals; but there is still the meter movement to worry about because there is insufficient voltage headroom to incorporate current limiting in series with it.

The sensible answer is to place the limitation in the resistance measuring unit such that whatever the condition of its input terminals its output cannot exceed a value just in excess of full scale deflection of the voltmeter on its lowest range. The voltmeter could then be left switched to this range (or be directly connected) and the resistance scale switching effected from the resistance unit.

Circuit description

The circuit is shown in Fig. 1. IC_1 is a small transistor-sized i.c. designed to allow a constant current to flow in any circuit with which it is connected in series. The value of the current is determined by a resistor R_{set} connected between the R terminal and the negative terminal of the device. The i.c. is tolerant of a fairly wide voltage range across its terminals, but its output is temperature-dependent. Compensation is provided by the addition of D_1 and R_{comp} ($R_{4,5,6}$).

Without compensation the value of the current is calculated as $I(mA)=67.7/R_{set}$. Addition of the compensating components approximately doubles this value, and so the formula to use in this case is $I(mA)=67.7/(2\times R_{set})$. R_{comp} should be about ten times R_{set}. The term approximately is used because, strictly, the value of R_{comp} should be found by trial and error for each particular device; but the values indicated here will be found satisfactory.

IC_1 and D_1 drop about 1.6 volts. To leave some leeway, the voltage across the unknown resistor was calculated not to rise above 1V during measurement. With no resistance being measured (that is, the input terminals open circuit) the terminal voltage would rise almost to the supply rail. To prevent this, IC_2 (protected by R_7) amplifies the voltage across the input terminals in such a way that when this voltage just exceeds the maximum value permitted for the range in use, the output limits. The gain of the amplifier is changed by R_8-R_{15} to ensure that this is achieved. Taps are taken from the feedback network so that whichever range is selected, the output to the voltmeter provides a full scale deflection of 10mV. This obviates the need to switch the voltmeter.

Since there is no ready means of checking the current out of IC_1, test resistors (one for each current range) can be optionally included.

The ability to measure resistances over 1 megohm is not often required in radio work and its implementation is not practical using this circuit. This is because of the low voltage available and the limitation on the voltage applied to IC_2 ($\pm$8V). Dedicated equipment is more suitable for the measurement of high resistance and insulation resistance.

For the odd occasion when high values need to be measured a fair indication can be obtained by connecting the unknown resistance in parallel with a high value known resistor, measuring the pair, then calculating the value of the unknown using Ohm's Law.

Construction

A suggested p.c.b. is shown in Fig. 2, with a component overlay in Fig. 3. The layout can stand alone or it can be printed on the same board as the voltmeter. Position 7 of the voltmeter switch can be used for the add-on unit if the resistors which only use the switch as a tag-board are moved round. There is no need to have the voltmeter input divider present at all since the resistance unit output is 10mV. If the input and output leads are kept separate then the wires between the switch and board can be laced together.

Calibration

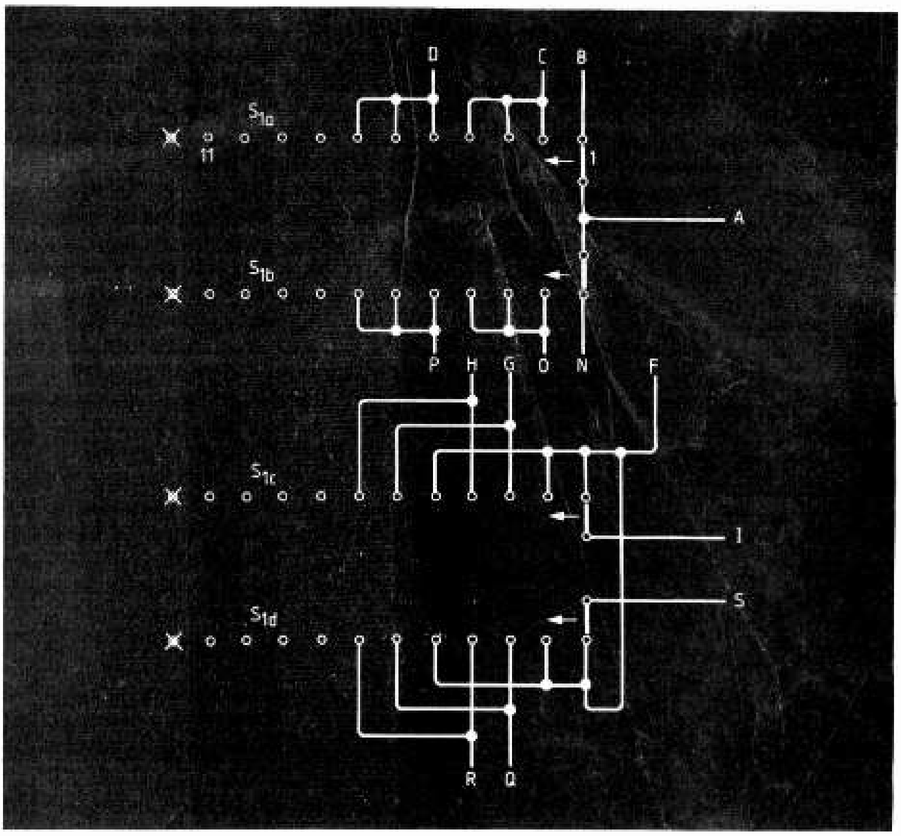
If the resistance unit is carefully set up there is no need for panel-mounted adjustments because the accuracy is independent of the supply voltage. There are two variables in the circuit: the test current and the gain of IC_2. It is unlikely that the average constructor will have the equipment to measure a current of one microamp with any degree of confidence except by indirect methods, so we must look for another reference point in the circuit. We have one if IC_2 is driven to its output limiting condition, provided that the supply voltages remain constant. However, as with the voltmeter itself, the internal current-limiting feature of the 7650 should not be used in this circuit (i.e. pin 9 of IC_2 must not be connected to pin 4).

Before starting to set up the unit, give the construction a final check, then put a pencil mark on the meter scale about two divisions (4%) past the end of the normal f.s.d. scale position. Leave the input terminals open circuit and set all resistance trimmers to half way except R_1 which should be set to maximum.

Power up the circuit and, if a battery model is being calibrated, set the supply voltage to 8V (equivalent to a low battery). Adjust R_8 on the 1Ω range, R_9 on the 100Ω range and R_{10} on the 100kΩ range so that the meter needle just rests over the mark previously made on the scale.

Now, a non-inverting amplifier under dynamic conditions has three points of equal potential: the two input terminals and the tap on the feedback divider. In this circuit the lower part of the feedback divider is fixed, therefore the voltage across this portion is equal to the input voltage. Those last three adjustments effectively set the gain of the amplifier so that with a 4% overload at the input we have a 4% overload at the output. At the same time we are defining the point at which the amplifier limits, thereby setting the maximum output to the following voltmeter when the resistance unit terminals are open circuit.

Fig. 4. Wiring the range switch S_1. Tags are shown diagrammatically, viewed from the rear of the panel. There are only 11 contacts on the front of each wafer: the twelfth is on the reverse side and is not used. The stop of the switch mechanism is positioned so that only the first seven contacts are used.



Having set the gain of IC_2 now set the test currents by switching the standard resistors to the input terminals and adjusting R_1 with 1Ω, R_2 with 100Ω and R_3 with 100kΩ to obtain full-scale deflection on the appropriate scales. The adjustments should be carefully carried out at each stage since the test currents and amplifier gains do not go in pairs: one test current serves three gain settings and so each adjustment should be as near perfect as possible.

In battery-operated models with a fresh battery fitted the limiting voltage of IC_1 is higher, so that under input open-circuit conditions the meter needle will hit the forward stop. Accuracy will not suffer, but IC_1 will not limit until an overload of more than 4% has been applied. The half-supply difference between a new battery at 9V and an old one at 8V is 12%. In the new-battery condition therefore the meter tries to read 112.5%, so it is in no great danger.

Scale	I	V(Rx)	IC_2 gain	V_{out}
1Ω	10mA	10mV	500	10mV
10Ω	1mA	10mV	500	10mV
100Ω	1mA	100mV	50	10mV
1kΩ	1mA	1V	5	10mV
10kΩ	1μA	10mV	500	10mV
100kΩ	1μA	100mV	50	10mV
1MΩ	1μA	1V	5	10mV

The table (left) indicates the status of the various parts of the circuit on different ranges; this may also be useful in interpreting the connections of the range switch.

For testing capacitors, the 1MΩ range can be used. The meter needle will move downwards indicating a low resistance until the capacitor becomes charged. Semiconductor diodes can be tested on the 1kΩ range, and the forward voltage drop of the diode deduced from the table. Obviously the test current cannot be forced through a reverse-biased diode.

Components

For the four sections of S_1, four one-pole 12-way miniature switch wafers may be used. The diodes and integrated circuits are obtainable from RS Components or from Technomatic Ltd. Cermet trimmers are recommended for the variable resistors. The fixed resistors should be 1% tolerance or better; a suitable range is available from Ambit International. WW

BOOKS

TV for Amateurs, by John L. Wood, G3YQC. Paperback, 52pp. Available from BATC Publications, 14 Lilac Avenue, Leicester LE5 1FN, for £1.75 including inland postage.

It is said that around one-sixth of British households now have a video recorder. No doubt amongst all those householders there must be quite a few who would like to use their video equipment on the air; and for them, this book provides an excellent practical guide. It does not attempt to replace the more comprehensive Amateur TV Handbooks also published by the BATC, but provides enough circuit designs and background information to enable the average radio amateur to set up a basic television station. There is a useful section on operating practices and, for the more faint-hearted, a list of sources of some of the commercially-made transmitting equipment now becoming available to the t.v. amateur.

STTI's International Satellite Television Reception Guidebook, by Stephen J. Birkill. 78 pages 8½in x 11in, paperback, from Satellite Television Technology, PO Box G, Arcadia, Oklahoma 73007, USA. Price $40.

After the less-than-rapturous reception accorded by the British public to the latest newcomers to the television airwaves, some may wonder how many more channels the viewer really wants. For satellite television enthusaiasts, such considerations of programme content do not apply. In the United States, and increasingly in Europe, commercially-available satellite receiving terminals for the home are making it possible even for non-technical people to eavesdrop on the multitude of programmes from the skies. This book is aimed at the installers and owners of such equipment, and it offers a satellite-by-satellite guide to the sort of transmissions to expect and where to look for them. As well as broadcasts for direct reception, these include distribution links for terrestrial t.v. services and international exchanges such as the daily news feeds.

The author is one of the leading British authorities on satellite t.v. reception, and he provides a great deal of practical information which is otherwise difficult to obtain – for example, technical details and operational information about some of the many Soviet communications satellites, much of which has been compiled from his own detailed observations. It must be hoped that the engineers at the Dubna ground-station are not already behind bars as a result of Mr Birkill's revelations: on Friday nights, apparently, they keep their Gorizont satellite channel open with such un-Soviet material as Bugs Bunny cartoons and old editions of BBC-tv's 'Top of the Pops'.

The book contains no constructional information, though it does offer a few technical suggestions for improving reception. Among these are hints at ways of getting round the video and audio scrambling on which some of the more unsporting telecommunications authorities insist. The text is extensively illustrated with off-screen photographs, mostly taken at the author's home in the North of England, and the many diagrams include visibility charts and band plans for a wide range of satellite-borne services. It is a pity that the book is so expensive.

LETTERS

KNOW HOW – RESOURCE OR PROPERTY

Your editorial (April, 1983) poses a fundamental question: to whom should the resources of the planet (including the airwaves) and technology (including the entire means of production, distribution and communication) belong? The Right and Left appear to have opposing answers, but in reality their social objectives are more similar than they are different. Both Right and Left stand for a minority possession of the earth's resources – even though the state capitalism of the Left is presented as 'public ownership'. Both Right and Left accept the market as the economic arbiter of need – with the Left indulging in Keynesian fantasies about regulating the market so as to make profit coincide with need.

The alternative to a system of minority ownership and control, where goods and services are produced for sale on the market with a view to profit, is a social order based upon common ownership and democratic control of the earth by all of its inhabitants. In such a system of society production will be solely for use, with no buying and selling, but free access to the available resources. The aim of creating a genuine socialist society defies the imaginations of both the Right and the Left, both of which confine themselves to the sterile debate between private and state capitalism. Yet in a world which modern communication technology has turned into a global village, are not those of us who aim to end property and the market and simply produce for use attempting no more than to harmonise productive forces – which are the product of an age of science – with social relations – which, in their present, capitalist form, are a product of centuries past?

Stephen Coleman
Clapham
London

PROGRESS?

By now your readers must all have a wide selection of electronic equipment around the house and in the interest of progress it is time to take a look at the most old-fashioned and inefficient of these, the telephone. To do so may assist anyone contemplating working for British Telecom.

In ten years in central London my phone has gone wrong dozens of times and has taken up to three weeks to repair. Lately research on these goings-on has uncovered an internal message system instituted since the split with the Post Office and rather slower, which is doubtless a good deal more costly as well on account of the much smaller traffic. Another discovery is that the microphone inserts are liable to failure every few years which leads to inadequate current for dialling, but they can often be ameliorated by banging. However at best they only yield faint speech at the other end due to their inherent weakness and the long runs of thin underground wiring met in calls across London; this lack of decibels cannot be cured as it does not officially exist.

However what we have here is a century-old instrument that has retained a tariff keeping its use to a fraction of the public (when modern technology would have started by considering every household a market and worked from there) and causing severe worry to commercial firms, with many exchanges still based on priniciples developed by an undertaker, Strowger, bent on preventing eavesdropping by operators who apprised his rivals of deaths, thus emphasising the lack of privacy carefully maintained by British Telecom today with massive bugging installations which Duncan Campbell of the New Statesman has pointed out beam to American bases by microwave the entire cross-channel telephone traffic for some reason – a wild allegation which a Parlimentary reply carefully avoided denying. (There are said to be rocks ahead over enabling BT *as a private firm* to continue this task.)

A friend who worked at the BT HQ complained that he was kept re-hashing stuff from 6 years before but in the matter of telephone exchanges their deficiencies are more serious. After taking 10 years to perceive that the gas-tube driven one at Highgate Wood did not actually work, they embroiled British manufacturers in the TXE4 which was an early Sixties design still being tidied up in the middle Seventies.

About that time they wrote to my mother explaining they were about to install the latest electronic equipment and I observed they wouldn't even recognise the latest electronic equipment if they saw it. How unkind was this? Well, the right thing to run telephone exchanges is a computer, but ITT, according to Anthony Sampson's book "ITT – the Corporate State", used to keep a man in New York specially to stop engineers developing computers, since this might have involved some sort of collision with IBM. So there they were messing around with r.t.l. in the TXE4, and System X was born, another failure the last I heard.

When I consider the robust telephones we had before the war which often had to be held away from the ear to reduce volume for comfort, much the same as the instruments people were using on 300-mile runs of robust overhead wires before 1900, I remark that since then we have been robbed of telephone numbers by the introduction of STD, whereby the dialling code is a function of two variables, caller's exchange and exchange called. We have been given coin boxes which do not take 20p pieces followed by coin boxes which do not take 5p pieces, and the latter have no provision for directories.

None of this is funny at a time when electronics everywhere is getting cheaper in leaps and bounds. Obviously the private telephone is a cost problem since many people only make 2 calls a week. The obvious answer these days is simply to incorporate elaborate micro-circuits to do something fairly appropriate; I suspect this would first involve bunching phones in fifties on a sort of ring main rather like the first transatlantic cable speech amplifiers, supplying +50V and −50V and allowing each phone a 1.5V drop as its supply; speech and instructions would be digitized and sent by packet-switching techniques, but later I would expect telephones to be powered from subscriber's mains so they could use optical fibre connections. In view of techniques of optical isolation available for decades now at speech frequencies, I would expect subscribers to be able to have such isolation if they wished and then to be allowed to connect anything they pleased provided it would receive and transmit calls while avoiding the frequencies used by BT for dialling via trunk lines.

Bernard Jones
London W1

AERIALS AT SEA

Perhaps we are tiring of the subject of 'Aerials at sea'. However, I have a suggestion relevant to liferaft aerials.

A useful aerial would be a vertical loop. This works well at low height, and as it is low-impedance, would not be too upset by salt spray. The main problem with a loop is to obtain a sufficiently low r.f. resistance. This is achieved by using a sufficiently large gauge of conductor, which may be hollow, because of skin effect.

I imagine a loop in the form of an inflated torus, similar to a large bicycle inner tube, metallized on the enclosed surface, made part of the structure of an inflatable liferaft.

As a starting point for a design, a land-based rigid loop, as used by the US Army, is described in "Amateur Radio Techniques" by Pat Hawker (G3VA) (p 234, 5th edition).

D. Parnell
Pickering
N. Yorkshire

RADIO AMATEURS EXAMINATION

The periodic review of the syllabus for the Radio Amateurs Examination is now due and the City and Guilds R.A.E. Subject Committee has established a working party for this purpose.

The principal objective of the examination is to ascertain the candidate's ability to operate an amateur station within the terms of the licence and not necessarily to test expertise in particular aspects of the Amateur Service. Suggestions for alterations or amendments to the existing syllabus would be welcome and should be sent to Mr S. D. Allison, City and Guilds of London Institute, 46 Britannia Street, London WC1X 9RG.

S. D. Allison
City and Guilds
of London Institute

CITIZENS BAND

Having followed, within the pages of *WW*, the running battle about CB in your country for some time, I am finally moved to make the profound comment, "history repeats itself".

To read these letters bemoaning the advent of CB by some amateurs, and the such lucid arguments for its introduction by those in favour, is to pick up dusty back issues of many local (Australian) magazines of nearly a decade ago.

Now it's legal, and still the battle continues. With the benefit of my 20-20 hindsight, may I make a few observations, as it is possible to interpolate between the British scene and that which convulsed Australia and led to so many changes.

Many amateurs believed that CB would lead to the demise of amateur radio as a hobby. This has as yet not happened in this country; in fact the opposite has taken place. The number of amateur licences has increased rapidly. The main "new friends" have come up through the ranks of the CB operators.

At first there was a large amount of piracy outside the legal allocations, but apart from the few 'hard core', who have always been with us, this seems to have lost its fascination. There was a time when nearly all the repeaters had their trouble makers, it took some time to educate some of the normal users of these devices not to react, as this surely gave 'them' the encouragement to continue. The worst of these offenders were caught and dealt with by the authorities, in due course.

It was a two way learning process, the staff of 'Telecom' had a lot of lessons to learn, not in the least hindered by the archaic wireless telegraphy act, that has yet to be brought up to date with changes since the two world wars. But now it seems to be working. The rationalization of the processes of obtaining a CB licence and the availability of cheap, mass produced equipment for the 'legal' channels, has provided the majority with what they want, personal two way radio.

The initial CB hysteria has died to quiet obscurity, in fact, many users have seen that they were used, by some, to make a great deal of money. Of the millions of CB users many now have amateur licences and many more have expensive CB equipment sitting in the cupboard unused for years. The once crowded bands are at times totally quiet: u.h.f. users have the repeater facilities once pioneered by the amateurs. In fact many amateurs have CB licences; you see the wife is not interested in A.R. but it's very useful to be able to contact her via CB.

Robert Wilkins VK3AUR
Tallangatta
Victoria

DESIGN COMPETITION

I was interested to see that one reader has come up with the idea of informing blind persons the contents of cans and packages without opening them. No further information was given.

I should like to suggest (if this is not the method used) that it would be a simple matter to 'read' the bar codes that are appearing increasingly on modern packaging by means of a light reader; decoding the information and removing extraneous information normally used in stock control; and presenting the edited information to the blind person by means of a voice synthesizer through a private earpiece.

Being completely without technological training I would nevertheless suggest that in this day of the chip it would not be beyond the realms of possibility to produce a fairly lightweight pack which could be worn like a handbag over the shoulder and weigh about the same.

Once the technique had been perfected there is no reason why bar-code labels could not be used in other circumstances to aid the blind to read. We already see these codes on the edges of supermarket shelves and on packaging. Why not make complete sentences and print books in the same manner. Naturally a monotonous Dalek 'voice' would never replace the enjoyment of silent reading that Braille offers but this would be ideal for official pamphlets for the blind, direction signs and other informatory instructions.

J. Devereaux
Wordsley
West Midlands

Some weeks ago you or one of your colleagues was interviewed on the BBC Radio London programme for the Blind "Guideline". I should like to put forward some suggestions for suitable projects that may be of interest to your readers.

Firstly, let me give you some background detail as to the reason for these suggestions. I am a member of the British Computer Association of the Blind, which is affiliated to the British Computer Society. The aims of the B.C.A.B. are to promote the employment and training of blind and visually handicapped people within the field of computing. Due to my specialist knowledge, I have a degree in electronics, I provide technical liaison for the association, particularly in relation to computer terminals for the blind and communications problems.

At the present time there are some 90 blind people in the UK, and the figure is growing every month, who use "paperless Braille machines". These are essentially microprocessor-based devices which have a "soft copy" electro-mechanical Braille display. They are used by blind people as computer terminals or word processors or simply to provide an electronic filing system. One of the major problems facing the blind, particularly the professional, is that of finding information, if, for example, a particular reference book is available on tape or in Braille. At the moment this information is held somewhat haphazardly in different locations and in different catalogues, with numerous supplements.

As a result of the increased availability of these machines the association has now begun to discuss the viability of setting up a data base for the visually disabled. Such a data base would provide information on Braille books, tapes and even aids available.

We would like ideally to use Prestel or a similar system. However, this poses a few technical problems which might be solved by one of your readers.

I should like also to make some general points of guidance to your readers. There is little point in re-inventing the wheel; talking terminals are already available from a number of sources. There is little chance that an individual will have the necessary resources to produce a better one. Simplicity is the best approach.

If a device is to be widely used, its cost must be low and it should be easy to use, remember that many blind are elderly.

Finally please do not hesitate to contact me if you would like any assistance or advice on the suitability of aids for the blind. The association is always pleased to support ventures which can benefit the blind and the field of electronics offers many as yet unexplored possibilities. My office telephone number is 0424 431344, ext. 6003.

Gary M. Robinson
St. Leonards-on-Sea
East Sussex

List of projects

Project 1.
Current Viewdata systems, Presstel etc use an asymmetric duplex system for the transmission and reception of the data between the users terminal and the data base. Unfortunately most of the paperless Braille machines used by blind people are designed to run under a more conventional symmetric duplex system.

A line speed convertor is therefore required to convert the 1200/75 asymmetric duplex signal used by the modem to a 1200/1200 symmetric duplex signal from the Braille machine. Since the conversion from 1200 to 75 baud is only required for the backward channel, and this data is coming from a keyboard any buffering problem will be minimal. Though commercial line speed convertors are available their cost is prohibitive and their capabilities are excessive for this simple task.

Such a device would enable a paperless Braille machine to be used in conjunction with one of the cheap "Presstel" type modems that are appearing on the scene and through it gain access to a data base.

Project 2.
A mains on/off timer.
This device which would control any mains device would plug into the standard 13 amp mains socket and the device to be controlled into it. The main feature would be that the time setting would be electronic and would have a spoken numeric readout. There are a number of simple numeric speech chips available so that speech in this simple case would not be difficult.

A more sophisticated version of this could be perhaps extended to give multiple settings both for on and off so as to allow the blind to have a timer control facility on things like tape recorders etc. Existing ones rely on the blind user being able to read Braille or have a good sense of touch and since they are tactile they can be somewhat inaccurate when trying to set a precise time.

Over the years there have been several methods for the disabled to signal help when they are in difficulties – cords, bells, lights, whistles etc. and, of course, the telephone. They are all so limited that they are virtually useless for the very people for whom they are most needed – the very severely disabled, including the frail elderly. When they fall to the floor, or in similar difficulty, they are helpless; they cannot reach any of the communication aids presently suggested.

What is needed is a portable fail-safe alarm, a device that can be worn round the wrist or neck which the person can immediately operate, activating automatically the telephone or similar means of communication to an outside source of help. I have to say that there are one or two such devices on the market, but they, too, are limited and, I think, expensive.

If something really suitable could be produced it would be a tremendous boon for the increasing numbers of disabled people. There would be an enormous market amongst them, and Social Services departments, especially with the increasing emphasis on community care.

I hope this will be taken up.

E. M. Cohen
Southend-on-Sea

STEPPER MOTOR DRIVE

Unfortunately, I do not seem to have got my main point over to B. S. Beddoe (May Letters), despite the headline description "simple, cost-effective."

My circuit is no more complex than the resistance limited drive it is intended to replace (just one extra small transistor Tr_1 per phase) and yet offers greatly improved efficiency, and hence savings in the cost of power supply components.

His circuit is only one resistor away from being a chopper drive (did he try positive feedback around the comparator?) and so is very much more complex then mine. He offers voltage control of current, better temperature independence and c.m.o.s. input. The price of these features in terms of component count, p.c. area and reduction of mean time between failures must be carefully evaluated.

Incidentally, nowhere in my article do I claim originality. I put the circuit in the category of "one of those obvious things that needs saying."

A. D. Bailey
Loughborough
Leicestershire

GATE SYMBOLS

May I ask for guidance through your columns as to what logic symbol is appropriate to indicate the function of the following circuit?

This gives an output only when one of the inputs is in the opposite logic state to the other two, and should thus, I presume, be called a Disparity Gate. The truth table is as shown

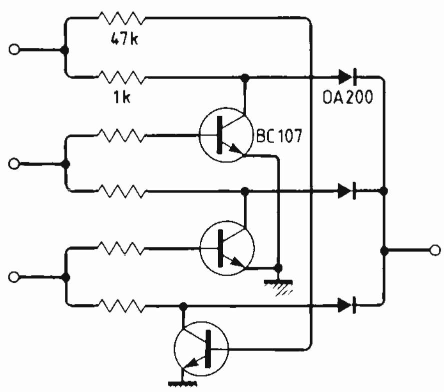
Inputs	Output
All 0	0
One as 1	1
Two as 1	1
All 1	0

When the new logic symbol pundits have worked out that one there is an elaboration of this circuit that can convert it into a Two out of Three Quorum Gate* which has the additional property of being exclusive.

Power supply? Anyone who has not been ordered to design circuitry without any power supply specified doesn't know what if feels like to be an electronic engineer!

J. C. Rudge
Harlington,
Middlesex

*J. C. Rudge (letter) Wireless World, July 1982.



INPUTS	OUTPUT
All 0	0
One as 1	1
Two as 1	1
All 1	0

HERETIC'S GUIDE TO MODERN PHYSICS

In his May article, Dr Scott Murray is yet again guilty of the inexcusable – misquoting facts out of context. This was blatantly manifested when he used Dirac's postulation of the positron as a pretext to an attack on the tunnel effect, despite the fact that there is no connection between the two.

Dirac's calculations had a square root in the result for the charge of electrons. This allowed them to have either negative charge-electrons, or positive charge-positons. Dirac predicted the existence of 'negative matter, in the sense that its constituent particles were oppositely charged, and so the term 'anti-matter' was coined. Dirac never suggested that positrons had negative mass. He did not have to 'explain' the positron; his mathematics predicted it and physics later confirmed its existence. Dr Murray appears to have confused the positron with its negative-mass 'cousin', the hole. The holes are gaps in a free electronic continuum, and in that context only can you have positively charged particles with negative mass.

In conclusion, Dirac's antimatter concept may appear in some science fiction, but it is very much science fact. Dr Murray's use of this, misquoted out of context and in any case totally irrelevant, is a very poor attempt to mislead gullible readers.

M. J. Niman
Manchester

In the May issue a number of letters critical of Dr Scott-Murray's long-running saga 'A Heretic's guide to modern physics' appeared. In commenting on mine Dr Murray wisely sidestepped the first two paragraphs and concentrated on the third. A number of ideas which were current half a century ago have not stood the test of time, and the notion of duality is certainly one of them. In a preceding, so far unpublished, letter I emphasized that 'quantum objects' such as photons and electrons were neither waves nor particles, exactly the point made by Mr Gleave in the May letters. Nevertheless Dr Murray in his first comment on my letter chose to flagrantly misrepresent me by stating that I had written as if 'light *is* both (particle and wave) simultaneously'.

In this context a feature not brought out by Mr Gleave is the fact that quantum mechanics provides a single mathematical description of photon behaviour which covers not only the quasi-particle and quasi-wave aspects, but in addition the in-between world typified by the remarkable kinds of behaviour shown in some types of Môssbauer experiments. Originally Planck and Einstein attributed properties to photons in an essentially *ad hoc* fashion, but for some decades now theoretical accounts of behaviour have been available (see Heitler's 'Quantum Theory of Radiation') which show that they must be regarded as behaving in a way far removed from the billiard-ball-like objects of Dr Murray's imaginings.

In the unpublished letter I also pointed out that the spectra of gamma rays from radioactive sources obtained using Ge(Li) detectors regularly showed features indicating that over a microsecond or so any bunching was less by some orders of magnitude than the millions which Dr Murray in his October article said he would settle for, yet that these gamma rays still showed interference effects, in that their energies (or wavelengths) could be determined by passing them through a quartz crystal acting as a diffracting grating. These facts too he felt entitled to ignore.

Turning to his second comment, I must first admit some order of magnitude difficulties of my own: a photon of visible light has a wavelength, not of some tens, but of some thousands of interatomic spacings. He asked in connection with the optical photo-electric effect 'why is it that only one of these (millions of) electrons is ejected by the photon's impact?'. The answer is simple – on the purely classical basis of the image force between a charge and a conductor it will take a finite amount of energy to remove even a conduction electron from a metal. Photons of visible light simply do not have enough energy to remove more than one conduction electron from alkali metals such as sodium and potassium.

He went on to ask 'what physical mechanism determines *which* electron is ejected, and 'how wide is a photon, please?' Now Doppler shift measurements show that the conduction electrons in metals have speeds of about 0.1% of the speed of light, some ten times the value to be expected from classical theory, but fully in agreement with the predictions of wave mechanics. If one assumes that the delay between a photon hitting the surface of a metal and any subsequent emission of a photoelectron is of the order of 1 ps, a typical conduction electron will in that time have travelled some thousands of times the average distance between neighbouring atoms, so that willynilly the photon will have interacted with electrons over an area comparable with the square of its wavelength. These same conduction electrons have De Broglie wavelengths of several interatomic distances, and according to wave mechanics this is the feature which allows them to move freely about in metals. Dr Murray really should try his hand at using his ideas to account for, say, the temperature dependence of the resistance of metals at liquid helium temperatures. Although no-one would realize the fact from reading his articles, it was the success of wave mechanics in interpreting this dependence and many other puzzling aspects of the behaviour of solid materials that first persuaded many physicists to consider the new theories seriously.

C. F. Coleman
Grove
Oxfordshire

Abstract Law is just as unbreakable in Copenhagen as anywhere else!

I have already touched briefly upon the law of pressure, resistance and flow: another is the law of decay from interaction.

The further interaction is reduced, the less decay there is. Insulators attempt to stop interaction, and they succeed more or less. There is not, nor can there ever be a perfect insulator, and any perfectly insulated device would be an absolute singularity having nothing to interact *with*: needless to say, there is one, and one only, and you are in it up to the eyes and beyond!

For these reasons, no potential barrier can be absolute, and I could not really care a tinker's cuss how electrons manage to get past it, though I am happy to hazard a guess (based upon the same deductive logic which says that energy exists) that there is a massive carrier in apparently empty space through which energetic interaction occurs.

Thus, while I positively adore Dr Scott Murray, it seems to me that his subjective arguments are so shallow and superficial that they merely invite argument from the specialists of this world: the drops in the ocean may be seen as particles in motion, and it takes one particle an impossible amount of work to make a wave.

What is all the fuss about? Rubbing the nose of a mess-maker in his mess merely makes him argue. Let them stew in it: make the prognosis, and let time prove it.

Dirac and Bohr must come to accept that space is not empty: it just appears that way because you can't catch a basic building block! There is nothing smaller with which an adequate mesh can be made, so that it inevitably slips through the holes.

It is a simple matter of inter-disciplinary analysis of which the single discipline specialist is mentally incapable. Farm the blighters!

James A. MacHarg
Wooler
Northumberland

In *Wireless World* of April 1983, p.48, Jones gives an impressive list of oversights and omissions which were present in the interpretation of the Michelson and Morley experiment. However, I missed one important problem I have always felt when dealing with this problem.

In this experiment it is always taken for granted that the velocity of light does not change at reflection. However, how can one be sure about that? Apart from Romer and similar determinations of the velocity of light I do not know of any other way of determining the velocity of light, thus without mirrors and lenses. On the contrary, from the point of view of light as a stream of photons it is at least just as likely that light might change its velocity at reflection: if a photon excites an electron which on its turn produces another photon there is no reason why the velocity of light of the original photon should be the same as the newly created one. But if the velocity of light may change at reflection, already for this reason the experiments of Michelson and Morley cannot produce a difference in the velocity of light (after reflection).
Dr M. Osinga
Haarlem
Netherlands

I was very interested to read M. G. Wellard's letter (January), including his comments on N. Rudakov's book "Fiction Stranger than Truth", which I have also read with considerable interest.

Wellard states that Rudakov has collected "more than enough evidence to show that the physics Establishment is in the hands of ideological extremists". It is a little unfortunate that he then goes on to mention, as a sample of that evidence, a somewhat exaggerated statement of Rudakov's. Wellard refers to Rudakov's citation of a review of one of Harold Aspden's books, and repeats Rudakov's assertion that the review says that Aspden is a crackpot. Although the review is somewhat pejorative, it is an exaggeration to say that it calls Aspden a crackpot.

On the same page of his book (p.9), Rudakov writes that "Lyttleton is of the opinion that the truth of relativity seems so self-evident as to be beyond need of discussion by any sane people." Although he does not give the source, he is fairly obviously referring to a letter to *The Times*, which is reproduced on pages 10-11 of Herbert Dingle's book "Science at the Crossroads". A careful reading of the letter shows that what Lyttleton wrote is completely different from what Rudakov attributes to him.

As Rudakov rightly says, (p.7), "Silence is the main weapon of the relativists." There is also ample evidence that members of the scientific community view scientific heretics with scorn and refuse to take their arguments seriously, and I was glad to see Wellard's reference to the scornful heading of an article in *New Scientist*. After perusing the relevant correspondence and seeing the heading "Einstein 6, Cranks 1", the reader may possibly conjure up a picture of Einstein playing golf. Whatever game the writer of the heading had in mind, it certainly was not cricket!
Ian McCausland
University of Toronto
Canada

The principle of indeterminacy is not a topic which I have studied to any great extent, but I would like to put a question to Dr Murray. He argues in your March issue that it is possible to determine what the velocity of an electron *was* "to any accuracy we please". But all electrons look alike. How then can we know whether the electron on which the second observation of position was made is the same as that on which the first observation was made?
K. S. Hall
City University
London

FORTH COMPUTER

In his article on a Forth computer Brian Woodroffe takes the dangerous step of comparing microprocessor c.p.us by preparing a number of examples of small isolated sections of code. Whilst I do not wish to take a standpoint in favour of any particular device I would like to point out that this sort of comparison is, at best, worthless and can be misleading. To quote one counter example, the 8088 '+' operation could be carried out via the instructions

```
POP AX
MOV BP SP
ADD [BP] AX
```

equal to the 6809 in terms of instructions, or, BP has a fixed relation to SP, as is the case in most executing programs,

```
POP AX
ADD [BP + α]  AX
```

where X is an assembly time constant. I hasten to point out that I am not trying to challenge his choice of processor but simply to point out that his reasoning is flawed. I have no doubt that any software engineer (sorry Mr Catt) familiar with the other c.p.u. mentioned could improve upon the quoted examples.
J. O'Connor
Crewe

ELECTROMAGNETIC DOPPLER

In the May issue Mr S. Hobson offers his explanation of e. m. Doppler. His assertion that the mechanism is 'v' is not helpful, 'v' is the cause, a change in frequency is the effect; the mechanism sought is that which links the two. The description he gives for 'wave crests' is equally valid if applied to a string of bullets fired at B by A and in this case the velocity of the bullets as seen by B would be the equivalent of (c-v).

What S. H. does is to divorce the fact that the light travels from A to B from the fact that A and B are moving apart, carefully avoiding describing the resultant composite motion. His final suggestion that v is not velocity but rate of change of distance is playing with words.

The light must leave A and must arrive at B and at each must have an observed velocity, frequency and wavelength which together conform to the equation:

$$v = f\lambda$$

The light leaves A at velocity c. If at B one assumed that it still travels at c relative to A then its velocity relative to B will be c-v. We can write

$$\text{at A} \quad c = f_A\lambda$$
$$\text{at B} \quad c\text{-}v = f_B\lambda$$
$$\text{and} \quad \frac{f_A}{f_B} = c\text{-}v$$

This then is a common-sense description of events which very elegantly produces the right answer but is of course heresy.

If it was not possible by observing the light from a source to tell whether or not the source is moving, one could logically deduce that the motion of light is unaffected by the velocity of the source. As it is possible to tell if a source is moving, then clearly something is affected by movement. If the frequency of a periodic function is lower, then either it is going past more slowly or the 'wave crests' are further apart. If one is not a heretic, light cannot be going slower, therefore the wavelength must have increased. What causes the wavelength to change? Where does the change take place?

Suppose at the moment of measurement B passes a third observer D stationary with respect to A. If the change in frequency observed by B is attributed to a yet unexplained change in wavelength which has occurred at a yet unspecified point between A and B how is it that D does not also observe this change in wavelength. He is at the same point of time and space as B, is observing the same wave as B observes, passing him at the same velocity as it passes B.

Heresy is so much simpler.
J. Kennaugh
Cornwall

Like your correspondent Kennaugh in *Wireless World*, May, 1983 I have been looking at the Doppler theory.

If one considers a particle stream where there is velocity, frequency and separation instead of velocity, frequency and wavelength then the Doppler effects can still be expected.

In calculating the relative velocities of the source and the particles with respect to the observer one can invoke the presence of an 'ether' against which the velocities are measured. These can then be summed to get the relative velocities and to remove the 'ether'. This may at first sight appear to be a pointless exercise but if it is done for an Einsteinian system then it is obvious that for every value of a relative velocity (of the source with respect to the observer) there is an infinite set of pairs of velocities (of each with respect to the 'ether') that produce the same Doppler effect. With a non-Einsteinian system there is only one set of velocities that produces the effect.

The reason for this is that in a non-Einsteinian system the movement of the source produces a change in the velocity and the separation of the particles but not the frequency whereas a movement of the observer produces a change in the velocity and the frequency of the particles but not the separations. Thus the movements of the source and the observer do not cause the same change in the Doppler effect whereas in an einsteinian system they do.

An interesting consequence of this is that in a non-Einsteinian system the universe has built into it a means of identifying which object, source or observer has changed its motion. The contributions of each body to the total relative velocity can thus be calculated.

It would appear, therefore, that some velocities are relative and some absolutely so.
James L. Smith
St. Albans
Hertfordshire

Table 2. Stop-list codes used in translate mode, Copeman Hart Chamber Organ, London, 1974/1982

Manual 1 49 notes C to c^{III}			**Manual II** 49 notes C to c^{III}			**Pedal** 30 notes CC to f		
Quintaton	16′	QD	Gedeckt	8′	G8	Prinzipalbass	32′	FD
Prinzipal	8′	P8	Prinzipal	4′	P4	Untersatz	16′	UB
Viola da Gamba	8′	V8	Hohlflöte	4′	F4	Prinzipal	8′	P8
Rohrflöte	8′	R8	Nasat	$2\frac{2}{3}'$	N3	Gedeckt	8′	G8
Oktav	4′	O4	Gemshorn	2′	G2	Oktav	4′	O4
Spitzflöte	4′	S4	Terz	$1\frac{3}{5}'$	T2	Nachthorn	2′	N2
Waldflöte	2′	W2	Sifflöte	1′	S1	Mixtur	II-I	MR
Quinte	$1\frac{1}{3}'$	Q1	Zimbel	II	MR	Kontraposaune	32′	KP
Mixtur	III	MR	Krummhorn	8′	K8	Posaune	16′	PB
Scharf	II	SK	Schalmei	4′	S4	Trompete	8′	T8
Rankett	16′	RD	Tremulant		TR			
Trompete	8′	T8						

Couplers:		
	Manual II to Manual I	KM
	Manual I to Pedal	KH
	Manual II to Pedal	KR

Note: As is usual, D indicates Double

Continued from page 41

variables for a rash of new pointers. Two further machine-code words provided nine-bit multiply and divide by two which greatly speeded up the process of transposition, made faster still by an alternative word to transpose by eight notes at a time. This is particularly useful for transposing between divisions of the organ – fortunately, care had been taken when the hardware was installed to wire the 128 keying register lines in a logical sequence.

To date, the extemporizations available are largely based on canon in two or three parts, with independent time and pitch offsets (mostly defined by variables) for each part. Each part has its own p.d.p. in the input data field (representing the theme) and its own input and output (i.e. transposed) console fields. The Forth program then combines the two or three parts into a new output data field, which can then be auditioned using play mode in the usual way. Up to now, therefore, the machine does not perform true extemporization, that is to say in real time, but the speed of operation suggests that this is feasible if the correct interrupt priorities can be established.

For a three-part canon, a seven-branch decision tree is needed to determine from the durations whether all three, which two or which one of the parts are (or is) the next to move. A decorated line, which can be combined with a two-part accompaniment, is provided by using the two-part canon routine but allowing only the latest part to move to appear in the output console field. With the appropriate time offset, this can provide a highly syncopated variation on the original theme, plus curious 'hocket-like' effects when the original notes depart slightly from strict time or strict legato.

The next thing to do was to provide some harmonization rules. By temporarily transposing the console field for one part and comparing it with another, any interval can be detected and changed into any other interval. To date, this has been used only to turn adjacent notes into minor thirds, but even this simple rule can produce charming suspensions and cadences (charming at least in relation to their somewhat austere surroundings).

The structure of the Forth words seems to clarify by an interative process (by the programmer, not the computer) as the work proceeds. For example, the harmonization rule mentioned above boils down to the word 'augment minor seconds', abbreviated to AMS. To use this, it is simply inserted at the beginning of the definition of 'transfer and/or console fields' which prepares the combined console field for output to the data field. Needless to say, if the machine were "performing" in real time, the output data field would not be necessary.

Perhaps the most charitable thing which could be said about the results from the extemporization routines after six weeks of spare time work is that they offer plenty of scope for further development. Probably the next fruitful step would be some rules for motion of the separate parts. WW

EVENTS

June 14-17
Tectronica 83; International exhibition for test, measurement and control and for the laboratory. Earls Court, London. Industrial and Trade Fairs Ltd. Tel: 021-705 6707.

June 21-22
World Electronics: Europe – the way ahead. *Financial Times* conference to be held in London. Details from Financial Times. Tel: 01-248 8000 ext 4123.

June 21-23
Compec North 83; Business computer show. Belle Vue, Manchester. Reed Exhibitions. Tel: 01-613 8040.

June 22-24
Subsea Challenge Conference; Progress in underwater technology. RAU Exhibition and Conference Centre, Amsterdam. Society for Underwater Technology, London. Tel: 01-222 3236.

June 27-July 1
Digital signal processing; course organised by the George Washington University (18 St George Street, London W1R 9DE), at Imperial College, London. Tel: 0626 83 3012.

June 27-29
Videotex '83; Conference and exhibition at the New York Hilton, NY, USA. Organised by London Online Inc. Details in UK from Online. Tel: 09274 28211.

June 27-July1
BKSTS '83; 8th International film and television conference and exhibition. Royal Lancaster Hotel, London. British Kinematograph, Sound and Television Society. Tel: 01-242 8400.

June 27-29
Frequency synthesizers; Course organised by the George Washington University, at Imperial College, London. Tel: 0626 83 3012.

June 27-30
Integrated optics and optical fibre communication. Fourth International Conference in Tokyo, Japan. Details from IEE. Tel: 01-240 1871 ext 330.

June 27-July 1
Integrated circuit engineering, with emphasis on vlsi and vhdic. Course organised by the George Washington University at Imperial College, London. Fer details tel: 0626 83 3012.

June 27-July 1
Laser 83 Opto-electronik. Sixth International Congress and trade fair. Trade Fair Centre, Munich. AMEG, Messegelande, Postfach 12 10 09, D-8000 München 12.

June 28-29
Comex 83; Conference and exhibition of m^bile radio communications and paging systems. De-Vere Hotel, Coventry. Federation of Communications Services. Tel: 01-635 2657.

June 30-July 1
An applications-oriented approach to artificial intelligence. Course organised by the George Washington University at Imperial College, London. For details tel: 0626 83 3012.

July 3-8
Semi-custom ic design and vlsi; IEE vacation school at Edinburgh University. IEE. Tel: 01-240 1871 ext 330.

July 3-8
Interfacing techniques for microprocessor instrumentation. IEE vacation school at University College of North Wales. IEE. Tel: 01-240 1871 ext 330.

July 3-15
Microwave solid state components and subsystem design. IEE vacation school at Leeds University. IEE, tel: 01-240 1871 ext 308.

Aspects of audio amplifier design

Given sufficiently high linearity of certain silicon bipolar transistors with initially linear regions of their input characteristic, it seems expedient to use them in audio amplifiers – especially those feeding horn loudspeakers – without overall feedback.

The perfection of audio amplifiers involves not only the perfection of electric circuits but the perfection of amplifying elements – transistors – as well. Efficiency in audio amplifiers may sometimes be considered a secondary technical requirement because of the existence of compact effective and relatively cheap power supplies with the mains to convert the 50-60Hz frequency at the power supply input to a higher one. This article illustrates, through the example of single-ended amplifier design for horn loudspeakers without overall feedback, some aspects that might become significant in the future, as well as in the present time. High stability and (as a rule) better dependence of non-linear distortion on output voltage can be achieved by simple methods and without sacrificing other parameters. In push-pull amplifiers, some compensation of the second harmonic exists but with an increase of third harmonic that is more considerable than the decrease of the second. Another essential feature of single-ended amplifiers is the equalizing of the amplifier load of the loudspeaker by the small resistance in the emitter of the Darlington output stage.

Modern horn radiators have an output exceeding 114-117dB (1m/1W) when using cobalt, samarium and other highly efficient magnets for normal polar response. The output of low-frequency loudspeakers without horns is limited by the flat amplitude response at low frequencies, this output usually being no more than 94-97dB. Bearing in mind that the maximum power of low frequency loudspeakers is limited by voice coil heat dissipation and by the nature of the moving system as a whole, and taking into account large intermodulation distortion in l.f. loudspeakers at $P_{out}>5$ to 25W (the ear becomes more

by Y. Miloslavsky, Dipl. Ing.

sensitive to a.m./f.m. as sound pressure level increases[1]), the maximum power of low-frequency loudspeakers cannot exceed 25-200W. And this has been borne out in practice. In addition horn radiators possess specific (non-smooth) distortions because of the change from a sinusoidal wave to a shock wave and a non-linear elasticity of air in the plenum chamber for large throat amplitudes. These distortions occur when the acoustic power divided by the input horn area is greater than about $0.25W/cm^2$. If the throat area is $6cm^2$ and the efficiency around 50%, then the rated amplifier power will be about 3W. Thus the power output of medium and high-frequency channels of power amplifiers should equal 0.25 to 2W, and taking account of the spectra of musical signals, we come to a value for power output of 1 to 4W.

Such amplifiers can be designed on the basis of a single-ended circuit, below, and can meet the most stringent up-to-date requirements provided that *all* of their components – capacitors, resistors, transistors – also meet up-to-date requirements.

Realisation of such an amplifier with either valves or field-effect transistors gives no advantage from the point of efficiency, output resistance and even linearity. The output resistance of valve and field-effect transistor amplifiers cannot be reduced sufficiently without overall negative feedback, or special complicated circuits if followers are used. Then the output resistance is

$$R_{out}=\frac{R_i}{1+\mu}\approx\frac{1}{S}\geqslant 20\text{ohm}.$$

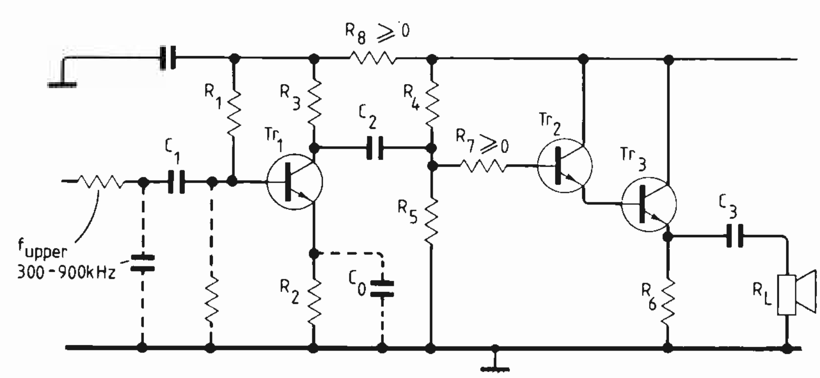
From equation 1 (appendix) the output resistance of followers using bipolar transistors, particularly a Darlington transistor, reduces to

$$R_{out}\approx r_{eTr3}+\frac{(R_3||R_4)||R_5}{h_{21ETr2}\cdot h_{21ETr3}}.$$

In this case $R_{out}\leqslant 0.4$ to 0.2ohm, with $R_3\approx 1.5k\Omega$, $h_{21e}\approx 3\times10^3$. This value of output resistance is enough even for a low frequency channel.

In general, the output resistance is a complex value Z_{out}, the modulus of which increases with increase in frequency due to weakening of local negative feedback (h_{21e}). The input resistance of Darlington transistor is limited by resistance r_{CTr2}, from equation 2 (appendix). In general, the input resistance of a follower is also a complex value and approaches R_{bTr2} with increase in frequency. Moreover $f_{ic}<f_{upper}$ (f_{ic} is pole frequency in Z_{in}, see appendix).

As a first approximation, one may ig-



Single-ended amplifiers can meet the most stringent requirements for horn loudspeaker drivers provided that components are carefully chosen.

Born in Moscow in 1947, Yuri Miloslavsky graduated from the department of physics of the Saratov State University in 1971. Assigned to a military plant in Saratov, he worked in the fields of microwave technology and digital telephone systems. Later he joined the scientific research institute of television and broadcasting in Moscow where he worked on problems of electroacoustics, architectural acoustics, subjective aspects of sound reproduction. Since 1978 he has been in the laboratory of architectural acoustics in the Moscow institute of the physics of construction. Last year he emigrated to the USA.

nore variations in non-linear resistances r_b and r_e, as well as weak variations in C_c and C_e as a function of signal level, and adopt their average values relating to the d.c. operating points $\{I_{c(dc)}, V_{CE(dc)}\}$ and rated P_o of 0.25 to $0.5P_{o\,max}$. (We ignore in our case internal voltage feedback due to base thickness modulation; $\mu=(dV_E/dV_C)_{IE\,const} = -\phi_T \times const/w\sqrt{V_c}$.

When supplying short pulses with small rise time to the follower the ouput cable capacitance may influence the form and amplitude of the pulses. The transition time of the follower should be smaller than the transition time of the signal.

In the calculation of the transient response (as, for example, using the integral of Duamel) it is not necessary to take into account the isolating capacitors used as crossover networks which cause the appearance of additional multipliers $(1+p\tau_k)$ in the numerator of the transfer function, as there are complementary transient responses in the mid and low-frequency channels and their corresponding radiators. But the problem of transient response still remains. In general, given the resistor in the emitter network and without taking isolating capacitors into account for the cascade of a common emitter and common collector (emitter follower) the transient function is usually written as follows (basing it on an equivalent circuit under certain assumptions):

$$K(p) = \frac{K_o(1+\alpha p)}{1+mp+np^2}.$$

Such a function points to possible oscillatory character of the transient process or a possible overshoot. With the calculated capacitor $C_L = C_{z=p2}$ connected in parallel with the resistor mentioned above, the transient function becomes ideal (ref. 8) under certain conditions:

$$K(p) = \frac{K_o}{1+\frac{np}{\alpha}},$$

where $m = \alpha + \frac{n}{\alpha}$

$f_{pole2} = f_{zero}$, $f_{pole2} > f_{pole1}$

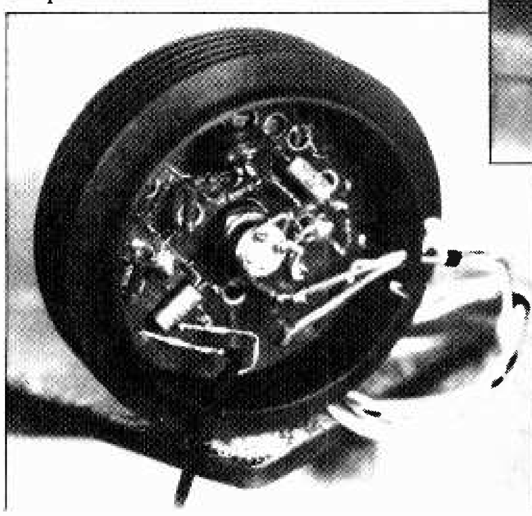
and $C_{z=p2} \neq C_L\, f_{upper\,max}$.

In the case of an emitter follower signal frequencies must be properly limited, since the abrupt displacement of the operating point into the region of small h_{21} is possible, and the transient process is defined by time constant $(Z_1 \parallel R_6) \times (C_{b'e} + C_L)$; with $R_{out} = R_{out}(t)$.

Because the output and input resistances are complex values and their module are accordingly dependent on frequency, there is a tendency to raise f_{upper} to 1 to 10MHz so that non-linear distortions, output reistance and frequency dependance of amplitude and phase responses deteriorate as little as possible in the operational frequency band of around 200kHz. This band width is necessary for more faithful reproduction of transient processes, for decreasing the level of difference tones for frequencies higher than 20kHz, and for decreasing amplitude and phase distortion of the whole system. The correct reproduction of transients becomes a decisive factor in many cases. Piano sound is the most characteristic case, with its abrupt attack and lack of stationary sound[2], which corresponds to conclusions given in reference[3]. Some of the basic parameters of amplifiers are upper frequency limit, coefficients α_2 to α_n in the power series transfer characteristic

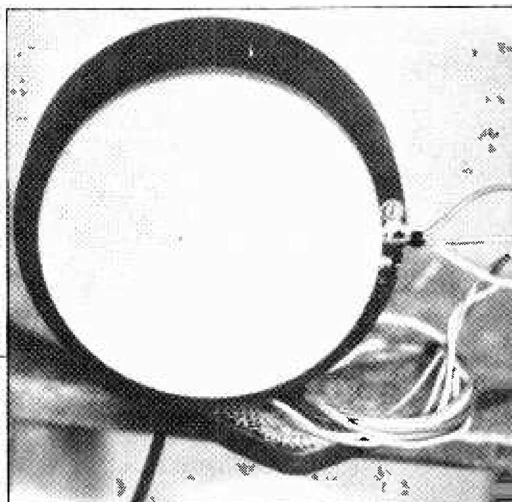
$$V_{out} = kV_{in} + \alpha_2 V^2_{in} + \alpha_3 V^3_{in} + \alpha_4 V^4_{in} + \ldots + \alpha_n V^n_{in}$$

the nature of dependence $\alpha_m = \alpha_m(\beta, \omega, \tau)$, signal-to-noise ratio, output resistance, reliability, life time, constructional design, and overall cost. Let us analyse some of the specified parameters in detail. The value 0.5 to 2MHz of f_{upper} can easily be achieved using proper high-frequency bipolar transistors and using small-signal source resistances R_S for each stage. We assume that this bandwidth is sufficient in the present situation.



Amplifier design without overall negative feedback is preferable according to Nyquist's "regeneration theory" and the theory of electrical networks, in particular t.i.m. But it is necessary to meet the most stringent and rational requirements to reduce non-linearity. The characteristics $I_C = I_C(I_B, V_{CE}\ const)$ and $I_C = I_C(V_{CE}, I_B\ const)$, especially in n-p-n transistors, are of the same order as the corresponding characteristics in valve pentodes $I_A = I_A(V_g)$, $I_A = I_A(V_A, V_g const)$, and in some cases are even better. The input characteristics $I_g = I_g(V_g)$ of amplification valves are linear, except in the special case $I_g \neq 0$, but the input characteristics $I_B = I_B(V_{BE}, V_{CE})$ of transistors are non-linear, except in some special cases. By these and other factors, one can explain lower non-linearity (i.e. sufficiently fast approach of transfer characteristic coefficients α_2 to α_n, especially α_4 to α_n, to zero) in circuits with valve pentodes and triodes. We should also take into account that in the presence of large overall negative feedback, and for a large non-linearity in a system without overall feedback, the law of feedback changes in an unfavourable direction[4]. In semiconductor circuits the signal often passes through an excessive number of p-n and n-p junctions, which in addition operate impulsively at high temperatures (for horn radiators one stage is more than enough for voltage amplification). Strong dependence of the junction temperature on signal level is also undesirable. Sometimes high junction temperatures cause undulation of output characteristics. As to push-pull stages with semiconductor components, a large asymmetry of arms additionally occurs as a rule through the overall

Undersirable non-linear distortion, e.g. in the second harmonic, can reach several per cent in a single-ended cascade in a small-signal regime[7]. Amplitude and phase distortion above 10kHz can be several orders more than corresponding internal distortions due to C_E and C_C in h.f. transistors[7]. Reference 7 gives possible methods of compensation for these distortions.



Elegant amplifier construction is easily attached to the loudspeaker and provides shielding for the circuit as well as heat dissipation for Tr3.

operational range of voltage and current, often of very complicated nature. All these factors make reduction of non-linearity in semiconductor amplifiers more difficult (though a sum of certain factors may partly compensate for some α_K).

For amplifier stages the class A operating mode is always preferable because the ear becomes more sensitive to harmonic and sum and difference tone distortion as sound pressure level decreases, based on specific features of hearing thresholds under masking[1], because of smaller $\alpha_2 - \alpha_n$ dependence on ω, β and because of weak dependence of junctions temperature from signal level. If operational areas of input and output characteristics of amplification elements are correctly selected class A distortions decrease or increase as a function of output voltage of the load linearly or strictly monotonically.

What can be expected from such an amplifier in practice? In this circuit I have used the following transistors: KT630B(b) as Tr_1 and Tr_2; KT912 as Tr_3 (see catalogue of Mashpriborintorg, USSR). The most essential known parameters are

KT630

$P_{Cmax} = 0.8W$ ($T=25°C$); $V_{CEmax} \geq 120V$; $I_{Cmax} = 1A$; $h_{21E} = 40$ to 240; $f_{T(Ic=2A)} \geq 50$ MHz; $C_C < 15pF (V_{CE} = 10V)$; $C_E < 65pF$

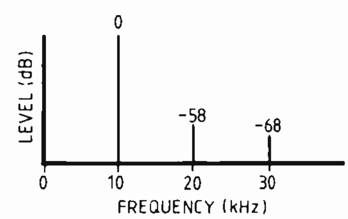
KT912

$P_{Cmax} = 30W$ ($T=85°C$); $V_{CEmax} = 70V$; $I_{cmax} = 20A$; $R_{(th)jc} = 1.66°C/W$; $h_{21E(Ic=2A)} = 20$ to 100; $f_{limit} = 90MHz$

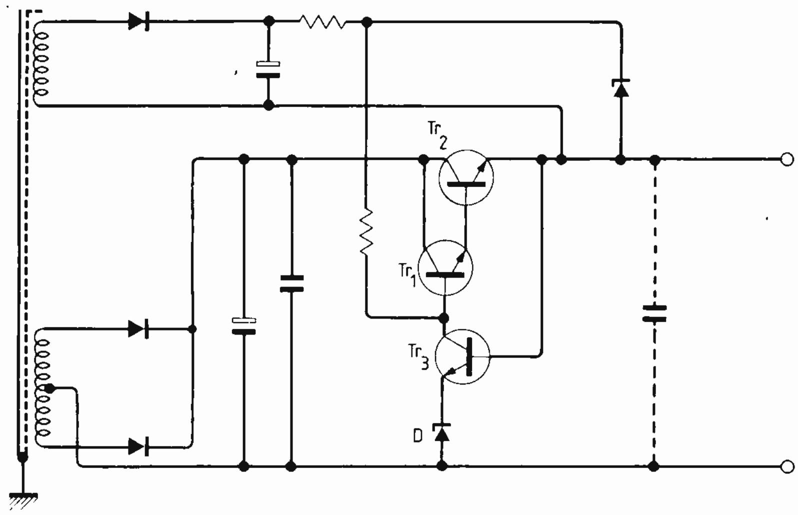
Transistor KT912 must be thoroughly selected on the basis of initial current $I_C = I_C(V_{CE}, I_B = 0)$, and stability of h_{21E} in the operational range of collector current and voltage. The collector, usefully, is electrically isolated from its package.

It should be specially mentioned that initial operational areas of the input characteristic $I_B = I_B(V_{BE})$ in the KT630 and KT912 – up to 0.3 and 0.6V respectively – are linear and do not practically change with variation in V_{CE}. Output characteristics $I_C = I_C(V_{CE}, I_B\text{const})$ and $I_C = I_C(I_B, V_{CE}\text{const})$ of these transistors in operational areas are also satisfactory.

Non-linearity attenuation, as measured with Brüel & Kjaer frequency analyser 2010 by the harmonic distortion method with rated power of 0.25 to 0.75W corre-



sponding to $P_{out(max)} = 1$ to 2W, is shown above. The rest of harmonics cannot be detected with the 2010 (dynamic range approximately 90dB). Distortion as a function of level follows an almost linear pattern. This non-linearity (specifically of high order $\alpha_4 - \alpha_n$) is no worse than in good valve circuits with overall negative around 20-25dB, and is no worse in most cases than for electroacoustic transducers at corresponding levels. Values of square and cubic non-linearity are much less than



Single-ended amplifiers are less tolerant of ripple than push-pull types; this additional transformer winding to supply the zener diode D increases ripple suppression by a hundred fold.

their sufficient values[5] and much less than values for the ear at corresponding levels and frequencies of sound pressure[1].

Article 9, which may well be unique, contains a strict calculation on the basis of probability theory of the perception of non-linear distortion in different cases, given square and cubic distortions. Its conclusions practically coincide with the corresponding content of this article even though some of the data used are somewhat dated.

Non-linear distortions become more perceptible with broadening of frequency range[5], improvement in signal-to-noise ratio of reproduction systems, and decreasing acoustic noise in listening rooms. All these factors are changing favourably; for instance, it's not too difficult nowadays to get an A-weighted signal-to-noise ratio of 85-100dB in power amplifiers.

In this design, crossover networks can be realised with C_1, C_2, C_3, and the input resistances of corresponding stages (see appendix). Overall steepness of crossover networks can be 6 or 12 dB/octave, and can be also variable (to 18dB/octave).

For ease of reference, the instability of current gain in bipolar transistors resulting from rises in junction temperature is defined by the following expression, where $T_0 \approx 25°C$,

$$h_{21E(T)} \approx h_{21E(T_0)} + (0.003 \text{ to } 0.006) \times h_{21E(T_0)}(T - T_0)$$

The reliability and longevity of semiconductor amplifiers (for example, instability of output current in the given amplifier is in the range 0.2 to 0.8%) are much higher than that of valve amplifiers provided that components operate well within their ratings. I have achieved excellent stability and subjective results while using this single-ended circuit for an l.f. channel with $P_{out\,max} = 8$ to 20W.

There are some special features in technical requirements to the power supply for single-ended power amplifiers. The value of permissable voltage ripple (less than for push-pull circuits), interference and noise is determined by the maximum power output of an amplifier and its dynamic range.

The output resistance of power supply including resistance of wires between power supply and amplifier should be low enough to prevent distortion of and transient responses. On the other hand, the requirements for the stability of the power supply voltage are very mild and the following version of power supply is likely to be optimum, see diagram, for which

$$R_{out} \simeq \frac{(r_{ZD} + r_{eTr3}) + r_{bTr3}/h_{21ETr3}}{h_{21ETr1} \cdot h_{21ETr2}}$$

and
$$K \approx \frac{\dfrac{r_{cTr1} \cdot r_{cTr2}}{r_{cTr1}/h_{21ETr1} + r_{eTr2}}}{r_{ZD} + r_{eTr3} + r_{bTr3}/h_{21ETr3}}$$

The existence of the additional parametric stabilizer (with additional winding of the transformer) for the supply of the zener diode D increases dramatically the ripple suppression coefficient (stabilization factor K), by approximately one hundred times. As a rule the frequency and transient properties of this stabilizer are better than in multistage stabilizers.

This power amplifier circuit can be designed on the basis of maximum possible efficiency (a push-pull version is also possible[6]), or on the basis of the smallest power dissipation by transistors Tr_2 and Tr_3. In general the maximum possible efficiency approaches 8.6%, or 25% with a dynamic current source as R_6.

Further reading

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Daugherthy. D. C. and Greiner, R. A. Design objectives for audio power amplifiers, *IEEE Trans* vol. AU-14, March 1966.

Stepahenko, P. Osnovi Teorii Transistorov I Transistornih Shem, "Energia" 1977.

Oren, R. Discussion of views on popcorn noise in bipolar transistors, *IEEEE Trans* 1971, vol. ED 18 no. 12.

Appendix 1

Output resistance R_{out} is approximately

$$r_e+\frac{R_S+r_b}{h_{21E}}\approx r_{eTr3}+\frac{r_{eTr2}+r_{bTr3}}{h_{21ETr3}}\cdot\frac{r_{cTr3}}{r_{cTr2}/h_{21ETr2}+r_{cTr3}}$$

$$+\frac{(R_3||R_4)||R_5+r_{bTr2}+\dfrac{(r_{eTr2}+r_{bTr3})\,r_{cTr2}}{r_{cTr2}/h_{21ETr2}+r_{cTr3}}}{h_{21ETr2}\cdot h_{21ETr3}} \quad (1)$$

where r_c function of many variables for the given type transistor and approximately equal to 2 to $4\times10^3/I_c$ ohm, and $r_e\approx0.026/I_c$ ohm.

f_{rise} of $|Z_{out}|_{for+3dB}=f_{zero}\ll F_{upper}$.

$$R_{in}\approx r_b+h_{21E}\left[\frac{r_c}{h_{21E}}||(r_e+R_6||R_L)\right]$$

Omitting r_b and r_e in our case

$$R_{in}\approx h_{21ETr2}h_{21ETr3}\left[\left(\frac{r_{cTr2}r_{cTr3}}{r_{cTr2}/h_{21ETr2}+r_{cTr3}}\cdot\right.\right.$$

$$\left.\left.+\frac{1}{h_{21ETr2}h_{21ETr3}}\right)||R_6||R_L\right] \quad (2)$$

and $R_{in}<r_{cTr2}$.

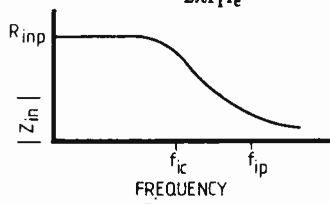
Value $r_c=r_c(I_c+S(t))$ depending on the signal current imposes a principle restriction on the attainable nonlinear distortion level, depending on R_2/R_{in}. Moreover, it is obvious that the value r_c is in itself a source of nonlinearity.

Appendix 2

Based upon Jiacoletto's simplified equivalent network for a bipolar transistor (Tr_1). If $R_2=0$,

$$Z_{in}\approx\frac{r_b+r_{b'e}+j\omega[C_{b'e}+C_c\cdot1/r_e\cdot R_3||R_4||R_5]r_b\,r_{b'e}}{1+j\omega[C_{b'e}+C_c\cdot1/r_e\cdot R_3||R_4||R_5]r_{b'e}}$$

where $r_{b'e}=r_e\,h_{21E}$, $C_{b'e}=\dfrac{1}{2\pi f_T r_e}$ and $C_c=C_c(V_{ce})$



$$f_{upper}\approx\frac{R_S+r_b+r_{b'e}}{2\pi[C_{b'e}+C_c\cdot1/r_e\cdot R_3||R_4||R_5]\,(R_S+r_b)\cdot r_{b'e}}$$

The function Z_{in} has a pole and zero, where the pole frequency is $f_{ic}<f_{upper}$

$$f_{ic}=\frac{1}{2\pi[C_{b'e}+C_c\cdot1/r_e\cdot R_3||R_4||R_5]r_{b'e}}$$

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LITERATURE RECEIVED

VisiCalc users can get 'hotline' answers to any problems they may have with the system from Gunther Computer Consortium, who also publish a newsletter each month and run seminars on the use of VisiCalc. Gunther Computer Consortium, Lake Drive, Southampton, NY 11968, USA. **WW400**

Microprocessor and memory i.cs from Fujitsu, monochrome and colour v.d.us from Panasonic, and Ethernet transmitter and control products are listed in shortform stocklist and price guide from Ambar Components Ltd, Gatehouse Road, Aylesbury, Bucks HP19 3ED. **WW401**

Wide range of **computer printers and interfaces,** mostly in the 16 to 40 column range are listed in a 22-page product guide and price list. Introduction contains useful information on the advantages of the various types of printer. DED, 47 Station Road, Lydd, Kent TN29 9ED. **WW402**

Uninterruptable power supply unit from 1 to 6kVA are designed to protect sensitive equipment such as computers, data loggers, controllers, communications networks and alarm systems, is described in leaflet. Avel-Lindberg Ltd, South Ockendon, Essex RM15 5TD. **WW403**

Half-wave **antenna for use with c.b. radio** has been manufactured by a British company who have also produced a data sheet about it. Claimed to be manufactured to a high specification, the firm has previously made mobile antennas for civil and military use. Bantax Ltd, Abbey Road, Park Royal, London NW10 7SJ. **WW404**

Hand tools and tool kits for the electrical and electronic engineer are described in a 40-page catalogue. Sections of the catalogue are devoted to wire and cable strippers, crimping tools, pliers, nut and screwdrivers, ancillary equipment and tool kits. AB Engineering Co, Timber Lane, Woburn, Milton Keynes MK17 9PL. **WW405**

Two Plessey handbooks, one on **Linear integrated circuits** (PS1973) includes details of op-amps, linear r.f. amplifiers, phase locked-loop circuits, limiting wideband amplifiers and other radio communication and power control circuits. The other on **high-speed data processing** (PS1989) covers crystal oscillators, ECL III, data conversion circuits, fast gates, comparators, flip-flops and a-to-d/d-to-a circuits. Both from United Components Ltd, Unit 5, Wye Estate, London Road, High Wycombe, Bucks HP11 1LH. **WW406**

Clamps and clips, board supports and all sorts of plastics fasteners and components are illustrated in a 52-page catalogue from Richco International Company, West Street, Erith, Kent. **WW407**

A Guide to Personal Computing, produced by Digital should be more accurately titled the Guide to Digital Personal Computing as that company's products are featured prominently. Nonetheless, it contains useful information on computers and their operation and is free from Digital Equipment Co Ltd, Customer Information Centre, Basingstoke, Hants. **WW408**

Aids for the production of p.c.b. artwork, circuit diagrams consist of self-adhesive symbols and shapes which may be accurately positioned using a registration system and stuck down by finger pressure. Fully illustrated in a catalogue from Circuitape Ltd, New Street, Aylesbury, Bucks HP20 2LN. **WW409**

Eurocards for prototyping may be hand-wired rapidly may be re-wired easily if the **Quick-connect i.d.c.** system is used, according to an eight-page brochure from AstraluxDynamics Ltd, Red Barn Road, Brightlingsea, Colchester, Essex CO7 0SW. **WW410**

Measuring instruments for temperature, air flow velocity, humidity, velocity and the presence of gases are shown in a shortform catalogue from Testoterm Ltd, Old Flour Mill, Queen Street, Emsworth, Hants PO10 7BT. **WW411**

Signal processing circuits. Formulae, definitions and application notes are included in a Designers Guide and Handbook produced by Analogic. Guide covers a-to-d and d-to-a converters, sample and hold circuits, analogue multiplexers, filters, isolation circuits, power supplies and various subsystems. Available free from Analogic Ltd, 68 High Street, Weybridge, Surrey. **WW412**

Soldering irons from miniature to 500W sizes, temperature controlled or uncontrolled are listed in a catalogue from S & R Brewster Ltd, 86 Union Street, Plymouth PL1 3HG. **WW413**

Nickel cadmium, sealed lead-acid batteries and a variety of battery chargers and battery holders are listed and priced in a leaflet from Sandwell Plant Ltd, 2 Union Drive, Boldmere, Sutton Coldfield, West Midlands B73 5TE. **WW414**

Multi-user computer system of British design based around the 16-bit 68000 processor, uses the Idris operating system and incorporates full C and Pascal compilers with disc drives which can read and write Unix, CP/M and RT-11 file systems, is fully described in brochure from Integrated Micro Products Ltd, Number One Industrial Estate, Medomsley Road, Consett, Co Durham DH8 6SY. **WW415**

Forth computer

Interface circuits and software for disc-drive control are main subjects of Brian Woodroffe's third article describing his 6809-based microcomputer. First, operation of the video controller is concluded and i/o software discussed.

by Brian Woodroffe

Character-code and row information for the video-controller i.c. is supplied as an address to a character rom. Character information for each row is fed to an LS165 shift register and serial output from this register is combined with synchronization signals in an analogue gate to give a standard 1V p-p composite-video signal which is subsequently fed to a u.h.f. modulator.

The dot clock, consisting of a Schmitt-trigger relaxation oscillator, should be adjusted to the minimum frequency to minimize the luminance bandwidth required in the monitor consistent with all text displayed on the screen. Character values 10 to 1F hexadecimal are programmed into the character rom to give coarse graphics. Two 2114 rams hold enough information for one 1024-character Forth screen to be displayed.

Two further video rams store text normally lost at the top of the screen. A switch allows a page of lost text to be displayed.

Terminal and i/o software

The Forth reset routine checks to see if there is an M6850 present and if not automatically redirects terminal i/o routines from the RS232 interface to the p.i.a. for parallel i/o. Forth words giving access to user ports are included in this operating system. These words, P@and P! act in the same way as Forth words @ and ! except that they allow access to user i/o ports.

The software-driven output word, P!, makes data available on the p.i.a. B lines then activates the address coded on the A lines. On-input, P@, reads data while the port address is made. Output ports ideally connect to LS273 latches and input ports to LS244 buffers. Port-strobe lines are decoded from the p.i.a. A lines using LS138 three-to-eight-line decoders. Eight read and eight write ports can be connected to this hardware and if more ports are needed then a further 6821 p.i.a. could be connected and mapped into the USER variable-address area. Cursor control codes, i.e. decimal codes for EMIT, are as follows.

8 left (backspace)
9 right (tab)
10 down (line feed)
11 up
12 home and erase
13 carriage return
14 home
15 carriage return and line erase

Disc interface hardware

Interfacing to the floppy disc[6] is done using the most readily available controller since it is cheaper than using s.s.i./m.s.i. devices. Complexity of the WD1793 controller is comparable to that of the 6809. The first problem was interfacing an 8080 style peripheral to the M6809 bus, the main difficulty being the writing data-hold times.

The problem of data-hold times was solved using the memory-ready signal, MRDY, which when active (low) holds the processor clock cycles in an E-not-Q state for at least one quarter of a bus cycle. This quarter cycle provides the hold time. The memory-ready signal triggers a monostable multivibrator each time the procesor wants access to peripheral-drive address space between C000 and DFFF on the rising edge of the Q clock and this signal forms the floppy-disc controller write signal.

A read signal is derived from clocks E and Q. Interrupt and data-request outputs of the floppy-disc controller are connected to the processor FIRQ pin so that data transfer can take place using the M6809 SYNC instruction. As noted before, a floppy-disc drive's data rate can cause problems when d.m.a. is not used. In double-density recording on a 5¼in floppy using a WD1793 controller, the worst-case data-transfer rate is 27µs/byte. Coding is shown in Table 1.

The trick is that SYNC stops the M6809's execution without affecting the clocks until the floppy-disc controller interrupt occurs and the processor resumes execution. This provides quick synchronization between the processor and controller. Despite that modifying the direct-page register gives quicker access to the f.d.c. which is in high memory, this feature was not used because of the extra coding needed. Had the processor clock been slower this alternative might have been necessary.

Interfacing the floppy-disc controller to the drive is the next problem. Most of this is covered in an ANSI standard[7] but the problem of clock recovery remains. Because of mechanical constraints, data read from disc will not be synchronous with any processor clock so clock information contained in the data stream must be extracted. In single-density recordings each bit cell has a clock bit and a possible data bit (no data bit is zero) and in double-density recording the position of the bit within the cell determines whether it is a one or a zero. A clock synchronous with incoming data is required to determine the incoming bit's position.

Although it gives the best performance, a phase-locked loop circuit was rejected on grounds of cost. Instead a crystal clock running at eight times the nominal read clock is used and a divide-by-eight version of this clock is phased with the incoming data to recover the original clock. First the incoming bit stream is synchronized to the crystal clock (×8) to produce pulses with accurately defined widths using an LS74. This pulse stream is fed to the floppy-disc controller (RAW READ).

The reading clock is provided by an LS161 counter which is normally held off until the controller wants to read the disc, when the counter is enabled by the read-gate signal. This counter would normally free run at about the nominal clock rate, but it is synchronized by applying the raw read signal to its load input. The load frequency locks its D output (READ CLOCK) so that it changes mid-way between input bits. As the maximum number of bit cells without read bits is three, the recovered clock never gets too far out of phase.

Table 1. Code showing how the M6809 SYNC instruction is used for floppy-disc drive data transfer.

	STB FDC	F7C000		send command byte to f.d.c.
BRED2	SYNC	13	2	wait for f.d.c. response
	LDB FDC	F6C000	5	get status
	BITB #2	C502	2	test byte-in
	BEQ BRERR	2710	3	no, then error
	LDA FDC+3	B6C003	4	get byte
	STA 0,Y+	A7A0	7	store, advance pointer
	LEAX −1,X	301F	5	reduce count
	BNE BRED2	26EF	3	loop back
BRED3	LDB FDC	D600		wait till
	BITB #1	C501		f.d.c. finishes
	BNE BRED3	26FA		
BRERR	RTS	39		

32 cycles at 1.5MHz = 22µs
Upon entry B=command code
Y=pointer to data destination
X=byte counter

The author is with Hewlett Packard in research and development.

Problems with phasing are most noticeable when double-density recording is used, so a means of preventing bunching[8] of the bits is used. Precompensation[8] prevents bunching by moving the written data bits slightly relative to the nominal position in a bit cell so that when the data is read back the bits appear to be in their correct positions. The matter of precompensation depends on the drive used. For those drives that do not require precompensation, including the TEAC FD50A used in the original design, the precompensation circuit is omitted.

The disc should be set to respond to its address and head-load on drive select and not to the motor-on signal, i.e. the TEAC FD50 disc drive should be set as follows (for further drives, follow the same pattern).

DRIVE 0
 HS=set, MX=set, DS0 set,
 DS1,DS2,DS3=unset,
 HM=disconnected.
DRIVE 1 (if fitted)
 HS=set, MX=set, DS1=set,
 DS0,DS2,DS3=unset,
 HM=disconnected.

Disc-interface software

Under command of the c.p.u., the floppy-disc controller takes care of head positioning, sector positioning, data serialization and cyclic-redundancy checking. As soft sectoring is used, sector positioning is determined by the address record read from the formatted disc. The controller may be programmed to format the disc. So long as certain inter-record gap and record sizes are adhered to, the formatted disc capacity may be increased, Table 2.

Different systems use different sector formats[9], numbers and sizes of sectors and sector numbering systems. In this system, all variables associated with disc formatting are defined by the user which means that most disc formats may be read. The sector size is written into the address record of each sector so it is possible for the system to adjust its buffer size to that of the disc. Forth word ?DISC is included to read the current disc and set parameters termed DENSITY, B/BUF and SEC/TRK to those associated with the disc. Only formats mentioned in Table 3 apply to the disc format program and ?DISC.

When formatting a disc, it can be advantageous to interleave the sectors on a track. With this in mind a dummy word SKEW was included which is currently defined as no operation, but it may be redefined to perform an interleaving algorithm during formatting, Table 3. Defining Forth word FORMAT for disc formatting is shown in Table 4.

Forth treats all disc memory systems in the same way, i.e. as a contiguous set of 1024byte screens, hence the choice of a v.d.u. Main Forth words used to gain access to screens on a disc are R/W, which moves data between a disc and memory, and BLOCK. As disc sector size depends on format, words BLOCK and constants B/BUF, bytes-per-sector, SEC/TRK, sectors-per-track, TRK/SIDE, tracks-per-side and SIDE/DISC provide a means for Forth to work out which sectors make up a screen. The size of virtual memory buffers in Forth should be the same size as a sector.

Table 2. Capacity of a formatted disc may be increased provided that certain record sizes and gaps are not exceeded.

Density	Single		Double	
Bytes/sector	128	256	256	512
Sectors/track	16	10	16	10
Bytes/track	2048	2560	4096	5120
Bytes/disc	82K	102K	160K	205K
Relative	100%	125%	200%	250%

Time taken for the head to position itself over the relevant track is a major constraint when using disc drives. Other time factors for a 5¼in floppy-disc drive are motor start-up time, head-load time and rotational latency. To speed up access time for double-sided discs it is usual to physically combine two tracks on opposite sides of the disc into one logical track. This minimizes head seek time for it is likely that the sector required will be on the same bigger logical track and the time taken to gain access to the other side of the disc is governed by the time taken for an electrical switch to act rather than by the delay of a mechanical head seek. But since Forth treats all discs in the same way, including this feature would have meant that one could not mix single and double-sided discs.

When using the Teac FD50A disc drive, access time is dominated by the start-up time of 1s. If faster disc drives are used, time constants may be changed (discussed in a following article). Start-up time and head-stepping rate constants are moved into ram from eprom by the Forth start-up word COLD and may be modified to suit faster drives. Forth constants normally hold the values of constants in the parameter-field address (p.f.a.) but as this system is rom based, modification of the constants would not be possible so they are coded with a new routine which stores the value in ram. This list shows how the constant DENSITY is altered from single to double density and gives other constants and their meanings.

DENSITY	=1 (double density, 0 for single density)
B/BUF	=512 (number of bytes per disc sector)
SEC/TRK	=16 (number of sectors per disc track)
TRK/SIDE	= (number of tracks on disc, normally 35-40 for a mini-floppy)
SIDE/DISC	=1 (2 for double-sided)
SEC-OFST	=1 (for numbering sectors 1 to n, 0 for numbering 0 to n−1)

1	(value to store, returned after execution of DENSITY)
' DENSITY	(find DENSITY p.f.a. address)
@	(p.f.a. in this special constant points to constant position)
!	(store 1 there)

Power supply

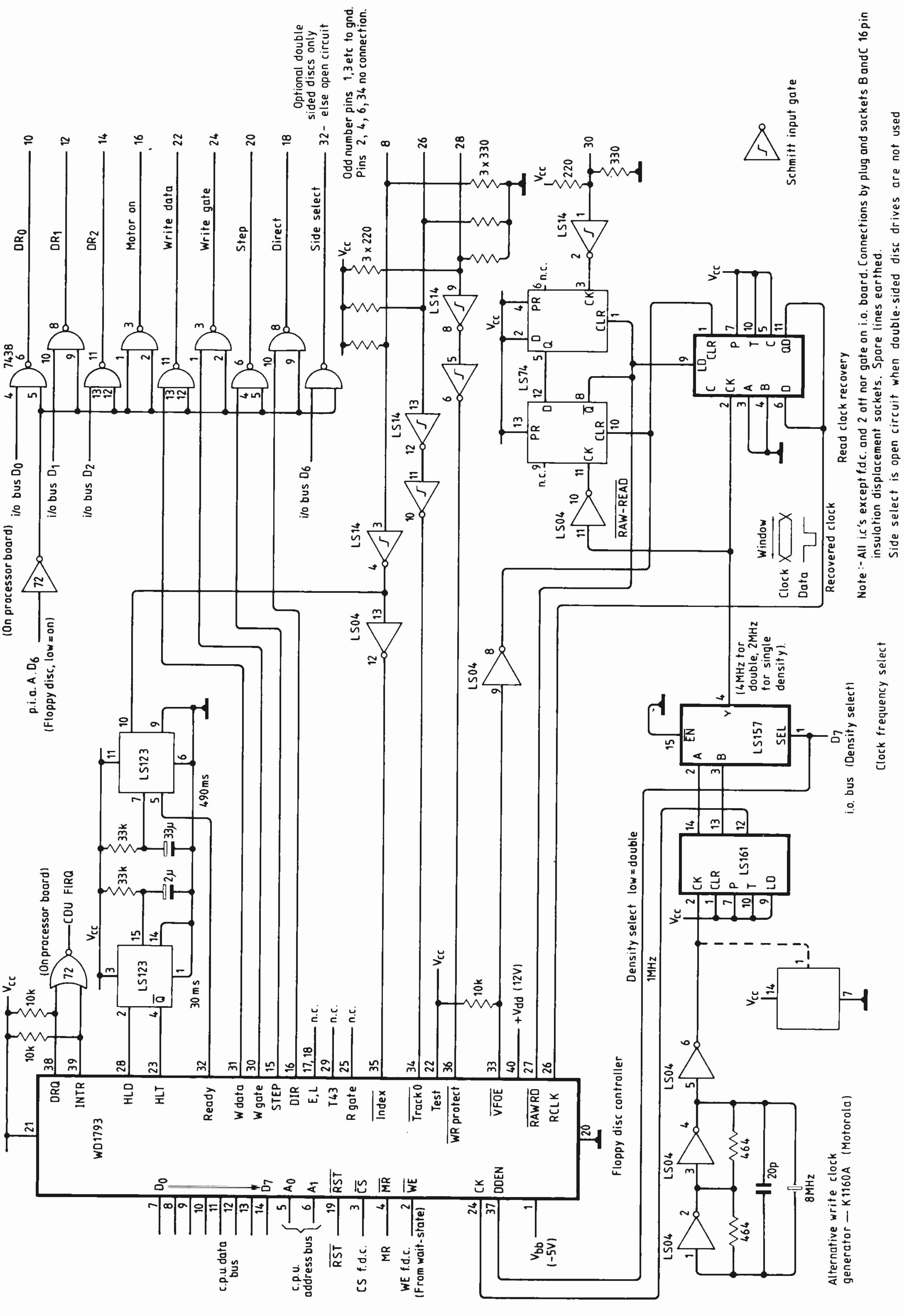
Only one 15V secondary winding is required on the transformer to provide a low-current −5V supply for biasing the dynamic rams, +12V for the rams and floppy-disc drive and +5V for all logic circuits. A minimum value for the unregulated supply is determined by the 12V rail; unregulated input should be 20V to ensure adequate regulation with low mains supplies. Heaviest current demands are on the 5V supply and using a linear regulator to provide this rail would have resulted in excessive heat generation with a loss of efficiency so a switching regulator was designed.

Table 3. Example of a routine for defining dummy word SKEW to give interleaved formatting.

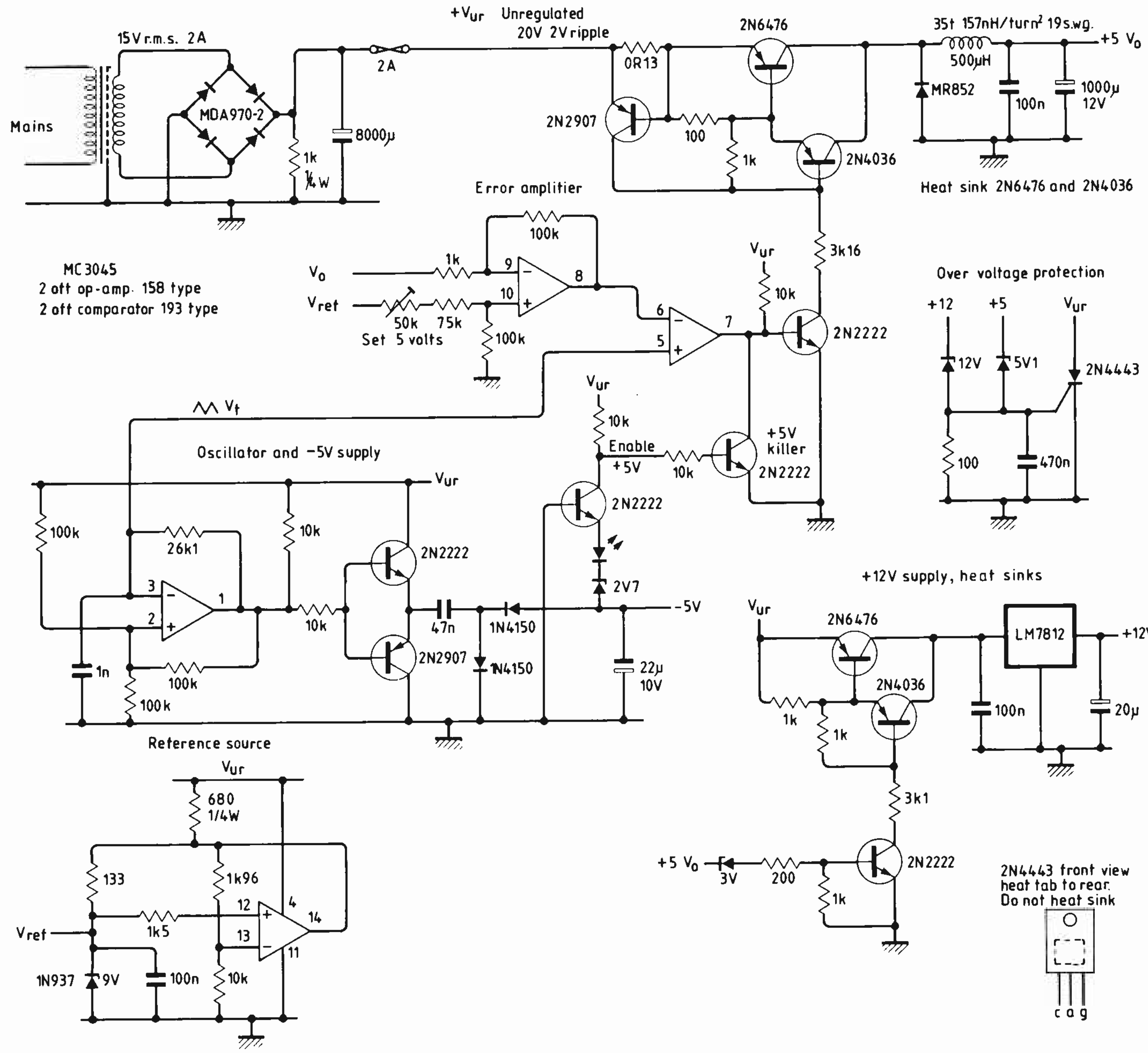
```
FORTH HEX                 ( select Forth and hexadecimal number base)
: SKEW1 DUP               ( new word, duplicate sector # to be interleaved)
 1 AND IF                 ( only even sectors are interleaved)
  SEC/TRK 2 / FE AND      ( sector offset by half the disc)
   + SEC/TRK MOD          ( add offset and keep with 0 ... n−1 sectors on
                            track)
  THEN ;
' SKEW1 2 −               ( find c.f.a. of new interleaving address)
' SKEW !                  ( find old skew p.f.a. and overwrite no-op there)
```

Table 4. Routine for defining Forth word FORMAT for disc formatting.

```
: FORMAT                          ( start compiling the word format)
 0 DR-SEL 100MS RATE CMND         ( turn disc drive on, seek track 0)
 #SIDES 0 DO                      ( do for both sides)
  TRK/DISC 0 DO                   ( do for all tracks)
   DP @                           ( save pointer to scratch area)
   I J BLD-TRK WR-TRK             ( build up image of track, write it out)
   ." track/side/status=" I . J . . CR  ( inform user, 0=good status)
   1 STEP                         ( step in for next track)
   DP !                           ( recover scratch area)
   LOOP
  RATE CMND LOOP                  ( for other side)
 DE-SEL ;                         ( turn drive off, finish compilation)
FORMAT                            ( carry out format)
```



Floppy disc controller
WD1793
LS123
490ms
30ms
7438
p.i.a. A.D6
(Floppy disc, low=on)
(On processor board)
(On processor board)
CDU FIRQ
i/o bus D0
i/o bus D1
i/o bus D2
i/o bus D6
DR0
DR1
DR2
Motor on
Write data
Write gate
Step
Direct
Side select
Optional double sided discs only else open circuit
Odd number pins 1,3 etc to gnd.
Pins 2, 4, 6, 34 no connection.
3 x 220
3 x 330
Schmitt input gate
LS14
LS04
LS74
RAW-READ
Window
Clock
Data
Recovered clock
Read clock recovery
LS161
LS157
(4MHz for double, 2MHz for single density).
i.o. bus (Density select)
Clock frequency select
Density select low=double
1MHz
+Vdd (12V)
Vbb (-5V)
c.p.u data bus
c.p.u. address bus
CS f.d.c.
WE f.d.c. (From wait-state)
Alternative write clock generator — K1160A (Motorola)
8MHz
Note :- All i.c's except f.d.c. and 2 off nor gate on i.o. board. Connections by plug and sockets B and C 16 pin insulation displacement sockets. Spare lines earthed.
Side select is open circuit when double-sided disc drives are not used



After bridge rectification and capacitive filtering, the 15V r.m.s. transformer output gives approximately 20V. Dynamic rams are sensitive to the sequence in which power is applied to them so the supply had to be designed so that −5V appears first, followed by +5V then +12V.

Heart of the switch-mode power supply is a relaxation oscillator, the squarewave output of which feeds a charge pump to produce about −20V peak. This is regulated by a zener diode to produce −5V. Reference for the +5V supply is a 10V zener diode connected in a feedback loop to maintain constant current even when the 20V unregulated supply varies. An error signal derived from the +10V reference and +5V supply, and the relaxation oscillator triangle wave are fed to a comparator. A portion of the triangle wave depending on the magnitude of the error signal is fed to the switching transistor. This pulse-width modulated base drive is disabled when the −5V supply is not present.

The free-wheel diode, inductor and smoothing capacitor are fed by the switching transistor and are chosen with the operating frequency in mind. Around 17kHz is used since it is the best compromise between high-frequency losses and component size. At low frequencies the smoothing capacitor and choke become too large and at high frequencies the switching transition time takes up a large portion of the cycle time and efficiency is reduced.

Unregulated supply passes to the 12V monolithic regulator under control of a transistor switched by the +5V supply. To prevent overvoltage problems, an s.c.r. is included which switches on and blows the secondary winding fuse if either the +5 or +12 rails rise too high.

Switch-mode power supply uses one 15V r.m.s. secondary winding for +12V, −5V and high-current +5V rails. Frequency of the relaxation oscillator is 17kHz, giving the best compromise between smoothing component sizes and loss in efficiency due to switch transition times eating away at the duty cycle. Gating ensures that dynamic rams receive their three supply rails in the correct sequence and s.c.rs provide overvoltage protection.

Disc interface uses a readily available controller which works out cheaper than an equivalent circuit using s.s.i./m.s.i. devices. Clock information in data read from disc is synchronized using a crystal-controlled oscillator running at eight times the rate of the incoming-data clock. The prototype computer has a standard Teac 51/4in floppy-disc drive.

To be continued with construction tips, parts list and vocabulary.

References

6. J. R. Watkinson, Disc drives, *Wireless World*, Mar.–May & July-Dec. 1982, Jan.-Mar. 1983, especially Oct. & Nov. 1982.

7. American National Standard, Interfaces between flexible disc drives and their host controllers, X3.80-1981 (ANSI).

8. J. F. Hoeppner & L. H. Wall, Encoding/e-coding techniques double floppy-disc capacity, *Computer Design*, Feb. 1980, pp 127-135.

9. E. Kadison, 5.25in floppy-disc formats, *Electronic Design*, 23 Dec. 1982, p.135.

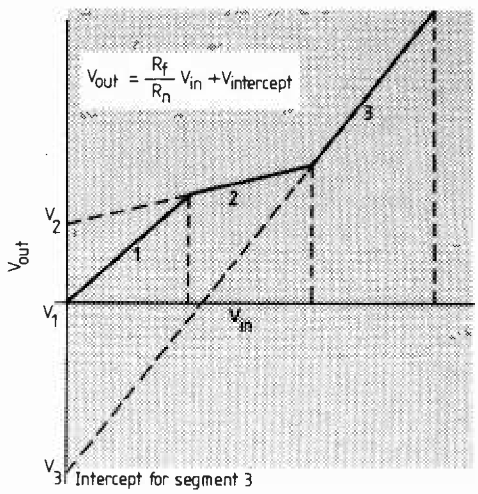
CIRCUIT IDEAS

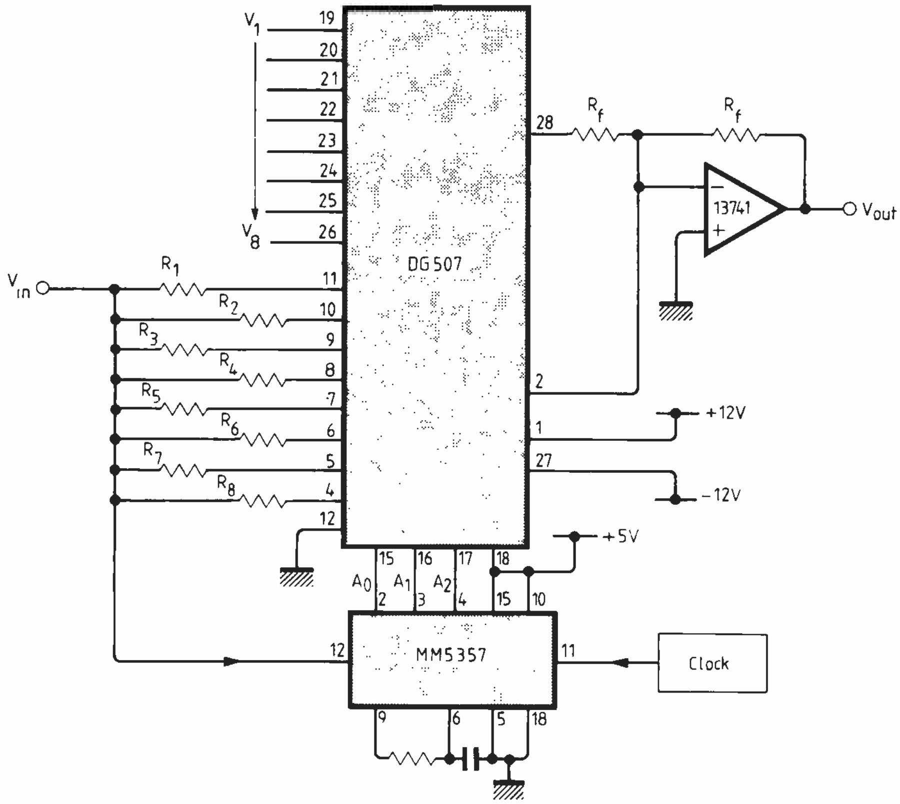
A-to-d realises non-linear functions

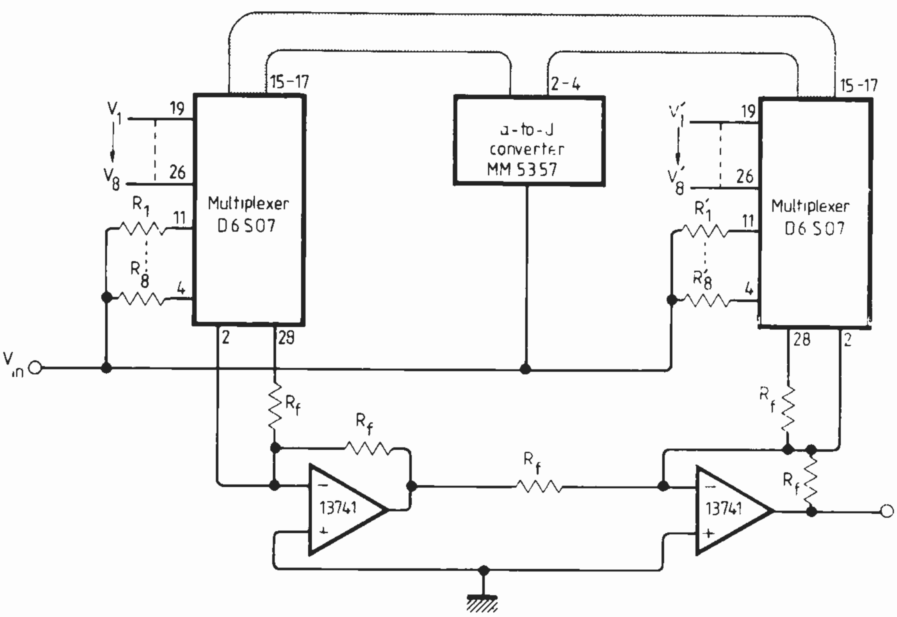
An analogue-to-digital converter and differential multiplexer can replace diode function generators to realise arbitrary transfer functions with flexibility and excellent drift characteristics. The circuit shown is for an eight-segment function using the three most significant bits of an inexpensive a-to-d converter to generate eight segments.

The converter is connected in continuous-convert mode and controls the multiplexer. Depending on the converter output, the appropriate slope-select resistor and intercept voltage are switched in to realise the transfer function. The number of segments may be increased and the circuit extended for positive and negative slopes as shown. These circuits can realise continuous or non-continuous transfer functions.

K. Neelakantan
Reactor Research Centre
Kalpakkam
India



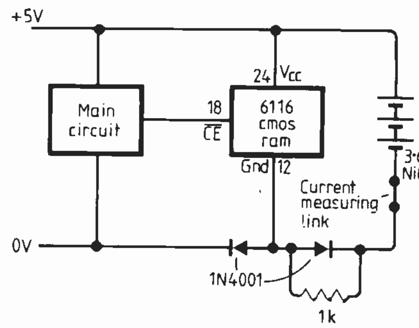




Simplified backup for cmos rams

The prime consideration when setting cmos ram in low-current standby mode is that the chip-enable voltage must be ≥ $V_{cc}-0.2$. Usually one would use back-to-back diodes with a charging resistor in the positive supply rail but anything connected to the chip-enable input must allow the voltage to drop to zero when the main supply is removed so a switch and pull-up resistor are usual. Current through the measuring link should drop from a few mA to a few μA when the main supply is removed.

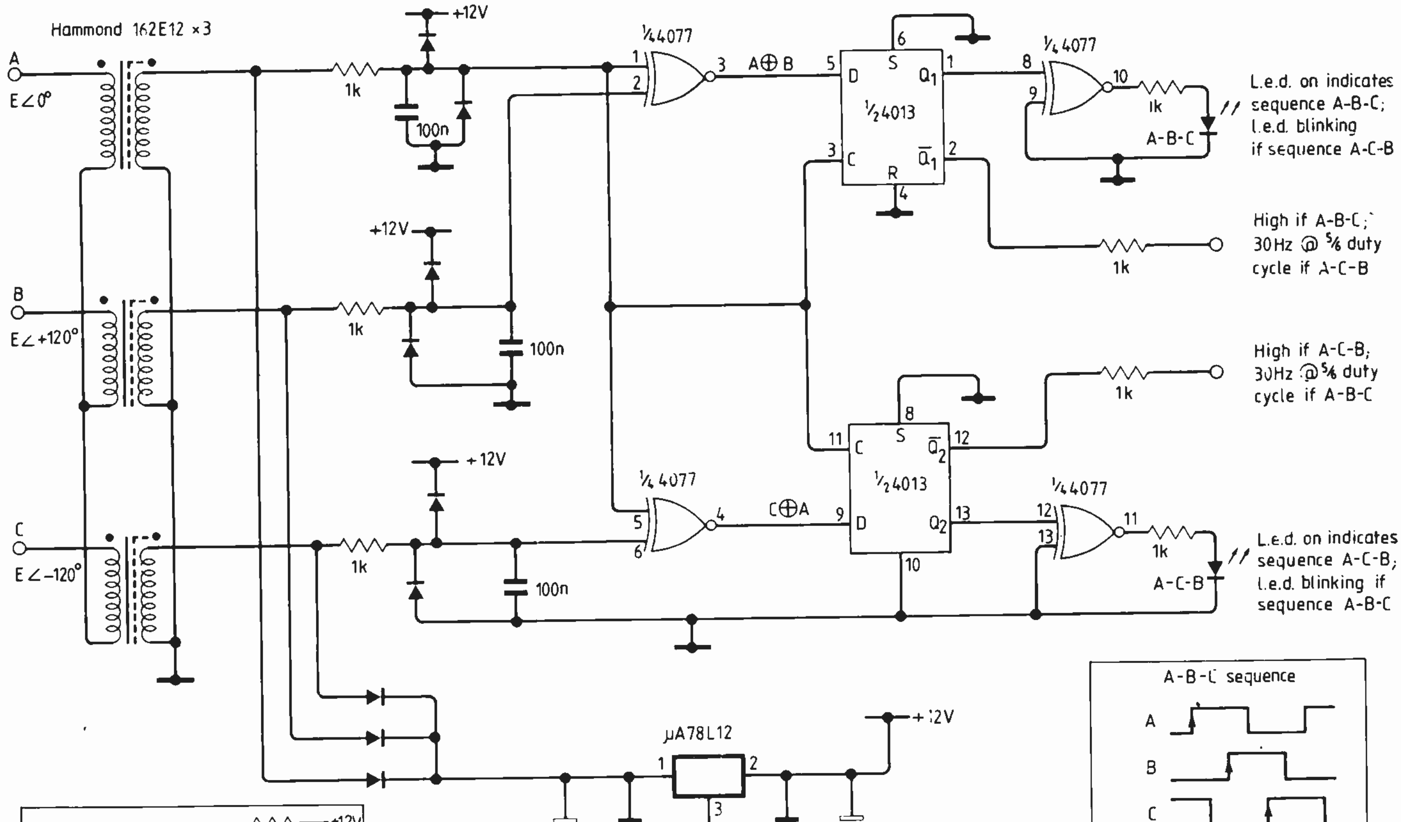
V. R. Halsall
Bushey
Watford

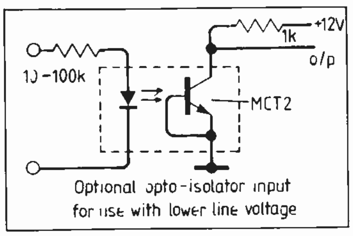


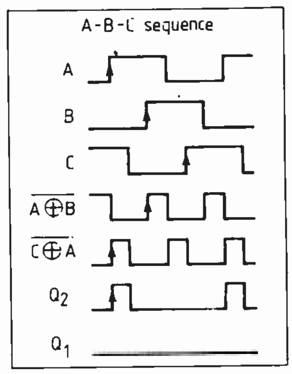
Three-phase sequence detector

Phase-sequence detection in three-phase systems can be accomplished by generating signals that contain the relative phase difference between two successive phases and comparing them with an arbitrary reference.

Two exclusive-NOR gates form phase comparators to produce signals representing the difference between phases A and B (A⊕B) and C and A (C⊕A). Since the voltages applied to A, B and C have phases of E∠0°, E∠+120° and E∠−120° respectively and exclusive NOR operation







produces signals that contains the ±120° phase difference. Appropriate outputs are compared with a reference clock to give sequence detection; outputs A⊕B and C⊕A are compared with the reference phase A using two D-type flip-flops.

The flip-flop output is low or switches at 30Hz with a ⅙ duty cycle depending on whether the sequence is normal or reversed. Two remaining NOR gates form inverters to drive the indicators through current-limiting resistors. A complementary output from the flip-flops may be used to activate reverse-sequence alarms, relay drivers, direction indicators for motors and gyrocompass synchro-repeaters or for inhibiting three-phase s.c.r.-controlled battery chargers to avoid misfiring which leads to line-to-line faults.

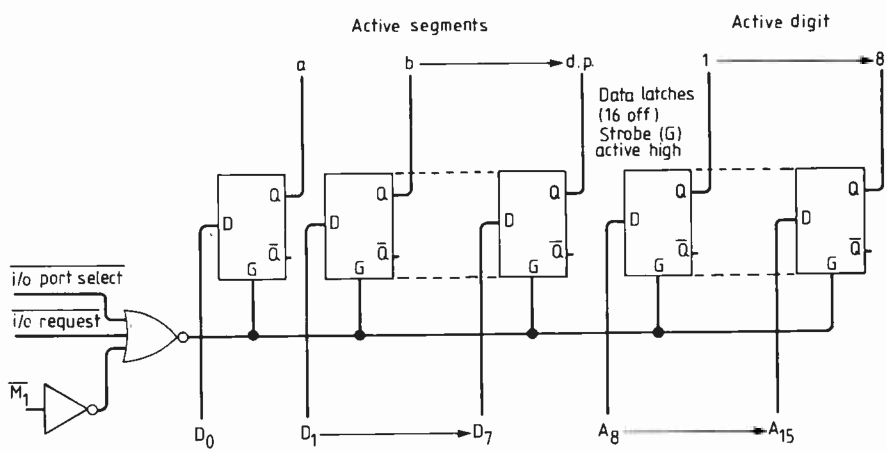
Three 230/12V isolating transformers are star-connected to allow a larger input-voltage swing and limit the upper input voltage to 440V. When the input voltage falls to 190V the regulator is affected. Input capacitors filter line harmonics and r.f. For lower line voltages opto-isolators may be used instead of transformers but a separate power supply is needed; batteries make the unit portable.

A. L. Eguizabal
Vancouver
Canada

Z80 16bit output

Normally one would use two output ports of the Z80 to give a 16bit word but if both bytes are to be strobed or latched at the same time, additional hardware is needed to synchronise the two output executions and complications arise. But during an OUT(C),r instruction the Z80 places data and the port address on data lines and the lower byte of the address bus respectively and places B-register contents on the upper eight address lines so only one output-port instruction and one output port are necessary.

The circuit was used to control eight multiplexed seven-segment leds for a small controller. I/O port-select was not decoded – A_5 was used instead. If one of address lines 0 to 7 is used it must be low to select.



Data to control the active segment is loaded into the accumulator, the active digit mask is loaded into register B and the port address is loaded into register C. An OUT(C),A instruction is then executed. Common-anode or common-cathode leds may be used. Active digit outputs should be buffered by transistors.

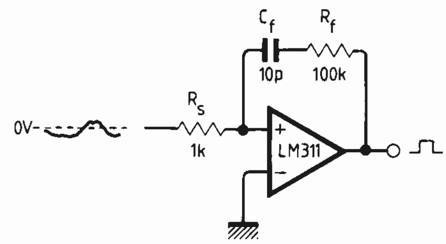
It is also possible to perform an eight-bit input and an eight-bit input with only one input instruction with a different circuit.

Javier Cazot
Horndean
Hants

Positive feedback without hysteresis

This circuit overcomes the problem of conventional d.c. hysteresis degrading precision low-level detection for comparators driven from poor voltage sources. To obtain reliable switching from low-level voltages (<100mV) exhibiting slow rates of change and non-zero output resistance it is usually necessary to provide positive feedback around the comparator. Direct-current positive feedback can generate significant hysteresis, substantially shifting the switching levels, resulting in an asymmetrical output.

The method operates by a.c. coupling positive feedback through C_f resulting in zero·d.c. hysteresis. The value of R_f is chosen to give the desired amount of feedback in conjunction with the source resistance R_s. Typical values for C_f are between 10-100pF. To operate correctly at high repetition rates requires that the time constant C_fR_f is less than the time constant of the input waveform to ensure that C_f has



time to recharge between transitions. For best results, comparator supply lines should be decoupled to ground by 0.01μF disc ceramic capacitors close to the i.c. For example, using a 311 comparator a 50mV 1kΩ triangular waveform can be reliably switched with no hysteresis up to 1MHz with C_f = 10pF and R_f = 100kΩ.

B. Wilson
Nottingham University

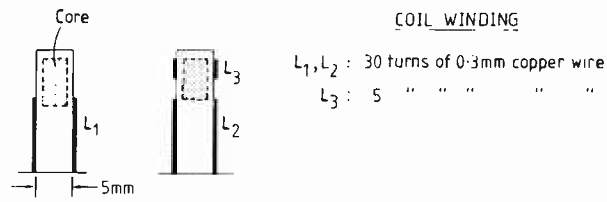
Single-frequency shortwave receiver

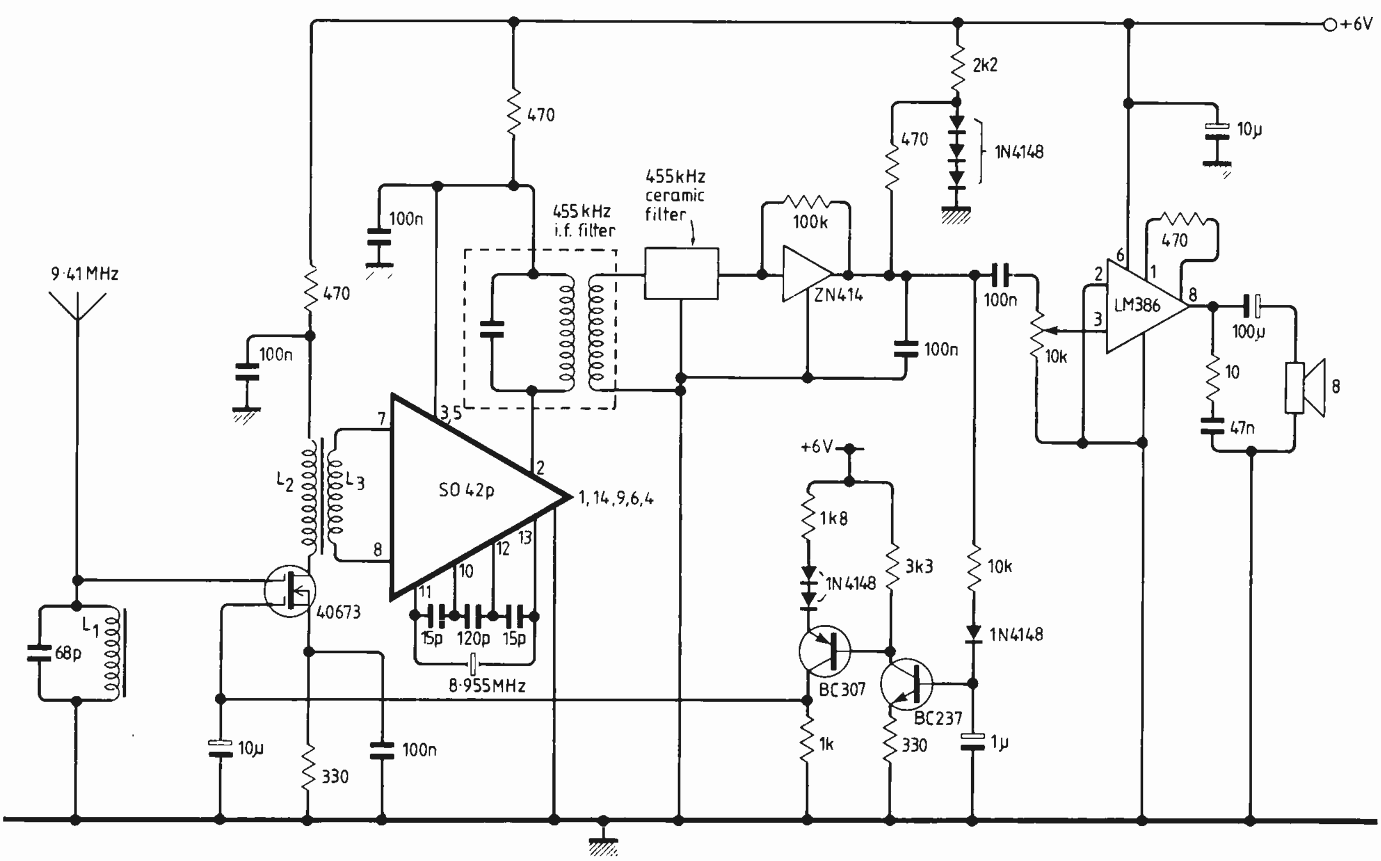
I designed this shortwave receiver for one frequency only; it has the advantage that the local oscillator can be crystal controlled. Our radio news in Demark is rather bad so the receiver is designed to receive BBC World Service on 9.41MHz.

An SO42P (Siemens) forms the local oscillator and mixer, the output feeding a 455kHz LC filter followed by a 455kHz ceramic i.f. filter. I.f. amplification and a.m. detection are performed by a ZN414 (Ferranti). This i.c. has its own a.g.c. but it is not sufficient to handle large amplitude variations on the shortwave band. To improve this the 414 output is amplified by about ten times after low-pass filtering. Output from this amplifier is connected to gate two of the mosfet h.f. stage to control gain and improve reception. Finally the l.f. signal is amplified by an LM386 (National Semiconductor) which gives about 0.2W into 8Ω with a 6V supply.

Per Hojlev
Copenhagen
Denmark

World Service frequency information can be obtained from BBC External Services Publicity, Bush House, PO Box 76, Strand, London WC2B 4PH.





Thévenin-Norton transient theorem

The Thévenin-Norton theorem is restricted to the manipulation of independent sources only. This new theorem manipulates all sources, but still produces equivalent generators, similar to those contributed by Thévenin and Norton. Finding the generator immittance is now greatly simplified.

by Harry E. Stockman

A theorem can be formulated that produces the two equivalent generators of a transient network[1], either entirely in the time domain, or in the s-domain. It extends to the case of dependent sources ki(t) or kv(t) being included in the network. Theorem:

A step-excited linear network with an accessible port has two equivalent generators, the series-form generator having the generator impedance in series with the open-port voltage due to all sources, the parallel-form generator having the generator impedance in parallel with the close-port current due to all sources, the generator impedance in time or s-domain form being the port looking-in impedance when all sources are removed.

In the theorem formulation, "all sources" means the driving sources together with all initial-value sources. Other kinds of driving sources may be substituted in accordance with the rules well known in the art. The proof of the theorem is provided by an application of the basic Source Transformation Theorem.[2]

As an example, consider the simple time-domain network in Fig. 1, where i(t) is the unknown. We wish to replace the

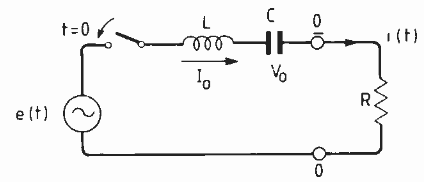


Fig. 1

network to the left of port 0,0 by a parallel-form generator, and we shall do this without leaving the time domain, making use of the D-operator. The desired network is shown in Fig. 2 (a). Employing the delta function,

$$i^*(t)=\frac{e(t)}{z^*(t)}+\frac{LI_0\delta(t)-V_0}{z^*(t)} \quad (1)$$

$$z^*(t)=DL+1/DC$$

The equation read-off from the Fig. 2(a) network is

$$i^*(t)-\frac{RTi(t)}{z^*(t)}-i(t)=0$$

and it is the same one that we would have obtained from the original network, proving our construction correct.

A common form of equivalent generator is shown in Fig. 2(b). To obtain this one, we pair the second term in equation 1 with the time-impedance z(t) in Fig. 2 (a) and the make use of the source transformation theorem[2] to change the combination into the series-form generator, shown as a shunt branch in Fig. 2 (b). Here $i^{\#}(t)$ is the first term in equation 1.

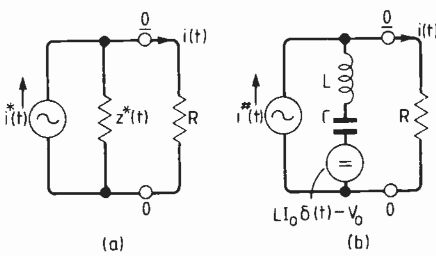


Fig. 2

The above is readily turned into an s-domain derivation by the observation of proper s-variables and the replacement of D by s. Many of the equivalent-network derivations are carried out much faster if we refrain from the use of the Lapalce trasnform with its dependence on proper tables and instead stay in the time domain all the time. The required time-immittance is made available by the versatile D-operator. However, when the answer has to be given as an operator-free time expression, Laplace's method usually provides the quickest route to the answer, except for periodic steady-state portions, where Steinmetz' method yields a still faster solution.

Application example

An interesting case is at hand when the theorem is applied to a segment of a larger network, the segment containing dependent sources only. Then the Thévenin-Norton theorem does not apply, while the new theorem allows us to construct an equivalent generator that replaces the segmented network. For a simple example see Fig. 3, where the network segment to be replaced is shown to the left of port AB, while the series-form generator that takes its place is shown in broken line to the right of port AB. Assume that the total network does not extend beyond the points marked x.

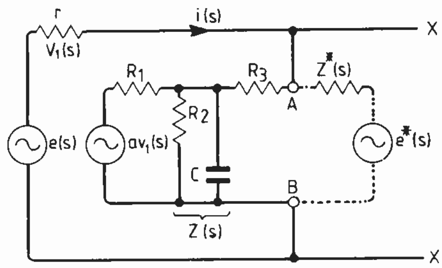


Fig. 3

If the driving voltage e(s) is a step voltage, we may use Laplace's method, but if it is a sinusoidal e.m.f. we would probably use Steinmetz' technique. Consider the unknown quantity to be i(s). The theorem yields directly

$$e^*(s) = arZ(s)i(s)/[Z(s) + R_1]$$

$$Z^*(s) = R_3 + Z(s)R_1/[Z(s) + R_1]$$

We readily find for the total network

$$i(s) = [e(s) - e^*(s)]/Z^*(s) + r].$$

In this simple example, a conventional solution using Kirchhoff's laws is almost as quick, but for more complicated cases the theorem saves time. This is particularly true when the segmented network contains a mixture of dependent and independent sources, and when initial conditions must be taken into account. WW

1. H. E. Stockman, Transient Analysis Aided By Network Theorems. Sercolab, 1983.
2. H. E. Stockman, Network Theorem Book. Sercolab 1982, second edn.

Craft and technology

Should modern technology be combined with the craftmanship associated with the past? Dr Ken Smith discusses the role of the industrial designer.

By K. L. Smith

At a craft fair in Kent, I discovered a bracket clock of modern design, with fine traditional metalwork mounted in an handcrafted case of umber tinted transparent acrylic. The silvered chapter ring, brass spandrels and finials were finely engraved and hand finished. It gave the impression of being a traditional English timepiece while using modern materials.

In answer to my question, the designer/craftsman, Mr R. Marchant said, "Contemporary artists and craftsmen must use modern materials and mould them to give a message of what we are doing now".

My sympathy with this philosophy led me to muse about the function of indust-

Resonance applied to timekeeping

Up to about 1650, the escapement of mechanical clocks was aperiodic with a bang-bang type motion. Thes foliot escapements had vertually no Q and their period was dependent on the driving force. The discovery of the gravity pendulum in the early 1600's, although imperfectly understood initially as a resonant system, soon resulted in continuing improvements that have only 'saturated' in recent times, as the graph indicates. Clock-makers soon realised that the maintaining force should be tiny, for the best tiemkeeping. A whole epoch of fine clock-making gradually developed – with much work on escapements and long heavy pendulums. The long case and bracket clocks of England reached a peak of fine craft.

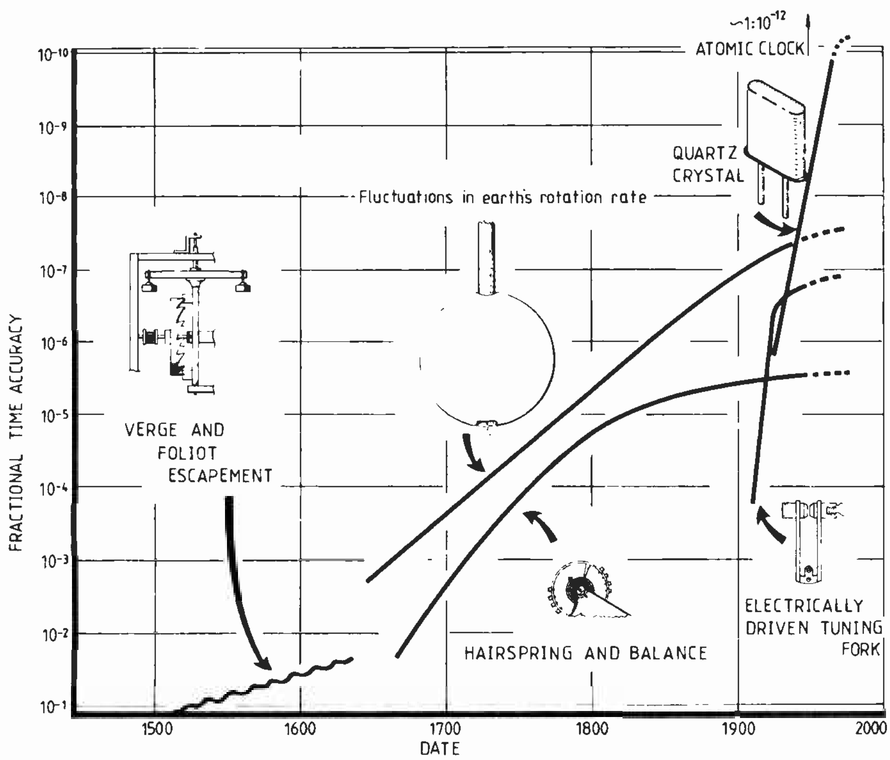
On the theoretical side, logarithmic decrement, δ, became the standard quality measure of mechanical vibrations; this is the natural logarithm of the ratio of any two successive amptitudes. A pendulum will swing freely for some 2000 to 20000 times before reaching half initial amplitude. Now $Q = \pi/\delta$ therefore $Q = \pi n/\log_e 2$, and because n is the number of oscillations to reach half amptitude, this indicates that a good pendulum has a Q ranging between 10,000 and 100,000.

The peizoelectric effect was discovered by Jacques and Pierre Curie in 1880.[1] By 1917, A. M. Nicolson[2] had used a peizoelectric crystal to control the frequency of an oscillator, while P. Langevin[3] used large resonant blocks of quartz from 1918 onwards in his experiments on submarine depth sounding and signalling. In 1925, K. Van Dyke[4] described the electrical equivalent circuit of a quartz plate, thus establishing the criteria for designing and calculating the Q of a quartz resonator.

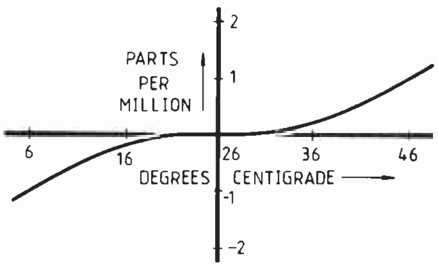
Much later (1947) Van Duke, with coworker Maynard Waltz[5] measured the decrement of a precision zero coefficient ring crystal made for high precision timing. They found that vibrating freely in a vacuum it would vibrate over a million times before the initial amplitute was halved. This indicates the Q was some 4.5 million.

The first person to propose the use of quartz crystals in clocks was Warren A. Marrison. His notebook for November 1924 clearly outlines a high frequency quartz controlled oscillator and frequency translation system for driving a clock motor. By 1927 with J. W. Horton[6] he described and demonstrated a working quartz clock with temperature controlled crystal at a meeting of the International Union of Scientific Radio Telegraphy. Marrison's 1930 paper "The Crystal Clock"[7] proposed the use of this clock as a world standard time source. It was developed and adopted and remained pre-eminent in this role until displaced only recently by the even higher precision atomic clock.

As indicated, the best crystal clocks[8] reached an accuracy of a few parts in 10^{10}, some 100 times more precise than the fluctuations and variations that go on continually in the motions of the earth.



Continuous improvements in the various methods of timekeeping is well illustrated by plotting the date of the attainment of results against the precision obtained. (Three parts in 10^7 amounts to about one second per year).



One of the most useful cuts across a quartz crystal is the AT. This gives a cubic relationship for the temperature coefficient of the oscillating quartz bar, as shown here. The point of inflection, where the drift is nearly zero, can be chosen at room temperature by selecting the aspect ratio of the bar.

rial design. Such artefacts as a well-structured p.c.b, with all the components colour-coded and laid out for strictly functional use, can be aesthetically (though unintentionally) very pleasing, and may be subjects of study by future art historians, much as we now collect and discuss vernacular objects from the past. Many mass-produced goods disguise themselves in poor design, however good the technology incorporated in them.

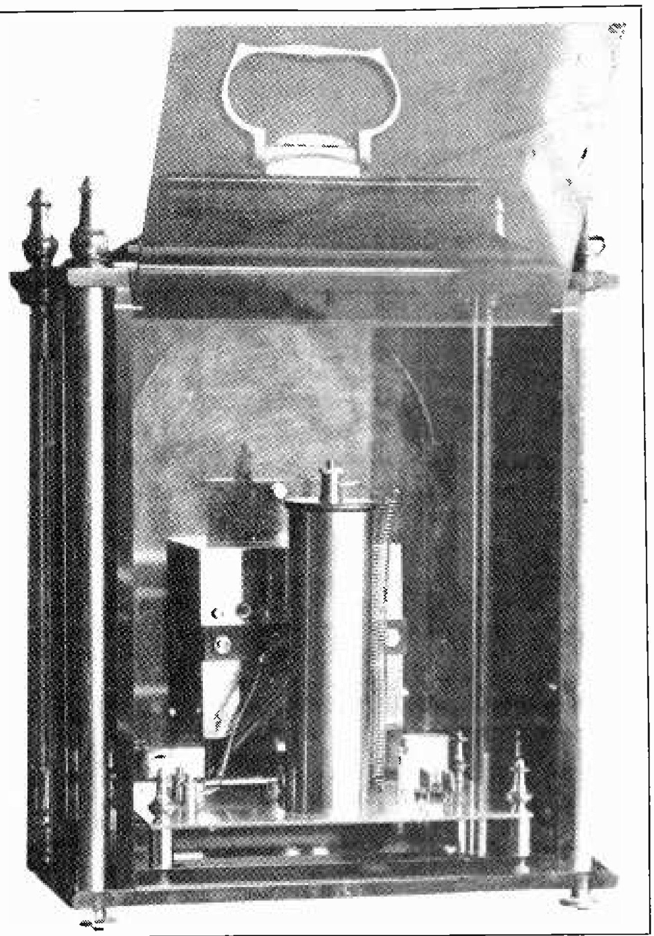
What relevance has all this in an electronics journal like *Wireless World*? The answer is that the clock I have mentioned, although it originated in a cottage industry established by a craftsman, uses a very up-to-date quartz drive.

Many clockmakers denigrate the advance of the quartz clock; they think of it as damaging and vulgarising their craft. It is true that microelectronics with tiny precision quartz resonators, has completely swept the clock and watch market. Millions of digital and analogue devices have appeared and digital watches seem to cost little more than the cells that drive them.

Yet with high craftmanship and deliberate exploitation of the medium, Mr Marchant's clock bridges the void between fine individually made objects and the anonymous mass-produced (although highly technological) goods.

The success of this design encourages me. It has a message that individualism in small scale industry is very much alive. There are artists and craftsmen on the fringe of capitalism who can use its media and materials to express themselves, and make an income. They do not need to go through the paraphernalia of 'management studies', 'rationalisation', factory development, growth and so on. In this age of depression, listlessness, unemployment, technocracy, with electronics engineers working as mercenaries on machines of death, this could be an important message, and much in keeping with some recent editorial comments in *Wireless World*.

Tall cylinder in the centre of the case is the battery holder, Horizontal p.c.b. is supported on brass pillars and held by brass knobs. Interconnection from the battery and to the stepper motor are by coiled, polished copper wires. Stepper motor and clock mechanism are housed in a brass case.



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8. Miniature Transistorized Crystal-controlled Precision Oscillators, W. L. Smith, *I.R.E. Trans on Insts*, September 1960. pp. 141-148.

Last chance to enter

Our cover reflects the theme of the competition announced in the March issue in which we invited readers to design an electronic device to help the disabled. We asked intending competitors to return their entry forms by the end of June, and so there is still an opportunity for you to take part if you have received this issue in good time.

An encouragingly substantial heap of entries is already with us. They come from participants of every description, including academic groups, professional designers working on their own or in teams and individual hobbyists. Some have already told us about the projects they are working on, and they range from small gadgets to complex computer-based devices. Complexity, however, will not win prizes if it means unreliability and a high cost to the user; and so the lone entrant with limited resources is not necessarily at a disadvantage. Our judges will be looking for devices which provide a practical solution to the problems of the type of person they are aimed at and which are affordable as well.

board to allow disabled people to use electric typewriters and home computers; and a device to allow cerebral palsy sufferers to communicate by converting head-movements into synthesized speech.

More information about the competition, with an entry form and list of rules, appears on page 76. Returning the form to us does not commit you at this stage to any specific project, but all entries must be completed and submitted to the Editor by 1st October.

COMPETITION £8,000 IN PRIZES

The competition has attracted entries dealing with a wide variety of disabilities. Projects we have heard about in the last few weeks include a device to allow blind people to detect colours; a specially-designed key-

Single-chip printer controller

Until recently the preserve of the high-volume manufacturer, the single-chip microcomputer is now becoming available to a wider market. Here is an original application for an Intel 8048 microcomputer, as the controller for a small dot-matrix printer.

by S. J. Pardoe

Although the microprocessor has become an accepted electronic component rather than a curiosity, most engineers and users are familiar only with the general purpose 8 or 16bit devices exemplified by the 8085, 6502 and 6800. These microprocessors are always accompanied by random access or read/write memory (ram), read-only memory (rom) and input/output (i/o) devices to make them into something useful in a multichip system. In fact, these devices represent only the tip of the microprocessor iceberg.

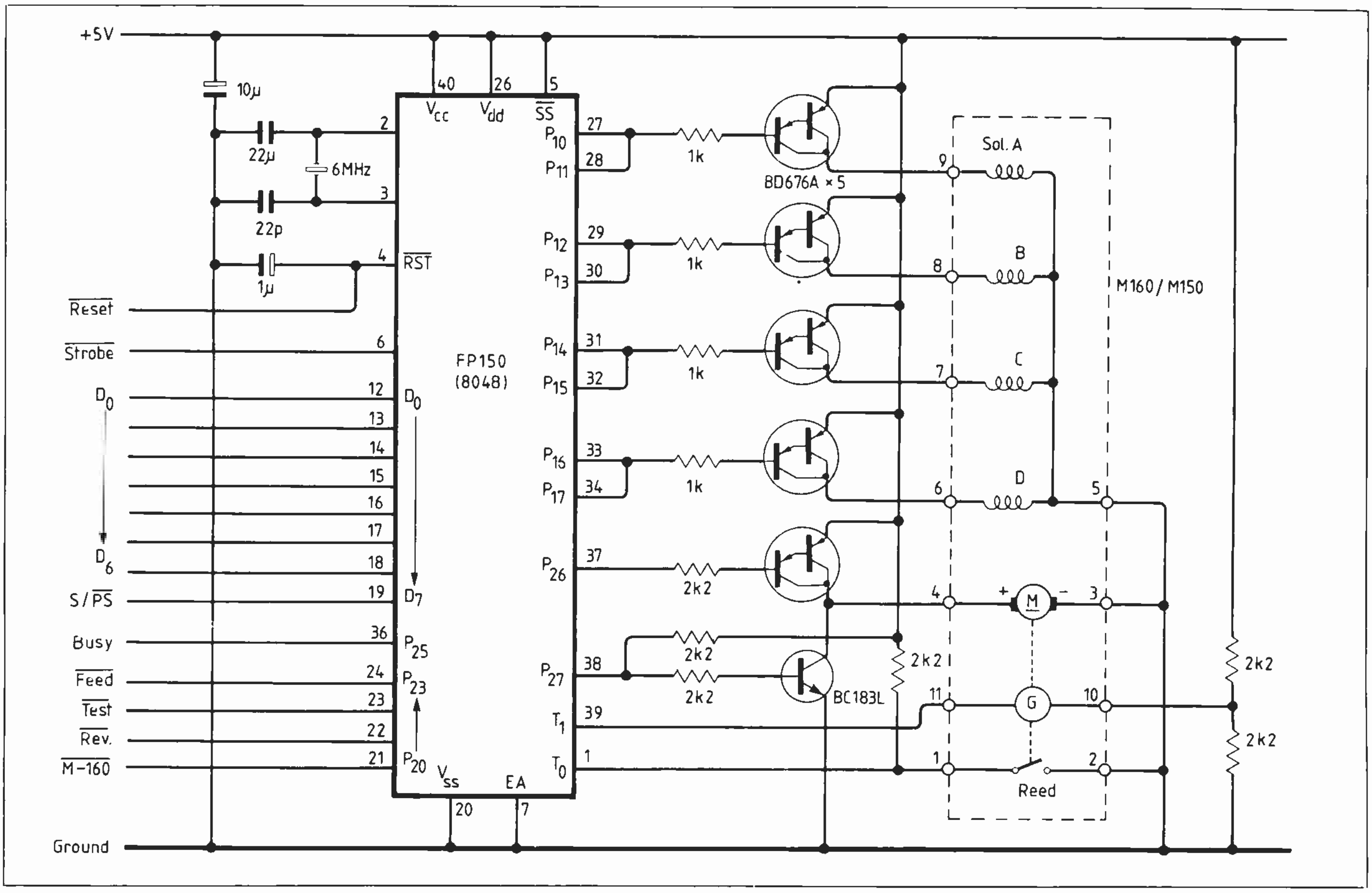
By far the majority of applications are too cost-sensitive to use a multichip system, and the semiconductor device manufacturers have responded by designing a wide range of simple, cheap computers in which the c.p.u., ram, rom and i/o are integrated into a single silicon chip. These find applications from toys to business machines, and are sold in tens of millions. Many have special architectures optimized for control rather than computation, though a few are derived from general-purpose processors, such as the 6502 or 6800.

The single-chip controller used as the basis of this article is the Intel 8048, an eight-bit microcomputer with c.p.u., 1K of rom, 64 bytes of ram, and 27 i/o lines in a 40-pin package. Such devices are mask-programmed; that is, the program is built into the chip during manufacture, and cannot be changed. An eprom equivalent, the 8748, can be used for development or small-volume manufacture.

The Epson M150/M160 series of miniature dot-matrix printers is unique in several ways. Exceptionally compact, yet printing on plain paper with a 5V supply and very inexpensive, they open up a whole new range of printer applications. It is now feasible to incorporate a printer into low-cost equipment; the M160 is the printer chosen for the new Epson HX20 hand-held computer. As it makes little sense to swamp such a small and inexpensive printer with a costly multichip interface, a single-chip controller was programmed to handle data input mechanism control and character generation.

The M150/M160 differ from most matrix printers in having only four printing solenoids, arranged horizontally in a shuttle which moves from side to side, building up characters as a raster of dot rows. A d.c. motor, gears and cams move the shuttle and feed the paper on synchronism; an a.c. tacho and reed switch time

Stephen J. Pardoe, B.Sc. (Hons) graduated in Chemistry in 1970, but transferred to Electronics soon after joining Glaxo Laboratories, where he developed a printing checkweigher. He has been involved in the design of printer systems ever since and is now a partner in Friday Partnership and a director of Able Systems of Northwich. He is married with teenage children and enjoys fell walking and high fidelity equipment design.



the dot pulses and indicate the start of each dot line. A dynamic brake is required to stop the motor quickly between dot rows.

The M150 prints 16 characters across the 44mm paper, four to each solenoid, the M160 prints 24 across 57mm, six to each. Interface hardware is identical, but the software is slightly different to accommodate the character format. From now on, the two will be referred to as the M150. The full electrical specification would occupy half his magazine, but briefly it is

Solenoids (4): 4.0V d.c. 1.5A 2.5A pk

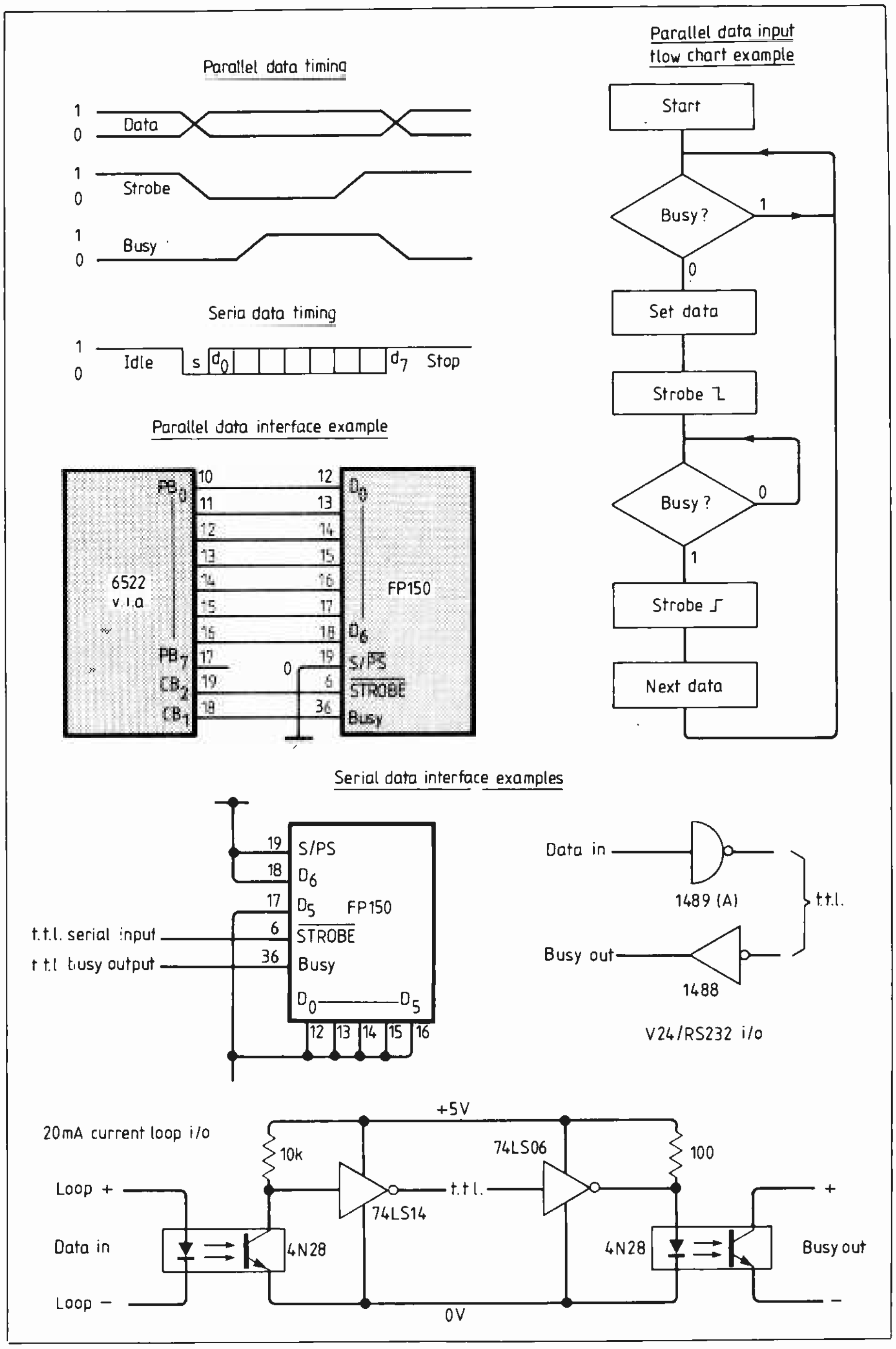
Motor (drive): 4.5V d.c. 0.17A 0.8A pk
(brake): 4.5V d.c. 0.3A

Tacho output: 3V pk-pk

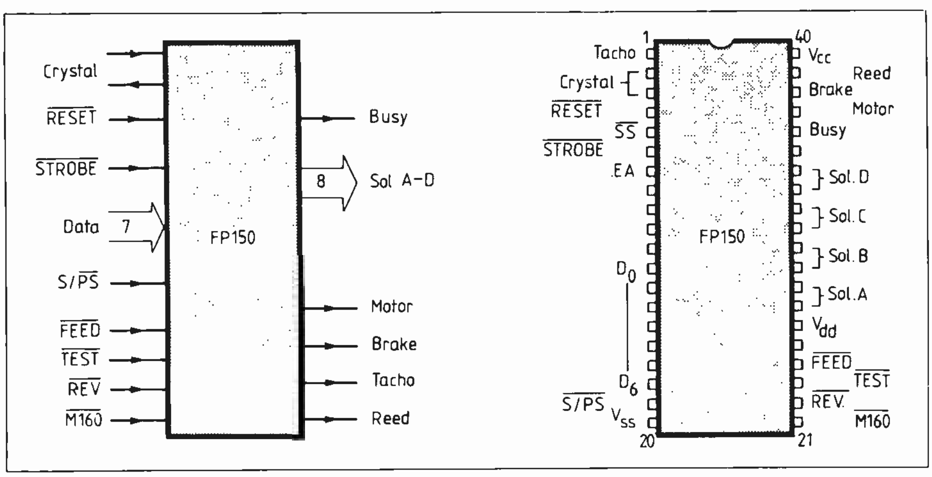
These requirements can be met by very simple circuits, as shown. The solenoid drives are paired as each 8048 output can sink only 1.6mA, whereas 3.2mA I_b is needed to produce a 2.5A I_c from a BD676 device. No flyback diodes are needed, as these rugged Darlingtons can easily absorb the turn-off spike, and the high instantaneous reverse voltage helps to collapse the solenoid field and makes for crisper printing. The brake circuit effectively shorts out the d.c. motor, which is rapidly brought to rest. Experience has shown that the tacho signal easily drives the 8048 T_1 input if suitably biased: some trimming of the divider may be needed to equalize print density between solenoids.

Data interfaces are provided that are parallel, rather like Centronics practice and designed for connection to the host via a PIA port and serial, following RS232 protocol at 110, 300, 1200 and 2400baud, though at 5V levels. The rate is selected on data 5 & 6, and serial mode selected by taking S/PS high. Four i/o pins are left for local control functions: paper feed, self-test, selection of reversed printing (for use in panel mounting applications), and selection of mechanism (150 or 160).

The FP150 chip accepts ASCII seven-bit data. Control codes select various print formats, including double width and height, and inverted print. It will also print graphics patterns by accepting binary-coded 'characters', again with special control codes. It is then possible to print any dot pattern that can be accommodated in a 96-wide field (144 in the M160).



The 8048 program memory area of 1024 bytes is divided into four pages of 256 bytes. The 64-character ASCII set is coded up as 320 bytes, or five per character, in hexadecimal, to give a 5 by 8 character set (the eighth bit is used for underlining and descenders on punctuation marks). The character generator software 'looks up' these data bytes, and shifts them into the appropriate pattern to form the dot matrix as the print solenoids move across the paper.



Character generation is complicated by the requirement to print in both normal and reversed modes, in single or double width and/or height, and to accept graphics input. In all, 16 printing modes are provided, so all through the character generator conditional jumps hop and skip through the listing to select the functions required. This has led to nearly half the available 1K program being devoted to character formation.

The other major software area is in the data interface. Here the parallel input is straightforward, consisting only of a bus read instruction and testing of the strobe input once that mode is established. The serial input routine is much more complicated: the strobe pin is sampled at intervals determined by the data rate chosen, to build up a replica of the transmitted char-

Frequency control of turntable motors

Many high-quality turntables use a small synchronous motor to drive a heavy turntable platter through a flexible belt. Where mains frequency fluctuates, the speed of the turntable alters. This circuit overcomes the problem by providing a reference frequency independent of the supply.

By Peter A. Stockwell

Synchronous motors achieve their constant speed by locking on to the mains frequency. However there are two main disadvantages: Firstly the wow and flutter performance depends on a constant supply frequency. This is not always met, particularly in my country, New Zealand, where periodic fluctuations, outside the stated limits are evident, presumably due to faults with generator regulation and where frequency is reduced when the grid is under heavy load, compounded by a subsequent speed-up to regulate the time on synchronous clocks. Then secondly, synchronous motors do not allow any convenient method of speed regulation, unlike many direct-drive or d.c. controlled turntables.

Synchronous motors use very little power and can lock on to the supply frequency over a wide range of voltages. Thus it is relatively simple to construct an oscillator that will produce the required frequency signal and then boost the output voltage to the level of the mains by the use of a power amplifier, which can be small and cost little, and an output transformer.

The motor needed a waveform close to a sinusoidal, or it could find difficulty locking on to the frequency and could even run backwards. Waveforms with excessive harmonic content could cause sound to be radiated through the motor and the belt. A Wein bridge oscillator with its inherent sinusoidal output would seem to be ideal, but it needed two resistors to be varied simultaneously to adjust low frequencies. During tests it was found that any mismatch in the tracking caused settling delays which could make the turntable stop and start and run in reverse. Another disadvantage was the ability to find a suitable thermistor to act as a gain control element.

Voltage-controlled oscillators (v.c.os) are an appropriate choice which give a constant amplitude of the output wave independent of the output frequency. Unfortunately v.c.os give triangular or square waves and these need to be shaped. The circuit shown in Fig. 1 has been devised to do this. IC_2, a 566, is a very stable v.c.o. whose frequency of oscillation is given by; $f_o = 2(V_s - V_c)/R_1C_1V_s$, where V_c is the control voltage at pin 5, V_s is the supply voltage and R_1, C_1 are as indicated in Fig. 1. If V_c is derived from a resistive divider, the ratio V_c to V_s is constant so the frequency should be indepèndant of the supply voltage. The only likely source of drift in the frequency is the temperature coefficient of IC_2 (300 p.p.m/°C), the divider chain, R_1 and C_1. The use of metal oxide resistors and a high quality potentiometer should help to minimise this. The motor was unable to lock onto high or low extremes of frequency so the resistor chain was selected to restrict the range. The potentiometer I used was a ten-turn Beckman Helitrim. A high quality wire-wound potentiometer was also used

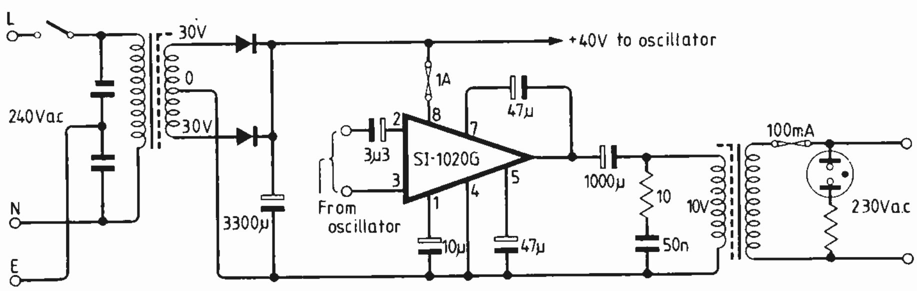
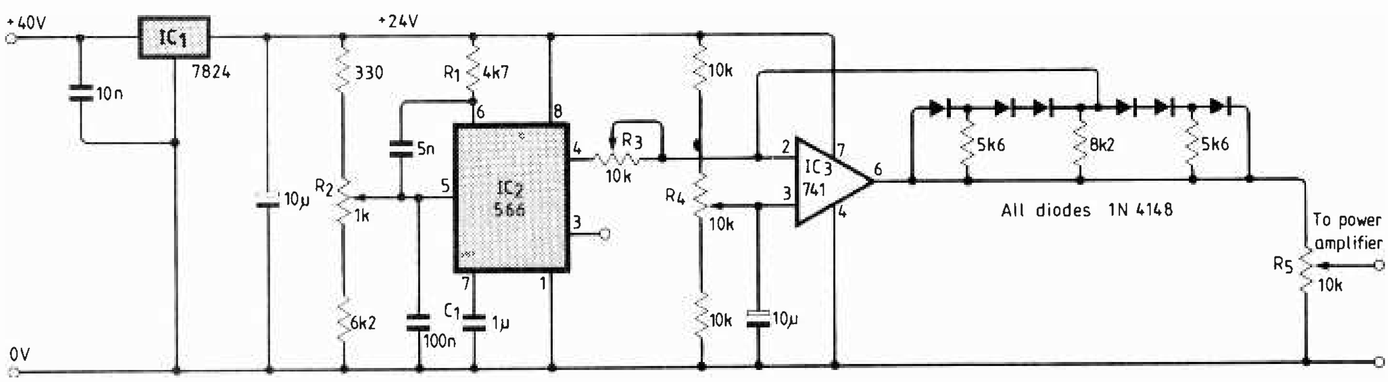


Fig. 2. Sanken hybrid amplifier feeds the signal to a mains transformer used backwards to provide the turntable motor with mains power at the chosen frequency.

Fig. 1. Frequency generator is based on a 566 v.c.o. R_2 is adjusted to give the frequency for the turntable speed for all records including 78r/m. The 741 with its feedback matrix shapes the waveform.



with a changeover switch to select a preset turntable speed.

The 741 has a diode resistor matrix in the feedback loop to convert the triangle wave output of the 566 into an acceptable approach to a sine wave. R_3 and R_4 both control the shape of the output waveform and are most easily set by using an oscilloscope on the output. R_3 controls the shape of the peaks while R_4 controls the positive and negative symmetry. R_5 is set to give the required voltage output to the motor.

Alternative v.c.os, like the Intersil ICL8038, can produce a sinusoidal output directly, but one was not readily available to me. However, by the time that the necessary external components are added, for controlling the symmetry, minimising the distortion etc, it is unlikely that the component count would be much below that for the circuit given.

Power amplifier choice was dictated more by the contents of my junk box than by any particular suitability for the application. However it does work satisfactorily even on the rather low supply voltage (the junk box again!). The output transformer is a small power transformer used backwards. It takes a few watts of power to provide the magnetising current or the core allowing for this, the power

Peter Stockwell holds an honours degree in Biochemistry and is currently involved in the development of computer programs to analyse DNA sequence data at the Biochemistry Department of Otaga University. 31 years old, his interests include electronics particularly as applied to high fidelity, music (he plays a pipe organ), and photography.

consumption of the motor with a little headroom must be considered when choosing a suitable amplifier. In addition falling impedance with frequency causes excessive power consumption, though this may be offset by a capacitor-coupled amplifier since the capacitor impedance increases with falling frequency.

The effects of the series capacitor at low frequencies and of the transformer inductance at higher frequencies mean that output voltage will decrease at higher frequency. The d.c. resistance of the transformer produces some reduction in the output voltage under load. However there is no need for output voltage regulation as the synchronous motor is very tolerant to variations in voltage. The neon across the output provides a simple indicator while the capacitors across the input prevent transients from getting into the mains and hence into the hi-fi system.

Satisfactory performance over several months has been achieved on my Thorens TD-160 turntable. It is suitable for a number of high quality turntables driven by synchronous motors including Linn Sondek, Transcriptors and other Thorens models. One difficulty has been finding a suitable way of measuring the correct turntable speed in order to regulate the output frequency. I used a stroboscopic disc under the mains lighting, but this is far from ideal as the whole point of the circuit is that the mains frequency is not constant. I leave it to the reader to devise the most satisfactory means of setting the speed. WW

Continued from page 69

acter in the 8048 accumulator by shifting the carry bit into it.

Once the parallel or serial character is received, the busy line is set high to tell the host not to send more data, and the processor then tests the received character to determine what should be done with it. Control codes are compared with a look-up table, a suitable response being made if a match is found; lower-case codes are arithmetically converted to upper case, and illegal codes discarded. Valid printing characters are stored in a designated area of the 8048 ram. When the ram is full or a line terminating character is received, the printing cycle starts.

The data input and sorting routines occupy about a quarter of the rom; the remaining quarter is taken up by a self-test routine, and various initialisation, timing and housekeeping subroutines. The entire 1K byte of program were written directly in machine code, leading to a very compact program with no wasted space.

Similar design techniques have since been applied to interface controllers for other dot matrix printers, l.c.d. interfaces, and an MSF Rugby clock decoder/display driver, recently featured in WW (New Products, February issue page 83) and the subject of a future article. WW

WW offer

For readers wishing to try the printer for themselves, Able Systems can supply the following items from stock:

M150 16-column printer mechanism £20.45

M160 24-column printer mechanism £27.80

Kit of p.c.b. FP150 controller chip, mechanism, connector cable, 6MHz crystal and application data £22.10

Paper rolls cost £12 per pack of 20, and spare ribbons £1.80 (M150) and £1.90 (M160). Carriage, packing and insurance costs £5, and vat is at 15%. Able accept payment by Access card or personal cheque at Unit 3, Kingfisher Court, Northwich, Cheshire CW9 7TU. Tel: 0606 48689.

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COMPUTER GRAPHICS SLIDES

Developed to meet a demand for electronic production of high-quality slides for use in audio-visual presentations, the Dicomed system is both fast and flexible. A wide range of support and commands are at hand, together with an extensive library of images including lines, circles and polygons as well as existing artwork, maps, logos, etc. Composition and balance from a choice of 64 colours can be altered and every element of the design can be moved, enlarged or reduced, replicated or rotated to any angle. Freehand drawing may be entered using a digitizing tablet. Animation is possible with start and end images; the computer can interpose in-between steps.

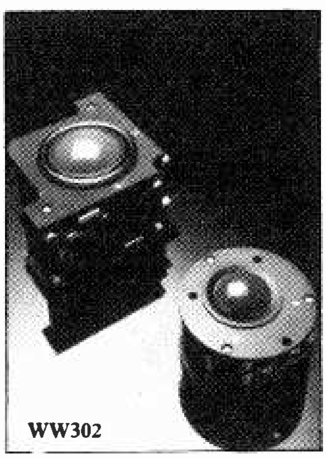
Designs are stored in digital form on a floppy disc and some 133 designs may be stored on one disc. The designs can be posted on a floppy disc or transmitted by telephone line to be reproduced on the company's slide production equipment. The images are photographed using a high resolution c.r.t. with 4000 lines. Also available is a software package for use with an Apple II microcomputer to allow creation of graphs, pie charts and histograms. Eidographics Ltd, 47 Marylebone Lane, London W1M 5FN.
WW301


WW301

BALL CONTROL

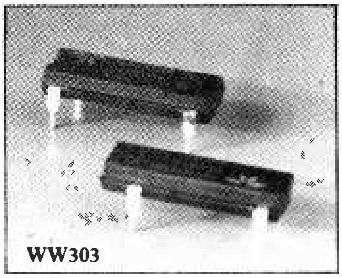
Tracker balls seem to be in competition with mice as computer input devices to plot x-y positions accurately on a v.d.u. Marconi have two controllers to translate the motion of a tracker ball into precise positional control. They can be used to position markers on a display, including radar and are claimed to be fatigue-free when used with interactive graphics displays in the engineering design field.

The protruding ball is in slip-free contact with two shafts positioned at right angles. Slotted discs attached to each shaft offer optically detectable motion which is translated by the electronic circuitry. The two basic versions are a rugged 2in diameter ball or a 3in ball. Marconi Electronic Devices Ltd, Doddington Road, Lincoln LN6 0LF.
WW302


WW302

RELAYS WITHOUT TRANSIENTS

Photo-s.c.r. coupling provides transient-free switching as well as 2,500V input-output isolation in the Teledyne SerenDIP, d.i.l. packaged solid-state relays. The maximum measured generated noise is claimed to be less than 15μV at all test frequencies from 0.45 to 30MHz, which makes the relays suitable for computer applications while the high voltage isolation is useful in industrial controls. There are three versions with output voltage ratings of 140, 250 (with 400V peak) and 250 with 600V peak. The 645 range is available from STC Electronic Services, Edinburgh Way, Harlow, Essex.
WW303


WW303

COMPUTING OSCILLOSCOPE

A digital storage oscilloscope waveform analyser, transient signal analyser, spectrum analyser and a data acquisition system are all combined into one instrument, the Analogic Data 6000. Built around a 16-bit microprocessor with an 8MHz internal clock, it has 48K-bytes of rom and 8K-bytes of ram.

The 'scope has been designed for the analysis of transient signals which may occur as digital glitches, or may arise during analysis of transient responses in networks. Other applications are in medical monitoring, wind tunnel, shock and destructive testing equipment. Data can be recorded for up to 5,000 hours. Analogic Ltd, The Centre, 68 High Street, Weybridge, Surrey. **WW304**

DUAL LOW-PASS FILTER

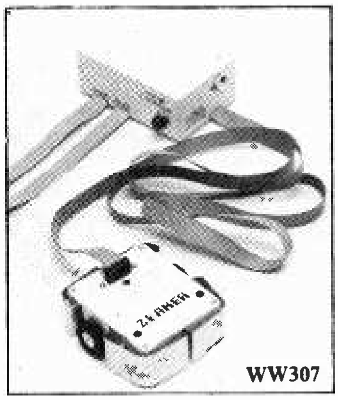
Suitable for continuously variable-slope detection or speech synthesis, the MC145414 is a dual, tuneable, low-pass filter using switched capacitor techniques. It consists of two fifth-order elliptical filters and includes two extra op-amps for gain adjustment or extra filtering. C-mos circuitry ensures low power consumption from a supply between 10 and 16V. Clock frequency may be varied between 15 and 400kHz to provide cut-off frequencies of 1.25 to 10kHz. Motorola Ltd, Semiconductor Products Division, York House, Empire Way, Wembley, Middlesex HA9 0PR. **WW305**

14-BIT A-TO-D

Claimed to be the first c-mos monolithic analogue-to-digital converter, the Intersil ICL7115 uses thin-film resistors together with an on-chip rom calibration table to give 14-bit linearity without the need for expensive laser trimming. Internally it works with 17 bits with an exponential (1.85) base. It can measure accurately signals up to 118% of full scale. The rom incorporates an error-correction code and therefore does not rely on the accuracy of the resistor ladder in its successive approximation algorithm. The rom is programmed after manufacture to take into account any measured variations. The circuit may be easily interfaced with microprocessor systems. Reference voltage inputs and signals have separate sense controls so that the device can accept positive signals relative to a positive reference and negative signals with a negative reference level. It operates from ±5V with a power consumption of 60mW. Conversion time is 40μs. Intersil Datel UK Ltd, Belgrave House, Basing View, Basingstoke, Hants. **WW306**

MICRO-TURTLE

A two-wheeled mobile robot which can be controlled by any microcomputer has been developed by Colne Robotics. Movements are controlled through an umbilical cable. The robot has touch sensors and the accompanying software 'teaches' it how to find another route. A retractable pen is attached to the underside and allows the machine to draw Logo graphics. The Zeaker Micro-turtle comes complete with interface, power supply, operating manual and software all for £69.50 assembled, or £52.00 in kit form (v.a.t. extra). Colne Robotics Co. Ltd, Beaufort Road, off Richmond Road, Twickenham, Middlesex TW1 2PH. **WW307**

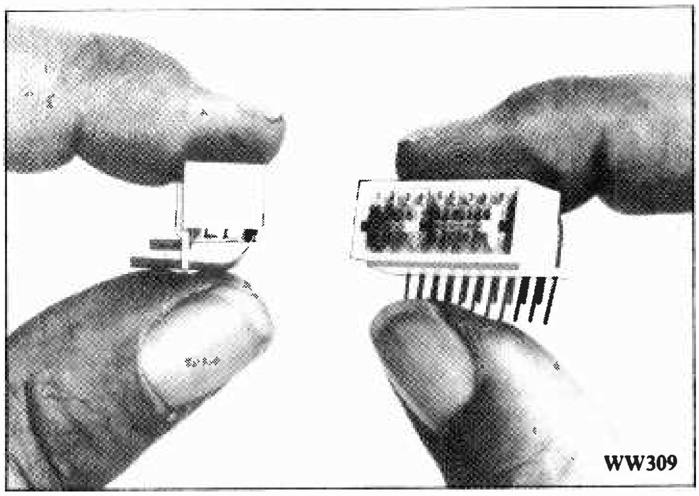

WW307

AID FOR THE COLOURBLIND

Component identification by the use of colour codes can lead to hazardous situations if the constructor is colourblind. Difficulty with the difference between red and green is the commonest form of colourblindness and a simple viewer incorporating selected red and green filters can assist in distinguishing between these colours. The makers of Viewbouy claim that, with practice, the severely handicapped can also identify most other colours. J. Holter, 10 Lancot Avenue, Dunstable, Beds LU6 2AW.
WW308

SPACE-SAVING PCB SWITCHES

By turning the dual-in-line switch on its side, Erg claim to save 30% of the p.c.b. area taken up by conventional switches. SDOS-10-023 contains ten on/off switches which may be edge-mounted to offer front-panel switching with no additional hardware. Two to 18-way switches, colour-coded and numbered, will be included in the range. Erg Components, Luton Road, Dunstable, Beds LU5 4LJ.
WW309



WW309

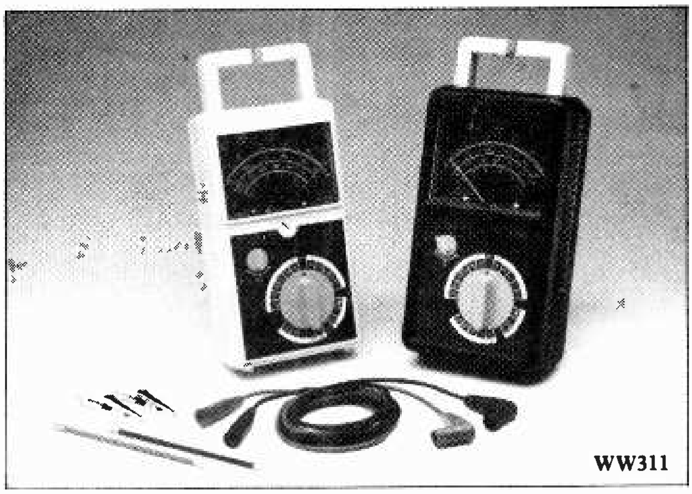
WIRELESS JOYSTICKS

A single-chip radio transmitter has been incorporated into a tv games joystick to allow the user to zap the space invaders from the comfort of an armchair, without the encumbrance of wires. A receiver is placed next to the games unit (and could be incorporated into it). It decodes the signals sent by the joystick into the same signals that would have been received if the joystick were connected directly, and feeds these through the normal joystick ports into the games computer. The 'serious' application of the joystick control is menu-driven computer programs. The product is the first of a series planned to be expanded to include a wireless computer keyboard. The Wireless Joystick is manufactured in New York by Cynex and marketed in the UK by Dynavest Ltd, 8 Waterloo Place, London SW1Y 4BE.
WW310

LOW-COST AVO METER

Despite the digital explosion of multimeters, Avo still have faith in analogue meters and have produced a series of test instruments called the 'analogue toolbag range'. The Avometer 1001 can measure direct and alternating voltages up to 1kV, direct current up to 1A and resistance up to 2MΩ. Sensitivity is 10kΩ/V on d.c. ranges. A continuity buzzer is included. The a.b.s. plastics case features an integral carrying handle which has a slot in it to allow for quick and easy lead stowage. The meter costs £28.50 (trade price) with a heavy duty version with a tougher case for £37.30.

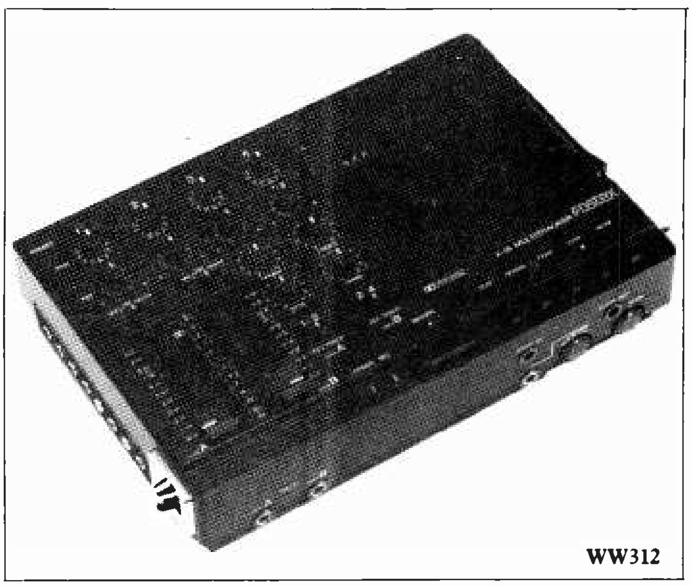
Announced at the same time is a series of Megger insulation testers which no longer have the generator handle on the side as they are battery driven, powered by a 9V (PP3) battery. Different models offer test voltages of 500 or 250V with continuity ranges on all models of 0 to 200Ω and 0 to 2Ω, the last-mentioned being used to suit the methods laid down by the IEE wiring regulations. One model has an additional voltage range while others provide intermediate resistance ranges of 1MΩ and 500kΩ. All the meters come complete with test leads, probes and clips which fit into moulded channels on the back of the case. Thorn EMI Instruments Ltd, Archcliffe Road, Dover, Kent CT17 9EN.
WW311



WW311

PORTABLE RECORDING STUDIO

A four-track cassette recorder combined with a mixer needs only microphones and monitor headphones to make multi-track recording almost anywhere. The Fostex X-15 Multitracker is battery powered and is little larger than an average cassette deck, yet incorporates many features found normally only in a recording studio. It has equalizer, gain and pan controls for each of the channels which may be used in overdub or mixdown. Punch-in may be remotely controlled and there is ±15% pitch control for tuning or for special effects. Dolby-B noise reduction is incorporated. Manufacturers claim that professional musicians can use the recorder as a 'sketch pad' to prepare a session, much as a Polaroid camera may be used to compose a shot in a photographic studio. The X-15 retails at £299, inclusive. Bandive Ltd, Brent View Road, London NW9 9EL.
WW312



WW312

ELECTRONIC OFFICE FROM BT

Word processors and computers with an accent on telecommunications are now being marketed by British Telecom. The Merlin range of business systems starts with the M1100 communicating v.d.u. terminal which may be used to access Prestel or data banks and can be used for electronic mail with automatic dialling.

The M2226 business computer has 256K memory internally with a 5Mbyte Winchester disc and 800Kbytes on floppy disc. It can operate with CP/M and therefore has access to a wide range of software; BT have added their own MerlinMaster software interface to make the whole system easy to use.

In addition there is the M3300 word processor which has two floppy-disc drives and a daisy-wheel printer. Both the computers can have auto-dial modems, can be linked to teleprinters and have full access to teletex and telex services. There is a range of peripherals and software launched at the same time. British Telecom Merlin, Room 2028 Howland Street, London W1P 6HQ.
WW313

RANDOM ECHOES

By Chirp

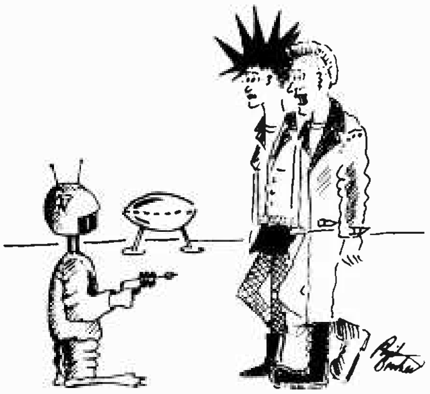
INFORMATION THEORY

There are many ways of gathering information. We all know the trials of formal study to pass exams or for more immediate and practical reasons. But, in general life, we gather most of our knowledge by piecing together fragments picked up in random conversations. Sometimes it is the experts talking but more often its just ordinary folk.

Moreover, the breadth of experience revealed in the most casual conversation is often quite surprising. There was that painter, for example, in the next office boasting to his mate about the marvellous television reception in Croydon – " . . . and all we had was one of those two-pronged indoor aerials that stand on the set like a Martian's helmet".

Then our cleaning lady was telling me about her young son, who came in wearing blue sun glasses. As he is only about four feet high and has red hair, she told me, those glasses made him look just like a Martian.

Weeks later, on a very wet morning our dedicated cyclist, Jimmy, arrived dripping with rain, clad in waterproof leggings and a pale blue plastic cape. Kathy, our office girl, gasped with astonishment. ". . . in those yellow trousers and blue top, I thought you were a Martian!"



'Kids! They'll do anything to get 'emselves noticed.

So I have discovered that a Martian is about four feet high, has red hair, wears blue spectacles, yellow trousers and a blue top, and protects his head with a two-pronged helmet. Actually, most of the Martians around our way are much taller with tight blue jeans and multicoloured Red Indian haircuts.

WORDS AND MUSIC MAESTRO

I have just been watching that programme on television about the British Leyland Maestro, and the way in which the more superior versions feature an audio readout of certain dashboard information. Do we call this a speakout? It is quite a status feature, and rather upstages such refinements as electric windows or remotely controlled door mirrors.

The only demonstration of the speakout was the rather bossy synthesized feminine voice telling the driver to fasten his seat belt. But I understood from the report that the thing is programmed to blurt out information when an alarm situation occurs; e.g., "we're nearly out of petrol!" I suppose it also draws attention to the engine overheating, very low oil pressure or lack of brake fluid. I wonder if it mentions tyre pressure – that is the one we usually forget.

In the report that I heard, the only microcomputer mentioned was the one that controls the engine, but you may be sure that the speakout system depends on at least one of these devices. No modern electronic system amounts to much without one. So we are naturally led to speculate on the conversational ability of the car of the future as more-and-more data processing power is compressed into smaller-and-smaller devices.

I read quite recently about a Japanese heavy-goods vehicle with solid-state television cameras mounted at "blind" locations on the truck body, with a c.r.t. in the cab to augment the conventional rear-view mirrors. There are already computer programmes for interpretation of signals and tv cameras into exact information for machine-tool control, etc., so who knows what the future may bring.

With the general trend towards the use of high technology for totally frivolous purposes, it is possible that the techniques mentioned will one day be combined to enable the car to utter those helpful comments currently made by one's passengers; e.g., "all clear left . . . if you're quick", or "that's a police car you're overtaking".

Such technical developments could ultimately do away with the need for passengers altogether; we could have quite chatty cars to keep us company on long journeys; and there may even be the optional electronic "hitch-hiker" which gives an authentic account of all the lifts he's ever thumbed while you are trying to listen to the test match commentary on Radio 3.

MORE TALKING MOTOR CARS

It seems that BL have started a trend with the talking Maestro. I have just read a report in the Financial Times about a new experimental car by the Japanese Nissan Company, which not only talks to the driver but also responds to spoken commands.

It has a voice dialogue system which enables the driver to ask for such things as lights to be switched on and wing mirrors adjusted. Have you ever tried to adjust a wing mirror for a friend in response to his spoken instructions? ". . . up a bit – no, not too far – now a bit to the left – etc." Its very difficult and always leads to bad feeling. Now imagine trying to instruct a stupid computer – in Japanese.

And that's only the beginning. This car also has a drowsiness monitor, which measures brainwave patterns and can tell if the driver is becoming tired. If he begins to fall asleep a flashing light and a buzzer operate, and the computer will eventually ask him to rest. With all these distractions it may, of course, be already too late; he may be resting permanently.

But he will not have driven into the back of the vehicle ahead, because this car is fitted with a radar which measures the distance to the vehicle in front, and if the gap becomes too small for any given speed the car is slowed until a safety distance is restored. Very useful in fog, but if it fails does it fail-safe? . . . and does fail-safe mean fail with the brakes on?

A SHOW BY ANY OTHER NAME

I see they are holding IFSSEC at Olympia as usual this year; and then there is HEVAC at the Barbican Centre a week or so later.

Of course, they are names of exhibitions. The first is the International Fire, Security and Safety Exhibition and Conference – not surprising that it is abbreviated to initials – and the second is the Heating, Ventilating and Air Conditioning Show. But only a cypher expert would find it easy to work out what is going on at these exhibitions from the title alone.

Some almost seem to be deliberately misleading. How about CONTEXT? Something to do with printing you may think, or some other form of self-expression. No, its the co-ordinated Furnishing Exhibition at Earls Court. Then there is TECTRONICA – not an exhibition of oscilloscopes but an international show for the life and physical sciences. POWTECH has nothing to do with turbo-generators or enormous high-fi amplifiers – it is all about powder and bulk solids.

Of course there are many exhibitions where the title is fully appropriate, so that one can guess what the show is all about immediately. There is ELECTRONICA in Munich, SHOPPEX in London, TESTMEX and TEST at Wembley; but, familiar though it may be, I have never worked out the meaning of INTERNEPCON and, judging by the variety of types of exhibit, I doubt if anyone else has either.

However, for the most appropriate exhibition name the prize must go the Farmers' Waste Management Exhibition at Stoneleigh. They call it MUCK – a show by any other name would smell as sweet?

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Our competition is open to individuals or groups resident in the UK. You register your entry using the form below, sending it to the Editor to arrive at his office not later than June 30th 1983. The designs themselves must be submitted to his office by 1st October 1983.

Entries, which will be judged by a group of eminent engineers and doctors, must consist of the following:- a statement of the design objectives; an overall description of the device; detailed circuit descriptions and diagrams; a model of the device or a model of a unique aspect of the design sufficient to demonstrate its feasibility.

The finalists will be invited to London to talk over their entries with the judges and be awarded their prizes. The prizes are:

1st prize £2,500
2nd prize £1,500

and the 4 runners up will be awarded prizes each of £1,000

To make sure you have the maximum time to undertake your design, return your entry form now!

"DESIGN AN ELECTRONIC DEVICE TO HELP THE DISABLED"
LIST OF RULES

1. The competition is open to U.K. residents only.
2. Entrants can be individuals or groups.
3. All participants must register their interest in entering the competition on the form provided which must be returned to the Wireless World Editorial Department by the 30th June 1983.
4. All entrants agree to give Wireless World first serial publication rights to an article describing the entry.
5. All entrants indemnify Wireless World from any liability in respect of injury to people or damage to property arising from the use of the design.
6. All submitted designs must be the original work of the entrant or entrants and must not infringe the rights of third parties in anyway.
7. All submissions should consist of:
   a) **A statement of design objectives**
   b) **An overall description of the device**
   c) **Detailed circuit descriptions and diagrams**
   d) **A model of the device or the unique aspect of the design sufficient to demonstrate its feasibility.**
8. The design will be judged on:
   a) **Originality and benefit to the handicapped**
   b) **Potential for production**
   c) **Elegance of engineering design**
   d) **Electronics content**
   e) **Design reliability**
   f) **Simplicity of operation**
   g) **Freedom from excessive maintenance**
   h) **Safety.**
9. Software only solutions are not accepted
10. The judges' decision is final.
11. All designs must be submitted to the Wireless World Editor by the 1st October 1983.
12. Shortlisted entrants must be prepared to travel to a venue in London sometime during November and December 1983 to demonstrate their design. All costs will be paid by the journal.
13. Employees of Business Press International are not allowed to enter this competition.

wireless world
COMPETITION ENTRY FORM

"Design an electronic device to help the disabled"

Name of competitor ______________________

Address ______________________

____

Telephone (home) ______________________

(business) ______________________

I intend to enter the competition and to abide by the rules as laid down in the July 1983 issue of Wireless World.

I understand that, in order to qualify, my entry must be in the hands of the judges by 1st October, 1983

Signature ______________________

Date ______________________

Please send this form, as soon as possible, to:

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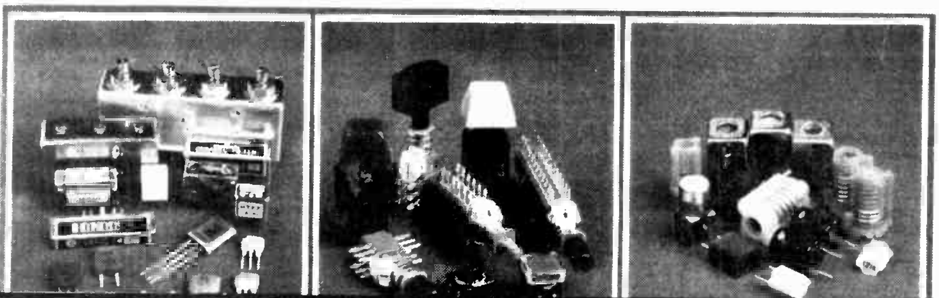

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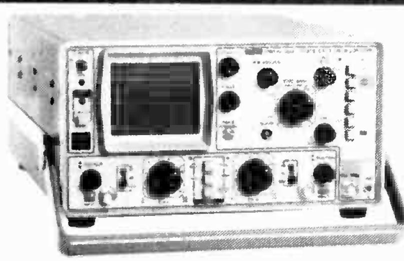

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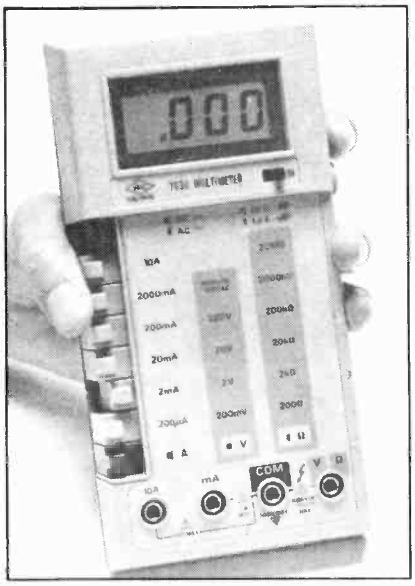

MODEL 6010
DC ACCURACY 0·5%

£29·95

PLUS VAT = £34·44

MODEL 7030
DC ACCURACY 0·1%

£35·95

PLUS VAT = £41·34

200μA – 10 AMP AC-DC
28 RANGES EACH WITH FULL OVERLOAD PROTECTION

SPECIFICATION
- Mode select: Push button
- AC DC current: 200μA to 10A – 6 Ranges
- AC voltage: 200mV to 750V – 5 Ranges
- DC voltage: 200mV to 1000V – 5 Ranges
- Resistance: 200Ω to 20MΩ – 6 Ranges
- Input impedance: 10MΩ
- Display: 3½ Digit 13mm LCD
- Overload protection: All ranges
- Battery: Single PP9 type (included)
- Battery life: 200 hours
- Dimensions: 170 × 89 × 38mm
- Weight: 400g inc battery

OTHER FEATURES:
Auto polarity, auto zero, battery-low indicator, ABS plastic case with tilt stand, battery and test leads, spare fuse and operators manual included. Optional carrying case.

AFDEC ELECTRONICS LTD

318 Kempshott Lane, Basingstoke
Hants RG22 5LT

I wish to order the following:

Quantity	Item	Amount
	Model 6010 @ £34·44 inc.	
	Model 7030 @ £41·34 inc.	
	Carrying Case @ £2·00 inc.	
	TOTAL	

All prices include VAT and post and packaging. All items include a full year guarantee. Allow up to 10 days for delivery. Cheques/Postal Orders etc. should be made payable to: AFDEC Electronics Ltd.

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Overseas customers add £4·00 post and packaging. WW7

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VALVE & COMPONENTS SPECIALISTS

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MC1496	1.25

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ML232B	1.75
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SAA5000A	3.05
SAA5010	6.35
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SAS570S	1.75
SAS580	2.85
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SN76227N	1.05
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SN76533N	1.65
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SN76666N	0.70

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TBA510Q	2.50
TBA520	1.10
TBA520Q	1.10
TBA530	1.10
TBA530Q	1.10
TBA540	1.25
TBA540Q	1.35
TBA550Q	1.45
TBA560C	1.45
TBA560CQ	1.45
TBA570	1.00

TBA641A12	2.50
TBA641BX1	3.00
TBA651	1.75
TBA720A	2.45
TBA750Q	2.65
TBA800	0.89
TBA810AS	1.35
TBA820Q	1.45
TBA890	2.50
TBA920	1.65
TBA920Q	1.65
TBA950	2.35
TBA950/2X	2.35
TBA990	1.49
TBA990Q	1.49
TBA1441	2.15
TCA270	1.10
TCA270SQ	1.10
TCA650	2.50
TCA800	2.15
TCA830S	1.40
TCA940	1.65
TDA440	2.20
TDA1001	2.50
TDA1004A	2.20
TDA1006A	2.50
TDA1010	2.15
TDA1035	2.50
TDA1037	1.95
TDA1170	1.95
TDA1170S	1.95
TDA1190	2.15
TDA1270Q	3.95
TDA1327	1.70
TDA1352B	1.43
TDA1412	0.85
TDA2002	1.95
TDA2020	2.45
TDA2030	2.80
TDA2522	1.95

TDA2523	1.95
TDA2524	1.95
TDA2530	1.95
TDA2532	1.95
TDA2540	1.25
TDA2541	2.15
TDA2560	2.15
TDA2581	2.25
TDA2590	2.95
TDA2591	2.95
TDA2593	2.95
TDA2600	3.50
TDA2610	2.50
TDA2611A	1.95
TDA2640	2.60
TDA2690	1.35
TDA3560	3.95
TDA3950	1.95
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UPC575C2	2.75
UPC1001H	2.50
UPC1025H	2.50
UPC1028H	1.95
UPC1156H	2.75
UPC1167C2	1.15
UPC1181H	1.25
UPC1182H	2.95
UPC1185H	3.95
UPC1350C	2.95
UPC2002H	1.95
ZTK33B	0.50
555	0.35
556	0.42
723	0.50
741	0.35
747	0.50
748	0.35
4042	0.50
7805	0.60

SEMICONDUCTORS

AAY12	0.25
AC126	0.22
AC127	0.20
AC128	0.20
AC128K	0.32
AC141	0.28
AC141K	0.34
AC142K	0.30
AC176	0.22
AC176K	0.31
AC187	0.25
AC187K	0.28
AC188	0.25
AC188K	0.37
AD142	0.79
AD143	0.82
AD149	0.70
AD161	0.39
AD162	0.39
AD161/2	0.90
AF115	0.75
AF124	0.34
AF125	0.35
AF126	0.32
AF127	0.32
AF139	0.40
AF150	0.42
AF239	0.42
AU106	2.00
AU107	1.75
AU110	2.00
AU113	2.95
BC107A	0.11
BC107B	0.11
BC108	0.10
BC108A	0.11
BC108B	0.12
BC109	0.10
BC109B	0.12
BC109C	0.12
BC114	0.11
BC116A	0.15
BC117	0.19
BC119	0.24
BC125	0.25
BC139	0.20
BC140	0.31
BC141	0.25
BC142	0.21
BC143	0.24
BC147	0.09
BC147B	0.09
BC148A	0.09
BC148B	0.09
BC149	0.09
BC157	0.12
BC158	0.09
BC159	0.09
BC160	0.28
BC161	0.28
BC170B	0.15
BC171	0.09
BC171A	0.10
BC171B	0.10
BC172	0.10
BC172B	0.10
BC172C	0.10

BC173B	0.10
BC174	0.09
BC174A	0.09
BC177	0.15
BC178	0.15
BC182	0.10
BC182LB	0.10
BC183	0.10
BC183L	0.09
BC184LB	0.09
BC204	0.10
BC207B	0.13
BC208B	0.13
BC212	0.09
BC212L	0.09
BC212LA	0.09
BC213	0.09
BC213L	0.09
BC214	0.09
BC214C	0.09
BC214L	0.09
BC237	0.10
BC237A	0.09
BC237B	0.09
BC238	0.09
BC239	0.12
BC251A	0.12
BC252A	0.15
BC258	0.25
BC258A	0.39
BC284	0.30
BC300	0.30
BC301	0.30
BC303	0.26
BC307	0.09
BC307A	0.09
BC307B	0.09
BC327	0.10
BC328	0.10
BC337	0.10
BC338	0.09
BC347A	0.13
BC461	0.35
BC478	0.20
BC527	0.20
BC547	0.10
BC548	0.10
BC549A	0.08
BC550	0.08
BC557	0.08
BC557A	0.08
BC557B	0.08
BC558	0.10
BCY33A	1.60
BD115	0.30
BD116	0.60
BD124P	0.59
BD131	0.32
BD132	0.35
BD133	0.40
BD135	0.30
BD136	0.30
BD137	0.32
BD138	0.30
BD139	0.32
BD140	0.30
BD144	1.10

BD159	0.65
BD166	0.55
BD179	0.72
BD182	0.70
BD201	0.83
BD202	0.65
BD203	0.78
BD204	0.70
BD222	0.46
BD223	0.48
BD225	0.48
BD232	0.35
BD233	0.35
BD234	0.35
BD236	0.45
BD237	0.40
BD238	0.40
BD241	0.40
BD242	0.50
BD246	0.60
BD376	0.32
BD410	0.55
BD434	0.55
BD437	0.50
BD438	0.60
BD506	0.50
BD508	0.40
BD520	0.65
BD538	0.65
BD597	0.75
BD697	1.10
BD698	1.10
BD707	0.80
BDX32	1.50
BDY57	1.65
BF115	0.35
BF127	0.24
BF154	0.12
BF158	0.22
BF160	0.27
BF167	0.24
BF173	0.22
BF177	0.38
BF178	0.26
BF179	0.34
BF180	0.29
BF181	0.29
BF182	0.29
BF183	0.29
BF184	0.28
BF185	0.28
BF194	0.11
BF195	0.11
BF196	0.11
BF197	0.11
BF198	0.16
BF199	0.14
BF200	0.40
BF241	0.15
BF245	0.30
BF246	0.28
BF256/LC	0.28
BF257	0.28
BF258	0.28
BF259	0.28
BF271	0.26
BF273	0.13
BF336	0.34
BF337	0.29
BF338	0.32

BF355	0.37
BF362	0.38
BF363	0.38
BF371	0.20
BF394	0.19
BF422	0.32
BF457	0.32
BF458	0.28
BF459	0.36
BF595	0.23
BF597	0.25
BFR39	0.23
BFR40	0.23
BFR41	0.28
BFR81	0.25
BFR88	0.30
BFR90	1.50
BFR91	1.75
BFT42	0.28
BFT43	0.28
BFW92	0.85
BFX29	0.30
BFX84	0.26
BFX85	0.32
BFX86	0.30
BFX88	0.25
BFY50	0.21
BFY51	0.21
BFY52	0.25
BFY90	0.77
BLY48	1.75
BR100	0.26
BR101	0.30
BRC4443	0.85
BT106	1.49
BT108	1.49
BT116	1.20
BT119	1.65
BT120	1.65
BU105	1.22
BU108	1.69
BU124	1.25
BU125	1.25
BU126	1.60
BU204	1.55
BU205	1.30
BU208	1.39
BU208A	1.52
BU326	1.20
BU407	1.24
BU500	2.25
BU526	1.90
BUY69B	1.70
MJ3000	1.98
MJE340	0.40
MJE520	0.48
MPSA12	0.20
MPSA13	0.20
MPSA92	0.30
MRF450A	11.50
MRF453	15.50
MRF454	23.50
MRF475	2.50
MRF477	10.00
OC23	1.50
OC42	0.55
OC44	0.75
OC45	0.55
OC70	0.45
OC71	0.40

OC81	0.50
R2008B	1.70
R2010B	1.70
R2322	0.58
R2323	0.66
R2540	2.48
RCA16334	0.90
RCA16335	0.80
SKE5F	1.45
TIP29	0.40
TIP29C	0.42
TIP30C	0.43
TIP31C	0.42
TIP32C	0.42
TIP33B	0.75
TIP34B	0.75
TIP41A	0.45
TIP41C	0.45
TIP42C	0.47
TIP47	0.65
TIP120	0.60
TIP125	0.65
TIP142	1.75
TIP146	1.75
TIP161	2.95
TIP2955	0.80
TIP3055	0.55
TIS91	0.20
TV106/2	1.50
2N2219	0.28
2N2905	0.40
2N3053	0.40
2N3054	0.59
2N3055	0.52
2N3702	0.12
2N3703	0.12
2N3704	0.12
2N3705	0.12
2N3706	0.12
2N3708	0.12
2N3773	1.75
2N3792	1.35
2N4427	1.50
2N4444	1.15
2N5294	0.42
2N5296	0.48
2N5298	0.60
2N5496	0.65
2SA715	0.60
2SC495	0.80
2SC496	0.80
2SC1096	0.80
2SC1172Y	2.20
2SC1173	1.15
2SC1306	1.00
2SC1307	1.50
2SC1449	0.80
2SC1678	1.25
2SC1945	2.10
2SC1953	0.95
2SC1957	0.80
2SC1969	1.95
2SC2028	1.15
2SC2029	1.95
2SC2078	1.45
2SC2091	0.85
2SC2166	1.95
2SC2314	0.80
2SD234	0.50
3N211	1.50

DIODES

AA119	0.08
BA102	0.17
BA115	0.13
BA145	0.16
BA148	0.17
BA154	0.06
BA155	0.13
BA156	0.15
BA157	0.30
BAX13	0.04
BAX16	0.06
BB105B	0.30
BT151	0.79
BY126	0.10
BY127	0.11
BY133	0.15
BY164	0.45
BY176	1.20
BY179	0.63
BY184	0.35

BY199	0.40
BY206	0.14
BY208-800	0.33
BY210-800	0.33
BY223	0.90
BY298-400	0.22
BY299-800	0.22
BYX10	0.20
BYX36-150R	0.20
BYX38-600R	0.60
BYX55-600	0.30
BYX71-600	0.60
BZY95C30	0.35
OA47	0.09
OA90	0.05
OA91	0.06
OA95	0.06
OA202	0.10
IN914	0.04
IN4001	0.04
IN4002	0.04
IN4003	0.04

IN4004	0.05
IN4005	0.05
IN4006	0.06
IN4007	0.06
IN4148	0.02
IN4448	0.10
IN5401	0.12
IN5402	0.14
IN5403	0.12
IN5404	0.12
IN5405	0.13
IN5406	0.13
IN5407	0.16
IN5408	0.16
ITT44	0.04
ITT923	0.15
ITT2002	0.10

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WW – 034 FOR FURTHER DETAILS

WW – 052 FOR FURTHER DETAILS

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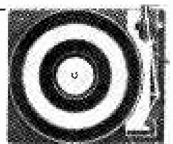
Large Turntables
240 volt AC. Post £2



Make	Model	Drive	Cartridge	Price
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BSR	P232	Belt	Ceramic	£24
GARRARD	6200	Rim	Ceramic	£22
GARRARD	Delux	Belt	Magnetic	£40
BSR	P232	12 volt	Magnetic	£24

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BSR	Delux	Rim	Ceramic	£18
BSR	Delux	Rim	Magnetic	£26

MAINS PRE-AMP FOR MAGNETIC CARTRIDGES to low gain amplifier 10mv to ½ volt, mono **£5**, stereo **£7.** P&P £1

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Cut out for most Garrard decks. Black or silver grey finish. Size 16×13¾in. **£4**

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17×12⅞×3½in.	£5	14½×13⅛×2¾in.	£5
22⅝×13⅞×3in.	£5	17¼×13¾×4⅛in.	£5
21½×14¼×2½in.	£5	21×13⅞×4⅛in.	£5
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Suitable for cassettes and all sizes of tape reels. AC mains 200/250V. Hand held size with switch and lead (120 volt to order). Will also demagnetise small tools and computer tapes.
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Stabilised output, 9 volt 400 m.a. U.K. made in plastic case with screw terminals. Safety overload cut out. Size 5×3¼×2½in. Transformer Rectifier Unit. Suitable Radios, Cassettes, models, **£5.** Post £1.

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All parts and instructions with Zener diode printed circuit, mains transformer 240V a.c. Output 6 or 7½ or 9 or 12V d.c. up to 100mA or less. Please state voltage required.

RELAYS. 6V DC **95p.** 12V DC **£1.25.** 18V **£1.25.** 24V **£1.30**
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ALI ANGLE BRACKET 6×¾×¾in. **30p.**
BRIDGE RECTIFIER 200V PIV 2a **£1.** 4a **£1.50.** 6a **£2.50.**
TOGGLE SWITCHES SP **40p.** DPST **50p.** DPDT **60p.**
MINIATURE TOGGLES SP **40p.** DPDT **60p.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, **2p**; 2W **10p.** Low ohm 1 watt 0.47 to 3.9 ohm **10p.**
HIGH STABILITY. ½w 2% 10 ohms to 1 meg. **10p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **20p.**
PICK-UP CARTRIDGES SONOTONE 9TAHC **£3.80.**
BSR Stereo Ceramic SC7 Medium Output **£2.** SC12 **£3.**
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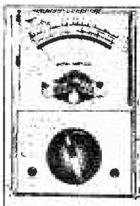
VALVE OUTPUT Transformers push/pull 15 watt **£14**; 30W **£18**;50W **£20**; 100W **£24.** Post £2. 100V/Line 20W **£3.75.**
MICROSWITCH, 50p, Miniature **65p.** SPDT.
ANTEX SOLDERING IRON 'C' 15W **£5.25.** 25W 'X25' **£5.50.**
WAFER SWITCHES. 1¼" dia. **60p ea.**
1P 12W; 2P 2W; 2P 6W; 3P 4W; 4P 2W; 4P 3W.
FERRITE ROD. 6"×½", 6"×⅜", 8×5/16" **50p**
XLR Lead Plug **£2.40.** Lead socket **£2.75**
XLR Chassis Plug **£2.20.** Chassis Socket **£2.55.**
BANANA 4mm Plugs/Sockets, red/black **20p**
JACK PLUGS Mono Plastic **25p**; Metal **30p.** Sockets **25p.**
JACK PLUGS Stereo Plastic **30p**; Metal **35p.** Sockets **30p.**
FREE SOCKETS – Cable end **30p.** Metal **45p.**
2.5mm and 3.5mm **JACK SOCKETS 25p. Plugs 25p.**
DIN TYPE CONNECTORS
Sockets 3-pin, 5-pin **15p.** Free Sockets 3-pin, 5-pin **25p.** Plugs 3-pin **20p**; 5-pin **25p**; Speaker plugs **25p**; Sockets **15p.**
PHONO PLUGS and SOCKETS ea. **20p**; Double sockets **30p.** Free Socket for cable end **20p.** Screened Phono Plugs **25p.**
B.N.C. PLUGS £1. Sockets **£1.** Free Sockets **£1.10.**
U.H.F. PLUG 50p. Socket **50p.** Reducer **20p.** Coupler **50p.**
300 ohm TWIN RIBBON FEEDER 10p yd.
300 ohm to 75 ohm AERIAL MATCHING TRANSFORMER £1.
U.H.F. COAXIAL CABLE SUPER LOW LOSS, 75 ohm **25p yd.**
COAX PLUGS 30p. COAX SOCKETS 20p. Lead Sockets 65p.
NEON INDICATORS 250V, round **40p.** Rectangular **45p.**
MORSE CODE TAPPER AND BUZZER SET £3.
CAR CASSETTE MECHANISM. 12V Controlled Motor Stereo Head **£5**

POTENTIOMETERS Carbon Track
5kΩ to 2MΩ. LOG or LIN. L/S **50p.** DP **90p.** Stereo L/S **£1.10.** DP **£1.30.** Edge Pot 5K. SP **45p.**

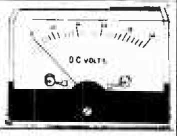
MINI-MULTI TESTER NEW



De luxe pocket size precision moving coil instrument. Impedance + Capacity – 4000 o.p.v. Battery included.
11 instant ranges measure:
DC volts 5.25, 250, 500.
AC volts 10, 50, 500, 1000.
DC amps 0-250μA, 0-250mA.
Resistance 0 to 600K ohms.
£7.50 Post 65p

De Luxe Range Doubler Model **£19.50** 50,000 o.p.v. 7×5×2in Post £1
43 Ranges, 1,000V, AC-DC, 20 meg, etc

PANEL METERS
50μa, 100μa, 500μa, 1ma, 5ma, 50ma, 100ma, 500ma, 1 amp, 2 amp, 25 volt, VU 2¼×2×1¼. Stereo VU 3¼×1⅝×1in. **£4.50** Post 50p



RCS SOUND TO LIGHT CONTROL BOX
Complete ready to use with cabinet size 9×3×5in 3 channel, 1000 watt each. For home hi-fi disco Input 200mV to 100 watt **£27** Post £1
OR KIT OF PARTS £19.50
Disco bulbs 100 watt, blue, green, yellow, red, amber, screw or bayonet **£2** each. Post £1.50 per six
"FUZZ" lights, red, blue, green, amber, 240V. **£23.** Post £1
200 Watt Rear Reflecting White Light Bulbs. Ideal for Disco Lights, Edison Screw. 6 for **£4**, or 12 for **£7.50.** Post £1.50. Suitable panel mounting holders **85p.**

RCS "MINOR" 10 watt AMPLIFIER KIT £14
This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono **£14**; Stereo **£20.** 10W per channel; size 9½×3×2in. SAE details. Full instructions supplied. 240V AC mains. Post £1

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and PC Board Can be ganged to make multi-way stereo mixers **£3.50** Post 65p

MAINS TRANSFORMERS

	Price	Post
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A	£6.00	£2
350-0-350V 250mA, 6.3V 6A CT	£12.00	£2
220V 25ma 6V lamp £3.00 — 220V 45ma 6V 2 Amp	£4.00	£1
250V 60mA, 6V 2A	£4.75	£1
Step-Up 115V to 240V 150W £9. 250W £10. 500W	£12.00	£2

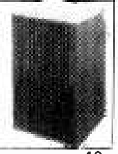
GENERAL PURPOSE LOW VOLTAGE

Tapped outputs available	Price	Post
2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	£6.00	£2
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£6.00	£2
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£10.50	£2
3 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£12.50	£2
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£16.00	£2

5-8-10-16V. ½ amp	£2.50	£1	15-0-15V 1 amp	£4.00	£1
6V. ½ amp.	£2.00	£1	15-0-15V. 2 amps	£4.50	£1
6-0-6V 1½ amp.	£3.50	£1	20V 1 amp	£4.00	£1
9V. 250ma	£1.50	£1	20-0-20V 1 amp	£4.50	£1
9V 3 amp	£4.50	£1	20-40-60V 1 amp	£4.50	£2
9-0-9V 50ma	£1.50	£1	25-0-25V 2 amps	£5.50	£1
9-0-9V. 1 amp	£3.50	£1	28V 1 amp Twice	£6.00	£2
10-0-10V. 2 amps	£4.00	£1	30V 1½ amp	£4.50	£1
10-30-40V 2 amps	£4.50	£1	30V 5 amp and 17-0-17 2a	£5.50	£2
12V. 100ma	£1.50	£1	35V 2 amps	£4.50	£1
12V. 750 ma	£2.50	£1	TOROIDAL 30-0-30V 4a and 20-0 20V ½a	£10.00	£2
12V 3 amps	£4.50	£1			
12-0-12V. 2 amps	£4.50	£1			

CHARGER TRANS	Post	RECTIFIERS	Post
6-12 volt 3a	£4.50+£2	6-12 volt 2a	£1.10+80p
6-12 volt 4a	£6.50+£2	6-12 volt 4a	£2.00+80p

OPUS COMPACT SPEAKERS £22 pair Post £2



TEAK VENEERED CABINET
11×8½×7in, 15 watts
50 to 14,000 cps. 4 ohm, 8 ohm or 16 ohm
OPUS TWO 15×10½×7¾in 25 watt 2-way system **£39 pair.** Post £3

LOW VOLTAGE ELECTROLYTICS Wire ends **10p**
1 mf, 2 mf, 4 mf, 8 mf, 10 mf, 16 mf, 25 mf, 30 mf, 50 mf, 100 mf, 250 mf. All 15 volts. 22 mf/6v/10v; 25 mf/6v/10v; 47 mf/10v; 50 mf/6v; 68 mf/6v/10v/16v/25v; 100 mf/10v; 150 mf/6v/10v; 200 mf/10v/16v; 220mf/4v/10v/16v; 330 mf/4v/10v; 500 mf/6v; 680 mf/6v/10v; 1000 mf/2.5v/4v/10v; 1500 mf/10v; 2200 mf/6v/10v; 3300 mf/6v; 4700 mf/4v.
500mF 12V **15p**; 25V **20p**; 50V **30p.** 1200mF 76V **80p.**
1000mF 12V **20p**; 25V **35p**; 50V **50p**; 100V **70p.**
2000mF 6V **25p**; 30V **42p**; 40V **60p**; 1500mF 100V **£1.20.**
2200mF 63V **90p.** 2500mF 50V **70p**; 3000mF 50V **65p**;
4700mF 63V **£1.80.** 4700mF/40V **£1.**

NON POLARISED CAPACITORS – REVERSIBLE
1mF 250V **25p**; 1.5mF 100V **25p**; 2.2mF 250V **30p**; 3.3mF 100V **40p**; 4.7mF 100V **40p**; 10mF 63V **40p**; 32mF 50V **25p.**

HIGH VOLTAGE ELECTROLYTICS

2/500V	45p	32+32+16/350V	90p	8+16/450V	75p
8/450V	45p	100+100/275V	65p	16+16/350V	80p
16/350V	45p	150+200/275V	70p	32+32/350V	85p
32/500V	95p	32+32+32/325V	75p	32+32/500V	£2
32/350V	50p	50+50+50/350V	95p	50+50/300V	50p
50/450V	95p	8+8/500V	£1	80+40/500V	£2.20

CAPACITORS WIRE END High Voltage
.001, .002, .003, .005, .01, .02, .03, .05 mfd 400V **10p.**
400V **14p.** 600V **15p.** 1000V **25p.**
.22MF 350V **12p.** 600V **20p.** 1000V **30p.** 1750V **50p.**
.47MF 150V **10p.** 400V **25p.** 630V **30p.** 1000V **60p.**
TRIMMERS 30pF, 50pF, **10p.** 100pF, 150pF **20p.** 500pF **30p.**
MICROSWITCH SINGLE POLE CHANGEOVER 40p.
GEARED TWIN GANGS 365+365+25+25pF **£2.**
BRASS SPINDLE EXTENDERS 85p. Couplers **65p.**
VERNIER DRIVE DIALS, 36mm **£2.50**, 50mm **£3**
SLOW MOTION DRIVE 6:1 90p. Reverse Vernier drive **90p.**
TRANSISTOR TWIN GANG. Japanese Replacement **£1**
SOLID DIELECTRIC 100pf £1.50

HEATING ELEMENTS, WAFER THIN (Semi Flexible)
Size 11×9×⅛in. Operating voltage 240V, 250W approx. Suitable for Heating Pads, Food Warmers, Convector Heaters, Propagation, etc. Must be clamped between two sheets of metal or ceramic, etc.
ONLY **60p** EACH (FOUR FOR **£2**) POST 50p.

NEW baker Star sound

high power full range quality loudspeakers. British made. Ideal for Hi-Fi, music P.A. or discotheques. These loudspeakers are recommended where high power handling and quality is required.

MODEL	INCHES	OHMS	WATTS	TYPE	PRICE	POST
MAJOR	12	4-8-16	30	HI-FI	£16	£2
SUPERB	12	8-16	30	HI-FI	£26	£2
AUDITORIUM	12	8-16	45	HI-FI	£24	£2
AUDITORIUM	15	8-16	60	HI-FI	£37	£2
GROUP 45	12	4-8-16	45	PA	£16	£2
DG 75	12	4-8-16	75	PA	£20	£2
GROUP 100	12	8-16	100	Guitar	£26	£2
DISCO 100	12	8-16	100	Disco	£26	£2
GROUP 100	15	8-16	100	Guitar	£35	£2
DISCO 100	15	8-16	100	Disco	£35	£2

BAKER AMPLIFIERS BRITISH MADE

NEW PA150 MICROPHONE PA AMPLIFIER £129
4 channel 8 inputs, dual impedance, 50K-600 ohm 4 channel mixing, volume, treble, bass. Presence controls, Master volume control, echo send return socket. Slave sockets. Post £3.

BAKER 150 Watt AMPLIFIER 4 Inputs £99
For Discotheque, Vocal, Public Address. Three speaker outlets for 4, 8 or 16 ohms. Four high gain inputs, 20 mv, 50K ohm. Individual volume controls "Four channel" mixing. 150 watts 8 ohms R.M.S. Music Power. Slave output 500 M.V. 25K.ohm. Response 25 Hz – 20kHz ± 3dB. Integral Hi-Fi preamp separate Bass & Treble. Size – 16"×8"×5½". Wt – 14lb: Master volume control. British made. 12 months' guarantee. 240v A.C. mains or 120V to order. All transistor and solid state. Post £2.
100 Volt Line Model £114. MONO SLAVE £80.
New Stereo Slave 150 + 150 watt 300 watt Mono £125. Post £4.

Complete Disco 150W. Twin console + amplifier + mike and headphones + twin speakers. £330. 300 watt version **£399.** Carriage £30.

ELECTRONIC ECHO CHAMBER £85. Post £2
BBD Delay System 30 m/sec to 200 m/sec. Variable echo and direct sounds. Maintenance free. 240V AC.

DISCO GRAPHIC MIXER EQUALISER £108. Post £2
4 Channel stereo, 5 band graphic, red + green LED, VU display, headphone monitor, mic + override switch.

PA CABINET SPEAKERS, Complete. 8 ohm 60 watt 17×15×9in. **£25.** Post £4. 4 or 8 or 16 ohm 75 watt 23×15×11in. **£50.** Carr. £10. 90 watt 32×15×11in. **£63.** 120 watt **£77.** Carr. £12.
WATERPROOF HORNS 8 ohms 10in. 25 watt **£20.** Post £2. 12in. 40 watt **£26. Ditto, 100 volt line £32.** Post £2.

Battery only Portable PA Amplifier 10w complete mike and speaker, OK for meetings, crowd control, stalls, fetes, traders, parties. Shoulder strap feature. **£25** post £2.

R.C.S. 100 watt R.M.S. VALVE AMPLIFIER
4 Channel mixing. Master treble, bass and volume controls. 5 Speaker outlets, suits 4, 8, 16 ohm. Disco group. **£125.** Carr. & ins. £15.

60 WATT VALVE AMPLIFIER,
3 mixer inputs, 4-8-16 ohm, 100 volt line. 5 controls, 2 mic inputs plus 1 input switchable for mic, phono, aux. Treble and bass and 3 volume controls, 7 valves. **£69.** Post £3.

FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

MAKE	MODEL	SIZE	WATTS	OHMS	PRICE	POST
WHARFEDALE	TWEETER	4in	30	8	£7.50	£1
GOODMANS	TWEETER	3½in	25	8	£4	£1
AUDAX	TWEETER	4in	30	8	£6.50	£1
AUDAX	MID-RANGE	4in	50	8	£7.50	£1
SEAS	MID-RANGE	4½in	100	8	£12.50	£1
AUDAX	WOOFER	5½	25	8	£10	£1
GOODMANS	HIFAX	7½×4¼	100	4/8/16	£27	£2
GOODMANS	WOOFER	8in	25	4/8	£7.50	£1
GOODMANS	HB	8in	60	8	£12.50	£1
WHARFEDALE	WOOFER	8in	30	8	£9.50	£2
CELESTION	DISCO/GROUP	10in	50	8/16	£19	£2
GOODMANS	HPG/GROUP	12in	120	8/15	£29.50	£2
GOODMANS	GR12/GROUP	12in	90	8/15	£27.50	£2
GOODMANS	HPD/DISCO	12in	120	8/15	£29.50	£2
GOODMANS	HP/BASS	15 in	250	8	£69	£3
GOODMANS	HPD/BASS	18in	230	8	£80	£4

SPEAKER COVERING MATERIALS. Samples Large S.A.E.
B.A.F. LOUDSPEAKER CABINET WADDING 18in wide **35p** ft.

MOTOROLA PIEZO ELECTRIC HORN TWEETER, 3⅜in. square **£5**
100 watts. No crossover required. 4-8-16 ohm, 7⅜×3⅛in. **£10**

CROSSOVERS. TWO-WAY 3000 c/s 30 watt **£3.** 100W **£4.**
3-way 950 cps/3000 cps. 40 watt rating. **£4.** 60 watt **£6.** 100W **£8.**
LOUDSPEAKER BARGAINS. Please enquire, many others.
4 ohm, 5in. 7×4in, **£2.50**; 6½in, 8×5in, **£3**; 8in, **£3.50.** 6½in 20W **£7.50.**
8 ohm, 2⅝in, 3in, **£2**; 5×3in, 6×4in, 7×4in, 5in, **£2.50**; 6½in, 20W **£7.50** 8×5in, **£3**; 8in, **£4.50**; 10in, **£5**; 12in, **£6.**
15 ohm, 2¼in, 3½in, 5×3in, 6×4in, **£2.50.** 6½in 10W **£5.** 8in **£4.** 10in **£7.**
25 ohm, 3in, **£2**; 5×3in, 6×4in, 7×4in, **£2.50.** **120 ohm,** 3¼in dia. **£1.**

EMI 13½x8in. LOUDSPEAKERS
Model 450A, 10 watts R.M.S. with moving coil tweeter and two-way crossover; 3 ohm or 8 ohm. "Final Clearance". **£8** Post £1.50
SUITABLE BOOKSHELF CABINET
Teak Veneers **£6.50.** Size 18×11×6in. Post £1.50.

RADIO COMPONENT SPECIALISTS

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SEMICONDUCTORS

AA119	0.10
AAY30	0.17
AAY30	0.17
AAZ13	0.15
AAZ15	0.15
AAZ17	0.15
AC107	0.55
AC125	0.25
AC126	0.25
AC127	0.25
AC128	0.30
AC141	0.28
AC141K	0.35
AC142	0.28
AC142K	0.35
AC176	0.30
AC187	0.28
AC188	0.28
ACY17	1.30
ACY18	1.15
ACY19	1.10
ACY20	1.10
ACY21	1.15
ACY39	2.50
AD149	0.75
AD161	0.35
AD162	0.35
AF106	0.35
AF114	0.75
AF115	0.75
AF116	0.75
AF117	0.75
AF139	0.33
AF186	1.00
AF239	0.39
AFZ11	4.00
AFZ12	4.00
ASY26	1.40
ASY27	0.90

ASZ15	1.20
ASZ16	1.10
ASZ17	1.00
ASZ20	2.30
ASZ21	2.50
AU113	2.50
AUY10	3.00
BA145	0.13
BA148	0.15
BA154	0.10
BA155	0.11
BA156	0.10
BAW62	0.05
BAX13	0.06
BAX16	0.06
BC107	0.16
BC108	0.16
BC109	0.16
BC113	0.15
BC114	0.15
BC115	0.18
BC116	0.19
BC117	0.23
BC118	0.18
BC125	0.18
BC126	0.18
BC135	0.15
BC136	0.19
BC137	0.19
BC147	0.12
BC148	0.12
BC149	0.13
BC157	0.13
BC158	0.13
BC159	0.13
BC167	0.11
BC170	0.11
BC171	0.11
BC172	0.11

BC173	0.11
BC177	0.28
BC178	0.28
BC179	0.28
BC182	0.11
BC183	0.11
BC184	0.11
BC212	0.11
BC213	0.11
BC214	0.11
BC237	0.11
BC238	0.11
BC301	0.33
BC303	0.34
BC307	0.11
BC308	0.11
BC327	0.12
BC328	0.12
BC337	0.12
BC338	0.12
BCY30	1.25
BCY31	1.50
BCY32	1.50
BCY33	1.10
BCY34	1.00
BCY39	3.40
BCY40	2.80
BCY42	0.30
BCY43	0.30
BCY58	0.19
BCY70	0.17
BCY71	0.18
BCY72	0.17
BCZ11	1.75
BD115	0.42
BD121	1.70
BD123	2.80
BD124	2.00
BD131	0.44

BD132	0.48
BD135	0.40
BD136	0.40
BD137	0.40
BD138	0.48
BD139	0.48
BD140	0.50
BD144	2.00
BD181	1.20
BD183	0.80
BD2137	0.54
BD238	0.54
BDX10	0.91
BDX32	2.00
BDY20	1.50
BDY60	2.75
BF115	0.35
BF152	0.16
BF153	0.16
BF154	0.17
BF159	0.17
BF160	0.17
BF167	0.24
BF173	0.30
BF177	0.35
BF178	0.35
BF179	0.35
BF180	0.28
BF181	0.28
BF182	0.30
BF183	0.28
BF184	0.28
BF185	0.30
BF194	0.14
BF195	0.12
BF196	0.13
BF197	0.14
BF200	0.40
BF224	0.25
BF244	0.28

BF257	0.27
BF258	0.27
BF259	0.28
BF336	0.34
BF337	0.33
BF338	0.36
BFS21	4.00
BFS28	2.25
BFS61	0.20
BFS98	0.20
BFW10	0.97
BFW11	0.96
BFX84	0.30
BFX85	0.30
BFX87	0.30
BFX88	0.30
BFY50	0.25
BFY51	0.25
BFY52	0.25
BFY64	0.30
BFY90	0.95
BSX19	0.27
BSX20	0.27
BSX21	0.29
BT106	1.20
BTY79/400R	2.00
BU205	1.30
BU206	1.50
BU208	2.00
BY100	0.40
BY126	0.13
BY127	0.14
BZX61 Series	0.17
BZY88 Series	0.10
CRS1/40	0.60
CRS3/40	0.75
CRS3/60	0.90
GEX66	3.00

GEX541	5.00
GJ3M	1.50
GM0378A	1.75
KS100A	0.45
MJE340	0.60
MJE370	0.73
MJE371	0.71
MJE520	0.47
MJE521	0.73
MJE2955	1.30
MJE3055	1.10
MPF102	0.35
MPF103	0.35
MPF104	0.35
MPF105	0.35
MPSA06	0.26
MPSA56	0.28
MPSU01	0.53
MPSU06	0.65
MPSU56	0.69
NE555	0.45
NKT401	3.50
NKT403	2.50
NKT404	2.20
OA5	1.20
OA7	0.60
OA10	0.55
OA47	0.12
OA70	0.25
OA79	0.12
OA81	0.17
OA85	0.17
OA90	0.08
OA91	0.08
OA95	0.08
OA200	0.15
OA202	0.15
OA211	1.50
OAZ200	1.50
OAZ201	1.50
OAZ206	1.50

OAZ207	1.50
OC16	2.50
OC20	2.50
OC22	2.50
OC23	4.00
OC24	3.00
OC25	1.00
OC26	1.50
OC28	2.00
OC29	2.00
OC35	1.50
OC36	1.50
OC41	0.90
OC42	0.90
OC43	1.50
OC44	0.85
OC45	0.65
OC71	0.55
OC72	1.00
OC73	1.00
OC74	0.70
OC75	0.65
OC76	1.00
OC77	1.00
OC81	0.65
OC81Z	1.20
OC82	0.90
OC83	0.80
OC84	0.80
OC122	2.75
OC123	2.00
OC139	3.00
OC140	4.00
OC141	4.25
OC170	1.25
OC171	1.25
OC200	1.50
OC201	2.50
OC202	2.75
OC203	3.00
OC204	3.00

OC205	2.75
OC206	2.75
OC207	2.50
OCP71	2.00
ORP12	1.00
R2008B	2.00
R2009	2.25
R2010B	2.00
T1C44	0.27
T1C226D	1.20
TIL209	0.16
TIP29A	0.43
TIP30A	0.45
TIP31A	0.33
TIP32A	0.36
TIP33A	0.54
TIP34A	0.67
TIP41A	0.44
TIP42A	0.42
TIP2955	0.70
TIP3055	0.56
TIS43	0.43
ZS140	0.25
ZS170	0.21
ZS178	0.54
ZS271	0.23
ZS278	0.57
ZTX107	0.12
ZTX108	0.12
ZTX109	0.12
ZTX300	0.13
ZTX301	0.14
ZTX302	0.18
ZTX303	0.18
ZTX304	0.20
ZTX311	0.13
ZTX314	0.25
ZTX500	0.14
ZTX501	0.14
ZTX502	0.18
ZTX503	0.19

ZTX504	0.21
ZTX531	0.24
ZTX550	0.25
1N914	0.05
1N916	0.09
1N4001	0.06
1N4002	0.06
1N4003	0.06
1N4004	0.07
1N4005	0.09
1N4006	0.11
1N4007	0.12
1N4009	0.07
1N4148	0.04
1N5400	0.13
1N5401	0.13
1S44	0.04
1S920	0.08
1S921	0.09
2G301	1.00
2G302	1.00
2G306	1.00
2N404	1.30
2N696	0.32
2N697	0.32
2N698	0.32
2N705	1.25
2N706	0.25
2N708	0.25
2N930	0.25
2N1131	0.30
2N1132	0.30
2N1302	1.20
2N1303	0.80
2N1304	1.20
2N1305	1.00
2N1306	1.50
2N1307	1.10
2N1308	1.75
2N1309	1.20
2N1613	0.32

2N1671	5.00
2N1893	0.32
2N2147	4.00
2N2148	3.75
2N2218	0.32
2N2219	0.32
2N2220	0.20
2N2221	0.20
2N2222	0.20
2N2223	4.25
2N2368	0.25
2N2369A	0.25
2N2484	0.25
2N2646	0.50
2N2904	0.32
2N2905	0.32
2N2906	0.21
2N2907	0.21
2N2924	0.26
2N2925	0.22
2N2926	0.15
2N3053	0.26
2N3054	0.55
2N3055	0.65
2N3440	0.70
2N3441	0.85
2N3442	1.25
2N3614	2.20
2N3702	0.11
2N3703	0.11
2N3704	0.11
2N3705	0.11
2N3706	0.11
2N3707	0.11
2N3708	0.10
2N3709	0.11
2N3710	0.10
2N3711	0.10
2N3771	1.40
2N3772	1.60
2N3773	1.80

2N3819	0.30
2N3820	0.39
2N3823	0.60
2N3866	1.00
2N3904	0.17
2N3905	0.17
2N3906	0.17
2N4058	0.20
2N4059	0.20
2N4060	0.16
2N4061	0.16
2N4062	0.16
2N4124	0.16
2N4126	0.16
2N4286	0.15
2N4288	0.18
2N4289	0.18
2N4400	0.11
2N4401	0.11
2N4402	0.11
2N5457	0.32
2N5458	0.32
2N5459	0.32
2S017	10.00
2S019	12.00
2S026	25.00
2S103	1.50
2S302	2.00
2S303	1.50
2S322	3.50
2S324	3.50
2S701	2.00
2S745A	0.95
2S746A	0.95

VALVES

A1834	9.00
A2087	13.50
A2134	17.50
A2293	16.00
A2426	18.75
A2521	22.50
A2900	22.50
A3343	45.00
AZ31	2.75
AZ41	2.60
BK448	114.90
BK484	155.35
BS90	58.00
BS452	60.00
BS810	60.00
BT5	58.95
BT17	151.00
BT19	44.05
BT29	349.15
BT69	354.80
BT95	129.00
CBL31	4.00
CL33	4.00
CY31	3.00
C1K	20.00
C3A	22.00
C3JA	22.00
DA41	25.00
DA42	18.70
DAF91	1.75
DAF96	1.75
DET22	35.00
DET24	49.00
DF91	1.75
DF96	1.75
DK91	1.75
DK92	2.00
DK96	1.75
DL92	2.00
DL94	1.75
DL96	1.75
DLS10	14.00
DLS15	12.50
DLS16	12.50
DLS19	12.50
DM70	2.00
DM71	2.00
DM160	4.75
DY87	1.50
DY802	1.50
E55L	22.00
E80CC	8.81
E80CF	11.27
E80F	13.58
E80L	13.37
E81CC	8.00
E81L	12.57
E82CC	8.10
E83CC	8.40
E86C	8.25
E88C	8.25
E88CC	8.00
E90CC	8.61
E90F	9.90
E91H	6.25
E92CC	8.75
E99F	9.10

E130L	18.50
E180CC	10.50
E180F	9.90
E182CC	13.25
E186F	11.50
E188CC	8.25
E280F	22.51
E283CC	12.00
E288CC	17.50
EA52	32.25
EA76	2.50
EABC80	1.25
EAC91	3.50
EAF42	2.50
EAF801	2.00
EB41	4.00
EB91	1.50
EBC33	2.50
EBC41	2.50
EBC81	1.50
EBC90	1.25
EBF80	1.50
EBF83	1.75
EBF89	1.50
EBL31	6.00
EC90	1.25
EC91	8.00
EC92	1.75
EC157	325.40
ECC33	4.50
ECC35	4.50
ECC40	4.50
ECC81	1.75
ECC82	1.75
ECC83	1.75
ECC84	1.75
ECC85	1.75
ECC86	2.50
ECC88	2.10
ECC89	2.00
ECC91	8.93
ECC189	2.10
ECC807	1.75
ECC808	3.50
ECF80	1.55
ECF82	1.50
ECF86	2.50
ECH35	3.00
ECH42	3.50
ECH81	3.00
ECH83	2.50
ECH84	2.50
ECL80	1.50
ECL81	1.75
ECL82	1.50
ECL83	3.00
ECL84	1.50
ECL85	1.50
ECL86	1.75
EF37A	5.00
EF39	2.75
EF40	5.00
EF41	3.50
EF42	4.50
EF50	2.50
EF54	5.00
EF55	3.50
EF80	1.75
EF83	4.00

EF85	1.75
EF86	1.75
EF89	2.50
EF91	2.95
EF92	6.37
EF93	1.50
EF94	2.50
EF95	5.99
EF98	2.00
EF183	2.00
EF184	2.00
EF804S	12.00
EF805S	9.80
EH90	1.75
EK90	1.50
EL32	2.50
EL33	4.00
EL34MUI	3.00
EL36	2.50
EL41	2.80
EL42	2.50
EL81	5.25
EL83	6.00
EL84	2.25
EL86	2.75
EL90	2.25
EL91	9.69
EL95	2.00
EL156	25.00
EL360	8.50
EL500/504	3.00
EL509	7.00
EL821	13.00
EL822	13.97
EM34	5.00
EM80	2.50
EM81	2.50
EM84	2.00
EM85	2.75
EM87	2.50
EN32	17.46
EN91	7.50
EN92	6.96
EY51	2.75
EY81	2.50
EY83	2.50
EY84	9.24
EY86	1.75
EY88	1.75
EY500A	3.00
EY802	1.75
EZ35	1.75
EZ40	2.50
EZ41	2.50
EZ80	1.50
EZ81	1.50
EZ90	2.00
FW4-500	3.50
FW4-800	3.50
G1.371K	35.00
G551K	12.00
G180.2M	17.50
G240.2D	12.00
G400.1K	17.50
GN4	9.00
GN4A	9.00
GS16	16.00
GT1C	15.00
GU50	20.00

GU51	20.00
GXU1	15.35
GXU2	30.00
GXU3	25.00
GXU4	44.50
GXU50	20.00
GY501	3.00
GZ32	2.50
GZ33	4.75
GZ34	3.00
GZ37	4.75
KT61	5.00
KT66	8.00
KT88	15.00
KTW61	2.50
KTW62	2.50
KTW63	2.50
M8079	12.34
M8080	8.25
M8081	9.82
M8082	9.69
M8083	8.58
M8091	10.43
M8096	6.80
M8097	8.10
M8098	6.15
M8099	8.00
M8100	9.52
M8136	10.23
M8137	10.23
M8140	6.00
M8141	6.50
M8142	8.75
M8144	7.50
M8149	6.50
M8161	9.35
M8162	10.40
M8163	8.25
M8190	5.00
M8195	10.85
M8196	7.50
M8204	7.05
M8212	11.37
M8223	6.00
M8224	6.30
M8225	4.50
M8248	14.03
MD2901	60.00
MU14	2.50
MX119	55.00
MX123	72.00
MX145	56.70
MX151	17.25
MX152	131.25
MX161	152.25
MX163	20.25
MX164	25.52
MX166	147.00
MX168	48.00
N78	15.00
OA2	3.25
OA3	2.50
OA4	6.00
OB2	4.35
OB3	2.50
OC2	4.35
OC3	2.50
GD3	2.50
OZ4	3.50

PC86	2.50
PC88	2.50
PC95	1.75
PC97	1.75
PC900	1.75
PCC84	1.50
PCC85	1.50
PCC88	2.00
PCC89	1.75
PCC189	2.50
PCC805	1.60
PCC806	1.60
PCE82	2.00
PCF80	2.00
PCF82	1.50
PCF86	2.50
PCF87	2.00
PCF200	3.25
PCF201	3.25
PCF801	2.50
PCF802	2.50
PCF805	1.70
PCF806	1.70
PCF808	1.70
PCL82	2.00
PCL83	3.00
PCL84	2.00
PCL85	2.50
PCL86	2.50
PCL805/85	2.50
PD500	6.00
PE06-40N	30.00
PFL200	2.50
PL36	2.50
PL81	1.75
PL81A	2.00
PL82	1.50
PL83	2.50
PL84	2.00
PL504/5	2.50
PL508	2.50
PL509	6.00
PL519	6.00
PL801	1.50
PL802	6.00
PY33	2.50
PY81	1.75
PY82	1.50
PY83	2.50
PY88	2.00
PY500A	3.00
PY800	1.50
PY801	1.50
QQV02-6	16.50
QQV03-10	14.00
QQV03-20A	48.38
QQV06-40A	48.38
QQV07-50	66.90
QQZ06-40A	62.20
QU37	12.50
QV03-12	6.80
QV04-7	3.50
QV08-100	136.85
QY3-65	54.26
QY3-125	60.40

QY4-250	73.15
QY4-400	76.80
QY5-500	175.00
QY5-3000A	335.00
QZ06-20	32.70
R10	6.00
R17	3.00
R18	3.00
R19	9.24
R20	2.50
RG3-250	32.68
RG3-250A	32.68
RG3-1250	59.50
RG4-1250	61.60
RG4-3000	99.45
RR3-250	40.00
RR3-1250	45.75
S11E12	65.00
S130	6.00
S130P	6.00
STV280-40	14.00
STV280-80	21.00
SU41	5.00
SU42	10.00
TD03-10	35.00
TD03-10F	35.00
TT15	35.00
TT21	23.00
TT22	23.00
TT100	60.00
TY2-125	60.00
TW4-400	71.40
TY4-500	98.35
TY5-500	175.00
TY6-800	188.00
TY6-5000A	375.00
TY6-5000B	395.00
TY6-5000W	325.00
TY7-6000A	374.00
TY7-6000W	303.60
TZ40	25.00
U18-20	3.50
U19	13.75
U25	2.50
U26	2.50
U37	12.00
UABC80	1.25
UAF42	2.50
UB41	3.00
UBC41	2.25
UBF89	1.50
UCC84	1.75
UCC85	1.85
UCF80	2.00
UCH42	2.50
UCH81	2.50
UCL82	1.75
UCL83	2.75
UF41	2.00
UF42	2.10
UF80	1.75

UF85	1.75
UF89	2.00
UL41	3.50
UL84	1.75
UM80	2.00
UY41	2.25
UY85	2.25
VLS631	15.00
XG1-2500	45.80
XG2-6400	141.90
XG5-500	26.60
XG2-6400	162.00
XR1-1600A	53.75
XR1-3200	81.97
XR1-3200A	
XR1-6400	102.00
YD1120	395.00
YD1240	351.00
Z759	25.00
ZM1000	8.00
ZM1001	8.00
ZM1020	9.00
ZM1021	9.00
ZM1022	9.00
ZM1023	9.00
ZM1040	19.36
ZM1041	16.66
ZM1042	17.77
1B3GT	3.00
1B24	25.00
1B35A	48.00
1B63	64.00
1R5	1.75
1S5	1.75
1T4	1.75
2AS15	11.50
2C39A	60.00
2C43	70.00
2D21	3.25
2E26	8.25
2J42	98.00
2J55	175.00
2J70A	383.00
2J70B	336.00
2K25	125.00
3-400Z	85.00
3-500Z	85.00
3A5	3.00
3B24	11.00
3B28	15.35
3B29	20.00
3B240M	17.50
3B241M	17.50
3C23	25.00
3C45	24.50
3CX100A5	47.00
3E29	45.00
3S4	2.00
3V4	1.75
465A	60.00
4-125A	60.00
4-250A	80.00
4-400A	87.00
4B32	20.00

4C35	78.00
4CX250B	40.00
4CX350A	73.00
4X150A	60.00
4X150D	56.00
5B254M	35.00
5B255M	35.00
5C22	160.00
5J180E	1650.00
5R4GY	3.50
5U4G	3.00
5U4GB	2.50
5V4G	2.50
5Y3GT	2.50
5Z3	4.00
5Z4G	2.50
5Z4GT	2.50
6-30L2	1.75
6AB4	1.75
6AB7	3.00
6AC7	3.00
6AF4A	4.25
6AG7	3.00
6AH6	5.00
6AK5	7.10
6AK6	2.50
6AL5	1.50
6AM4	4.00
6AM5	9.69
6AM6	6.00
6AN5	4.75
6AN8A	3.50
6AQ5	2.25
6AS6	8.66
6AS7G	8.75
6AT6	1.25
6AU5GT	5.00
6AU6	2.50
6AV5GA	4.50
6AV6	1.50
6AX5GT	3.00
6B7	3.25
6B8	3.25
6BA6	1.50
6BA7	5.00
6BA8A	4.00
6BC4	4.00
6BE6	1.50
6BH6	2.50
6BJ6	2.25
6BK4	4.50
6BL6	85.00
6BL7GT	4.50
6BM6	115.00
6BN6	2.00
6BQ7A	3.50
6BR7	6.00
6BR8A	3.50
6BS7	6.00
6BW6	6.00
6BW7	1.50
6BX7GT	5.00
6BZ6	2.75
6C4	1.25
6CB6A	2.50
6CD6GA	5.00
6CG7	2.50
6CH6	13.00
6CL6	3.75

6CW4	8.00
6D2	1.50
6DK6	3.00
6DQ6B	4.75
6EA8	3.00
6EB8	2.50
6EW6	2.25
6F6	3.00
6F23	1.60
6F28	1.60
6F33	33.50
6H1	14.00
6H2N	2.75
6H3N	2.75
6H6	3.00
6J4	5.50
6J6	8.93
6J7	4.75
6K4N	2.50
6K6GT	2.75
6K7	3.00
6K8	3.00
6KD6	7.00
6L6G	3.00
6L6GA	2.25
6L6GC	3.00
6L6GT	3.00
6L7	2.50
6N2P	2.50
6N3P	2.50
6N7	3.00
6P25	4.00
6Q7	3.75
6R7	3.25
6SA7	3.00
6SC7	2.75
6SF7	2.50
6SH7	3.00
6SJ7	3.25
6SK7	3.50
6SK7GT	3.00
6SN7GT	3.00
6SQ7	3.40
6SR7	4.00
6SS7	2.75
6U5G	3.50
6U8A	2.25
6V6GT	2.25
6X4	2.00
6X5GT	1.75
7B7	2.50
7C5	4.00
7C6	2.50
7H7	4.00
7R7	4.25
7S7	3.50
7Y4	2.25
7Z4	2.00
11E3	55.00
12AH8	5.00
12AT6	1.50
12AT7	1.75
12AU6	2.50
12AU7	1.75
12AV6	2.50
12AV7	3.50
12AX7	1.75
12AY7A	4.00
12B4A	3.50

12BA6	2.50
12BE6	2.50
12BH7	1.50
12BY7	3.00
12E1	20.00
12E11TT	170.00
12E14	35.00
13E1	20.00
19H4	27.50
19H5	47.50
24B9	67.25
30C15	2.00
30C17	2.00
30C18	2.00
30F5	1.60
30FL1/2	1.38
30FL12	1.80
30FL14	2.00
30L1	1.50
30L15	2.00
30L17	2.00
30P4	2.50
30P19	2.50
30PL1	3.00
30PL14	1.80
30PL15	1.80
35W4	1.00
50C5	1.50
75B1	6.05
75C1	4.50
85A1	7.50
85A2	4.45
90AG	12.96
90AV	12.96
90C1	6.00
90CG	14.54
90CV	15.45
92AG	12.96
92AV	12.96
95A1	8.45
150B2	6.50
150B3	8.35
150C2	3.25
150C4	6.00
211	35.00
723AB	125.00
803	25.00
805	45.00
807	3.75
811A	18.33
812A	18.33
813	125.86
833A	193.16
866A	20.03
872A	20.00
922	6.00
931A	18.50
1624	4.00
1625	3.50
2050	7.00
4212E	300.00
4212H	300.00
5544	81.97
5545	102.00
5551A	114.90
5552A	155.35
5642	9.00
5654	3.00
5651	4.45

5670	4.50
5675	28.00
5687	6.00
5696	4.50
5718	7.50
5725	5.50
5726	11.37
5727	7.05
5749	2.50
5751	4.00
5763	4.50
5814A	4.00
5840	4.00
5842	12.00
5876A	31.50
5879	5.00
5886	12.50
5963	2.50
5965	3.50
6005	2.25
6021	4.50
6057	10.23
6058	12.34
6059	6.00
6061	6.00
6063	3.75
6064	8.58
6067	10.23
6072	6.00
6080	14.00
6097A	235.00
6097B	200.00
6146A	8.25
6146B	8.25
6159B	19.00
6189	9.55
6201	11.40
6442	20.00
6883B	17.54
6973	4.00
7025	3.00
7551	6.25
7586	12.00
7587	18.50
7609	56.00
7868	6.00
7895	12.00
8005	110.49
8068	14.00
8122	90.00
8136	2.50
8417	6.00
18042	11.53
18045	10.49

Tested Ex-Equipment

4CX250B	6.50

BASES

B7G unskirted	0.22
B7G skirted	0.30
B9A unskirted	0.22
B9A skirted	0.30
Int Octal	0.35
Loctal	0.55
Nuvistor base	0.75
8 pin DIL	0.15
14 pin DIL	0.15
16 pin DIL	0.17
Valve screening cans all sizes	0.30

CRTs

2AP1	8.50
2BP1	9.00
3BP1	12.00
3DP1	5.00
3EG1	10.00
3FP7	6.00
3GP1	6.00
3JP1	8.00
3JP2	8.00
3JP7	10.00
3KP1	15.00
3RP1	35.00
3WP1	20.00

5ADP1	35.00
5BP1	10.00
5CP1	10.00
5CP1A	40.00
5FP15A	15.00
5UP7	25.00
DG7-5	63.32
DG7-31	58.07
DG7-32	58.07
DH3-91	56.83
DH7-11	113.12
VCR97	12.00
VCR138	12.00
VCR138A	12.50
VCR139A	8.00

VCR517A	10.00
VCR517B	10.00
VCR517C	10.00

Tube Bases Prices on application

INTEGRATED CIRCUITS

7400	0.16
7401	0.17
7402	0.17
7403	0.17
7404	0.18
7405	0.18
7406	0.43
7407	0.43
7408	0.20
7409	0.20
7410	0.17
7412	0.29
7413	0.32
7416	0.32
7417	0.32
7420	0.18
7422	0.20

7423	0.33
7425	0.30
7427	0.30
7428	0.43
7430	0.17
7432	0.30
7433	0.40
7437	0.32
7438	0.32
7440	0.32
7441	0.90
7442	0.72
7447AN	1.17
7450	0.18
7451	0.18
7453	0.18
7454	0.18

7460	0.18
7470	0.38
7472	0.33
7473	0.38
7474	0.38
7475	0.54
7476	0.42
7480	0.56
7482	0.75
7483	1.00
7484	1.05
7486	0.39
7490	0.60
7491	0.82
7492	0.60
7493	0.60
7494	0.82

7495	0.73
7496	0.82
7497	3.15
74100	1.54
74107	0.45
74109	0.73
74110	0.51
74111	0.71
74116	1.85
74118	1.00
74119	1.54
74120	0.83
74121	0.43
74122	0.62
74123	1.18
74125	0.58
74126	0.58
74128	0.63
74132	0.72

74136	0.51
74141	0.89
74142	2.30
74143	2.60
74144	2.60
74145	1.00
74147	2.00
74148	1.76
74150	1.80
74151	0.94
74154	1.80
74155	0.90
74156	0.90
74157	0.75
74159	2.20
74170	2.40
74172	4.40
74173	1.42
74174	1.60

74175	1.02
74176	1.16
74178	1.36
74179	1.36
74180	1.20
74190	1.90
74191	1.90
74192	1.90
74193	1.90
74194	1.25
74195	1.20
74196	1.35
74197	1.35
74198	2.70
74199	2.30
TAA570	2.30
TAA630S	3.50
TAA700	3.90
TBA480Q	1.84

TBA520Q	2.30
TBA530	1.98
TBA540Q	2.30
TBA550Q	3.22
TBA560CQ	3.22
TBA673	2.20
TBA700	1.52
TBA720Q	2.30
TBA750Q	2.07
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WW – 045 FOR FURTHER DETAILS

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Pye Reporter MF6 AM high-band sets, complete but less speaker and cradle. **£90 each plus £2 p.p. plus VAT.**
Pye Olympic M201 AM high-band sets, complete but less mike, speaker and cradle. **£90 each plus £2 p.p. plus VAT.**
Pye Westminster W15 FM G band 42-54 MHz sets, unused and like new, but less mike, speaker and cradle. **£65 each plus £2 p.p. plus VAT.**
Pye Westminster W15 AMD mid-band multi-channel sets, no mikes, speakers or cradles. **£45 each plus £2 p.p. plus VAT.**
Pye Westminster W15 AMD mid-band crystalled and converted to 129.9 MHz, 130.1 MHz, 130.4 MHz. Very good condition. **£120 each plus £2 p.p. plus VAT.**
Pye Westminster W15 AMD high-band and low-band sets available. Sets complete but less mikes, speakers and cradles. **£70 each plus £2 p.p. plus VAT.**
Pye Westminster W30 AM low-band sets only, no control gear. Sets complete and in good condition. **£45 each plus £2 p.p. plus VAT.**
Pye base station F30 AM, low band and high band available, remote and local control. **Prices from £220 plus VAT.**
Pye base station F401 high-band AM, local control, fully solid state, complete but less mike. **£275 each plus £15 p.p. plus VAT.**
Pye base station F9U, remotely controlled, 5 Watt output, UHF (440-470 MHz), single channel. **£90 each plus £5 p.p. plus VAT.**
Pye base station F412 UHF (440-470 MHz), 25KHz channel spacing, single channel, local control. **£250 each plus £15 p.p. plus VAT.**
Pye Beaver M254 high-band FM sets, 15 Watt, robust mobile radiotelephones for industrial use, sets complete but less crystals, as new condition. **£120 each plus £2 p.p. plus V.A.T.**
Pye Base Station type F9AM, remotely controlled, 5 watt output, high band & low band available. **£90 each plus VAT.**
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Pye PC1 radiotelephone controller, good condition, two only at **£50 each plus £2 p.p. plus VAT.**
Pye Tulip microphone as used on most base stations and PC1, 2400 ohm with ptt switch. **£15 plus £1 p.p. plus VAT.**
Pye PF1 UHF FM Pocketfone receivers, 440-470 MHz, single channel, int. speaker and aerial. Supplied complete with rechargeable battery and service manual. **£6 each plus £1 p.p. plus VAT.**
Ni-Cad Batteries for Pye PF1, used but good condition, Rx (Yellow) £2 each Tx (Red). **£3 each plus £1 p.p. plus VAT.**
Pye Pocketfone PF1 Battery Chargers, type BC14, 12 way with meter. **£10 each plus £1 p.p. plus VAT.**
Pye Pocketfone PF1 Battery Chargers, type BC5 single charger, brand new. **£20 each plus £1 p.p. plus VAT.**
Pye single sideband HF Mobile Radiotelephone, type SSB130M, 100 W P.E.P. output, 6-channel, 2-15 MHz. Complete and new condition but less power unit. **£250 plus £10 p.p. plus VAT.**
Pye fixed station transmitter, type T100 FM, 'G' band 38.6-50 MHz, 100 W output. 25 KHz channel spacing. New condition. **£100 each plus £10 p.p. plus VAT.**
Pye Pocketfone 70 type PF2UB, UHF Portables, complete with battery, aerial & mike, good condition. **£80 plus VAT. Sets only £50 plus VAT.**
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Pye Pocketfone type PF8 UHF handheld, complete but less batteries, single channel, 25 KHz channel spacing. **£90 each plus £1 p.p. plus VAT.**

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Airmec millivolt meter, Type 301. **£50 plus £2 p.p. plus VAT.**
Marconi HF Spectrum analyser, Type OA1094A/S 0-30 MHz. **£100 plus VAT (buyer collects).**
Servomex AC voltage stabiliser, type AC2, 240V @ 9 amp. **£45 each plus £15 p.p. plus VAT.**
Servomex AC voltage stabiliser, type AC7, 240V @ 20 amp. **£75 each plus £15 p.p. plus VAT.**
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Computer-grade electrolytic capacitors, screw terminals, 25,000mfd., 33 volts, brand new. **£1 each plus 50p p.p. plus VAT.**
60 amp alternator and general noise filters for use in vehicles. **£1 each plus 50p p.p. plus VAT.**
Modern telephones, type 746, with dials, colour grey, used but good condition. **£8 plus £1 p.p. plus VAT.**
Cigar lighter plug with lead. **£1 each plus 30p p.p. plus VAT.**
IC test clips, 28-way and 40-way, goldplated. **£2 each plus 30p p.p. plus VAT.**
Equipment wire, size 7/0.2mm, colour yellow, 500-metre reels. **£4 plus £1 p.p. plus VAT.**
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Power units, 70 volt @ 8 amp, 20 volt @ 3 amp. Brand new but no details. **£20 each plus £8 p.p. plus VAT.**
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Mains isolating transformer, 500VA 240V input, 240V C.T. output, housed in metal box. **£15 each plus £6 p.p. plus VAT.**
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UNIT TYPE	AR21	AR71
Description	VHF FM Receiver	UHF FM Receiver
Frequency Range	130-180 MHz	400-500 MHz
Number of Channels Available	2 (6ch also available)	2 (6ch also available)
Sensitivity	0.25μV P.D. for 20dB Sinad	
Selectivity	>80dB at ±25kHz	
Input Impedance	50 ohm	50 ohm
Audio Output Power	3 watts into 4 ohms	
Squelch Range	0.2-1.0μV	0.2-1.0μV
Supply Voltage	12.5 volts (11v min, 15.6v max)	
Current Consumption	50-600mA dependent on audio level	
Dimensions	135×123×26mm	

UNIT TYPE	AT25	AT75
Description	VHF FM Transmitter	UHF FM Transmitter
Frequency Range	130-180MHz	400-500MHz
Power Output	4 watts (normal) 0.5 watts (reduced)	2 watts (normal) 0.5 watts (reduced)
Output Impedance	50 ohm	50 ohm
Supply Voltage	12.5 volts (11v min, 15.6v max)	
Current Consumption	0·8 amps for 4w output 0·5 amps for 1w output	0·6 amps for 2w output 0·4 amps for 0·5w output
Dimensions	135×102×26mm	

UNIT TYPE	PRICE (exc. VAT)
AR21 VHF FM Receiver	£149
AR71 UHF FM Receiver	£177
AT25 VHF FM Transmitter	£84
AT75 UHF FM Transmitter	£110

The above items carry a 12 month guarantee, and we normally carry good stocks to ensure the minimum of delivery delays. If you have a requirement, or would be interested in quantity discounts, please contact our sales department.

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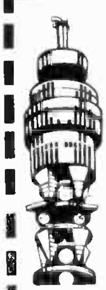
However, the successful applicant will be qualified in electronics and will also be responsible for servicing equipment at Newham Maternity Hospital, a service which is intended to expand to serve the District.

Application form and job description from:

District Personnel Department
St Clement's Hospital
Bow Road
London E3 4LL
Tel. 01-980 4899, ext. 7

Closing date: July 13th, 1983

(2157)



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1935

THE UNIVERSITY OF PAPUA NEW GUINEA – PORT MORESBY

Applications are invited from suitably qualified persons for the post of Senior Technical Officer in the Department of Physics. The successful applicant will be expected to join a technical group involved in carrying out electrical-electronic maintenance to scientific departments and facilities within the University. A proven record of experience is required covering maintenance and servicing in a wide range of teaching and research instrumentation commonly used in Bio-Medical Sciences. The Department of Physics houses modern and well-equipped electronics and teaching workshops to facilitate the work envisaged. He/she will be required to supervise and provide on-the-job training to national Papua New Guinean technical staff. Applicants should have a Higher National Certificate in Electrical/Electronics Engineering or equivalent qualification. Possession of a valid driving licence will be desirable.

Salary: K16,645 per annum plus gratuity. (£1 sterling = K1.3195)

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Applications should be forwarded to the Assistant Secretary (Staffing), University of Papua New Guinea, PO Box 320, UNIVERSITY, to reach him no later than 30 June, 1983. Applicants resident in the UK should also send one copy to the Overseas Educational Appointments Department, The British Council, 90-91 Tottenham Court Road, London W1P 0DT, quoting reference U78/83.

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They produce electro-optical surveillance and detection systems embracing thermal imaging; other day/night vision aids with laser integration.

SO WHAT'S THE ATTRACTION

The company's vigorous buccaneer spirit is reflected in a full order book – 80 per cent exports. To maintain this position new products must follow. A business development group has been formed to ensure that successful high technology concepts are generated to create a range of products which will satisfy the market demands of the future. They now require:

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GRADUATES WITH EXPERIENCE or ability to produce new concepts, to take designs to the breadboard proving stage. Applications and topics are varied. For example circuits for image processing modern laser applications, displays (CRT, PLASMA or LCD), designs incorporating the latest MPUs or high-volume memories.

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(2165)

Satellite Communications

- Spacecraft Systems • Communications Systems
- Antenna Design • Radar and Signal Processing
- Electronic Circuit Design
- RF and Microwave Equipments
- Mechanical, Thermal and Dynamics Design

Recently awarded contracts have created a need for immediate expansion of on-site facilities and the design team. Some senior appointments have been filled from within, but there are still opportunities for Engineering Managers and Group Leaders to head up additional teams now being formed.

At Senior Engineer/Engineer levels there are several vacancies in each of the above work areas.

Qualifications required are Degree/HND/HNC in a relevant discipline, plus experience.

Excellent salaries and comprehensive range of benefits are offered, together with relocation assistance if required.

Please complete the coupon below, and send it to: **Jack Burnie, Marconi Space and Defence Systems, Browns Lane, The Airport, Portsmouth, Hants. Tel. Portsmouth 674019.**

(All posts are open to both male and female applicants).

Design Engineers

Name ____________________

Address ____________________

____

Age ______ Telephone (Home) ____________ (Work) ____________

Qualifications ____________________

Area of interest (please tick)

Spacecraft Systems ☐ RF and Microwave Equipments ☐
Communications Systems ☐ Radar/Signal Processing ☐
Antenna Design ☐ Electronic Circuits (VHF/UHF) ☐
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Ref BL 73

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Test Engineers required with experience of digital circuitry. £7,700. Surrey.

3) Microcomputers and Peripherals
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6) £500 per week
We are paying very high rates for contract design and test engineers who have a background in RF, MICROWAVE, DIGITAL, ANALOGUE or SOFTWARE, at sites throughout the UK.

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(1640)

CLIVEDEN

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Senior Chief Technician

INCLUSIVE SALARY SCALE: £9,898-£11,395

Applications are invited for the above post which carries responsibility for the day-to-day administration of the technician staff in the Medical Electronics Section of the Medical Physics Department.

The main duties are associated with equipment management which includes maintenance, electrical safety testing and evaluation of new equipment. Extensive use is made of a minicomputer for record keeping and work scheduling.

Applicants should have considerable experience of electronic equipment and should currently be in charge of an equipment maintenance section.

The successful applicant will probably have a degree, HNC or HND in Electronic Engineering and will be appointed on the Medical Physics Technician I scale.

For further information please telephone Mr. C. G. Carter, Senior Electronics Engineer, on 01-748 2040, Ext. 2598.

For an application form and job description please contact the District Personnel Department, Brandenburgh House, 116 Fulham Palace Road, London, W.6. Tel: 01-748 2040, Ext. 2992.

Closing date: June 24, 1983. (2140)

Premier international electronics companies – very secure and expanding in London and the south of England – require professional senior staff (including departmental heads). Relocation allowance up to £3,000.

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Electronic engineers required with degree – H.N.C. – tech. cert. – O.N.C. Almost any background required but software and hardware experience will bring salary of absolute minimum of £6,500 p.a. and could be up to £11,000 p.a.

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Engineers required with experience of circuit or component design or development for microwave equipment or digital logic or computer peripherals or electronic packaging or film technology or telecommunications. Also above for updating in modern techniques. Salaries up to £15,000.

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Appointment until October 1985 in the first instance with good prospects of further extension.

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Department of Mechnical Engineering
Imperial College
London SW7 2BX

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If you like the thought of enjoying the success of one of the world's leaders in Brodcast technology, together with an attractive salary and benefits package, then write with details of career and current salary to Mike Jones, Senior Personnel Officer, Sony Broadcast Limited, City Wall House, Basing View, Basingstoke, Hampshire RG21 2LA. Telephone (0256) 55011

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Basing View, Basingstoke
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Attractively situated in a semi-rural area in one of the Home Counties, our client is engaged in the research, development and manufacture of a wide range of advanced systems for guided weapons, satellites and electronic warfare. The company is one of Britain's most successful and prestigious companies who have recently acquired major new contracts which necessitate the recruitment of people to work on state-of-the-art projects in the following disciplines:

Satellite Communications and E.W. c. £9K to £17K

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For interesting work in the design and development of digital circuits, or analogue circuits, or D to A and A to D converters. Or VLS, to discrete circuits or logic circuits; also for packaging and thermal design of components and assemblies.

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For software design associated with INTEL 8085 and 8086 microprocessor based real time systems or computer modelling and simulation, or data analysis.

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To work on advanced satellite communications or electronic warfare systems involving frequencies up to 40GHz on active or passive devices such as FET amplifiers, solid state oscillators, filters, couplers, frequency synthesisers, mixers, solid state multiplexers, and transmitters.

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To work on major projects using PERT techniques, with access to computer facilities in a demanding and stimulating environment.

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This includes vacancies for **PROJECT MANAGERS, DEPUTY PROJECT MANAGERS, ENGINEERING MANAGER, PRODUCT SUPPORT MANAGER, PROJECT LEADERS, AND TEAM LEADERS** in most of the above disciplines.

For an early interview please telephone FRED JEFFRIES C.Eng. M.I.E.R.E. in complete confidence on: HEMEL HEMPSTEAD (0442) 212655 (five lines) during office hours or on HEMEL HEMPSTEAD (0442) 49909 evenings or weekends (not an answering machine). Alternatively write to him at the address below.

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Appointments

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Join the Government Communications Headquarters, one of the world's foremost centres for R & D and production in voice/data communications ranging from HF to satellite – and their security. Some of GCHQ's facilities are unique and there is substantial emphasis on creative solutions for solving complex communications problems using state-of-the-art techniques including computer/microprocessor applications. Current opportunities are for:

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Two levels of entry providing two salary scales: £5980-£8180 and £8065-£9085

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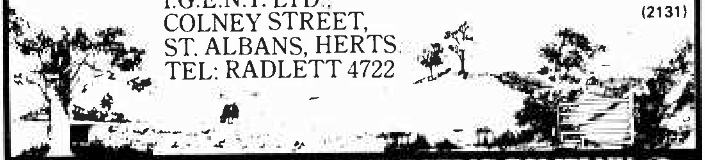

INTERNATIONAL GENERAL ELECTRIC COMPANY OF NEW YORK LIMITED

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CEL urgently require a field sales engineer to assist with the sales and support of a widening range of digital video products. Based at Saffron Walden, the post will involve work both at our factory and throughout the UK and Europe.

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(2141)

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★ TEC/SCOTEC certificate
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Directly responsible to Quality Manager for all quality aspects of the Company including audits, defect analysis, production test specifications, vendor ratings and sampling plans. Age group 25-45 preferred with experience of MOD Quality Procedures. Should have experience of day-to-day problem solving in electronic/electrical manufacturing environment.

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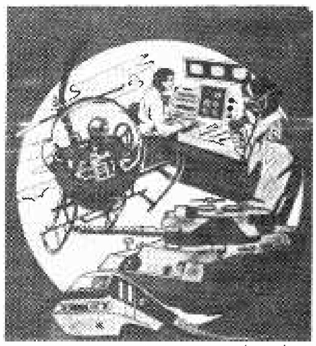
We specialise in the design and manufacture of electronic and electrical assemblies for Home Office, London Transport and the Ministry of Defence (approved to 05-21)



NL ELECTRICAL
Cranborne Road
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(0707) 58288

(2166)

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Salary:
Negotiable, depending on ability and experience.

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Due to continuing expansion of the medical division within the UK, Greiner have vacancies for the above positions.

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Tel: 01-803 8432

Greiner

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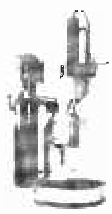

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Classified

SITUATIONS VACANT

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Broadcasting these days tends to refer to those people scattering information rather than barley, but then much has changed! If you could be interested in changing then here is a small sample of the positions we have within our Communications division.

RF Components Designer **to £14,500** **Rural Southern England**
To design very sophisticated components used by the communication industry. Ref: 046/1

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Required throughout UK. Many for smaller and unusual companies.

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(2145)

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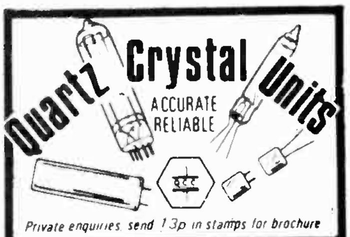

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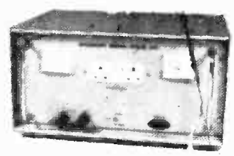

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