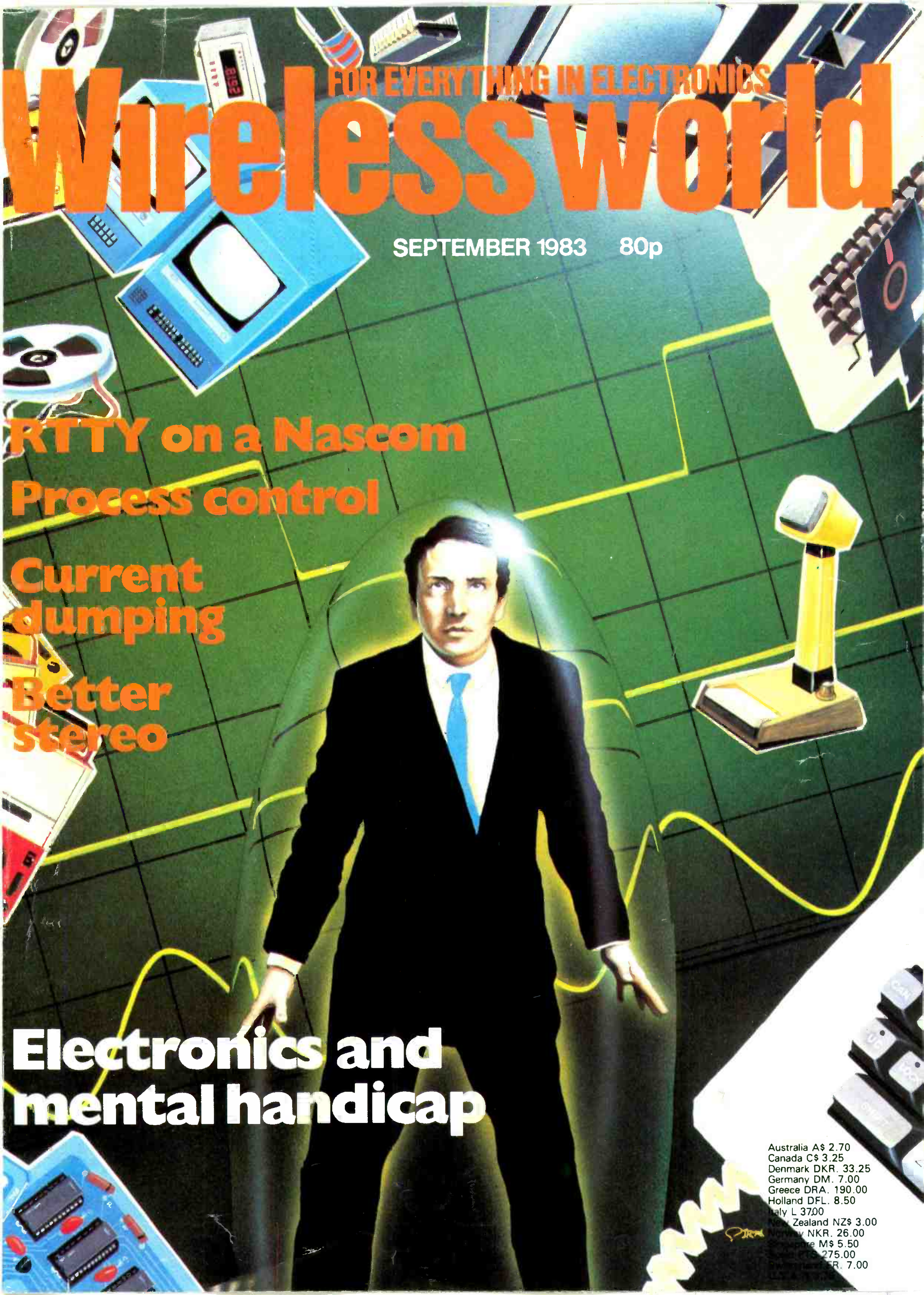

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Wireless world

SEPTEMBER 1983 80p

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WW-001 FOR FURTHER DETAILS

Wireless world

FOR EVERYTHING IN ELECTRONICS

SEPTEMBER 1983 VOL 89 NO 1572

New concepts of system modelling such as 'data marshalling' and 'thinking fatigue' are linked to hyperautism – this month's cover depicts the 'shell' condition – in R. E. Young's perceptive analysis.

NEXT MONTH

Low-frequency stereo imaging is improved using simple delay technique.

Professor MacCausland finds persistant inconsistencies in Einstein's Special Theory of Relativity

Ray Macario shows a need for monitoring the accuracy of world time standards.

Complementing his description of a 6809-based Forth computer, Brian Woodroffe starts to describe the Forth language.

Flow diagrams enable a program for ladder network insertion loss and delay equalization for a ZX81 to be modified for other computers.

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.
By post, current issue £1.23, back issues (if available) £1.80, order and payments to EEP General Sales Dept., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS Tel: 01-661 8668.
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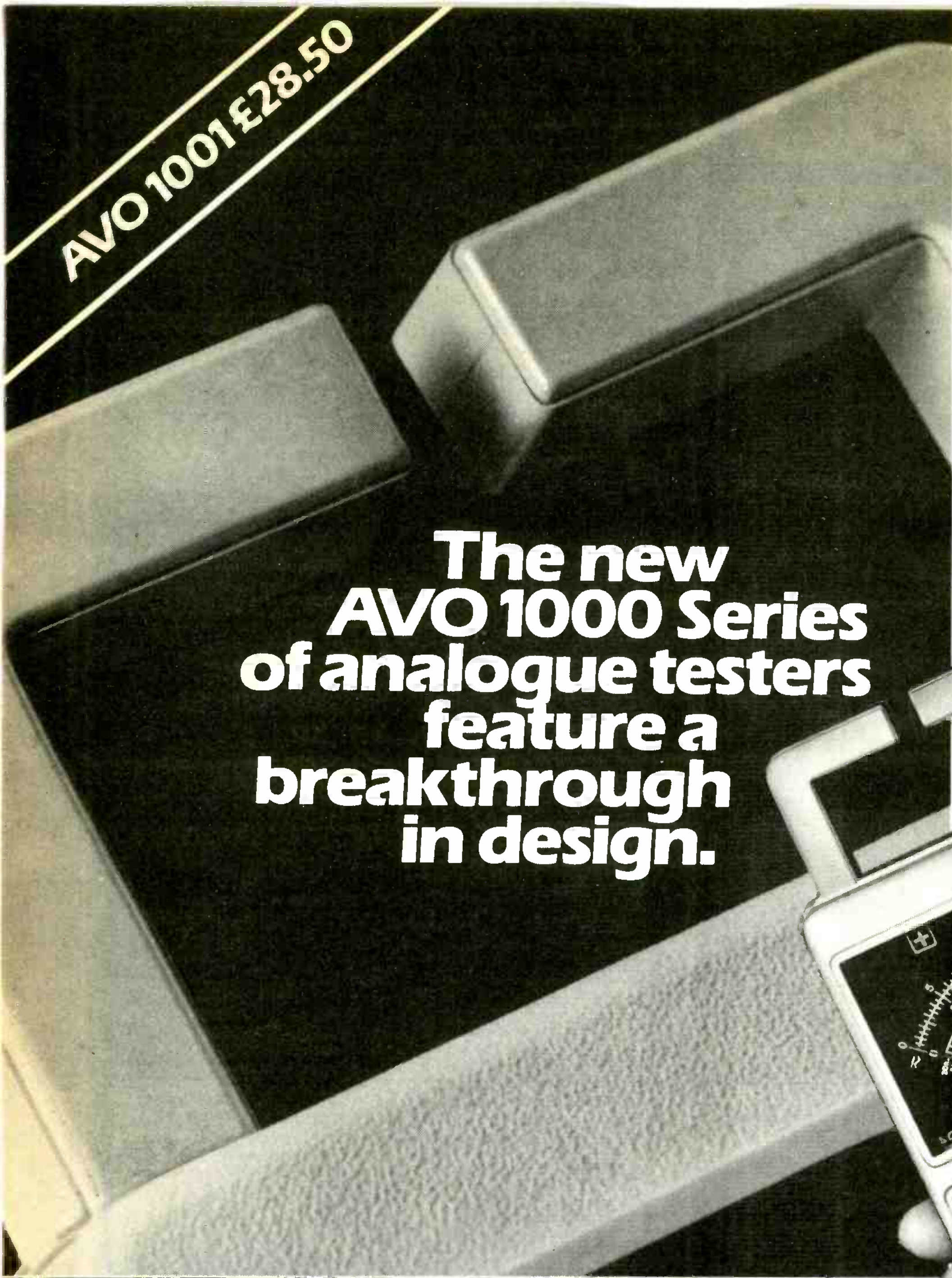

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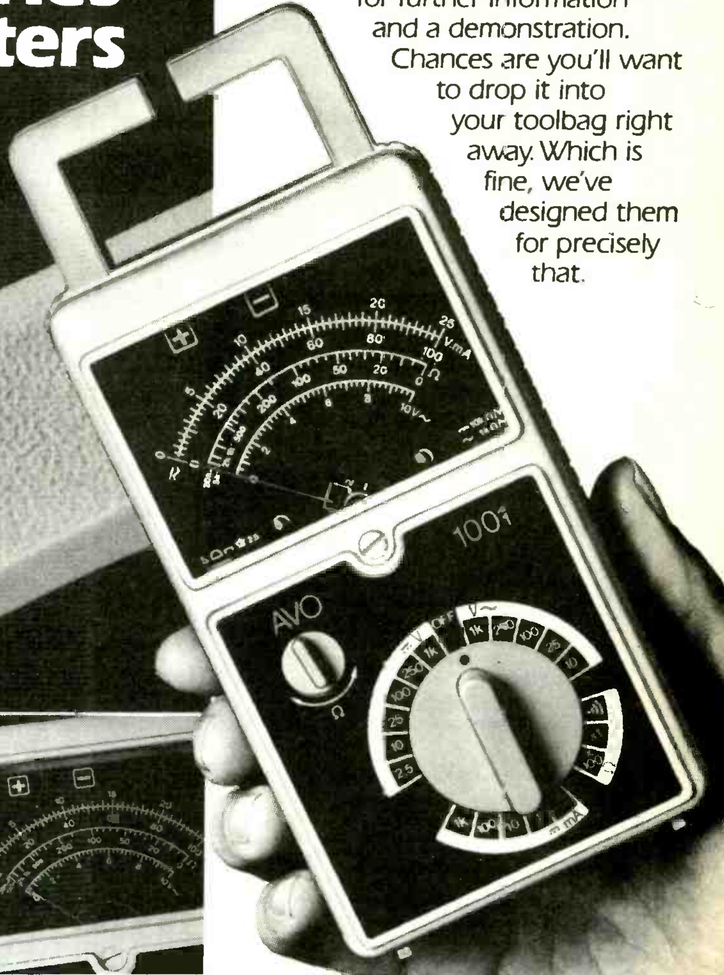

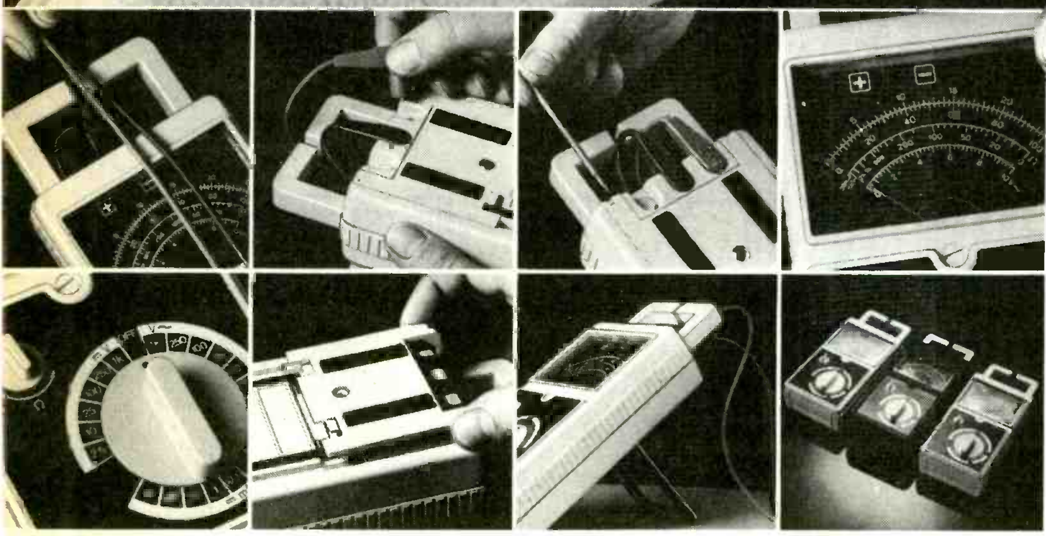

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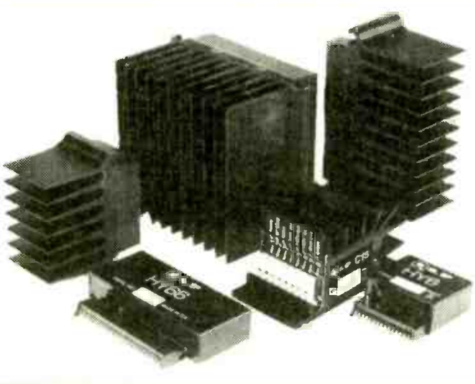

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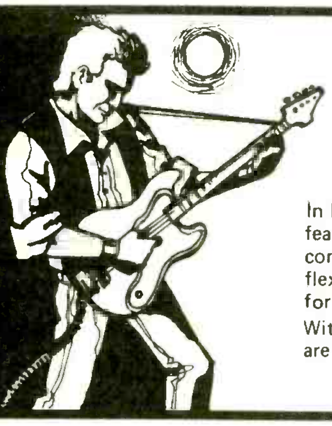

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Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68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

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

PRE-AMP SYSTEMS

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

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

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

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Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.14
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

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

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S/N ratio (DIN AUDIO) 80dB. Load Impedance 3Ω.
Input Sensitivity and impedance (selectable) 700mV rms into 15K Ω 3V rms into 8 Ω.
Size 95 x 48 x 50mm. Weight 256 gms.

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Stereo version of C15. **£17.19 (inc. VAT)**

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Model Number	For Use With	Price inc. VAT
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PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

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

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

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

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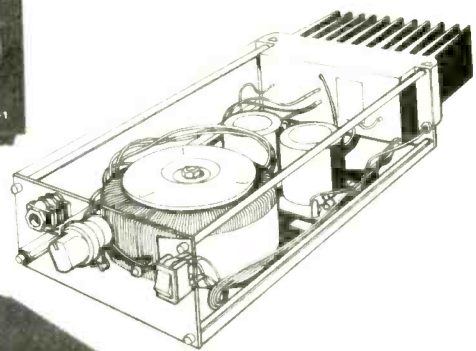

Unicase

Over the years ILP has been aware of the need for a complete packaging system for it's products, it has now developed a unique system which meets all the requirements for ease of assembly, adaptability, ruggedness, modern styling and above all price.

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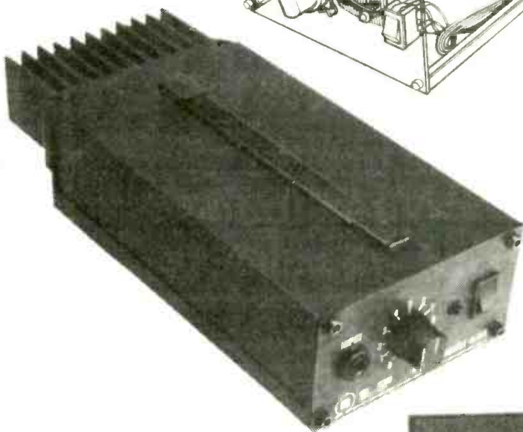

Hi Fi Separates

UC1 PRE AMP UNIT: Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

POWER AMPS: The UP series feature a clean line front panel incorporating on/off switch and concealed indicator. They are designed to compliment the style of the UC1 pre-amp. Performance for each unit which includes the appropriate power supply, is as specified on the facing page.

Power Slaves

Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

UNICASES

HIFI Separates					Price inc. VAT
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UP3X	60W/8Ω	Bipolar	Mono	HiFi	£54.95
UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
UP6X	60W/4–8Ω	MOS	Mono	HiFi	£64.95
UP7X	120W/4–8Ω	MOS	Mono	HiFi	£84.95
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US2X	120W/4Ω	Bipolar	Power	Slave	£79.95
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Please note X in part number denotes mains voltage. Please insert 'O' in place of X for 110V, '1' in place of X for 220V (Europe), and '2' in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

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6AK6	2.00	813A	60.00
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Essex Tiny Basic System

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'INSTANT ROM' is the trademark of Greenwich Instruments

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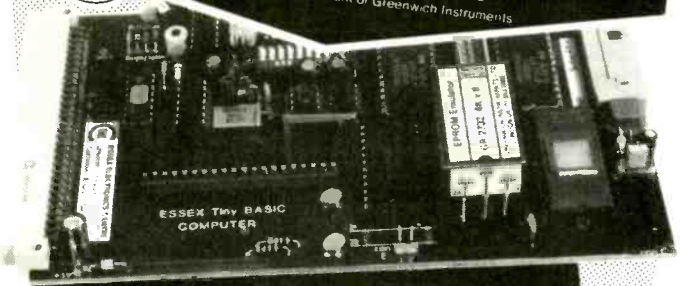
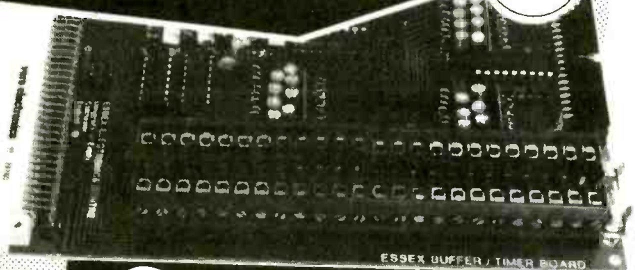


Essex Buffer Timer

A convenient means of buffering the I/O lines of the Essex Tiny BASIC Computer provides 24 inputs, 16 outputs and four hardware timers.

£78



Essex Opto-Isolator

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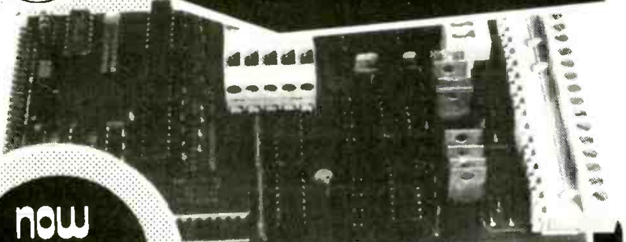

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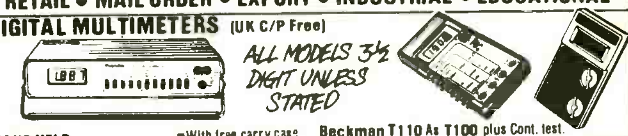

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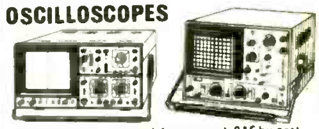

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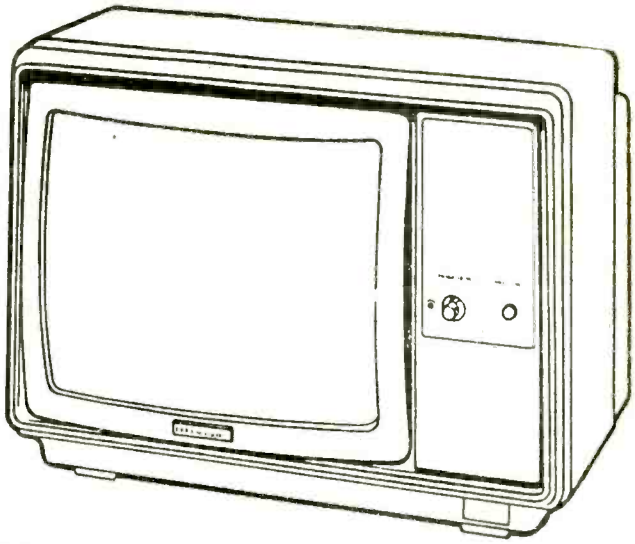

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BC108	0.16
BC109	0.16
BC113	0.15
BC114	0.15
BC115	0.18
BC116	0.19
BC117	0.23
BC118	0.18
BC125	0.18
BC126	0.18
BC135	0.15
BC136	0.19
BC137	0.19
BC147	0.12
BC148	0.12
BC149	0.13
BC157	0.13
BC158	0.13
BC159	0.13
BC167	0.11
BC170	0.11
BC171	0.11
BC172	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
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BF178	0.35
BF179	0.35
BF180	0.28
BF181	0.28
BF182	0.30
BF183	0.28
BF184	0.28
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BF194	0.14
BF195	0.12
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ZTX300	0.13
ZTX301	0.14
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ZTX303	0.18
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ZTX311	0.13
ZTX314	0.25
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ZTX501	0.14
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ZTX503	0.19
ZTX504	0.21
ZTX531	0.24
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1N914	0.05
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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
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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
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2N1302	1.20
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2N1304	1.20
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2N1306	1.50
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2N1308	1.75
2N1309	1.20
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2N2220	0.20
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2N2907	0.21
2N2924	0.26
2N2925	0.22
2N2926	0.15
2N3053	0.26
2N3054	0.55
2N3055	0.65
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2N3441	0.85
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2N3703	0.11
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2N3709	0.11
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DF91	1.75
DF96	1.75
DK91	1.75
DK92	2.00
DK96	1.75
DL92	2.00
DL94	1.75
DL96	1.75
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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	4.00
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	1.50
ECL82	1.50
ECL83	3.00
ECL84	1.50
ECL85	1.50
ECL86	1.75
EF37A	5.50
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
OD3	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	4.00
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
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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	15.00
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

Type	Price
4CX250B	6.50

BASES

Type	Price
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

Type	Price
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

Type	Price
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
TBA800	1.20
TBA920	2.90
TBA920Q	2.90
TBA990Q	2.90
TCA270Q	2.90
TCA760A	1.38

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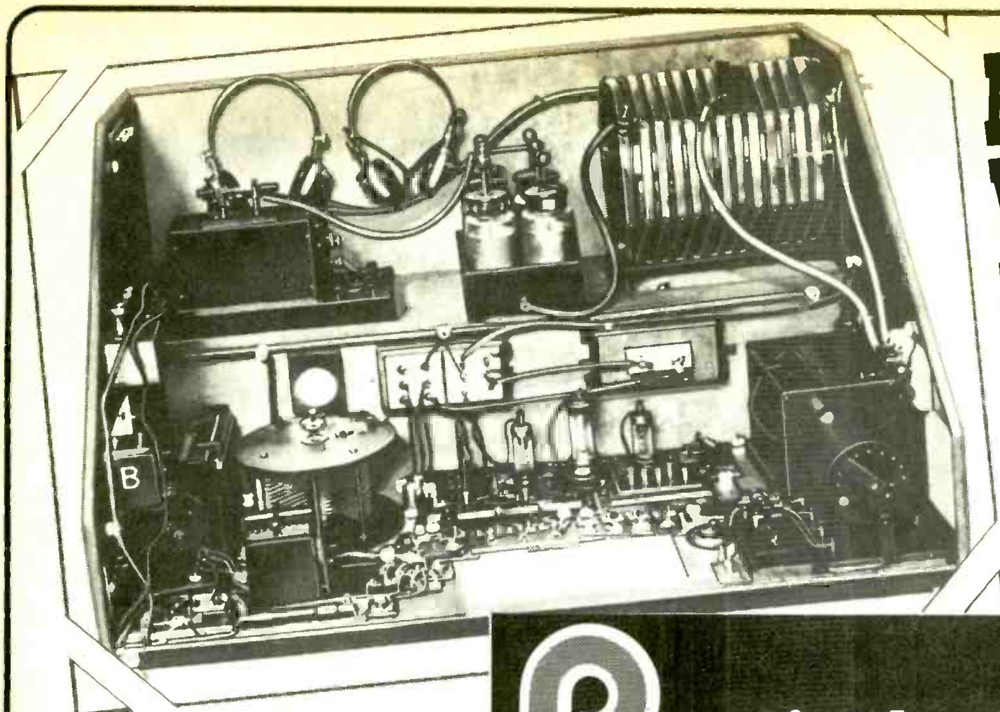

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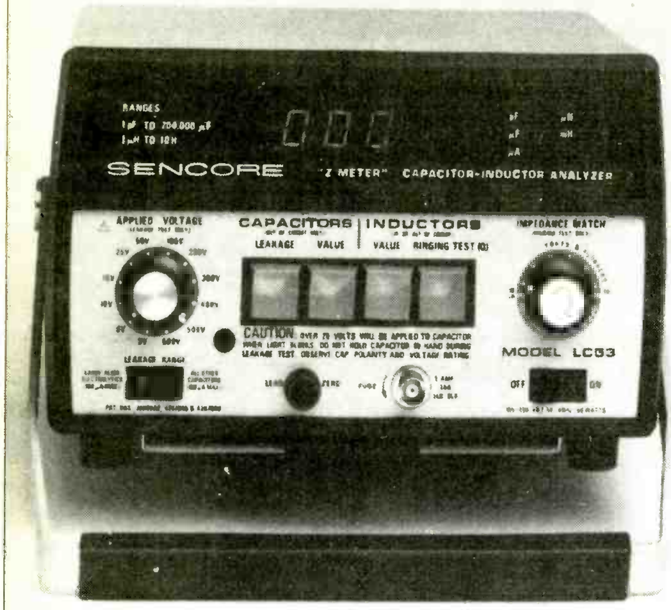

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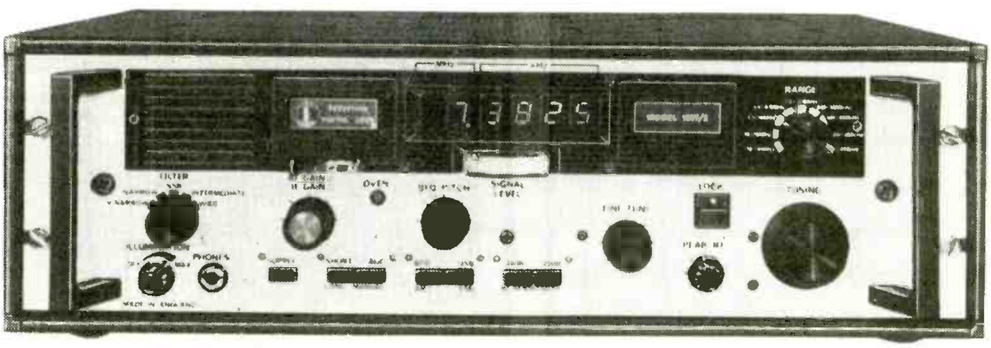

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Technology and people

As has perhaps been mentioned before on this page, it can be extremely dispiriting to take stock of society's scale of values, particularly when technology is the subject for discussion. Offensive weaponry, expensive trivia and the means to dispense one-way 'communications' constitute the overwhelming majority of applications in the field of electronics while other, more pressing, needs go unattended.

All the more encouraging, then, to report work which is supportive rather than sinister and which is designed to assist instead of to anaesthetize. In this issue, R. E. Young writes of his investigations into the alleviation of mental handicap by the breaking down of the communications barrier which is one of the symptoms of hyper-autism – the 'shell', as it has been called. The work stems from enquiries into human behaviour during unexpected emergencies,* in which people can exhibit some of the characteristics of mental handicap.

The use of technology to gain an insight into the ways in which humans operate and to alleviate abnormalities in behaviour illustrates the similarities between electronics and the human mind – if that is the word to use. It is possible that the similarities are contrived because we work in electronics and tend to think of most processes in electronic terms, but the correlation is quite marked. Young refers to "gating interfaces", "delay time", "inversion" and the blocking effect caused by the accumulation of too much data for a handicapped person to accept, sort and act upon.

Whatever the connexion, it is evident that even the most severely handicapped autistic has a latent capability and can be assisted to break the shell by a deeply understanding approach – one which recognises that communication is the basic problem and that removal of stress and help in carrying out even simple actions to achieve some kind of pride in performance are beneficial, particularly when previously considered to be impossible.

Electronics and other technologies can be of great and increasing help to workers in this field, since the similarities between the mind and electronic systems enable the patient to be included in a system, so that small irregularities in behaviour can be discovered in a reasonable time. Simple, continuous observation of behaviour is not of great value, since irregularities must be encouraged by conditions, and detection must be certain.

One of the most remarkable aspects of this research is the persistence shown in the face of disbelief, and the insight to recognise the 'concealed person' on the basis of extremely slight evidence – some of it offered diffidently for fear of ridicule. This is an important and humanitarian application of engineering skill and deserves ultimate success.

* Crisis control, R. E. Young, *WW* June, July, 1982

Better batteries

There can be few areas of more consequence to the future progress of portable communications, lightweight television production equipment and consumer-electronics equipment than the development of higher-density and/or more cost-effective batteries. Current progress is reported from the USA on the standard carbon-zinc cell, including the use of a zinc chloride electrolyte and oxidation-resistant coated-paper separator, (according to Ralph Brodd of Broddays Inc.) that is claimed, at low and medium drain over protracted periods, to provide performance comparable to the considerably more expensive alkaline cells. For low-power consumption over very short periods in microminiature applications, mercury-zinc and mercury-silver cells offer extremely high efficiency, but recent zinc-air button-cells are claimed to offer much higher power densities, of up to 15 watts per cubic inch. A disadvantage of the zinc-air button-cell is a life limited to about one month, due to continuous energy consumption once it has been put into use.

The rechargeable lead-acid cell appears to be gaining renewed interest for use in portable equipment as a result of the development of new forms of sealed, maintenance-free batteries, in addition to the older jelly-acid ("gel") cells: in some recent "flooded" designs the electrolyte is soaked in porous pads. With these starved acid-lead cells there is no emission of gases or acid, as oxygen released from the positive plate when the cell is overcharged reacts at the negative plate to reform water.

Layer batteries. In the 1930s there was a widespread belief that a long-lasting match had been invented, but that the match-box firms had brought up the patent and blocked production. I have no idea whether there was any foundation for this story, though it circulated widely. In "The Secret War of Charles Fraser-Smith" (Michael Joseph, 1981) a somewhat similar anecdote appears relating to improved dry batteries.

Charles Fraser-Smith, as an official in the wartime Ministry of Supply, was responsible for obtaining a wide variety of items for use by the intelligence, escape and special operations organizations. One of his tasks was to acquire miniature radio receivers that could be smuggled into the prisoner-of-war camps, so that morale could be raised by reception of news from Allied radio stations (though the news in the first few years could seldom have done much for morale!).

For this purpose he arranged for the production of some miniature receivers but encountered a "distinct lack of enthusiasm" when he approached the management of a large battery firm seeking more compact, longer-life batteries. He was told firmly that this was "not feasible". However when he later met the firm's chief engineer the immediate response was that this could certainly be done, with an improvement of about three-to-one on existing batteries. The book claims that when the management heard what had been promised one of them remarked "Don't let on to the Board of Trade. . . . If these ever get on to the regular market we'd lose a fortune . . . customers would need only one in place of three ordinary ones. And they cost about the same." What emerged was a battery of layer-type construction instead of the former round-cell h.t. batteries! These did reach the public post-war, but initially in the USA.

Polarization modulation?

In one of the now traditional "April Fool" articles in a recent amateur radio magazine, an elaborate spoof was based on a complex "polarization modulation" technique. However this reminded a reader, Eric Harman of the IBA, that back in 1968, Mark Epstein of the Radioscience Laboratory of Stanford University published a report of experiments in "communication by polarization modulation" (*Proc. IEEE*, June 1968, pp.1114-5) in which he suggested that channel capacity on h.f. could be doubled by the use of antennas that launch and receive waves whose polarizations correspond to the limiting polarizations of the magneto-ionic modes.

Experimental results over a 1900-km path from Lubbock, Texas to Stanford, California using signals switched alternately between left-hand and right-hand circular polarization showed a better than 15dB separation on one-hop signals. This suggested to Epstein the possibility of increasing channel capacity by modulating the transmitted wave polarization of existing on-off and f.s.k. telegraphy systems – two communications channels instead of one. That was 15 years ago but there seems to have been little follow up to this system – except as the basis of the April Fool article! Polarization diversity is an established h.f. technique, as is the use of mixed polarization to combat fading due to Faraday rotation – so why not polarization modulation?

III-V semiconductors

Further developments in 111-V semiconductor technology have been reported from the Central Research Laboratories of Thomson-CSF. Following work on indiumphosphide (InP) metal semiconductor field-effect-transistors (InP mesfets) for microwave power amplification, the laboratories have recently produced devices in which the gate is insulated by a silicon-oxide (SiO_2) layer. The InP misfet devices have achieved power outputs at 9GHz with 4dB gain of up to 1 watt, representing 3.5W/mm power per unit gate width, or roughly double that achieved with experimental gallium arsenide mesfet devices. The laboratory has also proposed a new form of GaAs enhancement-mode transistor with metal-insulated-metal gate. It is claimed that mim-gate fets would combine the advantages of both GaAs mesfet and GaAs misfet devices. Experimental devices have shown an enhancement current handing capability double that of more conventional mesfet devices.

Meteor aero-radio

Last April we noted the growing interest in the USA in meteor-trail communications for civilian as well as for secure military systems. The large number of meteors that enter the earth's atmosphere create short-lived ionized trails roughly 70 miles above earth. With computer-controlled high-speed burst transmissions it is possible to sustain teleprinter traffic at roughly normal speed, provided that the link is not required to provide instant access.

R. E. Martin of Guildford has pointed out that a good deal of work into extending the use of meteor-scatter systems has also been carried out in the UK, both for the NATO military systems and with a view to specialized civilian systems. Last year, at ICAP2, Dr H.P. Williams noted the potentiality of meteor-trail systems for medium-distance links over distances of up to about 2000km, using high frequencies when these are above the m.u.f. and therefore under-utilized. Dr Williams' paper (briefly noted on this page in July, 1982) pointed out that frequencies as low as 14 MHz or so can be used for these systems.

R. E. Martin points out that meteor-trail systems appear most attractive for providing, for example, economical r.t.t.y. networks for administrative purposes for power authorities, especially in developing countries. In such places there are often only inadequate PTT networks and distances of one or two-thousand kilometres are frequently involved. Provided that short delays are acceptable and speech communication is not required, the meteor systems have the cost advantage of not requiring any costly powered microwave repeater sites, can utilize low v.h.f. (or even above-the-m.u.f. h.f.) and do not encounter so many of the usual problems in obtaining frequencies.

R. E. Martin also draws attention to one of the curiosities of meteor communications – the greater number of meteors that enter the atmosphere in the morning than in the evening, due to the effect of the rotation of the Earth.

COMMENTARY

This point has also been noted in the investigations into meteor-scatter currently being made at the Royal Aircraft Establishment with a view to the use of meteor-trails for air-ground communication, as first suggested by A. J. Hannum *et al* (*IRE Trans. Com. Syst.* vol. 8, pp.113-133) in 1960. In a paper ("Meteor scatter communication in an air-ground environment") given at ICAP3, P.S. Cannon and G. Richardson of RAE note that the arrival rate is random with a 4:1 variation between the maximum in August (a "shower" period) and minimum in February. There is also a 4:1 variation between a maximum at around 0600 local time and a minimum at 1800 local time. Unlike amateur-radio use of meteor-scatter, which usually seeks to use only the longer-lasting "over-dense" trails created by the larger particles, commercial/military burst systems utilize the underdense trails which provide scattered signals that are "remarkably space and time-coherent", and are affected by the local time variations.

The RAE experiments have been based on an h.f. (27MHz) link between Kinloss, Scotland and Farnborough, Hampshire – a ground path length of 712km, with path losses of about 178dB, and a median "waiting time" of two seconds. The 27MHz frequency was chosen because of equipment available but future work is to concentrate on v.h.f. where less interference is likely. Cannon and Richardson conclude that the close correspondence between predicted and experimental results for a ground-to-ground link provides confidence in the prediction equations; they note however that the design of an airborne meteor-scatter system will be more difficult than, and different from, a ground-based system. Aircraft-to-ground communication is expected to be easier than ground-to-air; Faraday rotation of polarization is foreseen as a problem.

AMATEUR RADIO

Spiralling up

The cost to UK radio amateurs of "top-of-the-market" American and Japanese amateur-radio equipment has been rising at many times the official "inflation rate" due to the changes in the exchange rates, and the frequent up-dating of designs to include more and more "new technology".

Nowadays retailers and distributors, particularly in the USA, are increasingly coy about publishing prices, with list prices often heavily discounted. However a quick check shows that the top-grade Collins KW380 h.f. transceiver is now likely to cost a British purchaser almost £2200 compared with about £1600 a year ago – an increase of around 30 per cent. The comparative price in the USA (without vat) is around $2850. The Drake TR7A transceiver is about £1200 in the UK, under $1400 in the USA, whereas a year ago the earlier TR7 model, with power supply unit, could be bought new in the UK for under £1000. Japanese equipment prices have risen less steeply but are some 12-15% higher than at this time last year: the Yaesu FT-One, for example, has gone from just under £1300 to about £1450. There are signs that the present high cost of top-grade h.f. equipment is depressing demand despite the continued rise in the number of British licences. A more welcome change is the number of home-construction projects now appearing, although it is recognised that an h.f. transceiver design fully equivalent to the top factory models represents a major project beyond the capabilities of most home constructors. Although all-solid-state linear power amplifiers of up to about 1 kW rating are now possible using modules based on either bipolar or power mosfet devices, there still appears to be a cost differential of at least two-to-one on the higher power units in favour of valve amplifiers. The solid-state models base their appeal primarily on being wideband designs permitting band-changing without retuning. Also appearing are increasing numbers of aerial tuning or matching units with automatic tuning, but here again it is clear that operating convenience costs real money.

R.f radiation

Not all doubts surrounding possible behavioural ("non-thermal") effects of r.f. radiation have disappeared despite repeated efforts by the National Radiological Protection Board to stress that the only proven hazards of non-ionizing radiation are thermal, and that the safety limit of $10mW/cm^2$ is entirely adequate. The consultative document issued by NRPB in December 1982 proposes a reduced limit of $1mW/cm^2$ between 30 and 100MHz, where dipole resonances of the body reduce the safety factor. It even accepts that "an auditory effect occurs for some individuals when exposed to intense and sharp pulses of microwave radiation" but adds that "there appear to be no harmful effects resulting from this phenomenon".

At ICAP3 last April, however, Leonard S. Taylor of the department of electrical engineering and radiation oncology of the University of Maryland devoted part of his paper on "Therapeutic applications of electromagnetic radiation" to a balanced appraisal of conflicting views on whether long-term exposure to very low-level microwave radiation can be harmful. In doing so he presented a viewpoint significantly different from that of NRPB, although he accepts that "the significance of much of the experimental evidence is questionable". He notes the evidence of increased calcium ion efflux both in vitro and *in vivo* chick and cat brain tissues at levels down to $0.05mW/cm^2$ and considers this substantiates the influence of u.h.f. and microwave fields on the brain-cell microenvironment.

Here and there

Apart from the Syledis and Maxiran position-locating radio-naviagational systems, the 430 to 440 MHz amateur band (with its "secondary" status in the UK) appears to be coming under increasing pressure from other users, including the Ministry of Defence. MoD have established a radio-communications network ("Mould") connected with civil defence between 433.0 and 433.5MHz. There have also been unconfirmed rumours that the Belgian authorities have reduced their amateur allocation to 435 to 439MHz and closed all microwave bands to Belgian amateurs.

By the time these notes appear, the Oscar 10 satellite, the first of the Phase 3 series, launched last June, should be in its final high orbit. The apogee motors were due to be fired about July 14. An early problem with the solar array also needs to be overcome or Oscar 10 could have an operational life of only a few months. The c.w. beacon is on 145.81MHz.

In brief

The RRL membership has confirmed overwhelming opposition to code-free licences even on v.h.f. bands. . . . At the annual Dayton, Ohio convention two operators were able to read Morse at 68 words per minute, 4 word/min short of Ted McElroy's pre-war "world record" of 72 word/min. . . . A draft new constitution for the International Amateur Radio Union was drawn up at an Administrative Council meeting in Tokyo and is to be further considered at a second meeting later this year. . . . A "wireless museum" in Orkney features radio communications equipment of World War 2 as used by the Services in Orkney during that period. Research and restoration was carried out by James McDonald, GM88FG. . . . New Zealand amateurs have made a 545km contact on 3.4GHz between Cape Reinga (North Island) and Mount Egmont using one-watt output and 4 ft dish aerials . . . Since May 22, American phone allocations in the 14MHz have extended down to 14,150kHz with 14,150 to 14,175kHz reserved for "extra class' licences 14,175 to 14,225kHz reserved for "advanced" and "extra" licences. . . . The Scottish Amateur Radio Convention is to be held on August 27 at Cardonald College, Mosspark, Glasgow followed by a dinner/dance at the Bellahouston Hotel. . . . The Welsh Amateur Radio Convention is at Oakdale Community College, Blackwood on September 25.

PAT HAWKER, G3VA

Mental handicap and electronics

Stemming from enquiries into human behaviour during unexpected emergencies – reported in the author's previous Crisis Control article – R. E. Young writes of his investigations into the alleviation of the communication breakdown of hyberautism with the help of electronic systems, and proposes a new specialized mental handicap unit.

by R. E. Young
B.Sc. (Eng.), F.I.E.E., M.R.Ae.S.

What was little more than an abstract idea has been taken to a development-backed set of proposals for setting up an operational complex. A project that grew on an ever-increasing scale from its mental-handicap base to make contributions in other fields, both humanitarian and technological, and in its own right, progressed towards the establishment of a research-based care unit for the severely handicapped[1]. The aims of this unit are firstly to arrest the deterioration (regression) which is almost without exception taken to be inevitable with these 'most disadvantaged' people; and secondly to proceed to rehabilitation, with their development continuing *from within*.

In view of the picture of mental handicap presented by the media it would seem that to attempt to stop the retreat into the isolation of the blank-look shell of non-talker is just not 'on', still less 'on' is any effort to reverse the trend. Nevertheless, these things have been done, albeit on a limited basis. In the two-part article in *Wireless World*, where mental handicap was linked with the stress conditions of crisis control[2], a brief outline was given of some of the methods adopted to bring-out the handicapped and, in particular, to help them to communicate from within. This question of communication is vital, and, as shown on the flow chart (phase 3) the statement of mental handicap being in essence a communication problem constituted the beginning of a defined research programme on the disability.

This does not mean that the work of phases 1 and 2 was not research nor that it was relatively unimportant. In the event, the development of the main project has demonstrated how far-reaching this earlier work has proved to be. Primarily it brought out the fact that there were people in the UK and other countries, notably Australia, who – by virtue of their own thinking and observation – held the conviction that "something was there" with even the most severely handicapped. Two major points emerged during this period.

- These people were almost invariably widely separated from one another (i.e. were isolated), and in general were surrounded by quite understandable scepticism. Despite these and other adverse factors, they had persisted in their belief; and the importance of this cannot be over-emphasized, especially in relation to the almost insuperable difficulties of building-up any real observational data on mental handicap (see next section).
- Not only had this observational data to be gathered purely on a human basis, but it also had to be expressed in these human terms.

The full implications of this statement do not become clear until one looks at the circumstances surrounding these potential 'witnesses'. First, because of their isolation and the difficulty of putting words to phenomena which very often they had seen only fleetingly, 'data acquisition' could not be carried out by direct questioning. It had to be a matter of establishing contact in some way, a problem in itself, and then almost literally waiting for the information to 'come out'. The other, much more obstructive, aspect was the natural reticence to talk about something which was almost totally intangible and in addition was surrounded by incredulity. An associate of some years' standing – and responsible for the highly descriptive name of 'false handicap' – recently admitted that he had had moments of doubt – "have I got it wrong?" when thinking over some manifestation he had seen of the person behind the handicap.

Another major obstacle was the 'set-back' of regression which is so easily brought about without the cause being obvious; and which, unless countered, made positive observation impossible.

But this basic information *did* emerge from these early activities, and it says much for the 'quality' (and even more for those who produced it) that the resulting statements remain, in effect, as some of the guidelines in the proposals for the unit. Furthermore, the point was reached where, as indicated for phase 3, it appeared possible to attempt to make an attack on mental handicap from an entirely new base.

The position at the end of phase 1 was that considerable insight had been gained into this "most mysterious of all human complaints"; but that the evidence would remain intangible until, as a minimum, a "language" (technical vocabulary) had been evolved to enable some of the features of the disability to be identified and consequently described. In yet other words produced at the time: "If we had something to get hold of we could at least talk about it."

This was one of the first occasions on which it was possible to combine the 'thinking' from independent sources and to link this with the technological approach to the problem which had begun to take shape and which was eventually to form part of the 'human electronics' around which the remainder of this article is centred.

Human electronics

The term system modelling and hyper-autistic effects such as 'delay time', and distortion of speech by 'inversion', are representative of the technical vocabulary shown as being developed in phase 3; but the outstanding importance of them is that they had been predicted from the results of system modelling. In one sense this process came into being with the development of the concept of mental handicap being a communication engineering problem; and which, in common with others of these concepts, was introduced initally as a form of extended working hypothesis. But it soon became evident that the 'communication approach' was opening up other lines of attack which could be linked with the observations of phases 1 and 2; and, not only reinforced them but – most significantly – began to explain them. Thus it was in the context of electronically-based communication that 'clutter' – as a new concept – was developed.

Clutter, with the definitions it carried, provided an important bridge between electronic technologists and those who were looking for 'something to get hold of' in the intangibility of mental handicap. It was, however, the 'human electronics' contribution that was then built up which produced the full electronic approach and which has been recognized by non-technologists as virtually the only way in which the 'deceptive' nature of mental handicap could have been overcome, certainly within an acceptable time. Full tribute must be paid to the medical authorities

Human electronics – project flow chart for mental handicap
Taken up to the point of publication of the proposals for a new 'Research Care Unit' for the mentally handicapped

	Phase 1 Build-up of observational data	Phase 2 'Enlarging the view'	Phase 3 Establishing technological base (essentially electronic)	Phase 4 Statement of areas of research	Phase 5 Development and assessment of specialised techniques
Direct Project Action	Making contact with 'witnesses'	Bringing-in 'associates' outside the immediate field	Statement of main concepts, initially 'a communication problem'	Identification of electronic-type 'mechanisms' involved, including 'system modelling'	Construction of electronically-based equipment, and trials under 'research care' conditions
			Developing original 'technical' vocabulary and overall picture	Full coordination of this work and all observational results	Expansion of main concepts, production of integrating reports
Indirect Project Action	Analysis of 'Human' position	Feed-in of 'human' aspect into direct project	First—largely exploratory—publications in the press	Correlation with 'outside' areas e.g. deafness and geriatric care	Extension of correlation to other fields, particularly with 'crisis control'; and with maximum two-way 'spin-off' flow
					Second—selective publications in the press

who, despite all these difficulties, had set up the facilities which already existed in the UK. That the 'new thinking' has been made possible – and has taken place – is largely by virtue of the environment so soundly established by these authorities in the past.

The human electronics has been described, again by a non-technologist, as providing the equivalent of a ". . . microscope on mental handicap". System modelling is shown on the project flow chart (phase 4) as being concerned with the "identification of (electronic-type) mechanisms" involved in such effects as 'thinking fatigue' and 'delay in response'. Although system modelling does not appear on the chart until phase 4, investigation and analysis of this kind had been going on during the earlier phases. It was not until phase 4 that sufficient correlation of the information has been obtained for this process to be regarded as a 'firm' section of the work.

Examples of these early findings included the identification of (telegraph-type) 'start-stop' working and 'thinking fatigue'. The first-mentioned has been selected to show how a comparatively minor point was made to yield confirmatory and other information for application in the main programme. First, the underlying principle is simple: for communication, the transmission of a message entails the sending of a start alerting signal and of a corresponding stop signal for 'end of message'. It was found that a similar practice could be useful in certain circumstances when communicating verbally with the severely handicapped; and this information was fed in to, and coordinated with, the other data which was beginning to give a picture of some of the elements entering the hyper-autistic condition. Also it had been possible, even at the stage, to "separate-out" some of the factors involved in the hyper-autistic state; and, as such an identified factor, 'start-stop' brought clarification both in itself and in respect of other effects as exemplified by the various aspects of clutter.

It will be realized that the work heavily depended on observation, and – not so obviously – on the way in which the findings were translated into action with ('handling') the individual. Thus, continuing with start-stop as a representative example, it was vital that usage of it should not be imposed on the person, but should be introduced only when it corresponded with something 'coming from within'.

A large number of interlocking issues are involved here; and some of these are examined later in the context of a specialised unit and in relation to its staffing. This treatment is preceded by descriptions of some of the new methods and techniques which have been used in the various phases of the project, and which form much of the basis for the Proposals for the unit.

To complete this brief review, it is relevant to show how the role of the observer, while remaining central to the whole project, changed in character as electronics moved more and more into what had become an entirely unique form of systems engineering.

Initially, observation had to be accepted as being 'passive' in that near-infinite periods could elapse between any manifestations of the person behind the handicap. Indeed the only way to overcome the randomness of these occurrences was to provide "utterly *continuous* observation" (ref. 1); and in other than exceptional cases only parents were in a position to approach this. The whole attitude to mental handicap was such that any suggestion by them of the existence of concealed capability was almost certain to have been dismissed, bearing in mind the evidence available and (always present) the dangers of raising false hopes.

The first step was therefore to set up conditions for the controlled observation which favoured occurrence and also made detection much more likely. The last-mentioned point was made a matter of giving some indication of where and when to look for these occurrences, and which was made possible by elementary system modelling, itself founded on the correlated (observational) information which by then was available.

Thus in phase 4, it had been established that interconnected gating type systems – 'gating interfaces' – appeared to be involved in the thinking process in such a way that the physical condition of mental handicap reduced the transfer efficiency between interface levels and also, in effect, reduced the isolation between channels required for 'multi-channel' thinking[2]. When correlated with direct observation in this and other fields such as crisis control emergencies, there were two far-reading conclusions.

● That 'inversion' of speech could take place largely as the result of 'imperfect read-out'. Inversion as used here covers a variety of distortion effects, including stuttering. In one relatively common form, syllables in a single word are transposed, sometimes with a loss of one or more, e.g. "poose" may be "spoon". As in all work on inversion, these transpositions are difficult to detect, particularly with loss of part of the original word (they are not, in general, classical spoonerisms); but even more difficult to pick out is the composite word made up of the end of one word and the beginning of the next. A specific example which combined the features of both cases was afforded by "byer" which was traced to "fire burn". Of course, distortion may be so great that only what appears to be a noise or succession of noises is produced. Here again, as shown later (see full system modelling) detection may be achieved, especially if a benign atmosphere can be set up to encourage attempts at communication.[3]

● The other major aspect – 'data marshalling' – which arises here has effects such as 'delay in response' and 'thinking fatigue' associated with it, and from the point of view of the outside world is seen as a condition ranging from a severe lack of confidence to the shell of the total non-talker. This aspect is therefore linked with the stress condition under which the mentally handicapped can live for long periods; and which can be explained in relation to system modelling, largely in terms of data marshalling.

Data marshalling (refs 2 and 4) may be defined in the present context as the "streaming" and "sorting" of "masses of data". A full definition also includes the systematic presentation of the data, and it is in this final transfer *outward* that the handicapped often find the most difficulty.

Only just recently this last problem was demonstrated most dramatically by a young man who is easily driven into the non-talking state. On this occasion he selected a gramophone record which, from the sleeve, he knew to be of a piano; but instead of saying the word as usual he mouthed it – there is no ambiguity when lip-reading "piano". Although he could be sensed to be making an intense effort to achieve the transfer to voice production the pressures were such that he found it impossible.

Apart from its importance in providing direct evidence of something that cannot be detected in most circumstances – the failure to transfer – this incident carries a number of other important implications. Outstanding is the single aspect of delay-time which it covers (the "microscope" mentioned earlier). This specific element is part of the general build-up of delay which seems to be associated with the checking process of streaming and sorting which enter into data marshalling in the hyper-autistic condition. The evidence is sufficiently widespread to justify the statement that every new step – even for an action – has to be checked and re-checked before the individual feels that he can carry it out, unless some assurance which is acceptable has been given beforehand. However, the main reason for quoting this incident is that it gives an example of the "control" which is a feature of full system modelling. The chances of picking up an isolated event of this character are infinitesimal without some control of the attendant circumstances. To set up such controlled circumstances demands prediction by "primary" system modelling; and in this case the use of the gramophone provided a form of control (see later for an account of this approach) while experience combined with knowledge of the individual gave a likely time for observation. It is the inability to obtain repetition of such incidents which has made it so difficult to maintain continuous lines of research. This difficulty has been fully recognised as one of the problems facing the specialised unit[1] and in effect forms one of the "design criteria" for it.

Similar lines of argument had to be followed to derive the remainder of these design criteria or the equivalent; and that the course of their development was linked with:

- the corresponding phases of the project itself and
- the progress of the trials which have been carried out with electronically-based techniques and equipment and which have underlain, and have been correlated with, the project as outlined in the foregoing description.

It is hoped that this has given at least an indication of the difficulties facing anyone entering this field and having to assimilate all the new concepts which have been introduced. Again briefly, it does seem that the only real solution is through on-the-job study and experience (see ref. 2 for link with training for emergency control) so that overall perspective and atmosphere can be gained. This general requirement has been covered in the proposals for the specialised unit in that allowance is made for high-calibre learners to work alongside the permanent research-care staff. These learners would thus be favourably placed for ". . . coming to grips with so many new concepts" and " . . . in building up their own know-how" (ref. 1). It is envisaged that they would spend at least a year in the nominal learning role, and then as part of the general policy for the unit would undertake the passing-on of their know-how and relevant experience to others.

How these possibilities would be realized in the unit is perhaps best shown by giving some account of the techniques and equipment which have already been developed. This account is concluded with a description of an advanced language laboratory which would provide facilities – already tried out in principle – to enable individual aspects of hyper-autism to be investigated in the controlled circumstances of total system modelling.

It cannot be stressed too highly that, although the laboratory would provide unique facilities for research into various aspects of mental handicap which have already been "separated out", the basic objective would remain to develop ever-improving care for the handicapped. And in so doing to remove the worry and the other pressures from them, which is utterly obligatory if this work is to be at all successful – quite apart from the humanitarian issues which arise. It has been suggested that the present methods could be expanded and could feed this "source" information into a health authority organization "concerned with all vulnerable members of the community[1]"

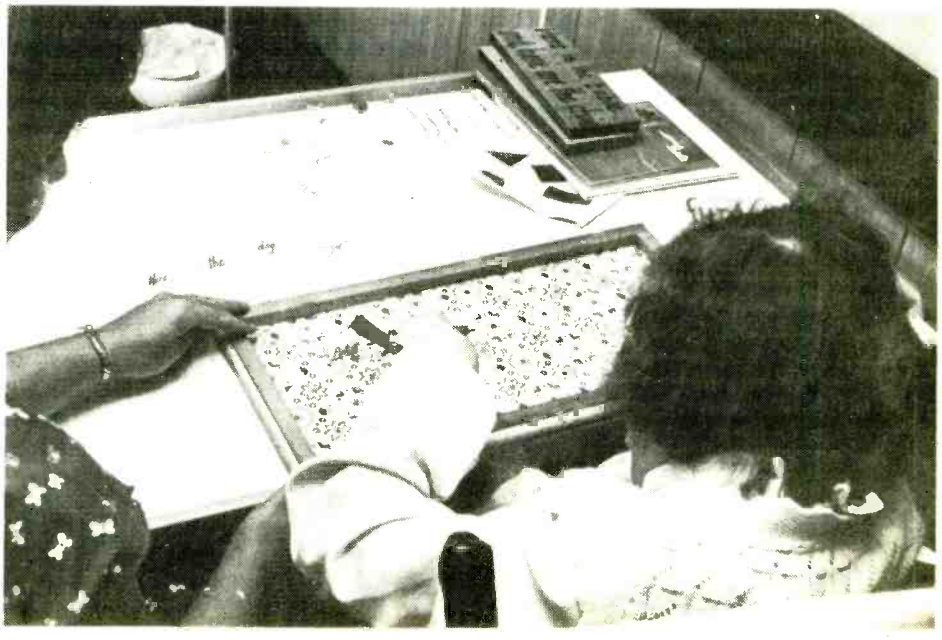
Magnetic board

The first piece of equipment specially designed to provide research-based care ("research-care") facilities for a young woman who suffered from a mental handicap and multiple physical handicap was the magnetic board. Full tribute must be paid to the staff who worked with Christina. They had established a rapport despite her inability to do more than make a small range of noises, while communication through the hands was near-impossible because of severe malformation of her wrists.

Nevertheless, it did seem that the last-mentioned avenue of communication might be investigated, and that this might even yield some spin-off; and full acknowledgement must be made to the head of the unit in that this spin-off was of a major character especially in terms of some basic principles that have been brought into the design of the advanced language lab.

The so-called magnetic board consisted of a square of sheet iron faced with 0.2mm-thick plastics over which converted magnetic door-latch pieces could be moved by

Christina at work with the magnetic board – tutorial techniques being established in parallel.



a magnetic stick. The first decision taken – to have "words" rather than individual letters as the movable pieces – though simple, was of major importance in other applications. Thus in practice, the speed of selection was found to be matched to Christina's concealed capability and – as confirmed by other examples – the alternative of letter-by-letter build-up was tedious and time-consuming. This is of interest in those control systems employing speech synthesis[4] and, as will be seen, in the human electronics of the advanced language lab.

In the same way, the results of the attack on the problem of the physical handicap – to enable the pieces to be moved by Christina – were of wider interest because severe mental handicap is frequently accompanied by some form of physical disability and, as with Christina, this calls for courage and determination of the highest order. (The mentally handicapped have been described as "the most courageous people on earth".)

Similar considerations also applied to the development of the "ruggedized gramophone" (see below), where one of the aims was to enable those with an appreciable degree of physical handicap to do something, hitherto accepted as quite impossible, *themselves*. Furthermore, as has been shown to be crucial for progress and to help offset the effects of their difficult circumstances, they are working with a mature objective.[1]

As a practical example of the attention needed for the apparently simple component design required in these instances, with their human implications, it may be useful to consider the "magnetic stick" as finally adopted. As the result of a series of trials – which helped Christina to supplement her own efforts to improve her command of the stick – its dimensions, found to be quite critical, were 25cm long and a diameter of 8mm. The actual configuration was tee-shaped with a croupier-type end tipped with a small permanent magnet. The magnet was selected, in conjunction with the rake end, to provide the push/pull action required to move the words against the magnetic "sticktion" of the board.

Ruggedized gramophone

In its do-it-yourself role, the ruggedized gramophone is noteworthy for the large amount of spin-off that was gained from it. Developed specially for this application, the basic design aim was to provide a unit which could be operated by the most severely handicapped individual; and, as implied by its original title, would stand up to any form of clumsy handling that could be envisaged. Provision was made to restrict access to the turntable and pick-up when a record was being played. Thus the mechanical design of the box was extremely robust with power interlocks on the lid which had to be shut before playing. On the operational side, "start" was by a plunger-type control external to the box; while an alternative cone-shaped spindle provided easy juke-box centring for compatible records where physical handicap made this difficult.

When this unit was brought into service a definite break-out from the shell was produced with *every member* of the group concerned, and that this could be repeated. This meant that concealed capability could be demonstrated effectively "to order" for the first time. This depended upon the maintenance of stable conditions i.e. by preventing disturbance, particularly by avoiding intrusion by strange visitors.[2]

That this point had been reached was of particular significance in terms of intensifying research, because it proved that it was possible to set up the equivalent of the controlled conditions which were being evolved even then, on the basis of rather more indirect evidence; and not to have to depend entirely on random – passive – observation for firm vital data.

On the human (care) side a summary of the position is perhaps best achieved by quoting from statements made by the staff at the time:

> "It (the gramophone) has given them great satisfaction being able to do something completely by themselves" and
> " . . . expressions change and the mentally handicapped start to communicate more freely than they have ever done before".

The statement that " . . . people there was little hope for, who remained silent throughout long periods . . . progress from gestures to more comprehensive sounds and words . . . and more awareness of what is going on around them" is given as being representative of the evidence that has been collected from many witnesses. However in this instance there are two vital differences: firstly that the evidence is for *all* of a group and secondly that it has been obtained in a controlled, non-random fashion.

The last statement quoted also includes a reference to ". . . clearer voices . . ." (when progress is being made with communication). These may be regarded as being early manifestations of "second voice" (and "super-second voice" effects which are covered elswhere.[3] By their very nature they are difficult to detect, but work continues on this aspect of "the person underneath".

On the technical side, the bringing into operation of the gramophone may be said to have marked the beginning of system modelling proper. The composite system – planned to produce certain research answers – consisted of the individual with a "thinking mechanism" sub-system, the sound-track "data content" of the record and the instructions (roughly software) given to the student.

With regard to this last aspect, one element in the control programme was that the student selected "his" record by looking for his photograph on the sleeve which also carried his name (for possible "subliminal" recognition); and, for instance, information could be obtained on delay time which was "tied" to a specific parameter and set of circumstances.

Continuing with this example, the next step now could be to look into gating interface blockages, for example, when sufficient linking information had become available. Thus, analysis of delay times in telephone communication with, say, variation in side-tone content could be made – assuming isolation had been achieved from such effects as "back-comparison" time.

The crystal transducer and amplifier unit were used with a small hand-held loudspeaker unit for the original speech reinforcement development. In the proposed advanced language lab application, the speech output would be fed into the laboratory loudspeaker system (page 00); and it is of interest that a similar arrangement might be adopted for the main operating space for "two-tier" full emergency control.[2]

The unit gave remarkably good quality, and as far as the main problem of acoustic feedback was concerned, this could be kept below the howl-back threshold for all but the maximum loudspeaker volume. The initial speech reinforcement requirement was set at a minimum of increasing the intelligibility-content of sounds produced by the less-heavily mentally handicapped who were prevented physically from making almost any form of utterance. (Precedents with the non-mentally handicapped have been seen.) Accompanying this initial requirement was the hope that the work would encourage attempts to produce sounds which were more speech-like; and in the trials that were possible this did indeed take place.

With regard to improvement of speech sound production a basis was established the work planned in this area for the a.l. lab. Taking advantage of the early magnetic board findings, it appeared possible to "fill-in" words such as those produced as little more than exclamations by a word on the board and vice versa.

This has been taken further in planning to include in the a.l. lab. a 'talking typewriter' for 'filling-in' by the handicapped person with words instead of individual letters on the keys – following the principle accepted for the magnetic board. This does mean that only a very restricted vocabulary is available; but in many cases this is desirable, especially in cases where system modelling is being carried out and where mental search time has to be kept to a minimum.

The lightly handicapped occupy a special place in the proposals in that it is suggested that they should be made part of the unit's back-up staff, acting as contact helpers. Information has been collected from a variety of sources on their ability to interpret the distorted (e.g. inverted) speech of those at a lower level of attainment; and in undertaking this work they would derive enormous benefit for themselves from doing something that is adult, carries recognizable responsibility, and – perhaps for the first time – shows them that they can be successful at doing this mature work. Experience can be quoted than the resultant enthusiasm is then transmitted to the others; and this access of confidence – as opposed to a dread of 'getting it wrong' – can be seen in their ability to act as team-leaders to the more handicapped. They are, in fact, achieving the equivalent of rehabilitation in bringing themselves and their team out of the hyper-autistic shell.

Such a successful arrangement should not be disturbed; continuity and hence stability are vital even for those at the higher levels of attainment if they are to retain this position. Also, they still require highly sensitive guidance and particularly, encouragement, as with all the handicapped.

Language laboratory tutorial scheme

As envisaged the first application of the tutorial system would be to the talking typewriter scheme. It is assumed that the move to this scheme would be preceded by a build-up of contact experience where interpretation would become increasingly tripartite in character, i.e. students, helpers and main care staff would develop more and more mutual understanding, and as time went on more and more interdependent.

Such an arrangement could be made more formal with, say, the d.i.y. gramophone operating with a definite team programme. To prepare for the final scheme, individual members of the team might be introduced to basic language lab. conditions with the use of the telephone under controlled conditions[2]. Thus, providing the telephone is accepted, the student can be expected to gain in confidence and in facility of verbal communication.

This question of acceptance of the unfamiliar (with the anxiety it may cause) is perhaps where the helper can make his greatest contribution. Association of ideas effects[1] are often enough to prevent such acceptance in these circumstances; but the trust placed in the helper may enable him to smooth the way to compliance. It should be added that non-compliance usually takes the form of entrance into the isolation of the shell for an indefinite period (and which should not be confused with sulking).

With this background, it becomes more than evident that human considerations must always be given absolute priority in the design of these systems and in planning their operation. Thus human electronics takes on its full meaning; with failure even to avoid, say, an unsuitable shape of a control liable to vitiate the whole scheme.

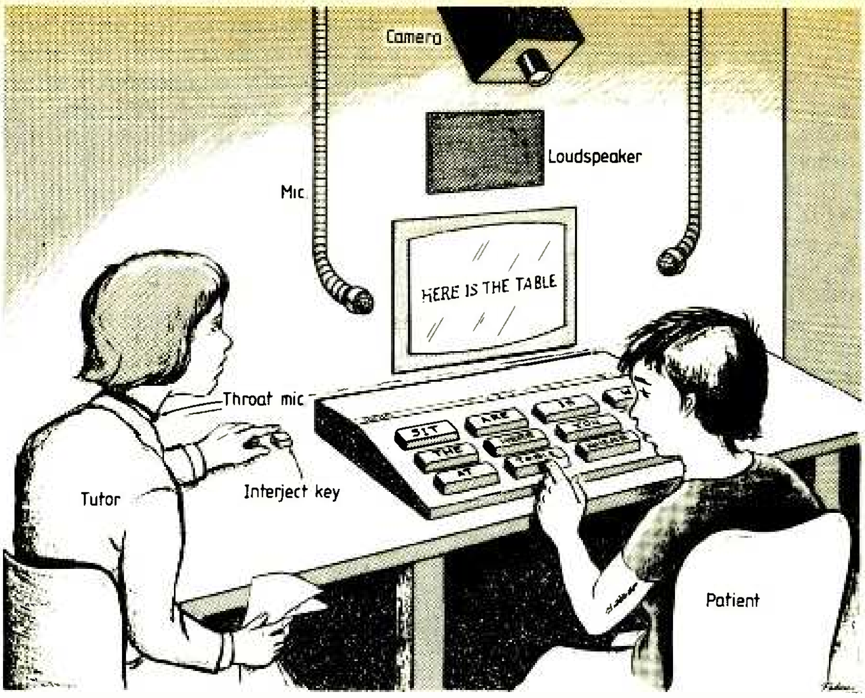
Something of the way in which these principles are applied may be seen with the talking typewriter development. This scheme is centred round a word-keyboard speech synthesizer with software arranged to display the words being keyed-in. In the word mode, the words would be spoken as they were keyed-in. In the phrase mode, they would still be displayed word-by-word, but not put out as speech until a speak button was pressed for the group of words to be transmitted out from store.

Insert mode would have two sub-modes. In the first, this button would bring in a throat microphone worn by a tutor to give an insert (interject) facility for 'filling-in'. In the second sub-mode, this interject facility would be made available to both tutor and student so that the tutor could back up any attempts made by the student to produce coherent speech by mixing his own sounds into the controlled, synthesized speech. In general this would only be used by lightly handicapped students (they will accept the throat microphone) particularly by those who were potential tutors; but as the result of experience it might be possible to evolve a simplified version of this system for the more handicapped.

The aim throughout is to develop 'subliminal' methods for learning to read, combined with improvement of speech. Not long ago it would have seemed astonishing that systems of this kind were being suggested for the mentally handicapped. Now, as has been shown, more than sufficient evidence exists to justify further extension of these advanced methods; and in the last system to be described, the extension is taken into 'visual mathematics'. This concept has been evolved in the context of mental handicap, and not least in the light of an interest in numbers that has been detected.

The ideas entering into this concept come from several areas, and started with an aerospace calibrated display system[5]. This continued with the suggestion that this system – essentially for multi-channel 'histogram' working – would be made in single-channel form to meet a specific requirement in crisis control. A further development for operation under 'survival' control conditions[6] appeared to offer possibilities in the evolution of visual mathematics; and in view of the interest being shown in this area, the principle was applied to the tutorial side. As in other instances of this kind, spin-off flow built up in both directions.

In its original form the calibrated display enabled the time-division multiplexed output from several transducers – appearing as a histogram – to be shown simultaneously with an adjustable calibration line on a c.r.t. display. Histogram and calibration line were shown on alternate strokes of the time base, and thus measurements in terms of calibration frequency were made on common equipment. The calibration – and therefore the accuracy of measurement – were thus independent of changes in the chain because the calibration and histogram signal were fed into it at the same point.



'Tutorial' position in advanced language laboratory as envisaged for the talking typewriter. Tutor operating with throat microphone and 'interject' button. Demonstration/teaching c.c.tv camera and microphones overhead.

This same basic principle is used in the crisis control application. Here the raw data output from a single 'frequency' transducer is measured by moving the calibration line to coincide with the top of the pulse representing the transducer output value. In the illustration, the pulse is shown as repeated in order to read more easily through 'locked' interference; while the sine wave shown below the calibration line is a direct representation of the transducer output.

This last feature has been added for visual mathematics where the idea of number might be associated initially with this picture of a variable-frequency tone reproduced on a loudspeaker. This would be related to the numerical value shown on the calibration adjustment control at a suitable point as judged by the tutor, with this followed appropriately by interchange of setting and reading between him and the student. It is envisaged that this facility might be extended to more computer-like displays; but this would only be after a protracted exploratory period. And the outcome of this work might only reveal a logical aptitude; but this alone would be worthwhile, as in a comparable case when one discovers that a non-communicator is making himself understood with words which it was not known that he had mastered.

Project summary

The position now reached with this project as shown in the five phases of the flow chart can be stated in terms of 'research-care' and the developments which have stemmed from the establishment of a technological (essentially electronic) base – phase 3.

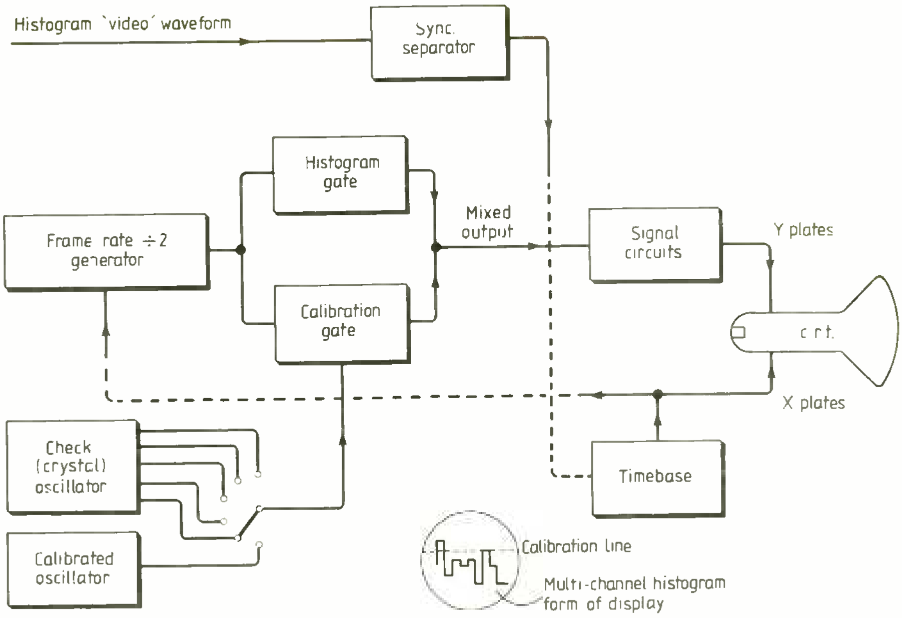
The growth in the wider aspects of research-based care has been maintained throughout the project; the most important element in it continuing to be information (observational data) obtained from witnesses at all levels, and giving direct insight into the concealed capability of the mentally handicapped. The work of interpretation of these reports and their correlation has been strengthened with the development of the required technical vocabulary; and has been increasingly interlocked with the results of trials which it has been possible to carry out, particularly during the latter part of the programme.

It has become increasingly clear with the progress of the project that over-riding priority must always be given to the human considerations. Thus, although the accepted research-care is an abbreviation of research-based care, and although research is fundamental to the whole concept of the unit, it must be made subordinate to care at all times. This principle has already been stated with regard to the design of electronic equipment for use by the handicapped themselves, where disregard of their special requirements is quite likely to result in non-acceptance and consequent entry into the shell.

Therefore, broadening this principle not only to include system design but also to include the planning of any research it becomes clear that a close watch must always be kept for any signs of the development of set-back, not least for the serious economic penalty that can be incurred with the inordinate amount of time and effort that may have to be expended to restore the position.

Precautions can be taken to reduce the chances of set-back conditions being set up; and one part of this approach is to make sure that a step forward in a programme is not taken until the current step has been understood and accepted. This is vital, particularly where research is being carried out by indirect methods designed to pick up answers to questions arising from, say, system modelling, and where it is difficult to separate-out the factors.

Some of this has already been outlined in the earlier sections on tutorial techniques; and can be seen in more detail by taking the case of the young man who failed to make the final transfer to audible speech. The question of "Could failure to transfer always be traced to the last interface (or at others?" could be tackled by an indirect approach using suitable facilities available in the advanced language lab. These might well include observation of delay time with the 'talking typewriter' and the telephone with its side-tone effects; and would involve finding how representative these students were, in order to avoid causing distress to individuals not immediately capable of using these pieces of equipment.

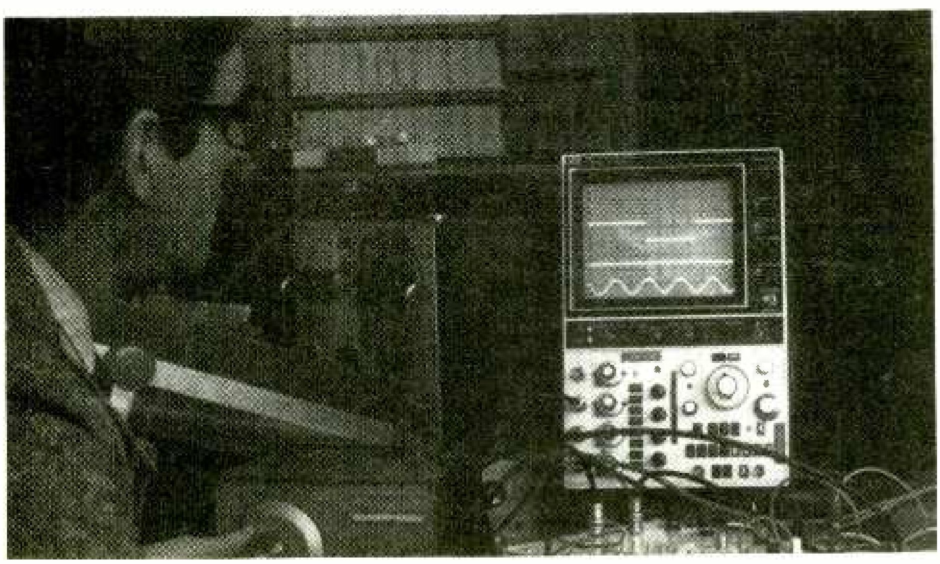


Original calibrated display for multi-channel working.

Such a research investigation would be complex, but could be kept under control; and could give valuable information in a number of fields such as ordinary autism and geriatric ability to speak, and, of course, for getting a better picture of this aspect of mental handicap communication.

Acknowledgements. Special acknowledgement must be made of the part in this project played by Dr Gordon Avery, District Medical Officer of the South Warwickshire Health Authority, particularly with regard to the publication of proposals for a specialised unit, which is approved and backed by him. A personal acknowledgement is made to Professor Harold C. A. Hankins of the University of Manchester Institute of Science and Technology for his major contribution to this work both with continuous practical interest and with full-ranging discussion throughout. Finally, full recognition must be given to Peter Watts and the UMIST Medical Engineering Unit for the originality shown in the design and development of the ruggedized gramophone and throat microphone, and for the research done on the microphone. WW

Laboratory equipment arranged for 'visual mathematics' display. In tutorial use, auxiliary traces would be shown on separate displays. Photo by Manchester Polytechnic.



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RTTY on a Nascom

Now that home microcomputers are replacing the old-style electromechanical teleprinters, interest in transmitting teleprinter messages by amateur radio (RTTY) is on the increase. Ian Wade describes how a Z80-based Nascom microcomputer can be used for RTTY, and includes full details of the special hardware and software required. Most of the techniques apply to any micro-based system.

Despite the fact that the Z80-based Nascom microcomputer was first introduced several years ago, many of these excellent machines are still in use today in amateur radio stations. About two years ago I decided to build a rtty system around a Nascom, and this article describes how it was done. The package started life as a small collection of rudimentary subroutines performing little more than conversion between the ascii and Baudot character codes, but as operational experience increased, more and more software and hardware facilities were progressively added until the system eventually assumed its present form. The panel opposite lists the features now incorporated in the system.

The first part of this article summarizes the basic operation of the system, and then covers suggested hardware modifications to make the Nascom function as a rtty terminal. Each of the modifications is accompanied by a short test program, so that the changes can be checked out individually before running the rtty program proper. The second part describes the software in detail, and includes a machine code listing of the rtty program. Whilst some of the material is naturally specific to the Nascom, most of the techniques described are equally applicable to any micro-based rtty system, and may be adapted for use on other machines.

by Ian Wade
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RTTY system

Starting at the top left-hand corner of the simplified block diagram, Fig. 1, the two-tone audio output from the receiver is passed through the terminal unit, in this case a home-made version of the well-known ST5 design[1]. The output from the terminal unit is a stream of ±5 volt pulses, −5V corresponding to a mark (1445Hz) and +5V corresponding to a space tone (1275Hz). These serial pulses, representing Baudot characters, are then input to the uart in the Nascom. The rtty software now takes over, converting the Baudot characters into their ascii equivalents, and saving them in the ascii text buffer. From there they are sent to the tv screen, and optionally, to a printer connected to the parallel interface (p.i.o). In the reverse direction, characters to be transmitted are typed in at the keyboard and saved in the ascii text buffer. These characters are displayed on the screen and again optionally printed, before being converted to Baudot for transmission, via the uart, to the two-tone generator[1]. The audio output from the generator is connected to the microphone input of the transmitter, which operates in vox mode.

The author

Along with other holders of G3N callsigns, Ian Wade is fast approaching his first quarter century as a licensed amateur, and has dabbled in most aspects of this fascinating hobby at one time or another. His particular interest is in data communication, satellites and very low power operation, but other obsessions include photography, music (from Bach to Heavy Metal, but drawing the line at Harpsichords) and linguistics. Professionally, he is managing director of the software house Dowermain Ltd, specializing in industrial, process control and telecommunication systems.

The single-bit drive output from the Nascom (normally used to control a cassette tape recorder motor when saving programs on tape) is used in the rtty system to switch the two-tone generator on and off. When DRIVE is asserted low, the generator operates normally, sending mark and space tones to the transmitter. When DRIVE is asserted high, however, no tones are generated at all. Thus the drive output controls transmit/receive changeover, and when used in conjunction with vox there is no need to make any direct control connection to the transceiver. In

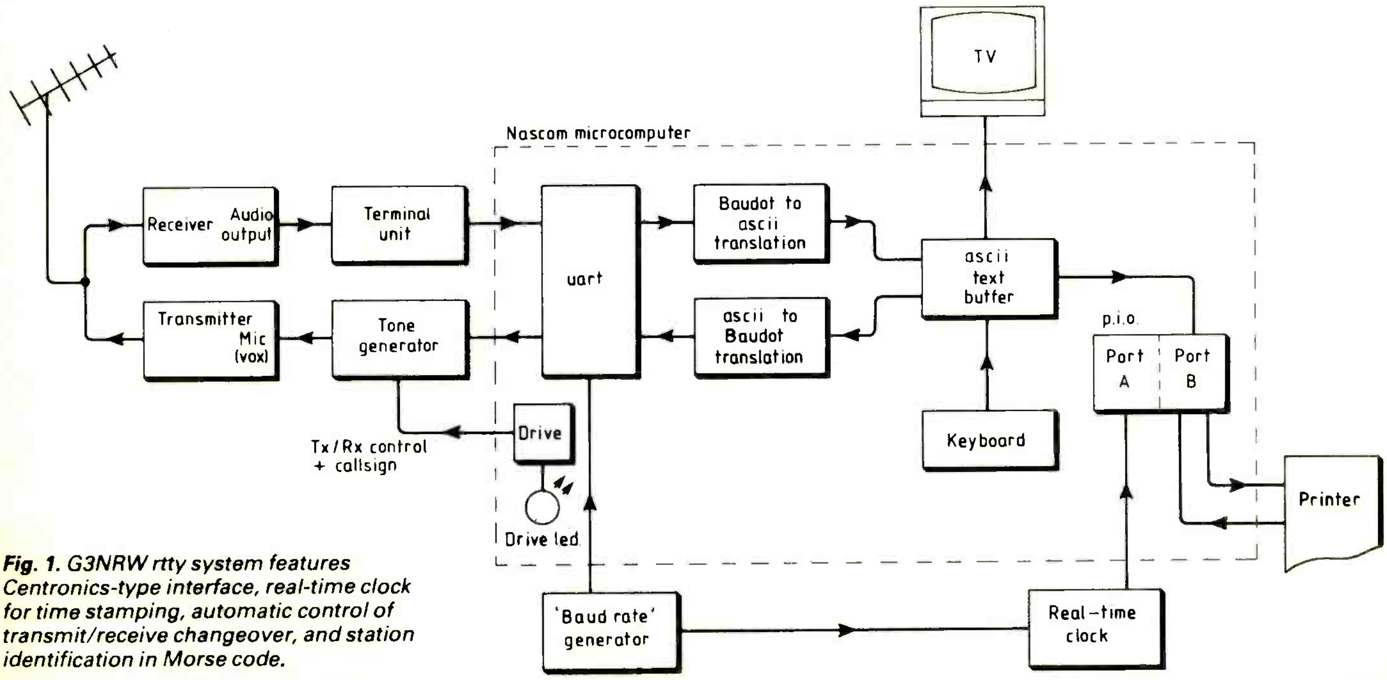


Fig. 1. G3NRW rtty system features Centronics-type interface, real-time clock for time stamping, automatic control of transmit/receive changeover, and station identification in Morse code.

FEATURES OF THE G3NRW NASCOM RTTY SYSTEM

The rtty program runs on a basic Nascom 1 or 2 microcomputer, under the standard Nas-Sys Monitor, and occupies just 896 bytes of user ram (in the address range 0C80 to 0FFF).

Only minor hardware changes are required to the Nascom hardware, to make the uart handle five-bit characters at 45.45baud. An alternative uart clock generator covering all the standard rates is also described.

Supports an external real-time clock, operating under interrupt, allowing the current time to be displayed on the tv screen and to be included in messages.

Supports a Centronics-compatible printer via the parallel i/o (p.i.o.) interface, also operating under interrupt, to provide hard copy of all transmitted and received messages.

Uses the drive output from the Nascom to control transmit/receive changeover, and to transmit the station callsign in Morse code for identification.

When transmitting, provides:
- keyboard buffering, allowing type-ahead
- automatic carriage return/line feed insertion, to prevent overprinting at the end of a line
- automatic insertion of shift character after a space
- automatic transmission of a pre-defined message (e.g. a CQ call)

When receiving, provides:
- automatic carriage return/line feed insertion
- facility to insert a Letter Shift or Figure Shift character into incoming text, to correct characters being received in the wrong shift
- automatic testing of uart status, with rejection of invalid characters (i.e. characters having overrun or framing errors)
- facility to set up a message for later transmission

Received message text is displayed on the tv screen in lower case letters, and transmitted text in upper case, to allow easy distinction between incoming and outgoing messages.

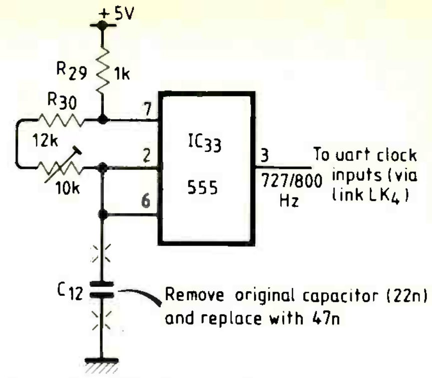


Fig. 2. Modification to 555 clock generator to run the uart at 44.45/50baud. Component numbers refer to those in the Nascom 1 manual.

addition, the system has a command which causes the drive output to be keyed with the station's callsign in Morse code, for identification.

The optional real-time clock interrupts the processor at regular intervals, and forms the basis of a time-of-day clock which is displayed on the screen and which can also be transmitted as part of a message if desired.

The computer in my system is a basic Nascom 1, with 896 bytes of user memory, and running under the standard Nas-Sys Monitor program. All of the options listed above work in this system, but any of them can be omitted if the corresponding hardware is not available.

Hardware modifications

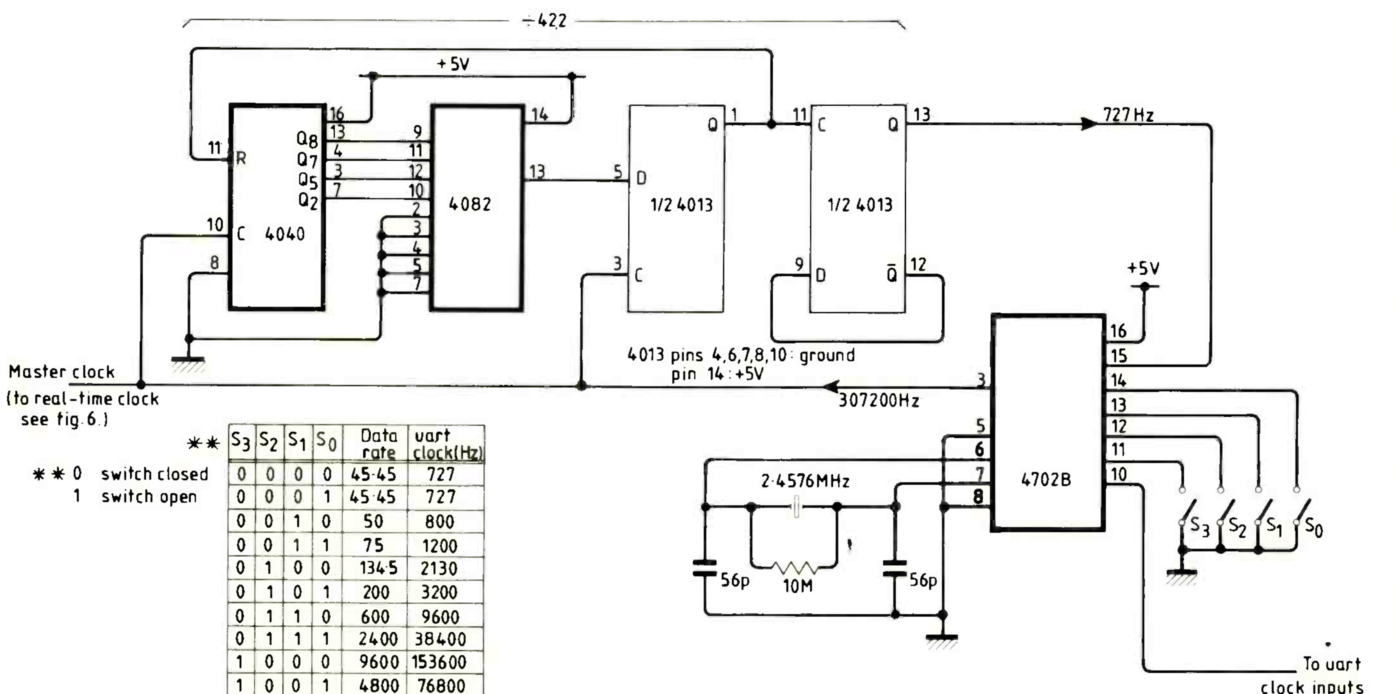
The essential modifications to the Nascom are
- to provide a uart clock running at 727Hz for 45.45baud operation (or 800Hz for 50baud), and
- to set up the uart control inputs for 5 bits per character and 1½ stop bits.

The remaining modifications (i.e. for the printer, real-time clock and drive control) are optional, but once fitted can be used in a wide range of other applications apart from rtty. The modifications are described in detail below, and are suitable for both the Nascom 1 and 2 computers. The test programs to check out the changes are keyed in from the keyboard, using the Nas-Sys modify memory (M) command, and they all start at address 0C80; i.e. execution is started with the command EC80. All references to memory addresses and their contents, here and elsewhere in the article, are in hexadecimal.

UART clock

Two methods of providing a uart clock are described. The first involves a minor modification to the existing 555 clock generator (which normally runs at 1760Hz for 110baud operation), and the second is an external clock which produces all of the standard clock rates from 45.45 to 9600baud.

To make the 555 clock run at 727 or 800Hz, it is only necessary to replace the existing 22nF timing capacitor (C_{12} in Fig. 2) with a 47nF capacitor. This should be a



** 0 switch closed
1 switch open

S_3	S_2	S_1	S_0	Data rate	uart clock (Hz)
0	0	0	0	45·45	727
0	0	0	1	45·45	727
0	0	1	0	50	800
0	0	1	1	75	1200
0	1	0	0	134·5	2130
0	1	0	1	200	3200
0	1	1	0	600	9600
0	1	1	1	2400	38400
1	0	0	0	9600	153600
1	0	0	1	4800	76800
1	0	1	0	1800	28800
1	0	1	1	1200	19200
1	1	0	0	2400	38400
1	1	0	1	300	4800
1	1	1	0	150	2400
1	1	1	1	110	1742

Fig. 3. External uart clock generator is based on c-mos 4702B 'baud rate' generator, whose output frequency is selected by switches S_0 to S_3 – see table.

polycarbonate film type or similar to reduce thermal drift. It is then a matter of adjusting the preset, ideally using a frequency counter, until the desired frequency is achieved. This modification was used successfully for several months, but does of course have the minor disadvantage that it is not then possible to revert to 110baud operation without having some means of switching the timing capacitor back to its original value.

To overcome this disadvantage, an external uart clock generator was developed (Fig. 3). This is based on the cmos 4702B 'baud rate' generator chip, whose output frequency can be selected by means of the four s.p.s.t. switches S0 to S3, according to the table shown in the diagram. The basic 4702B chip provides all of the standard clock rates for operation from 50 to 9600baud, and the three additional cmos chips produce the clock for 45.45baud by dividing the master clock frequency (307200Hz) by a factor of 422. The four clock select switches do not require pull-up resistors. Pin 4 of the 4702B chip is normally left unused, but if it is grounded the clock output on pin 10 is disabled.

The unit can be built on a small piece of stripboard and requires no setting up. After construction, the output frequency should be checked with a frequency counter for each of the 16 possible combinations of the clock select switches, and should be within a few Hz of the values given in the table. The 'unusual' frequencies for 110 and 134.5baud arise from limitations in the design of the chip, but are still well within acceptable limits for the uart.

UART control

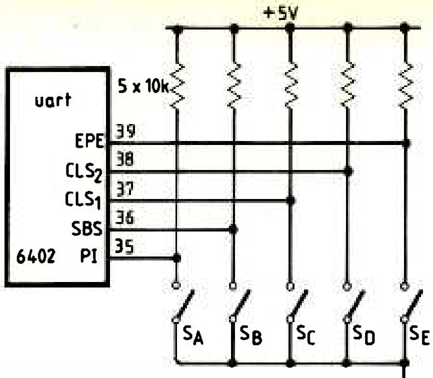
The uart control inputs (pins 35 to 39) need to be set up for five-bit character operation. This requires these pins to be connected as follows (corresponding to 5 data bits, 1½ stop bits, no parity):

Pin 35: high
36: high
37: low
38: low
39: high or low (does not matter).

To achieve this, it is required first to remove the existing connections to these pins, if necessary by breaking the p.c.b. tracks. Then the pins can be connected to s.p.s.t. switches with pull-up resistors, as shown in Fig. 4, so that any combination of control inputs can be set up.

Printer interface

The rtty program will drive a Centronics-compatible printer to provide hard copy of all received and transmitted messages (Fig. 5). The printer is connected to port B of the p.i.o. and operates under interrupt. When the printer is ready to receive a character, its acknowledge output (and therefore the BSTB input to the p.i.o.) goes low, thus causing the interrupt. The data strobe from the p.i.o. to the printer is connected to the B_7 data pin of the p.i.o. because the print strobe is generated by software.



Switch settings for rtty

SA	Open
SB	Open
SC	Closed
SD	Closed
SE	Open or closed

Fig. 4.

To test the printer, load the program listed in Table 1, and start it running with the EC80 command. Then type any characters on the keyboard. As each key is struck, the program outputs the corresponding character via the p.i.o. to the printer. Having accepted the character,

Table 1. Printer test program.

```
0C80: 21 86 0C E5 ED 4D 3E 0F
0C88: D3 07 3E AC D3 07 3E 87
0C90: D3 07 3E 0C ED 47 ED 5E
0C98: FB DF 7B 32 B9 0C CB FF
0CA0: D3 05 CB BF D3 05 CB FF
0CA8: D3 05 18 EC AE 0C 08 3A
0CB0: B9 0C 32 F9 0B 08 FB ED
0CB8: 4D
```

the printer should then respond with an interrupt, and the interrupt service routine in the test program now echoes the character at the top right-hand corner of the screen. If no characters are echoed, the printer is not interrupting correctly. Note that although the characters are echoed on the screen, nothing is actually printed until carriage return is typed (or 132 characters have been input).

Real-time clock

A real-time clock can be connected if desired to the ASTB input of the p.i.o. The clock could be at 50Hz, derived via a suitable step-down transformer from the mains, or could be generated by a crystal oscillator. Any frequency in the range 1Hz to about 1500Hz could be used, provided that it is accurately known and stable. In the G3NRW system, the clock is obtained from the uart master clock, which is divided by 256 to give a square-wave output at 1200Hz; see Fig. 6. This frequency was chosen to allow the Nascom to run Amtor, but that is another story!

To test the clock, first load the program listed in Table 2, setting locations 0CAC and 0CAD (indicated by Y and X in the program) to correspond to the clock frequency in use. X is the most significant byte of the frequency and Y is the least significant byte. Examples of the hexadecimal values of X and Y for various clock frequencies are shown in Fig. 6. Now start the program with the EC80 command. If the clock is working correctly, the two-byte counter at locations 0BF7 and 0BF8 will be decremented after every individual clock interrupt, and the counter at location 0BF9 will be incremented once per second. As these three memory locations correspond in fact to the last three character positions on the top line of the tv screen, the counters can be observed very easily. Thus the first two of these characters will be changing at the clock rate (and hence will be quite blurred except for very low clock frequencies), whereas the last character on the top line will only change once per second. If these characters do not change at all, the clock is not interrupting correctly.

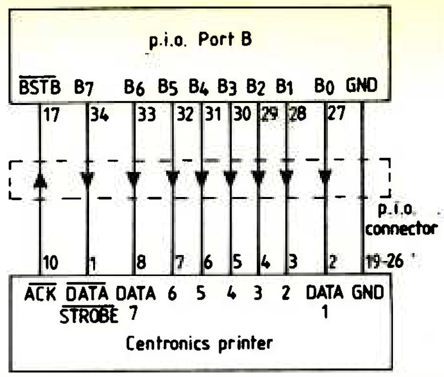
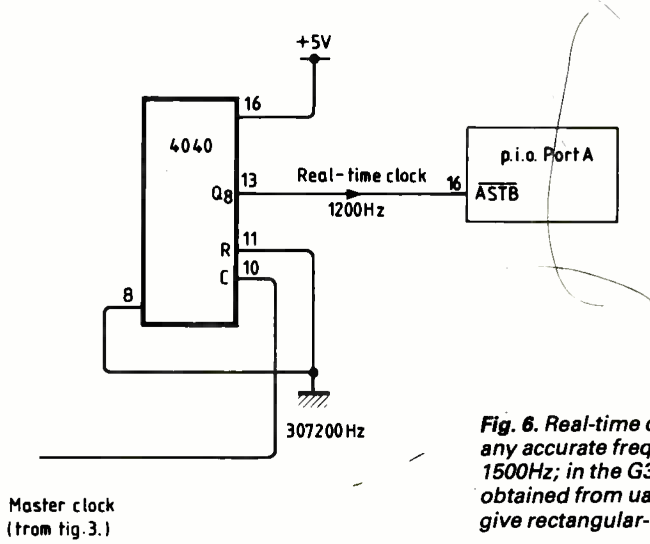


Fig. 5. Program will drive a Centronics-compatible printer to provide hard copy of messages.



Real-time clock program constants

Frequency Hz	Hexadecimal X	Hexadecimal Y
1	00	01
25	00	19
50	00	32
100	00	64
1000	03	E8
1200	04	B0

Fig. 6. Real-time clock could be driven by any accurate frequency between 1Hz and 1500Hz; in the G3NRW set-up clock is obtained from uart and divided by 256 to give rectangular-wave output at 1200Hz.

Table 4. G3NRW rtty program to run under Nas-Sys 3. To run under Nas-Sys 1, change location 0CDE from 7C to 82 and 0D8E from 80 to 86. Real-time clock frequency XY is at 0FD0 (Y) and 0FE1 (X). Callsign constants occupy locations 0FD4 to 0FDF.

0C80:	21	98	0C	E5	ED	4D	0D	0A	20	54	49	4D	45	20	30	30
0C90:	30	30	20	55	54	43	20	20	2E	0E	11	91	0C	3E	30	CD
0CA0:	C4	0F	23	CD	C4	0F	2E	86	11	CA	0B	01	12	00	ED	B0
0CB0:	AF	CD	56	0E	2A	86	0C	22	F7	0B	3E	DB	32	C0	0E	CD
0CC0:	CD	0F	3E	0F	D3	06	D3	07	ED	47	3E	87	D3	06	D3	07
0CD0:	3E	C0	D3	04	D3	06	3E	C2	D3	07	ED	5E	FB	3E	7C	CD
0CE0:	34	0E	CF	4F	FE	20	38	39	FE	74	CA	8D	0D	FE	6C	28
0CF0:	4C	FE	66	28	43	FE	7A	28	1B	FE	78	28	1E	3A	F9	0B
0D00:	B7	28	DF	2A	0E	0C	3E	F7	95	20	02	2E	DC	71	23	22
0D10:	0E	0C	18	CE	3E	0D	CD	56	0E	18	C7	AF	32	F9	0B	18
0D20:	C1	DB	02	E6	0E	28	04	3E	20	18	23	47	79	B7	28	B2
0D30:	FE	1F	28	09	FE	1B	20	0D	21	61	0F	18	03	21	41	0F
0D40:	22	10	0C	18	9D	2A	10	0C	09	7E	FE	0A	28	94	CD	68
0D50:	0E	F3	DF	65	FB	FE	0D	20	89	CD	50	0E	3E	0A	18	EE
0D60:	AF	4F	21	D4	0F	16	08	5E	B3	28	2C	CB	13	38	16	CB
0D70:	79	CB	F9	20	04	F3	DF	5F	FB	AF	06	06	CD	40	00	15
0D80:	20	E9	23	18	E0	CB	79	CB	B9	28	EE	18	E8	3E	80	CD
0D90:	34	0E	3E	1F	32	1D	0C	DF	5F	DF	62	30	30	FE	69	28
0DA0:	BF	FE	72	28	23	FE	68	20	01	AF	CD	68	0E	FE	0D	20
0DB0:	07	CD	50	0E	3E	0A	18	F2	FE	0A	20	04	3E	20	18	EA
0DC0:	FE	20	20	09	3E	1F	18	E2	DF	5F	C3	DD	0C	DB	02	E6
0DD0:	40	28	5E	2A	12	0C	ED	5B	14	0C	CD	AD	0E	FB	28	31
0DE0:	ED	53	14	0C	22	12	0C	4F	FE	1F	28	31	FE	0D	20	04
0DF0:	3E	08	18	29	FE	0A	20	04	3E	02	18	21	06	00	21	61
0E00:	0F	09	7E	21	1D	0C	CB	7F	28	0B	CB	56	28	0F	CB	96
0E10:	7E	D3	01	18	1C	CB	56	20	04	CB	D6	18	F3	D3	01	79
0E20:	FE	1F	28	04	F3	DF	65	FB	3A	12	0C	CD	9F	0E	32	12
0E30:	0C	C3	99	0D	32	75	0C	21	2E	0C	22	16	0C	22	12	0C
0E40:	22	18	0C	21	41	0F	22	10	0C	AF	32	1E	0C	32	F9	0B
0E50:	3E	C0	32	1C	0C	C9	32	F9	0B	21	DC	0B	22	0E	0C	06
0E60:	1B	3E	2E	77	23	10	FC	C9	F3	4F	21	1C	0C	34	20	0A
0E70:	06	FF	70	FE	20	20	03	3E	0D	4F	ED	5B	16	0C	12	7B
0E80:	CD	9F	0E	32	16	0C	5F	3A	1E	0C	B7	20	0F	3C	32	1E
0E90:	0C	79	B7	28	04	ED	53	18	0C	CD	34	0F	79	FB	C9	3C
0EA0:	FE	61	20	03	3E	2E	C9	FE	FA	C0	3E	CA	C9	F3	3A	16
0EB0:	0C	95	C8	7E	B7	C0	CB	54	28	08	7D	CD	9F	0E	6F	11
0EC0:	DB	0B	EB	18	E8	D9	08	DD	E5	3E	CA	32	C0	0E	2A	0C
0ED0:	0C	2B	22	0C	0C	AF	47	4F	ED	42	20	2D	CD	CD	0F	3A
0EE0:	F9	0B	ED	44	32	F9	0B	21	1F	0C	34	3E	3C	BE	20	19
0EF0:	AF	77	21	D5	0B	06	04	DD	21	BB	0F	34	7E	DD	23	DD
0F00:	BE	00	20	05	36	30	2B	10	F2	DD	E1	08	D9	FB	ED	4D
0F10:	D9	08	2A	18	0C	ED	5B	1A	0C	CD	AD	0E	28	11	ED	53
0F20:	1A	0C	CD	34	0F	7D	CD	9F	0E	6F	22	18	0C	3E	01	32
0F30:	1E	0C	18	D7	CB	FF	D3	05	CB	BF	D3	05	CB	FF	D3	05
0F40:	C9	00	65	0A	61	20	73	69	75	0D	64	72	6A	6E	66	63
0F50:	6B	74	7A	6C	77	68	79	70	71	6F	62	67	00	6D	78	76
0F60:	00	00	33	0A	2D	20	27	38	37	0D	24	34	27	2C	21	3A
0F70:	28	35	2B	29	32	23	36	30	31	39	3F	26	00	2E	2F	3D
0F80:	00	04	8D	85	94	89	00	9A	85	8F	92	00	91	8C	83	9C
0F90:	9D	96	97	93	81	8A	90	95	87	86	98	8E	9E	8F	9E	92
0FA0:	99	00	03	19	0E	09	01	0D	1A	14	06	0B	0F	12	1C	0C
0FB0:	18	16	17	0A	05	10	07	1E	13	1D	15	11	3A	36	3A	33
0FC0:	C5	0E	10	0F	ED	67	12	1B	ED	67	12	1B	C9	2A	E0	0F
0FD0:	22	0C	0C	C9	3A	88	0E	E8	AB	B8	E8	BA	2E	E0	00	00
0FE0:	B0	04	B8	AA	56	FC	FA	0B	48	0C	79	02	B8	01	0C	0C
0FF0:	6B	07	0C	0C	00	00	34	0C	FC	03	35	00	FD	03	05	00

Table 2. Real-time clock test program. Clock frequency=XY.

0C80:	21	86	0C	E5	ED	4D	3E	0F
0C88:	D3	06	3E	9E	D3	06	3E	87
0C90:	D3	06	3E	0C	ED	47	ED	5E
0C98:	AF	47	4F	FB	18	FE	A0	0C
0CA0:	2A	F7	0B	2B	22	F7	0B	ED
0CA8:	42	20	0A	21	B0	04	22	F7
0CB0:	0B	21	F9	0B	34	FB	ED	4D

Y X

Drive control

To control the transmit/receive changeover of the transceiver, and to allow the callsign to be sent in Morse code, the drive output from the Nascom can be used to switch the tone generator on and off. The output is

– intermittently low and high when sending the callsign (low corresponds to the 'on' or audible elements of the callsign)
– continuously high during receive
– continuously low during transmit.

To check for proper operation of the drive and generator outputs, load the program listed in Table 3, press the reset key and start the program running withe EC80 command. Then strike any key on the keyboard. This should cause the drive l.e.d. to light, indicating that the drive output is low, and the tone generator should be enabled. Then strike another key. Now drive should go high, the drive l.e.d. should go out, and the tone generator output should be inhibited. Repeated entry of keyboard characters in this manner will toggle the drive output from high to low and back again as many times as required.

Table 3. Drive output test program.

0C80:	DF	61	30	FC	DF	5F	18	F8

RTTY software

The main features of the rtty program are described followed by the operating instructions, illustrating the start-up of the program and the various commands used in transmitting and receiving messages. The machine code version of the rtty program is listed in Table 4. Copies of the full assembly listing, which runs to some 20 pages, are available direct from the author[2].

Receive mode

The main functions of the receive section of the rtty program are to translate incoming Baudot characters to ascii, to deposit them in the ascii text buffer, and to display them on the tv screen. In addition, the characters can be output from the text buffer to the printer. Several features have been included in the receive section of the program to allow error correction and to allow reply messages to be prepared for later transmission.

○ The program tests the uart status as each character is received. If a status error (i.e. framing or overrun error) is detected, the received character is discarded and replaced by a space character. This is very useful under noisy conditions, or when receiving characters at the wrong speed, considerably reducing the number of garbled characters displayed and printed.
○ If an incoming letter shift or figure shift character is corrupted so that subsequent characters are displayed in the wrong shift, it is possible to inject a shift correction character via the keyboard to restore the correct shift. For example, if a series of numbers are displayed, and it is suspected that they should be letters, the <SHIFT> L (lower case L) command can be typed. This inserts a Baudot letter shift into the character stream, and all following characters will then be displayed as letters (until, of course, a figure shift character is received, or a <SHIFT> F command is typed at the keyboard). This feature is again extremely useful under noisy conditions particularly when the transmitting station sends line after line of plain text without shift characters.
○ The program automatically inserts carriage return/line feed (CRLF) into the incoming message stream, at the first space following the first 64 characters on a line. Thus when using the printer, overprinting at the end of the line is prevented.
○ All received message characters are displayed in lower case on the screen to distinguish them from transmitted characters which are displayed in upper case.
○ When receiving messages, it is possible

Fig. 8. Morse callsign program constants for 'DE G3NRW' are loaded into memory from location 0FD4.

Binary	Hex
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

to set up a one-line reply or calling message on the top line of the screen, Fig. 7. When transmitting, this heading message can be sent automatically, by simply typing the <SHIFT> H command. This can be repeated as many times as required. The first half of the line contains the time (updated every minute by the real-time clock), and the second half contains the message, which can be any string of characters which fit into the available space; e.g. 'CQ DE G3NRW' or 'EA5CNG DE G3NRW'. This message can be changed at any time whilst receiving, in readiness for the next transmit over.

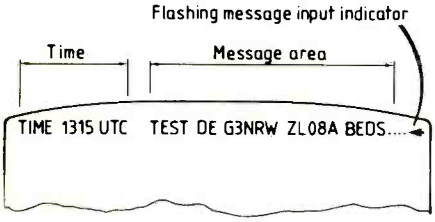


Fig. 7. When receiving a one-line heading message can be set-up at the top which can be transmitted automatically by keying 'shift' H.

Transmit mode

When transmitting, the program invokes several further features which simplify operation.

- ○ Message characters typed in at the keyboard are buffered, so that it is possible to type much faster than the characters are transmitted. The characters are not echoed on the screen until the instant they are actually sent, so that it is possible to monitor the progress of the transmission.
- ○ Baudot letter shift and figure shift characters are inserted automatically into the message.
- ○ After each of the space characters is transmitted, the program automatically inserts a shift character. Thus even if a particular word is received in the wrong shift, because an earlier shift character was garbled, the next word should be received properly.
- ○ As on receive, CRLF is inserted automatically into outgoing messages at the first space after the first 64 characters on a line. This allows the operator to type long messages without needing to consider when to start a new line, thus preventing overprinting on his own printer and on the printer at the other end. In fact, the CRLF sequence consists of four characters: carriage return, line feed, space and letter shift. The space is a pad character to allow additional time for the receiving printer to complete the mechanical movement to the left margin, and the letter shift character ensures that the new line starts in a known shift state, in case the shift was corrupted in the previous line.
- ○ When no message characters are being transmitted, the program automatically sends null (i.e. blank) characters, rather than just a continuous mark or space. This ensures that there are a regular transitions between mark and space all the time, even when the system is idling. This can be helpful to a receiving station equipped with a terminal unit containing separate mark and space amplitude demodulators, as opposed to the more usual f.m. discriminator; it is claimed that such an a.m. terminal unit can perform better than an f.m. unit under noisy conditions, provided that the demodulators are kept 'topped up' by regular transitions between mark and space[3].
- ○ As mentioned above, a one-line heading message can be set up on the screen whilst on receive, and then transmitted with the <SHIFT> H command. This can save considerable typing effort for repetitive messages, such as CQ or test calls, as once the message has been set up it is only necessary to type <SHIFT> H each time the message is to be transmitted.
- ○ At any time it is possible to transmit the station's callsign in Morse code.
- ○ Any spurious output from the *receive* section of the uart is discarded when transmitting. This was found to be necessary because random noise generated in the terminal unit was occasionally treated by the uart input as valid characters. These characters were regarded by the transmit program as keyboard characters, and consequently transmitted along with genuine keyboard characters.

Tailoring the rtty program

Before the rtty program can be used certain memory locations need to be set up to make it applicable to the hardware options actually fitted to the system. This is a once-only job. That is, the rtty program listed in Table 4 is loaded into memory, then the necessary modifications are made, and finally the modified version is saved on cassette tape for future use. If, on the other hand, none of the options are fitted, the program listed in the table can be used without any changes.

The three areas of the program which may require setting up are:

a. two Nas-Sys table pointers (Nas-Sys1 only)
b. real-time clock frequency
c. callsign in Morse code.

No changes are required if a printer is not connected.

Running under Nas-Sys. The rtty program listed in Table 4 runs under the Nas-Sys 3 Monitor, which is the version now normally supplied with the Nascom. To run the program under the earlier Nas-Sys 1 Monitor, just two modifications are required:

- change location 0CDE from 7C to 82
- change location 0D8E from 80 to 86.

Setting up the real-time clock. If a real-time clock is fitted, the clock frequency XY is set up in locations 0FE0 (Y) and 0FE1 (X), in the same way as in the real-time clock test program listed earlier.

Callsign generation. Locations 0FD4 to 0FDF are set up with constants which correspond to the on and off elements of the Morse characters of the callsign. As an example, Fig. 8 shows how the constants for the message 'DE G3NRW' are derived. First, the individual dots and dashes are drawn on squared paper, with each square representing a single dot-time. The usual rules for Morse code timing are followed:

- individual elements of a character are separated by one dot-time
- a dash is three dot-times
- individual characters are separated by three dot-times
- individual words are separated by seven dot-times.

Then, the squares are grouped into fours, and each group is allocated a hexadecimal digit, according to the table in Fig. 8. Finally, these hexadecimal digits are grouped into pairs. These pairs are the constants which are stored in memory from location 0FD4 onwards. The constants occupy 12 locations, giving a total of 96 dot-times. If the callsign requires less than this, the trailing bits should be set to zero, and the callsign will terminate when the first all-zero byte is encountered. If the callsign contains many dashes, it may be necessary to omit the initial 'DE' to make it fit into 96 bits. The speed of callsign transmission is controlled by the software delay constant at location 0D7B. The value of 06 corresponds to about 12 words per minute, with the c.p.u. clock running at 2MHz. If the c.p.u. clock frequency is 4MHz, this constant should be doubled to

0C. Larger values of the constant will reduce the speed of callsign transmission, and smaller values will increase it.

Using the program

The rtty program is now ready for use. After loading it into memory, strike 'reset' and start the program running at address 0C80, using as usual the EC80 command, followed by the time in hours and minutes (24-hour clock) if the real-time clock is fitted;

for example: EC80 1715.

The time, as set up above, will be displayed on the top line of the screen and will be updated every minute thereafter. If the clock is not fitted, simply type the EC80 command by itself to start the program.

Program command summary

To start the program

EC80 time

Receive commands

<SHIFT>L insert Baudot letter shift

<SHIFT>F insert Baudot figure shift

<SHIFT>Z start building a heading message

<SHIFT>X finish building a heading message

<SHIFT>T change to transmit

Transmit commands

<SHIFT>H transmit the heading message

<SHIFT>I transmit the Morse code callsign

Receiving rtty messages

On start-up, the program goes automatically into receive mode, and incoming Baudot characters are translated to ascii and displayed in lower case on the screen. If the printer is fitted, the ascii characters will also be printed.

When in receive mode, there are five command characters which can be entered from the keyboard. Each of these characters is a shift character; that is, to enter a command, hold down the <SHIFT> key, strike the command key, then release the <SHIFT> key. The commands are

<SHIFT>L: insert Baudot letter shift into the incoming message
<SHIFT>F: insert Baudot figure shift into the incoming message
<SHIFT>Z: start building a heading message
<SHIFT>X: finish building a heading message
<SHIFT>T: change to transmit.

The <SHIFT> L and <SHIFT> F commands are very useful for changing the Baudot shift of incoming message characters when previous shift characters have not been received correctly.

The <SHIFT> Z and <SHIFT> X commands are used to set up the one-line heading message on the top line of the display. This message can then be transmitted later when in transmit mode. To set up the message, input the <SHIFT> Z command. This causes a flashing arrow to appear at the top right hand corner of the screen, signifying that the system is ready to accept a new message. Also, a row of dots is displayed on the top line, indicating the maximum extent of the message area.

Now type in the message. As each character is input, it will appear on the top line. When the end of the line is reached, the next character will appear back at the beginning of the message area. If a typing mistake is made, give the <SHIFT> Z command again and retype the line from the beginning.

When the message is complete, input the <SHIFT> X command. The flashing arrow will then disappear, and any further keyboard characters (except commands) will be ignored.

The heading message can be set up or changed at any time whilst in receive mode. Note that when setting up the message, incoming Baudot characters are still displayed on the remaining lines of the screen without interruption. Therefore it is possible to tune in to a station, ascertain its callsign, then set up an appropriate reply, all without missing any incoming characters.

Transmitting rtty messages

The <SHIFT> T command changes the program from receive to transmit mode, whereupon the drive output from the Nascom goes low. To send a message, simply type in the required text at the keyboard. As each character is transmitted via the uart, it appears in upper case on the screen, and hard copy is produced on the printer.

In transmit mode there are three command characters:

<SHIFT>H: transmit the heading message
<SHIFT>I: transmit the station identification in Morse code
<SHIFT>R: change to receive mode.

The <SHIFT> H command causes the top line of the display to be transmitted (the whole line, including the time, if the real-time clock is fitted, or the message only if the clock is not fitted). The command causes the line to be transmitted once; to transmit it more than once, simply type <SHIFT> H as many times as required.

The <SHIFT> I command causes the program to transmit the Morse callsign to identify the station, and can be used at any time whilst transmitting.

The <SHIFT> R command causes the program to change back to receive mode, and the drive output goes high.

The final test

Before using the rtty program on the air, it can be tested using a cassette recorder in place of the transceiver. That is, messages are 'transmitted' to the recorder, and then 'received' by playing back the tape. This method of operation was used extensively when developing the program, to make sure that the message characters were being transmitted exactly as expected (and this technique has proved to be even more useful in developing other data communications programs such as Amtor which transmit and receive synchronous bit streams).

Experience

On the air, the system described in this article has been in regular use at G3NRW for over a year, and many very interesting contacts have been made on h.f. and v.h.f. Low power operation on 20m has been particularly rewarding – you simply can't beat the thrill of getting a 539 report from Italy when running 50 milliwatts of rtty to a dipole – and the many features built in to the program have more than proved their worth.

There are, of course, limitations in the software, arising mainly from the very small memory available. With not one single byte to spare there was just no room, for example, to store a library of standard messages (such as 'RYRYRY' or station description), which would considerably reduce typing effort on transmit. However, the whole exercise has been extremely instructive, in that it forced me to find out exactly how Nas-sys works and how it could be used to maximum efficiency in supporting the required input/output functions.

On the hardware front, few problems were experienced in making the computer system work by itself, but the fun really started when the system was attached to the h.f. transceiver. On receive, r.f. hash from the computer virtually blotted out all but the strongest signals, and on transmit an output power greater than about 15 watts caused the computer to stop running. Eventually, after much experimentation with ferrite beads, decoupling capacitors, r.f. chokes and screened leads, almost all of the interference in both directions was cured by connecting a single 150pF capacitor between the +12V d.c. supply and ground. A simple remedy, but it took a long time to find.

Finally a special thankyou to Bob, EA5CNG (perhaps better known in the UK as G3FXG). Bob has been using the program on his Nascom 2 for several months and has provided much useful feedback and suggestions for further development. Incidentally, the program itself was originally transmitted to Bob over the air, Nascom to Nascom on 20m, and since then several other experiments in direct computer-to-computer communication between the UK and Spain have been carried out. But that is yet another story!

References

1 'RTTY The Easy Way'. A popular booklet describing how to build simple rtty terminal units and two-tone generators. Published by the British Amateur Radio Teleprinter Group (BARTG) at £1.15 including packing and postage. Available from the BARTG Secretary, 27 Cranmer Court, Richmond Road, Kingston-upon-Thames, Surrey.

2 Assembly listing of the G3NRW RTTY Program. Available direct from the author at £2 to cover stationery, photocopying and mailing at 7 Daubeney Close, Harlington, Dunstable, Beds.

3 'Two-tone terminal unit'. A three-part article describing an a.m. terminal unit, published in the *BARTG Newsletter:* March/June/September 1979.

Common-mode rejection explained

by B. L. Hart

Common-mode-rejection ratio characterizes the ability of a differential amplifier to discriminate between the differential-mode and the common-mode components of a signal. It is often conveniently ignored in amplifier circuit analysis because in many op-amp applications – perhaps the majority – the non-inverting input is connected to earth and a large amount of d.c. negative feedback forces the inverting input to be close to earth, so the common-mode component is insignificant, even in second-order calculations. But there are some practical op-amp circuits, such as direct-coupled voltage followers, in which the finite c.m.r.r. cannot be ignored. This article clarifies the c.m.r. properties of an op-amp – its origin and meaning, its graphical interpretation and its representation by a voltage generator for circuit calculations. A second article deals with practical aspects of c.m.r. and explains how c.m.r.r. can be measured directly.

Classification of op-amps

An understanding of the origin of common-mode rejection of a real op-amp can be built up by introducing a classification system. Postulate initially the existence of an almost perfect op-amp having the symbol shown in Fig. 1(a). This symbol is almost the same as that used for any differential voltage amplifier but the vertical side of the triangle is thickened to denote that the amplifier characteristics depart from the conventional 'ideal' (infinite input impedance output admittance and bandwidth) in that there is a finite voltage gain A. The total instantaneous input signal V_+ and V_- can be considered as two parts, (b), a c.m. component V_c given by $(V_+ + V_-)/2$, and a d.m.c. V_D defined as $V_+ - V_-$. There is general agreement in the literature that the meaning of c.m.c. is the algebraic average of V_+ and V_-, as just defined. There is an alternative choice for d.m.c. of $(V_+ - V_-)/2$ which corresponds to $V_D/2$. This is certainly useful in analysis, as shown by redrawing (a) in the form of (c).

The quasi-perfect op-amp, which I shall term a Class 1, is completely specified by a single transfer characteristic, (d). For all values of V_C this is a straight line a_0b_0 with slope $+A$ that passes through the origin of co-ordinates on a plot of V_0 *vs* V_D. So $V_0 = AV_D$. A is clearly the d.m. gain, i.e. $A = A_D$. In elementary analyses a Class 1 op-amp is implied, usually with the additional assumption $A_D \rightarrow \infty$ corresponding to a transfer characteristic coincident with the vertical axis.

The gain A_C for the c.m.c. is zero. Thus

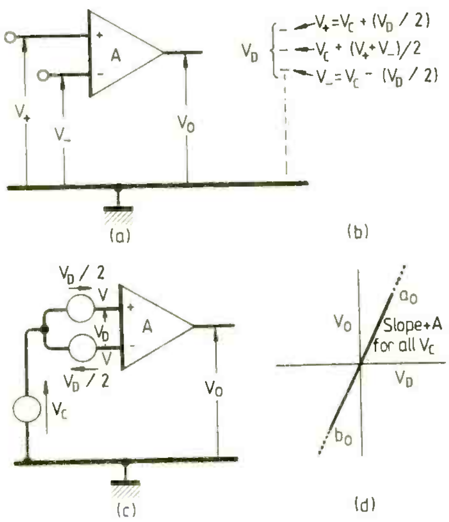


Fig. 1. Symbol for 'quasi-perfect' op-amp uses thickened line to denote non-ideal behaviour (a). Signals V_+ and V_- can be split into common-mode component V_C and differential component V_D (b). Redrawn version (c) emphasizes significance of V_C and V_D. This class 1 op-amp is completely specified by transfer characteristic (d).

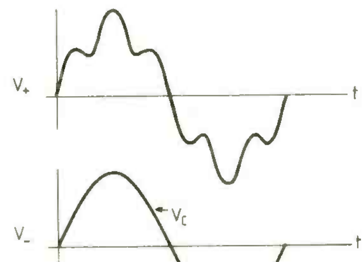


Fig. 2. Common-mode gain for class 1 op-amp is zero so if V_+ and V_- have the form indicated, V_0 is an amplified version of V_D only.

if V_+ and V_- have the form indicated in Fig. 2, V_0 is an amplified version of V_D only; V_C is totally rejected. This is an ideal never achieved in practice. The reason for this rejection is that though V_+ and V_- are applied at different input points to the amplifier they undergo identical magnification in their passage through it. (Magnification means an increase in signal amplitude without regard to polarity.) To emphasize the fact that the initial signal paths are different we can imagine the op-amp as comprising three separate units for which $A_D = A = A_IA_0$, Fig. 3.

The author

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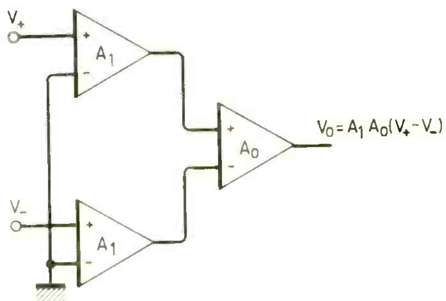

Fig. 3. Common-mode signal is rejected due to identical magnifications, though the signal paths are different, as indicated.

Class 2

A second class of op-amp is best defined graphically. For all magnitudes of V_C there is a single transfer characteristic – a straight line a_1b_1 with slope $+A$ and intercept OX_1 on the V_D axis, Fig. 4. By definition OX_1, arbitrarily shown as positive, is the input offset voltage and its

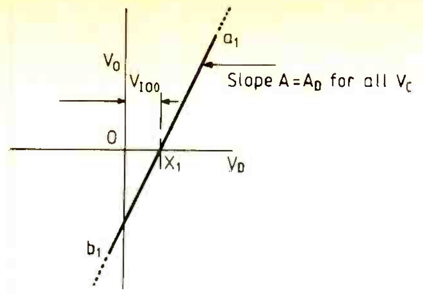

Fig. 4. *Class 2 op-amps have straight-line transfer characteristic with intercept on the V_D axis, equal to the input offset voltage, V_{IO0}, arising simply from small differences in the active devices.*

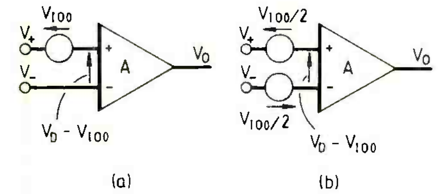

Fig. 5. *Class 2 op-amp is represented by a class 1 with an offset voltage generator in either of its inputs (a). Alternatively, for analysis, offset voltage can be split into equal components one in series with each input (b).*

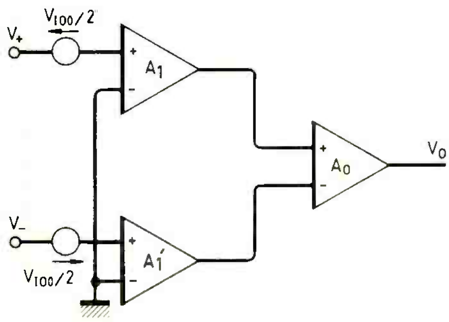

Fig. 6. *Unequal magnifications of V_+ and V_- together with offset voltage are taken into account in this class 3 equivalent circuit.*

magnitude is V_{IO0}. The cause is due to a number of factors, including the nature of the active devices used in the amplifier and it could arise merely through a small difference in the emitter areas of two otherwise identical bipolar junction transistors forming part of a long-tailed pair in the input stage.

A Class 2 op-amp can be represented by a Class 1 op-amp with an offset voltage generator in series with either of its input terminals as shown in Fig. 5(a), in which the non-inverting input terminal is arbitrarily chosen. For analytical convenience, V_{IO0} can equally well be split into two equal components, one in series with each input terminal, as in Fig. 5(b). Then

$$V_0=A\{V_+-(V_{IO0}/2)\}-A\{V_-+(V_{IO0}/2)\}$$

and substituting for V_+ and V_- gives

$$V_0=A_D(V_D-V_{IO0}). \qquad (1)$$

Notice that $A_D(=A)$ now relates to *changes* in V_0 and V_D i.e. $A_D=\Delta V_0/\Delta V_D$. V_{IO0}, unless zero, causes a d.c. offset at the output. V_C is still completely rejected as V_+ and V_- are magnified equally in passing from input to output.

Class 3

Complications must be expected when the signals V_+ and V_- are magnified by unequal amounts in their passage through the amplifier, as is the case in practice. Taking V_{IO0} into account, the equivalent circuit representation of a Class 3 op-amp is shown in Fig. 6. In this case

$$V_0=A_0\{V_+-(V_{IO0}/2)\}-A_0\{V_--(V_{IO0})/2\}A_I'.$$

Substituting for V_+ and V_-

$$V_0=\{A_0(A_I+A_I')/2\}\{V_D-V_{IO0}\}+A_0(A_I-A_I')V_C$$

which can be rewritten

$$V_0=A_D(V_C-V_{IO0})+A_CV_C \qquad (2)$$

where by definition

$$\begin{aligned}A_D&=\text{d.m. gain}\\&=\Delta V_0/\Delta V_D \text{ with } V_C \text{ constant}\\&=\{A_0(A_I+A_I')/2\}=A_0\bar{A}_I\\A_C&=\text{c.m. gain}=\Delta V_0/\Delta V_C \quad V_D \text{ const.}\\&=A_0(A_I-A_I')=A_D\Delta A_I.\end{aligned}$$

The voltage V_0 contains an undesirable c.m.c. because of the existence of a non-zero gain difference ΔA_I. This arises through unbalanced passive and active component parameters.

A quantitative description of the extent to which a differential amplifier rejects the c.m.c. in favour of the d.m.c. is the common-mode rejection ratio ρ or k_{CMR}, the usual definition of which is

$$\rho=|A_D/A_C| \qquad (3)$$

Thus
$$\rho=|\bar{A}_D/\Delta A_I|. \qquad (4)$$

Although this indicates an origin for c.m.r.r. its potential usefulness to a device designer or circuit engineer for calculating ρ to any degree of accuracy depends on the particular amplifier configuration. One circuit for which this is applicable is the single-stage resistively-loaded fet long-tailed pair differential amplifier shown in Fig. 7, in which the output in question is taken from the drain of Tr_2.

The low-frequency incremental output resistance of the tail current generator is assumed infinite: the nominally matched n-channel j-fets have voltage amplification factors μ_1 and μ_2. It can be shown (see Part 2, in which a derivation is given for completeness) that

$$A_I=\lambda\mu_1/(1+\mu_1) \text{ and } A_I'=\lambda\mu_2/(1+\mu_2)$$

where λ is a constant fixed by a resistor ratio. Putting

$$(\mu_1+\mu_2)/2=\mu(\gg 1) \text{ and } \mu_1-\mu_2=\delta\mu(\ll\mu)$$

it follows that

$$1/\rho=|\delta\mu/\mu^2|. \qquad (5)$$

As μ usually only weakly depends on operating current, so does ρ. Equation 5 will be familiar if you recall the use of matched thermionic valves in d.c. amplifiers for biomedical applications. Accord-

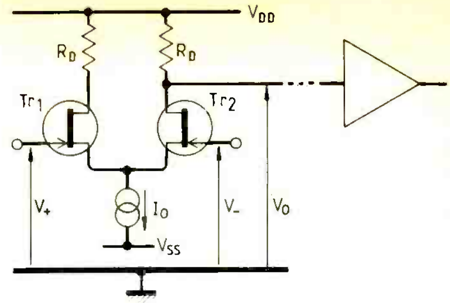

Fig. 7. *Typical circuit for which common-mode rejection is quantitatively given by the ratio of the mean amplifier gain to the difference in gains.*

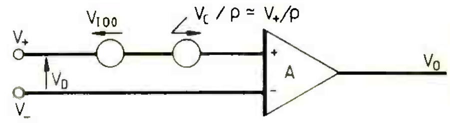

Fig. 8. *Effect of finite c.m.r. can be allowed for by including a voltage generator V_C/ρ in series with one of the inputs.*

ing to Middlebrook[1], effectively the same result was obtained – though by a different analytical technique – for a valve stage by, among others, Parnum[2] as long ago as 1945. What is perhaps not generally appreciated is that this equation also applies to the case of a single-stage resistively-loaded and voltage-driven long-tailed pair amplifier using bipolar transistors. This can be shown by an extension of the proof given in the Appendix, or alternatively follows from a different approach[3].

For the case of bipolar transistors $\mu=g_mr_{ce}$ where $g_m\approx40I_c$mS, the quiescent collector current I_c being expressed in mA, and r_{ce} in kΩ is the low frequency collector incremental output resistance with base-emitter voltage drive. Values for r_{ds} for a fet and r_{ce} for a bipolar transitor are normally comparable in magnitude but $g_m\gg g_{fs}$ at similar operating current levels. As a result, for a modern planar bipolar transistor, μ is considerably greater than that for a fet, typically about 5000. Consequently, for a given percentage match in μ, ρ for the bipolar stage exceeds that for the fet stage. Actually, the majority of op-amp input stages are not simple long-tailed pairs: ingenious circuit design techniques attempt to obtain a ρ superior to that given by equation 5. Nevertheless equation 4 is still a useful relationship from a system viewpoint. As specified by device manufacturers, ρ is obtained from measurements on production samples and is commonly expressed in dB: even low-cost op-amps typically have $\rho\sim$80dB.

Equations 2 and 3 give a clue to the equivalent circuit representation of c.m.r. as we can combine them to obtain

$$V_0=A_D\{V_D-V_{IO0}+V_C/\rho\} \qquad (6)$$

Like offset voltage, the effect of finite c.m.r.r. can be allowed for by including a voltage generator (V_C/ρ) in series with one of the input terminals of the op-amp, as in Fig. 8. The positive sign for the third term, as with the negative sign for the second, arises through an arbitrary choice.

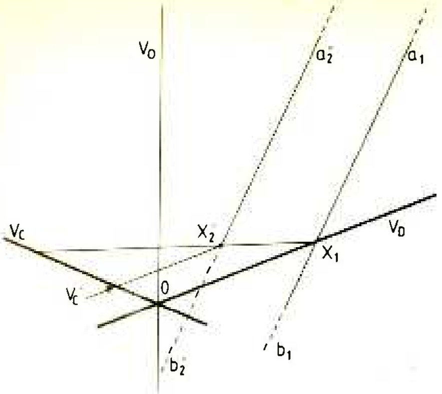

***Fig. 9.** 'Three dimensional' characteristic plane displays functional dependence of V_0 on the two dependent variables V_D and V_C. As A_D and A_C are constant, equation for V_0 is the plane surface defined by two parallel lines.*

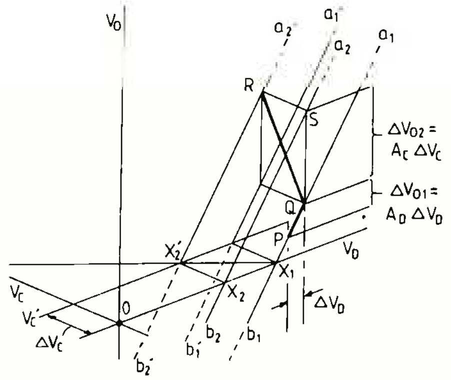

***Fig. 10.** With V_{IOO} constant, the incremental form of the V_0 equation is as shown.*

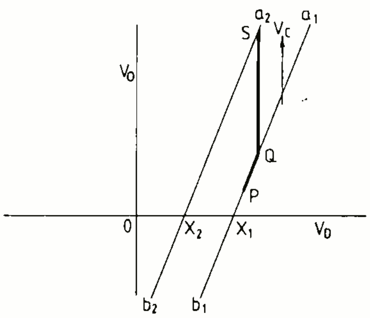

***Fig. 11.** Transfer characteristic of class 3 op-amp comprises a series of parallel lines, two of which are shown, corresponding to the projection of lines such as $a'_2b'_2$ on the plane*

The way in which the sign-uncertainty is dealt with in practice will be considered later (Part 2). For calculation, equation 6 is unnecessarily complicated and can be simplified. Thus from equation 6

$$V_+ - V_- = V_D = (V_0/A_D) + V_{IO0} - V_C/\rho$$

$$\text{or} \quad V_- = V_+ - (V_0/A_D) - V_{IO0} + V_C/\rho$$

substituting $V_- = 2V_C - V_+$ in this expression gives

$$V_C = V_+ - (V_0/2A_D) - (V_{IO0}/2) + V_C/2\rho$$

$$\text{or} \quad V_C = [V_+ - (V_0/2A_D) - V_{IO0}/2]/[1 - 1/2\rho]$$

Typically, $V_0 < 10V$, $A_D > 80dB$, $\rho \gg 1$, $V \sim 1mV$. Hence, if $V_+ \gg V$, then $V_C \approx V_+$ and $V_C/\rho \approx V_+/\rho$.

Mathematically, equation 2, unlike 1, indicates that V_0 is a function of two dependent variables, V_D and V_C. So to display the functional dependence we must plot in three dimensions. In Fig. 9 the axis for V_C is perpendicular to the V_0 and V_D axes. As A_D and A_C are presently assumed constant, equation 2 is the equation of a plane surface that is defined by any two parallel straight lines such as a_1b_1, corresponding to $V_C=0$ and $a_2'b_2'$ for $V_C=V_C$, that cut the plane $V_0=0$ at points X_1 and X_2' respectively. As V_{IO0} is constant the incremental form of equation 2 is

$$\Delta V_0 = A_D \Delta V_D + A_C \Delta V_C. \qquad (7)$$

A geometrical interpretation is given in Fig. 10, in which a_2b_2 is the projection of $a_2'b_2'$ on the plane $V_C=0$ and $a_1'b_1'$ is the projection of a_1b_1 on the plane $V_C=V_{C'}$. Suppose, initially, we are biased at the point P. Then an increase in both V_D and V_C can be imagined to occur in two separate steps. The change from P to Q with V_C constant (at zero) gives $\Delta V_{01}(=A_D\Delta V_D)$: similarly, the change from Q to R at constant V_D gives $\Delta V_{02}(=A_C\Delta V_C)$. Point S is the projection of R on the plane $V_C=0$.

The transfer characteristics of a Class 3 op-amp comprise a series of parallel straight lines – two of which are shown in Fig. 11 – corresponding to the projection of lines such as $a_2'b_2'$ on the plane $V_C=0$. The lines are equally spaced because $|A_C|$ is constant: a_2b_2 is drawn to the left of a_1b_1 because we are assuming $A_C>0$. The construction in Fig. 12 not only gives information about the spacing of the parallel characteristics but also leads to an alternative definition of c.m.r.r. that is useful for measurement.

Suppose we operate at $V_0=0$ corresponding to $V_C=0$ and $V_D=V_{IO0}$, i.e. point X_1. If $\Delta V_0=0$ when V_D and V_C both change, then the path traced out is X_1 to T (V_D constant, V_C changes) and T to X_2 (V_C constant, V_D changes). From equation 7,

$$0 = A_D\Delta V_D + A_C\Delta V_C$$

The spacing of the characteristics in Fig. 12 is thus

$$|\Delta V_D| = |\Delta V_C/\rho| \approx |\Delta V_+/\rho|.$$

The same result would, of course, be obtained had we started with $V_0=V_0'=0$ and again made changes in V_D and V_C, this time for $\Delta V_0'=0$. Now V_D for $V_0=0$ is defined as the input offset voltage V_{IO}, so the reciprocal of ρ is the rate of change of input (offset) voltage with common mode input voltages. Thus

$$1/\rho = |\Delta V_D/\Delta V_C| \text{ for } V_0 \text{ constant at zero}$$

$$= |\Delta V_{IO}/\Delta V_C| \qquad (8)$$

On data sheets the input offset voltage is commonly given two subscripts, e.g. V_{os} or V_{IO}: an additional subscript (0) is used in this article to refer to the usual practical measurement condition $V_C=0$. In general

$$V_{IO} = V_{IO0} \pm V_C/\rho \approx V_{IO0} \pm V_+/\rho.$$

The negative sign applies for $\Delta A_t>0$. Notice for comparison, that in a Class 2 opamp $V=f(V_C)$ so for that case the line

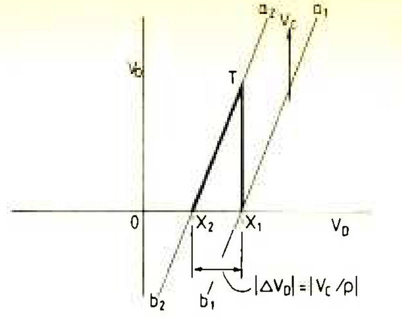

***Fig. 12.** Construction not only gives information about line spacing but also leads to an alternative definition of common-mode rejection that is useful for measurement.*

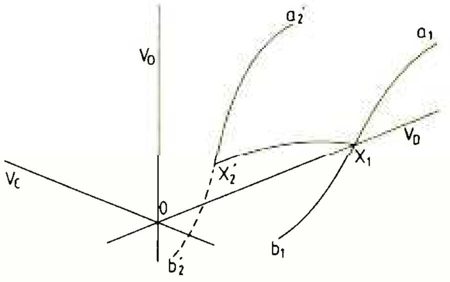

***Fig. 13.** Class 4 op-amps are defined by non-planar characteristic surface such as that shown.*

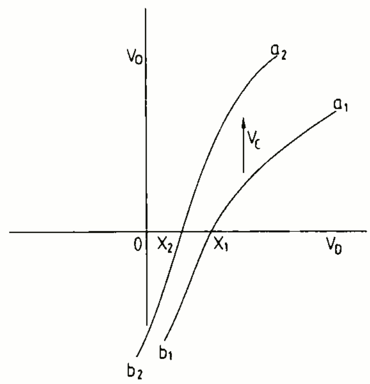

***Fig. 14.** Family of Class 4 transfer characteristics associated with Fig. 13 obtained by projection onto the plane $V_C=0$ are now neither straight nor parallel.*

X_1X_2' in Fig. 9 would be parallel to the V_C axis.

Class 4

A fourth class is defined by a non-planar characteristic surface such as that shown in Fig. 13. The associated family of transfer characteristics obtained by projection on to the plane $V_C=0$ are now neither straight nor parallel, Fig. 14.

A_D, A_C and ρ are all dependent on the d.c. operating conditions but can be considered sensibly constant if the changes in V_0, V_D and V_C about the selected bias point are small enough for the characteristic surface to be well-approximated by a tangent plane. Then

$$A_D = \partial V_0/\partial V_D \text{ at constant } V_C$$
$$A_C = \partial V_0/\partial V_C \text{ at constant } V_D$$
$$1/\rho = |\partial V_{DS}/\partial V_C| \text{ at constant } V_0.$$

To be continued

1

Current dumping review – 1

Crossover distortion is a problem in designing any class B audio amplifier. Bias current provides the basis for the usual solution, but introduces the threat of thermal instability. Current dumping is an alternative to bias current, aiming to abolish crossover distortion without further difficulty.

by Michael McLoughlin

In his original article in this periodical (December 1975), P. J. Walker explains a new technique for abolishing crossover distortion in audio amplifier output stages. His ideas are backed by the commercial success of the Quad 405 amplifier, and the subsequent 1978 Queen's Award for technological achievement.

Seven years have now passed, but the discussion continues unabated. The early contributions in these pages were from practitioners in the audio field, including many well-known names, while later material has come from universities over the world. This article presents in good order the results so far obtained. The discussion reads rather like an epic, full of sudden reversals of fortune.

As the new method is often referred to as something of a mystery, it will first be related in terms of familiar ideas. Walker's own explanation is in terms of the circuit of Fig. 1. For small output currents the driver amplifier A itself supplies the load Z_L directly, via Z_3. Larger currents turn on a dumper, and as Z_4 is chosen to be small the dumper then supplies the bulk of the output current. Then A never has to supply much power, and so it can operate in class A, with no crossover distortion. Indeed, A is just the usual driver amplifier, and we shall refer to it as such.

It is therefore appropriate to call the output transistors in Fig. 1 the "current dumpers", and the substantial distortion which remains will be their crossover distortion. Walker has shown how to choose circuit values that result in complete cancellation of this distortion. It is this choice which is the heart of the matter.

Feedback explanation

To start detailed discussion of Fig. 1 with an intuitive idea of its working, that offered by P. Baxandall (July 1976) relies on the most familiar ideas.

He starts from a circuit similar to that of Fig. 2, with S_1 closed and Z_4 shorted as drawn. Now imagine Z_3 removed. There will be no feedback, and the V_{out}/V_{in} characteristic will look like that of Fig. 3, except that the central segment will be horizontal. This occurs while V_{in} makes progress across the dead region, while the output of A is traversing the voltage gap between the levels required to drive the transistor bases. Adding Z_3 assists matters: while this gap is being crossed there is still some output to the load, as shown by the reduced but positive slope of the central segment.

Now open S_1 of Fig. 2, to provide 100% voltage feedback to A. The variation in open-loop gain shown will be violently assaulted, and the ratio of the gains in the dumpers-off and dumpers-on regimes will be very close to unity. There is now scarcely any crank between the three segments of Fig. 3. (Also the horizontal scale has changed dramatically.)

Baxandall observes that there is now a way to make all three segments line up perfectly. All that is needed is a little extra feedback in the dumpers-on regime, to reduce the gain slightly to that found at the central segment. Then the outer segments tilt gently on their point of meeting with the central section, to provide a perfect straight line!

To provide the extra feedback it suffices to remove the short on Z_4. When the dumpers are off this resistor has no influence on feedback, but when they are on the hotter end of Z_4 carries more output voltage than the load itself. So there is now extra feedback when the dumpers are on, as required. Naturally, Z_4 must be chosen with care to produce just the correct flexing in Fig. 3.

If desired, Z_2 may be connected between N and B in Fig. 2. It is however clearly quite unnecessary. Indeed its contribution to total feedback at N is retrograde, actually feeding back more of V_{out} when the dumpers go off. But if Z_2 is inserted, its harmful effect can readily be cancelled by an increase in Z_4, to boost the desired feedback as necessary.

When the correct Z_4 is in circuit the transfer characteristic is perfectly linear. As a result the grounded terminal of the signal source V_{in} may now be connected instead to V_{out}, and the signal source made to float. Of course, much less signal will now be required for a given output.

Following Baxandall closely we have arrived at Walker's circuit in Fig. 1, with S_1 as drawn. And when S_1 is switched the essential invention now appears as the introduction of Z_4, to provide a little extra feedback in the dumpers-on regime to counter the extra gain introduced into the system when the dumpers bypass Z_3.

Algebra

Baxandall's intuitive explanation can easily be extended into algebra, to derive the Walker balance condition on the four bridge components. The discussion will now centre on Fig. 1, taking the floating "zero volts" rail as zero for the discussion of all voltages. It should be helpful initially to think of this line as "earth", and to regard Z_3 and Z_4 as amplifier load resistors connected to this.

We shall study the total load current I flowing to "earth", and deduce the balance condition in three short paragraphs. Before starting define F as that fraction of output voltage across Z_3 fed back to the negative input terminal of A. And recall that for an amplifier of infinite gain the closed-loop gain is inversely proportional to F.

(A) When a dumper is on, its base-emitter junction cannot support voltage variations, so $F=1$. But when the dumper goes off the junction is an open circuit, and $F=Z_1/(Z_1+Z_2)$. So F has been multiplied by this last fraction. As A has infinite gain, the closed-loop gain to B promptly multiplies by the inverse fraction, namely $1+Z_2/Z_1$.

(B) However, as the dumper goes off the load impedance which controls I rises from $Z_3\|Z_4$ to Z_3. Dividing, we see that load impedance has been multiplied by $(Z_3+Z_4)/Z_4$, which is $1+Z_3/Z_4$.

(C) There is no charge in gain through to I when the dumper goes off if the gain multiplies by the same factor as the load impedance. The relevant factors are at the ends of the two previous paragraphs, and concur if the Walker condition is met:

$$Z_2/Z_1=Z_3/Z_4 \qquad (1)$$

Actually the argument neglects two minor factors. When F was established for the dumpers-off condition in (A), the effect of Z_4 on the potential division was neglected.

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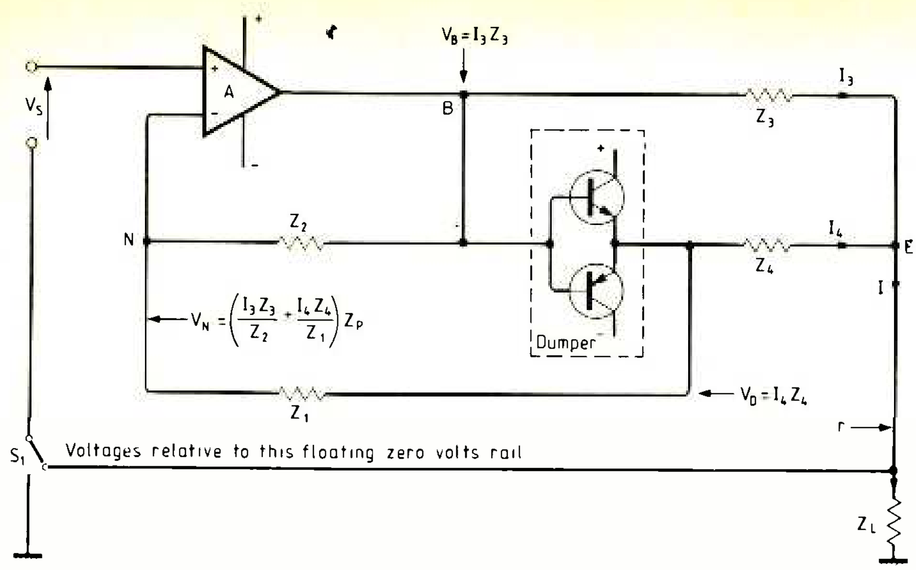


Fig. 1. Walker's basic current dumping circuit. It is a standard class B circuit with elaboration of the feedback network, and floating signal source. (Z_p means Z_1/Z_2)

It should be added to numerator and denominator in the fraction for F. Secondly, when the dumpers go off the output impedance is not exactly Z_3 as stated in (B); there is a second parallel path, and the symbols $\|(Z_2+Z_1+Z_4)$ must be juxtaposed to Z_3. Both these factors are clearly minimal. In fact some straightforward reworking of the argument now shows that they cancel out perfectly, proving (1) exactly. So much cancelling suggests that we are not yet looking at the problem in the simplest possible way.

Lifting the circuit up and down on the floating rail cannot falsify V_s, by definition of that quantity. Nor will it disturb the inputs to A, both of which are carried up and down together. But it will normally falsify the output volts of A, because any amplifier delivers its output relative to its negative rail, and not with respect to a hot point chosen for our convenience in the calculation. In this case, however, we can take refuge in the infinite gain of A. Fig. 4 should make the point clear.

Bridge explanation

It is now clear that with current dumping there need be no gap between intuition and algebra: one passes naturally into the other. It has to be admitted, however, that the argument so far has depended on a simple on/off transistor model, which is not really valid at the edges of the crossover region. We assumed that the base-emitter junction of a dumper either clamped like a short circuit, or passed no current as an open circuit. But the level of intuitive understanding can be extended to include the edges of the crossover region as well, most simply by using an idea of Vanderkooy and Lipshitz (June 1978).

They model the dumpers of Fig. 1 as a voltage source V having zero internal impedance, but varying throughout the cycle just as does the real dumper V_{be}. They then redraw the circuit as a bridge, Fig. 5. The current envisaged as flowing through V in that figure is the dumper emitter current.

Actually only the base current flows in the upper battery arm, but this difference can be ignored as A has zero output impedance. Otherwise the voltages and currents remain undisturbed by the substitution of this "battery". Reduction of current in the upper battery arm is noted by Vanderkooy and Lipshitz as a flaw in their argument. This is because their amplifier has been taken as a perfect current amplifier with infinite output impedance, and so alteration of its output current is unthinkable. Then there is no way of tidying up the current discrepancy, and it follows that in their model the potentiometer rules we are about to use can have no validity.

Suppose now that an arbitrary increase ΔV arises in V of Fig. 5, quite unrelated to the input V_s which remains unaltered for the moment. Well, V_s has not changed, and the voltage between the input terminals of A must remain zero, so V_N remains unchanged. (A can readily secure this by raising the potential at B suitably, while the voltage at D falls sufficiently to make up the remainder of ΔV.)

Now the point E delivers current I, and that current may be calculated on the basis that E is a generator of the e.m.f. that would arise there if the line to I were cut, while the volts at B & D were unchanged. The generator must also be thought of as having output impedance $Z_3\|Z_4$.

Then the output current I will not change if the open-circuit e.m.f. just mentioned does not change in response to ΔV. We know that the change at V_N was zero, so in requiring zero change of this e.m.f. we are simply requiring a bridge balance: $Z_2/Z_1=Z_3/Z_4$.

Meet this condition. Then arbitrary changes in V do not affect output current. If this is true for arbitrary changes of V, then it will be true for that particular track followed by V during the signal cycle. This completes our first rigorous proof of the Walker balance condition (1), where any transistor behaviour is allowed for, even that found at the corners of the crossover region.

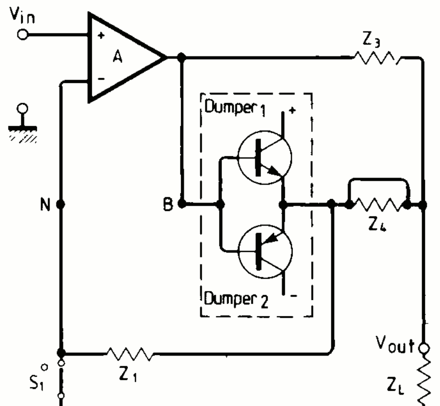
The proof can readily be extended to the real case, where A is finite. When ΔV arises, the amplifier will again control the redistribution of potentials. Indeed for every millivolt that V_N falls, the amplifier will insist on a rise of A (mV) at B. Thus the point of zero voltage change is no longer at V_N, but is $1/(A+1)$ of the way up Z_2. So the open-circuit e.m.f. at E mentioned above will not change if

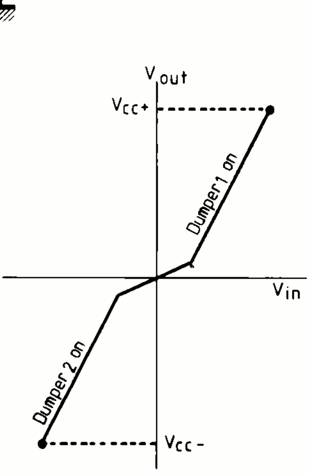
$$\frac{Z_3}{Z_4}=\frac{\frac{A}{A+1}.Z_2}{Z_1+\frac{1}{A+1}.Z_2}. \qquad (2)$$

Thus even when A is finite there is no difficulty in choosing Z_4 to obtain perfect freedom from dumper distortion. Of course (2) can be tidied in various ways. Notice that when A becomes large it tends to (1).

When V_N falls 1 mV, B rises A mV, both measured relative to the floating zero volts rail of Fig. 5. This floating rail causes no embarrassment to the inputs of A, which are both equally affected. But in fact the output of A is produced relative to its negative supply rail, and not relative to any floating rail. This time the difficulty can be deflected by observing that our condition sets $\Delta I=0$, so no voltage difference arises between "zero volts" and ground.

It is still essential to assume zero output impedance in the driver amplifier, to cope with the varying deficiencies in the upper battery arm current as ΔV arises. Of course in a voltage amplifier this output





Figs 2 & 3. When Z_3 is present in this class B output circuit the output transistors could be called "current dumpers" just as in Fig. 1. Transfer function is shown bottom at Fig. 3.

impedance will be very small. In terms of algebra this bridge model is very powerful, and also in terms of intuition. Fig. 5 with an inductor at Z_4 and a capacitor opposite shows that the basic idea is just to balance a traditional LC bridge, according to $L=R_1R_3C$.

Feedforward explanation

It may seem strange that current dumping claims to cancel distortion completely. Certainly in normal correction of error by negative feedback the distortion can never be totally eliminated because a residue must be left to be sensed and so drive the amplifier into opposing the source of distortion. But what if one sensed the distortion in the output current (by comparing it with input voltage) before it was fed into the load, and then injected a further correction current into the load, but forward of the sensing element? The difficulty disappears, because correction does not now reduce sensing and so perfect cancellation of error is then theoretically possible. For example, the crossover distortion of a heavy-duty class B amplifier can be corrected perfectly in principle by a small class A amplifier of high quality.

In practice resistor tolerances do impose serious limitations, though these do not often seem to be analysed. In contrast to feedback, this type of error correction is called feedforward, and has sometimes been aired here (May 1972, October 1974, twice in May 1978). But suppose only four 5% resistors are used in the defining chains. Then the correction may be 20% out. One would do better to increase the

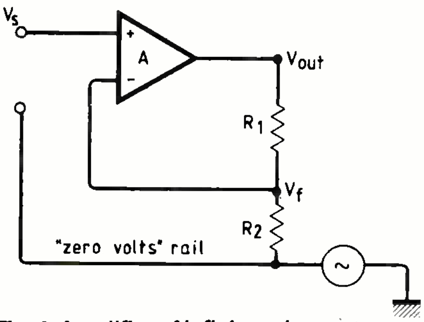


***Fig. 4.** Amplifier of infinite gain must produce V_f equal to V_s even when a voltage source drives the floating "zero volts" rail with respect to which these quantities are measured. Think what would happen if V_f fell short.*

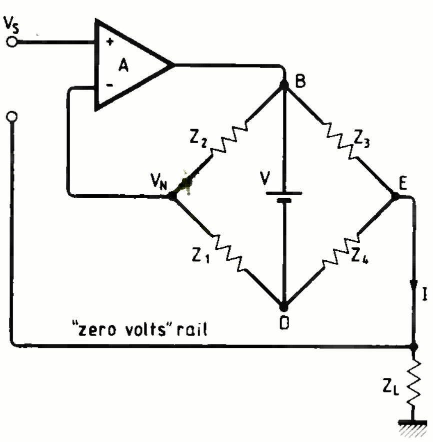


***Fig. 5.** Modelling the dumpers of Fig. 1 as a voltage source V_1 Vanderkooy & Lipshitz redraw the circuit as a bridge.*

gain of the main amplifier by a factor of five, and then use feedback to cut it back again. And this is a great deal easier to do. Nevertheless, the idea of feedforward demonstrates that a claim to perfection of error correction is not objectionable in principle.

Does current dumping use feedforward? Following Baxandall we have presented it entirely in terms of feedback. Imagine Z_4 of Fig. 1 shorted: then the transfer characteristic returns to the style of Fig. 3. The solution was to consider the slope of the central section as basic, and to insert just the right Z_4 to adjust into line the gain of the outer segments. The picture is one of negative feedback being adjusted during the cycle, to make the gain conform to its value at the centre. This is not classical feedback, because the feedback fraction is varied during the cycle, but it is negative feedback, and no further picture is required.

Walker's explanation

In his original article, however, Walker gives a perfectly valid discussion of Fig. 1, which is entirely feedforward in style. He regards Z_4 as the output sensing element, and compares V_s with the sensor voltage I_4Z_4. His argument may be simplified and presented as follows.

A is taken to have infinite gain, so the voltage between its input terminals is zero. Now think of both input terminals as a new "zero volts" point for reference. Viewed from here, $-V_s+I_4Z_4$ appears at the far end of Z_1. As usual when such a signal is fed to the negative input terminal of an amplifier, it reappears at the output terminal but multiplied by $-Z_2/Z_1$. To obtain this output voltage relative to the floating rail of Fig. 1, it is only necessary to add V_s again. (Ignore the expression V_B in Fig. 1.)

So $V_s-I_4Z_4$ is heavily amplified, and if I_4Z_4 is at all sluggish in following V_s a large protest voltage will appear at the output of A, forcing extra current through Z_3 forward of the sensing element Z_4. We have just found the output voltage, so we may choose Z_3 and then write down I_3. Then add I_4 to obtain the total output current, which is just

$$\frac{1}{Z_3}\left[\frac{Z_2}{Z_1}(V_s-I_4Z_4)+V_s\right]+I_4.$$

It is now clear that if Z_3 is chosen according to (1) then I_4 actually cancels out in this expression! Whatever particular I_4 the dumpers choose to allow at any particular time, the output current will remain untouched, provided just the right Z_3 has been fitted.

The language used here is entirely feedforward, though the situation is not classical, for two reasons. Firstly, the protest volts generated by A do actually power the sensing element Z_4 as well as the sensor bypass Z_3. Also Z_3 is not a pure bypass element, but reports back to the amplifier via Z_2, as can be seen clearly in the dumpers-off condition.

Mr Walker's accompanying discussion seems to take as basic the gain when the dumpers are on, feeding current through $Z_3\|Z_4$. Of course there will be a short departure from these arrangements during crossover. And during this brief period of error a suitable correction will be fed through Z_3. The whole picture is perfectly valid, and indeed nothing more than this feedforward is required to explain current dumping.

Much binding

Suppose a tuned circuit is energized at its resonant frequency. Then the circulating current is large, compared with its value at adjacent frequencies. Bloggs explains that this is because C is cancelling the high impedance offered by L. Smith objects that this could not be more false. It is L that is cancelling the high impedance offered by C! And so they rattle on.

Obviously high farce has effected an entry. This illustration establishes the principle that a complex situation may sometimes be viewed quite validly in alternative ways. In this case the fullest understanding seems to be obtained when one has seen both explanations, seen that they are both valid, and grasped that they are complementary views of the same situation.

There seems to have been a similar division of opinion about the operation of Walker's amplifier: does it use feedback or feedforward? In good part the discussion seems to stem from a resolve to class a new and hybrid idea as one or the other of the two existing categories. But a major factor might be a failure to realize that a complex idea can sometimes be explained in several different ways. Our own view is that current dumping may be adequately explained by feedback, or by feedforward, or as a bridge, or as a measuring instrument (see below).

Everyone agrees that use of (1) aligns the three segments of Fig. 3. But it is fruitless to argue whether this is because the correct Z_4 has been chosen to make the outer segment slope equal to that found at the centre (feedback), or because the correct Z_3 has been chosen to ensure that the central section slope concurs with the outer parts (feedforward). We followed Baxandall initially as a matter of taste (indeed so does Walker in November 1976): the feedback ideas involved are more familiar.

In their most recent article (cited later) Vanderkooy and Lipshitz again insist that feedforward alone is the only correct explanation. Their argument consists of a logical structure presenting a "conceptual development of current dumping from feedforward." But one has to ask "whose concepts?" An equally clear set of concepts is the basis for Baxandall's feedback explanation. (It is a mistake to list Baxandall's letter here in support of feedforward.) In short, an explanation in terms of feedforward, however clear, does nothing to exclude other explanations.

An objection

In Fig. 1 the value of Z_4 is carefully chosen to yield the correct additional feedback when the dumpers are on. But how can a single value of Z_4 cancel perfectly the

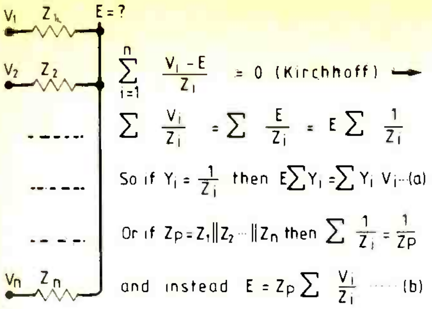


***Fig. 6**. Millman's theorem allows ready calculation of the voltage E at which a junction will settle. Strictly speaking it is result (a), stated in terms of admittances, and it is useful to abolish denominators in difficult algebra. Form (b) is more useful in easier cases.*

peculiar vagaries of dumper V_{be}? And how can anyone assert such a thing without examination of the vagaries concerned?

The objection could easily be met by observing that the result is already secured by different thinking. But it can also be met directly and on the intuitive level by presenting the circuit as a measuring instrument. The dumper behaviour from instant to instant is measured by Z_4, which controls the feedback accordingly to hold the gain constant. Naturally any talk of gain variation within a cycle refers to incremental gain. This intuition is built into a rigorous proof below. We shall not impose the detail on the printer, and all except enthusiasts are urged to bail out at once, as far as the next heading.

Replace the dumpers of Fig. 1 by a resistor R, to stand for the small-signal emitter input resistance of the operating dumper; this variable R connects from Z_2 to Z_4. Now measure all voltages relative to the floating zero rail. Then for unit increment of V_B there will be an increment of V_N given by

$$\frac{Z_4 + \frac{Z_1}{Z_1+Z_2}[R//(Z_1+Z_2)]}{Z_4 + R//(Z_1+Z_2)}.$$

Add 1/A to this to yield ΔV_s. Now the ΔI resulting from the unit change in V_B is just the reciprocal of the impedance from B to E: write down this simpler expression. Then solve $\Delta V_s = K\Delta I$ in such a way that K does not depend on the varying R. This constant proportionality will provide an undistorted output. Provided it is noticed early that R only occurs as $R\|(Z_1+Z_2)$ and this quantity is labelled x, a page of work will produce a rigorous proof of (2). This time, Z_4 has been regarded as a measuring instrument, noting how much current R passes in response to changes of voltage at B, and then controlling gain accordingly.

There is the usual fallacy in that argument, which it is easier to correct after deriving the result. If the output volts of A rise one unit relative to the floating conductor, then relative to true ground they rise an additional $Z_L\Delta I$. This must be taken into account when calculating ΔV_s, which must therefore be augmented by a further $Z_L\Delta I/A$. But this addition does not contain R and is already proportional to ΔI, so provided K has the value found as above a relationship of proportionality will still prevail between ΔV_s and ΔI.

This analysis is really an extension of Baxandall's feedback approach, showing that it can be extended to include any transistor behaviour, even when A is finite.

Algebraic explanations

In an attempt to dispel mystery the above-mentioned arguments have remained close to intuition, even at the cost of complexity. But we shall now study straight algebra, and discover much simpler arguments.

The obvious method of studying Fig. 1 is to regard Z_2 and Z_1 as a potential divider, whose lower end is at I_4Z_4 volts and whose upper end is maintained a further $I_3Z_3 - I_4Z_4$ volts higher. Ignoring the expression in Fig. 1 an expression for V_N is therefore

$$I_4Z_4 + \frac{Z_1}{Z_1+Z_2}(I_3Z_3 - I_4Z_4).$$

Take A large: then this can be taken as an expression for V_s and tidied:

$$V_s = \frac{Z_1Z_3I_3 + Z_2Z_4I_4}{Z_1+Z_2}$$

Suppose now $Z_1Z_3 = Z_2Z_4$ as in (1). Then the coefficients of I_3 and I_4 are equal in this expression for V_s. So the output current (I_3+I_4) has been locked into a proportionality relation with V_s, and the output is undistorted.

An even briefer analysis seems to underlie the remarks of J. Halliday (April 1976). He appears to rely on the circuit theorem of Fig. 6, which gives in two convenient forms the potential adopted at the meet of several impedances. We shall rely heavily on this theorem henceforward.

When Fig. 6 (form b) has been mastered, it will be easy to verify the expression for V_N marked in Fig. 1, where only two arms Z_1 and Z_2 are connected to marked voltages. Now $V_s = V_N$ because the gain of A is large. Simply by looking at that expression for $V_s = V_N$ it is clear that if $Z_4/Z_1 = Z_3/Z_2$ then V_s and (I_3+I_4) are trapped in a linear relation.

Given the expressions of Fig. 1, the last sentence provides a fifth proof that cancellation of distortion is possible, and gives the condition for it.

Output current

For practical reasons Z_4 is much smaller than Z_3, and provided the balance condition holds then

$$Z_3 \gg Z_4 \Rightarrow Z_2 \gg Z_1 \Rightarrow Z_P \approx Z_1$$

(Strictly speaking the first four symbols should have modulus signs.) So the $V_s = V_N$ of Fig. 1 now simplifies to

$$V_s = V_N = (I_3+I_4)\frac{Z_4}{Z_1}.Z_P$$

and if $I = I_3 + I_4$ we have

$$V_s \approx IZ_4 \qquad (3)$$

In other words the output current can be calculated simply by supposing that V_s is applied to Z_4, and it can be modelled by the output current I in the emitter follower circuit of Fig. 7 (with S_1 as drawn.)

The operator H

Before entering on our conclusions we have a duty to look at the difficult article of H. S. Malvar (March 1981). Its early algebra can be much simplified, as shown by K. G. Barr (June 1981). The article relies heavily on a multiplier B, which it will be safer here to call H, and it is used to relate two voltages of our Fig. 1 according to $V_D = HV_B$. This H is the most general possible multiplier, and it changes with V_B as necessary, to maintain the above equation true to what happens in an amplifier. Certainly if one makes a printout of these two voltages at small increments of either, then H could be listed in a third column. Indeed for a given amplifier H could be presented as a list opposite small increments of input signal to the amplifier. But of course such a system leaves the list for H violently dependent on any variations in driver gain that are being considered.

Well, briefly, there is no need to consider what happens when H is off-course by ΔH. The course is defined as above by what H does, and it cannot be off-course. ΔH is meaningless and should be set at zero throughout (equation 8 misleading). If this is not liked, then an alternative description of H must be given. Also it is clear from the above equation that one may not reason on the basis that H=0 when the dumpers are off (equation 12 wrong). And when A is allowed to tend to infinity, then his (6) requires either that R_3 does likewise, or R_4 tends to zero (equation 9 wrong). Finally, once it is admitted that a change in driver gain will cause shifts in H, the Maclaurin expansion used is not only incorrectly computed (equation 10 wrong) but quite invalid in method (H has been treated as a constant in the differentiation.)

Quad 405

Walker explains that he takes (1) as the basic design equation for the Quad 405 design, with $Z_1 = R_1$ and $Z_3 = R_3$, so that both are straight resistors. But Z_4 is an inductor L and Z_2 is a capacitor C. Ingeniously enough, substituting the necessary $j\omega L$ and $1/j\omega C$ in (1) yields nevertheless the frequency-independent balance condition found in the bridge model:

$$L = R_1R_3C \qquad (4)$$

This ensures that the coefficients of I_3 and I_4 found at V_N in Fig. 1 are equal and will stay equal to each other at all frequencies.

But it does nothing to ensure that these coefficients remain constant as frequency varies, and disaster has in fact struck at this point. Indeed, simply by looking at (3) one can see that if Z_4 is an inductor then output current is inversely proportional to frequency. In circuit terms, what happens to the frequency response in Fig. 7 if Z_4 is an inductor?

This conclusion can be confirmed by substituting R_1, $1/j\omega C$, R_3 and $j\omega R_1R_3C$

for the four bridge values in V_N of Fig. 1 and simplifying, to obtain

$$V_N=\left[\frac{j\omega R_1R_3C}{1+j\omega CR_1}\right]I.$$

The bracketed factor is almost constant when ω is large, but its modulus does fall with frequency. Indeed, with $R_1=500\Omega$ and $C=120pF$ as in the Quad 405, the denominator is essentially unity below 1MHz. Hence V_N varies as f in the audio range, and output varies as 1/f there.

The use of L and C in the bridge has resulted in a ferocious dependence of gain on frequency. The solution applied is the use of massive negative feedback, applied in the usual way by switching S_1 in Fig. 1. This can be modelled by switching similarly in Fig. 7. In this figure Z_4 now causes no attenuation of output across Z_L at low frequencies, but at 20kHz it may reduce output noticeably. Suppose we decide that at 20kHz we will tolerate a 0.1% reduction in output volts. Then if $Z_L=8\Omega$, $Z_4=0.36\Omega$ inductive, so $L=2.85\mu H$. Actually $3\mu H$ is fitted.

Many pairs of L and C would satisfy (4), and there has been no explanation of the choice made. It seems that feedback is unable to overcome the effect on gain if L is any larger, even when the amplifier gain is infinite. It follows that above 20kHz the performance of this amplifier must begin to deteriorate, and this explains the exhortation not to make tests with square waves.

Somersaults

The operation of the circuit in Fig. 1 may now be summarized in a sentence. Firstly bridge values are balanced to ensure that $V_N \propto I$, and then the driver amplifier is used to ensure that $V_N=V_s$, thus locking into proportionality V_s and I.

This full discussion of current dumping equips us to examine the controverted points, and we shall now witness three successive somersaults before the end of this article.

Firstly Halliday, supported by Olsson (July 1976), rides in from the flank. He agrees with all that has been said, but points out that it is entirely superfluous. We have just seen that the method depends on deriving a feedback V_N proportional to (I_3+I_4). Then why not derive it from a small resistor in series with the load at r in Fig. 1?

Indeed, supposing that (1) holds and examining V_N of Fig. 1, the value of r required to give identical feedback voltage is readily seen to be $Z_PZ_4/Z_1 \approx Z_4$. (The accurate figure is $Z_3 \| Z_4$.) And J. G. Bennett (April 1976) drives the nail home. Such an r will provide feedback strictly proportional to I, but Walker's bridge owing to tolerances cannot be expected to balance perfectly the two coefficients in V_N in Fig. 1. The bridge will not produce a feedback strictly proportional to I, and current dumping is actually worse than the simpler conventional approach proposed.

Walker in his reply does not oppose these arguments. He points instead to the real case where A is finite, and quotes result (5) below, in a slightly different algebraical form. The result may readily be derived, by noting that if A is finite then a voltage V_B/A exists between the input terminals of A in Fig. 1. This yields a second expression for V_N, given on the left below and equated to that of Fig. 1:

$$V_s-\frac{I_3Z_3}{A}=\left(\frac{I_3Z_3}{Z_2}+\frac{I_4Z_4}{Z_1}\right)Z_P$$

$$\Rightarrow V_s=Z_P\left[I_3\left(\frac{Z_3}{Z_2}+\frac{Z_3}{AZ_P}\right)+I_4\cdot\frac{Z_4}{Z_1}\right]$$

So V_s is again locked linearly to (I_3+I_4) if

$$\frac{Z_4}{Z_4}=\frac{Z_3}{Z_2}+\frac{Z_3}{AZ_P} \qquad (5)$$

The usual difficulty arises from the floating zero-volts rail of Fig 1. The real output voltage of the amplifier is not just V_B: in fact $(I_3+I_4)Z_L$ needs to be added. Divide by A and use the result to alter the figure used above for volts between the amplifier input terminals. But the extra term has I_3 and I_4 already balanced, leaving unaltered the above balancing requirement (5).

Thus the current dumping circuit can still provide freedom from crossover distortion with finite A. Further, fixing an eye on (5) and examining V_N of Fig. 1, it is now clear that the coefficients of I_3 and I_4 in that expression are no longer equal. Hence V_N cannot now be derived from a resistor in series with the load. Current dumping is sound after all, because Halliday's objection only applies when A is infinite.

But Walker does not go on to revise his explanation of the Quad 405 to show how he has used (5) instead of (1). Indeed, it would appear that he did use the last mentioned. For a start, his explanation is in terms of (1), and also of (4) which is a form of it. Further, the driver in the Quad 405 is a current output device whose working load adopts three values over the cycle. According to (5) there is still a solution: make the gain very large, and then the last term can be dismissed, together with its several gyrations. Then variations in A during the cycle will not upset the bridge balance. Now whether one thinks of A as infinite or merely as large, neglect of the third term of (5) means that the coefficients of V_N of Fig. 1 are set equal. And so identical feedback can be derived from the small resistor mentioned earlier. Halliday's criticism is sound: the Quad 405 would work better without its current dumping. These matters will recur in Part 2.

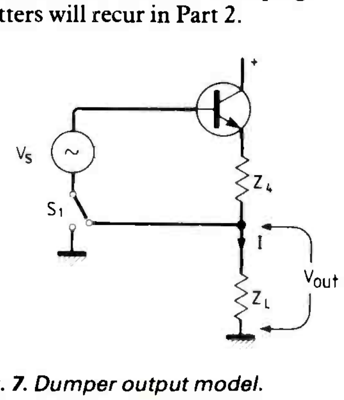


Fig. 7. Dumper output model.

In principle, however, current dumping is now once more of value, provided that A is not taken as large, but is allowed instead to influence (5). The dumpers may do as they please as the cycle progresses, provided only that A is not given too much work. So any crossover distortion caused by the dumpers, or indeed any other harmonics, noise, hum or delays that they introduce into the circuit will all cancel perfectly.

Tolerances

All that is theory, however, and the position is reversed for the third time when practical considerations are taken into account. Components do not have their nominal values, but are produced to tolerances. It follows that if A is large, the designer cannot give any serious weight to the last term in (5), whose contribution will be overrun by tolerance errors in the other terms. He might as well specify $Z_4/Z_1=Z_3/Z_2$, and once this is done Halliday's observation on V_N recovers all its power. Such an amplifier would do better to abandon current dumping.

What sort of amplifier could use current dumping with advantage? Certainly not one where A is so high that the third term of (5) disappears under the tolerance of its predecessor. If this has happened then a designer attempting to allow for the third term will actually do harm to a proportion of his production run. The critical value of A is the figure which reduces the third term in (5) to 10% of the value of the previous term, because the third term is then getting inside the 10% uncertainty of its predecessor. (We are assuming 5% components, as in the Quad 405.)

Indeed the noose can now tighten, if variation of the first term of (5) is taken into account. Now the third term must not fall below 20% of its predecessor. So the critical value of A satisfies

$$\frac{Z_3}{AZ_P}=\frac{1}{5}\cdot\frac{Z_3}{Z_2}\Rightarrow A\approx\frac{5Z_2}{Z_1}\approx\frac{5Z_3}{Z_4}$$

(where really the moduli are under consideration).

We are kinder to current dumping if this upper limit on A is set high. But Z_4 cannot really be made smaller than 0.1Ω, or the resistance of the soldered joints will get into the act. And Z_3 might be 47Ω as in the Quad 405. In which case the upper limit on A is around 2,500 or so. If A exceeds this no designer can allow for it because of tolerances. In particular, the circuit is no use if the driver is an op-amp.

To recapitulate, if A is thought of as large and the last term of (5) neglected, the current dumping circuit is actually worse than normal negative feedback. Indeed, even if A is linear, and known, and used in (5), tolerances defeat the designer's efforts unless A is under 2,500 or so. There might just be a window of gain up to this figure where current dumping could be useful. This point is pursued in part 2 of this article. Meanwhile, it appears that reactive components should be kept out of the bridge.

To be continued

Automatic 'loudness' compensation uses microphone

Using a microphone-derived control signal to adjust the response of electronic filters, Swede Eric Jansson has produced a circuit that gives loudness compensation at all listening levels, regardless of the listening environment, source-signal levels and loudspeaker impedance.

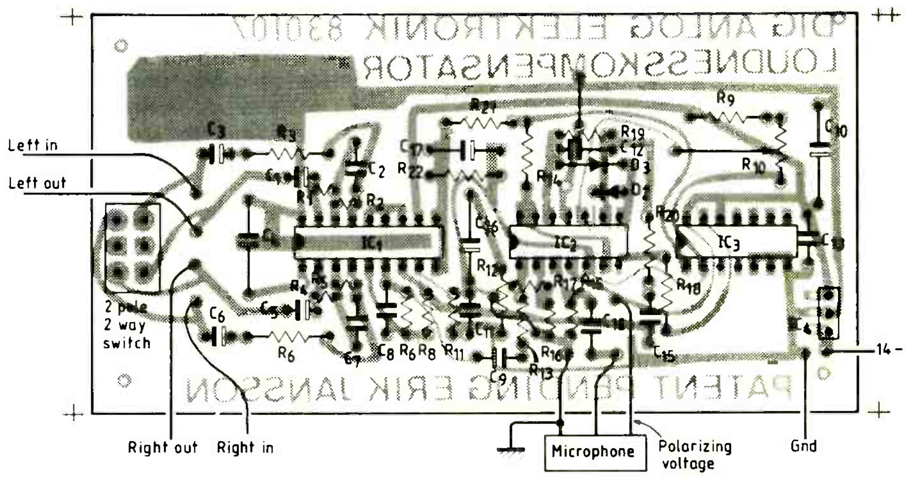
Sound pressure is sensed by the microphone and the amplified signal rectified to feed a voltage-controlled loudness-compensation filter which processes the source signal. The output signal is now compensated for the equal-loudness contours but so are sound pressure levels sensed by the microphone, so to correct this a subfilter whose function is the inverse of the main filter is connected between the microphone and rectifier. Output of the active subfilter also depends on the control voltage so the signal feeding the rectifier is effectively uncompensated.

Positioning of the microphone is not critical as loudness compensation mainly affects frequencies below 1kHz. Components C_1 and R_1 form a 48Hz high-pass filter before the voltage amplifier which feeds the subfilter. Output of the subfilter feeds rectifier IC_{2C}. A comparator, IC_{2B}, causes analogue switch IC_3 to short the control voltage at C to point A when sound pressure level is above 86dB. When these points are shorted the control voltage is zero and both filters have a flat amplitude response. Resistor R_2 sets the control voltage; at 0dB sound pressure level the voltage over points A and C should be 310mV and above 86dB the reading should be zero. Circuit IC_1 is a quad voltage-controlled filter; two sections of the device are loudness filters for each channel and a third section forms the subfilter.

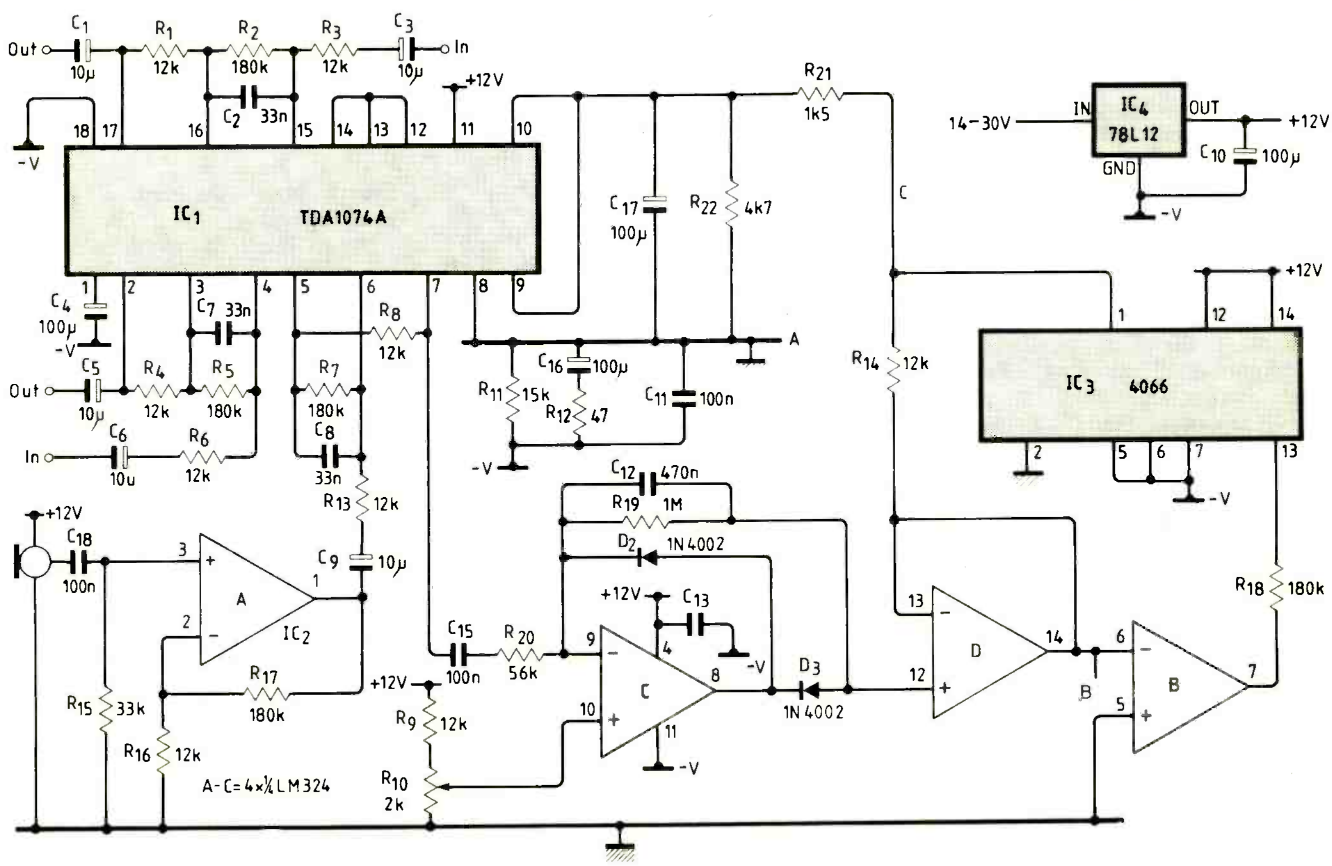
The circuit is designed for a microphone sensitivity of 0.56mV/μbar. Jansson has applied for a patent for his circuit.

WW

A microphone-derived signal controls the electronic loudness filter and a further voltage-controlled filter removes loudness compensation from the microphone signal. ▶



Loudness compensation governed by sound pressure levels and independent of listening environment, source level and loudspeaker impedance is claimed for this circuit. ▼



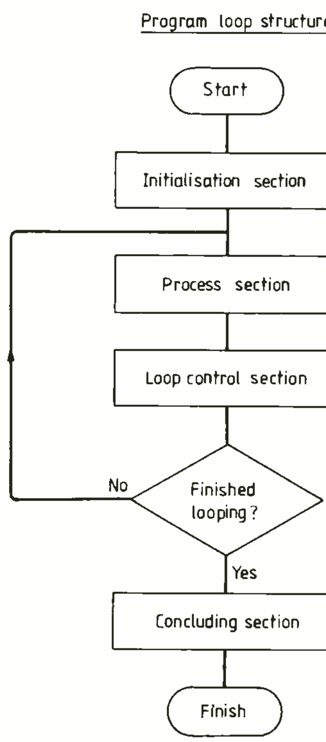
Assembly language programming

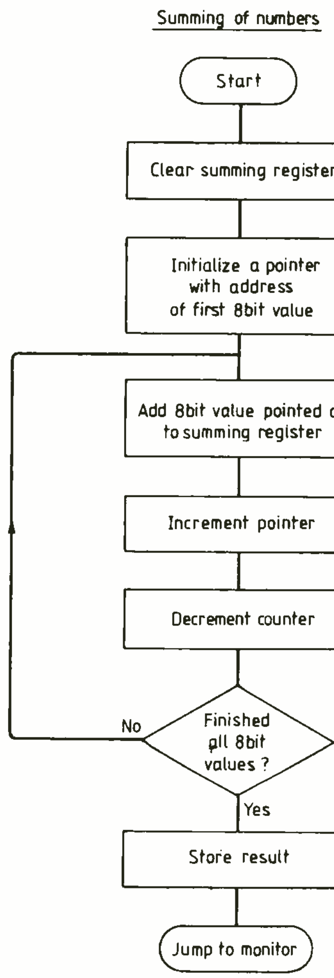
Emphasizing the use of flow diagrams to aid programming, Bob Coates illustrates how microprocessors perform arithmetic in his sixth tutorial.

by R. F. Coates

Flow charts provide a pictorial representation of a procedure. A simple programming loop illustrates how flow charts are applied as an aid to assembly-language programming, see diagram below. Programmers use flow charts to help program writing and to provide documentation for future reference. When constructing flow charts, one must first decide how much detail is required; charts can range from a brief outline to a highly detailed description. Textbooks often expound that the 'correct' method for program writing is to draw up a neat flow chart using all the proper symbols – of which there are many – but in practice few programmers work in this way. Flow charts are an aid to writing programs and should be constructed in the way that suits you.

If a section of a chart proves difficult to sort out it is useful to consider the section as one block and to work the block out later using a second flow chart. Things can get a little disjointed but it doesn't matter as long as you understand what is happening. The time to write a flow chart conforming to the rules for future reference is when the program works correctly.





Summing numbers

As a first example, consider a simple looping program. Requirement of the program is to sum eight-bit binary numbers stored in successive memory locations and store the result in a specified location. The number of binary values is specified by a value in a memory location. Memory locations for the Picotutor* are

- 024 start of program
- 050 result store
- 051 number of values
- 052 first 8-bit value
- 053 second 8-bit value
- 054 . . .

and so on. Flow diagram 'Summing of numbers' represents the operation required, and you can see how this chart corresponds to the basic structure shown earlier. The job of this program is to circulate the loop section once for each eight-bit value, adding each value to the result. Using the index register as a pointer, assembly language for the program is shown in List 1.

Two instructions which clear the summing register and set the pointer to the first data-byte location form the initialisation section of the program. The processing section is the single ADD instruction which adds the contents of the memory location addressed by the index register to the accumulator. INCX updates the pointer so that the next iteration adds the next value to the summing register. To keep track of the number of iterations still to be carried out, DEC VALUE decrements the location containing the number of values. BNE causes a branch if the zero flag is not set. Offset is a twos complement number which when added to the program counter causes a branch to the address of label LOOP. If the zero flag is set the next instruction in sequence, STA RESULT, is executed. The last instruction affecting the zero bit before the branch instruction is DEC VALUES and branching continues

*Picotutor is a low-cost assembly-language trainer described in *Wireless World* December 1982 and January 1983. A Picotutor kit is available from Magenta, see advertisers index.

List 1. Assembly language for summing numbers on the Picotutor.

```
024  AF              CLRA              CLEAR SUMMING REGISTER
025  [illegible]     LD     #VALUE     INIT. POINTER [illegible]
027  [illegible] LOOP ADD   0,X        ADD 8 BIT VALUE TO SUMMING REG.
028  [illegible]     INCX              INCREMENT POINTER
029  [illegible]     DEC    VALUES     DECREMENT COUNTER
02B  [illegible]     BNE    LOOP       BRANCH IF COUNTER NOT ZERO
02D  [illegible]     STA    RESULT     STORE RESULT
02F  [illegible]     JMP    START      RETURN TO MONITOR
```

until this instruction causes the location called 'values' to decrement from 01 to 00. If the initial content of location 'values' is 02, two loops will be performed hence two numbers added.

Try filling the data locations with these values

052	08
053	13
054	2A
055	1C

and set the values location 051 to 04. Result location 050 should contain 61 when the program is completed and control is returned to the monitor.

Reassembling the program as shown in Lists 2 and 3 allows it to run on systems, using 6800 and 6809 microprocessors. The only significant difference is that there is no INX register incrementing instruction in the 6809. A more versatile load effective address instruction, LEA, replaces it. Here the effective index-register address is formed from the index-register value plus the twos complement offset. With an offset of one, one is added to the index register as with INX but the register is incremented or decremented using a single instruction which is not possible with the 6800 or 6805.

List 2. Summing numbers using the 6800.

```
1000    4F                CLRA
1001    CE1052            LDX     #VALUE1
1004    AB00      LOOP    ADDA    0,X
1006    08                INX
1007    7A1051            DEC     VALUES
100A    26F8              BNE     LOOP
100C    B71050            STA     RESULT
100F    7E7DE7            JMP     START
```

List 3. Summing numbers using the 6809.

```
1000    4F                CLRA
1001    8E1052            LDX     #VALUE1
1004    AB00      LOOP    ADDA    0,X
1006    3001              LEAX    1,X
1008    7A1051            DEC     VALUES
100B    26F7              BNE     LOOP
100D    B71050            STA     RESULT
1010    7E7DE7            JMP     START
```

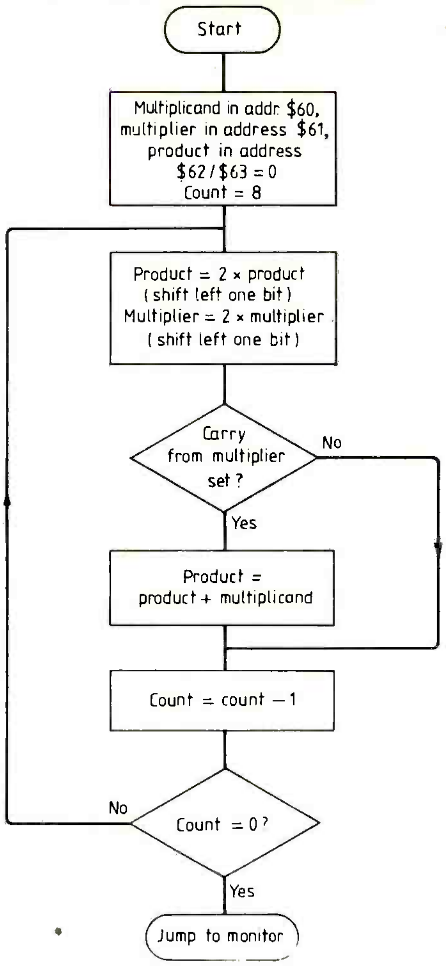
All of the examples shown depict just one way of performing a given operation and even the simplest programs may be reconstructed to perform the same operation. Generally, examples given are chosen because they indicate clearly what is happening. They are not necessarily the most efficient solutions. It may be wise to modify programming techniques for different processors, as can be seen by applying the summing example to the Z80, List 4.

With the Z80 there is no specific clear-accumulator instruction but it is possible to perform an exclusive-or function on the accumulator and any other register – including the accumulator. An exclusive-or operation on a number with itself gives all

List 4. Z80 number summing program.

```
2000    3A5120            LD      A,(VALUES)
2003    47                LD      B,A
2004    AF                XOR     A
2005    215220            LD      HL,VALUE1
2008    86        LOOP    ADD     A,(HL)
2009    23                INC     HL
200A    10FC              DJNZ    LOOP
200C    325020            LD      (RESULT),A
200F    C30000            JP      0
```

8 × 8 multiplication



zeros so performing exclusive-or on the accumulator, XOR A, has the effect of clearing the accumulator. Secondly conditional jump DJNZ decrements the B register and causes a relative jump if the B register does not hold zero. This instruction replaces two in the 6800-series programs. The B register cannot be loaded on its own, only as a pair with the C register, so the A register is loaded with data which is subsequently transferred to the B register.

Four basic arithmetic functions are frequently carried out in further examples. Sixteen-bit addition and subtraction has already been illustrated, leaving multiplication and division to be explained.

8-bit multiplication

An algorithm for 8-by-8 bit multiplication in which two eight-bit numbers in locations 60 and 61 are multiplied and the eight most-significant bits of the result placed in location 62 is illustrated in the multiplication flow diagram. Eight bits of location 63 are set to one. How one can multiply when the processor can only add and subtract needs explaining. Consider these binary numbers

0101	multiplicand
0110	multiplier

To multiply these numbers, for each bit in the multiplier the multiplicand must be shifted left to realign with the bit in the multiplier. If the bit in the multiplier is set the shifted multiplicand is added to the value in a result register and if the bit is clear no addition takes place. For the first bit in the multiplier the multiplicand is shifted left by one bit to give binary 1010 which is stored as a partial product. For the second bit the multiplicand is shifted left again to give 10100 which is added to the partial product, i.e.

first shift	1010
second shift	10100
total	11110

resulting in 1E ($5 \times 6 = 30$ decimal giving 1E hex.). Consequently one only needs to shift and add in order to multiply.

Details in the flow-chart differ from this slightly because shifting an eight-bit multiplicand eight times would require a further byte to shift the value into. Instead the multiplicand is added to the product store and that is shifted left, saving a byte of ram. Program derived from the flow chart for the 6805 is shown in List 5.

List 5. Multiplication program for the 6805.

```
024     3F62      MUL     CLR     PROD
026     3F63              CLR     PROD+1
028     AE08              LDX     #8
02A     3863      MUL1    LSL     PROD+1
02C     3962              ROL     PROD
02E     3861              LSL     MPLIER
030     240B              BCC     MUL2
032     B660              LDA     MCAND
034     BB63              ADD     PROD+1
036     B763              STA     PROD+1
038     4F                CLRA
039     B962              ADC     PROD
03B     B762              STA     PROD
03D     5A        MUL2    DECX
03E     26EA              BNE     MUL1
040     BCEC              JMP     START
```

Sixteen-bit register PROD and PROD+1, which is initially cleared, holds the result. Counting is carried out by the index register which is set to the number of bits in the multiplier, in this case eight, to determine how many times the program will run.

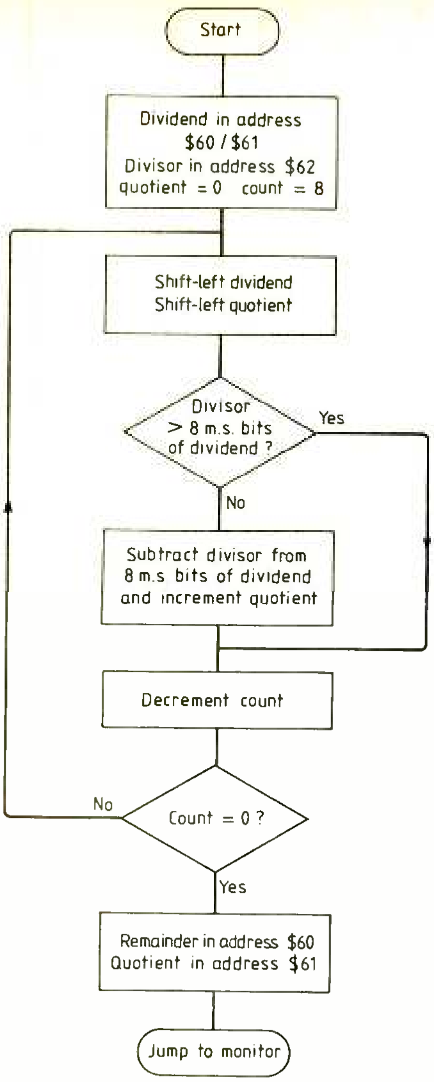
Shifting of the 16-bit product store is required in the first part of the looping section but only eight-bit registers can be shifted (except with 6801/3 processors) so shift and rotate are used to give the same effect. Program section LSL PROD+1 shifts the first eight bits of the product left, placing bit seven into the carry position. ROL PROD then rotates the most-significant eight bits left and the previous carry indication moves into bit zero of PROD, resulting in a 16-bit left shift.

Next, the multiplier is shifted left to place each of its bits in the carry location where they can be tested for one or zero on each loop. A digital one causes the multiplicand to be added to the 16-bit partial product, the result being returned to the partial product locations, and a zero causes the add section to be skipped over by the BCC instruction. Decrementation of the loop counter then takes place and the program loop restarts if all eight bits of the multiplier have not been tested; otherwise looping ends with the partial-product locations containing the final result value.

15-by-7-bit division

Division on a microprocessor can be carried out using a series of trial subtractions. For each step in the division it must be determined whether or not the divisor can be subtracted from the remainder of eight

15 × 7 divide



most-significant bits of the dividend without causing a borrow. If the divisor can be subtracted the corresponding bit in the quotient is one, if not, the bit is zero. Dividend and quotient are correctly aligned by shifting them left one bit before each trial subtraction.

In this example dividend and quotient occupy the same 16-bit register at locations 60 and 61. This is possible because the algorithm, see flow diagram, clears one bit of the dividend at the same time as it determines one bit of the quotient, leaving an integer quotient and the remainder, i.e. what is left of the dividend. Program for the 6805 derived from the algorithm is List 6. To try the program, a 15-bit or less dividend is entered in locations 60/61 and a seven-bit divisor placed in address location 62. After running the program, location 61 will contain the quotient and location 60 the remainder. This simple program only allows an eight-bit quotient and only works if the dividend/divisor combination give an eight-bit or less quotient. As an example, using dividend 1234 (4660) and divisor 1F (31) gives quotient 96 (150) remainder A (9).

Decimal arithmetic

All arithmetic functions so far discussed operate on binary numbers but manipulation of decimal numbers is more acceptable to humans. There are two ways to accommodate decimal numbers; one is to write arithmetic routines that handle decimal numbers, the other to convert decimal input numbers to binary. I will cover both methods.

True decimal routines. Some modern processors contain instructions which perform decimal or binary-coded decimal (b.c.d.) arithmetic directly, but not those that we are considering. To enable one to write decimal arithmetic routines, the fundamental requirement is addition of b.c.d. numbers. An eight-bit binary number can contain two b.c.d. digits but as the greatest decimal digit is nine, the greatest binary value is 1001.

With 6800/09 and Z80 processors, if the accumulator holds two b.c.d. digits which are added to another two b.c.d. digits, i.e.

```
LDAA  $99
ADDA  $49
```

the processor produces the result E2 in binary form. Binary numbers in the accumulator can be converted back to b.c.d. after an add or add-with-carry instruction using DAA, the decimal adjust accumulator instruction. Using DAA the result is 48 and the carry bit is set, indicating 148, so

```
LDAA  $99
ADDA  $49
DAA
```

allows b.c.d. numbers 99 and 49 to be added correctly.

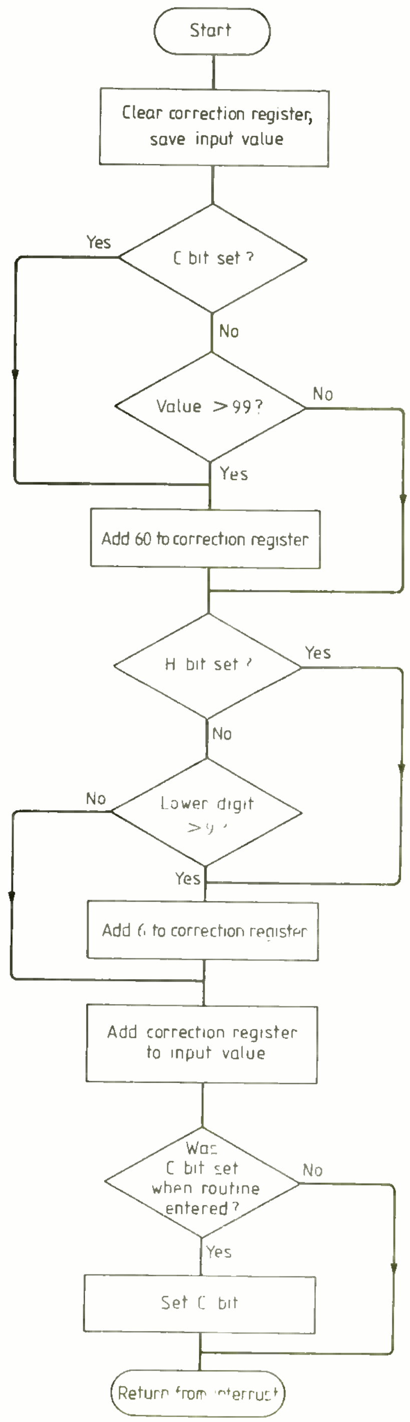
The 6805 has no DAA instruction but b.c.d. addition can be performed by using a subroutine which is the equivalent of DAA. Explaining this subroutine also explains how the DAA instruction works. To perform a decimal correction it is necessary to know whether a bit-seven carry took place in the addition, indicated by the condition-code register (c.c.r.) carry bit, and if there was a carry from bit three to bit four indicated by the c.c.r. half-carry bit, bit H. Only ADD and ADC instructions affect the half-carry bit in Motorola processors but decimal subtraction with the Z80 is simplified as this bit and the add/subtract flag are affected. Normally the half-carry bit is only used by the DAA instruction but on the 6805 there are two conditional branch instructions, branch-if-half-carry-set and branch-if-half-carry-set, which partly compensate for the absence of a DAA instruction.

Decimal correction is shown in the flow diagram. If the carry-bit is set or the number is greater than 99 then high-digit correction by adding 60 to the number is necessary. Low-digit correction by adding six to the number is required when the half-carry bit is set or the units half of the byte is greater than nine. Adding 99 and 49 shows how this works

```
       99
      +49
      ---
total  E2
```

Adding two nines gives two and sets the half-carry indication, and adding nine, four and the carry gives E. Applying the decimal-adjust algorithm, result E2 is

Decimal addition correction



List 6. 15-by-7-bit division using the 6805.

[illegible]

greater than 99 so 60 is added and the half-carry bit is set so a further six is added. With correction of 66 added, result E2 becomes 148, i.e. 48 with the carry indication set.

Because this algorithm is often used and ram space in Picotutor is limited the subroutine for this shown in List 7 is included in eprom at address 33. I used a different assembler for this program so entering of hexadecimal numbers is different; numbers entered are prefixed with H. List 8 illustrates how 99 and 49 are added using this subroutine. When the first SWI instruction is encountered, press the register key and check that the H bit is set, that the C bit is clear and that the accumulator contains E2. Leave register mode and press the cn key to continue the program. Pressing the register key should now indicate that the H bit is clear and the carry bit is set. The accumulator now contains 48 and multiple-precision addition may be carried out as described earlier using the carry indication.

Number conversion

Converting a decimal number to binary, manipulating it and converting it back to decimal form is the second alternative. These conversions are often used, for instance the d.v.m. program referred to in the January issue obtains an eight-bit binary value equivalent to the input voltage and converts it to decimal form for display. Subroutines for converting numbers in both directions are included in the Picotutor monitor as 'system calls'. How b.c.d. is converted to binary in its BCDBIN program is illustrated in the flow diagram shown. Here, for each of the thousands, hundreds and tens digits the equivalent hexadecimal number is added to a result register by the number of times equal to the number of the digit. Finally, units are added to the result. Table 1, system calls, shows that the b.c.d. number should be placed in POINT and POINT+1, the first being the ram register used by the monitor at address 1 A and the last the next location, 1B. As these locations are used by the monitor they cannot be set up by the memory-open command (mo) which uses POINT for other purposes but must be set up within the user program. Setting up of the index register is also required so that it points to where the result of the conversion is to be placed.

List 8. Adding two numbers using the simulator of List 7.

```
024   A699        LDA   #$99
026   AB49        ADD   #$49
028   83          SWI
029   BD38E       JSR   DAA
02C   83          SWI
```

List 9. Converting decimal 2748 to binary form using Picotutor.

```
024   A627        LDA   #$27
026   B71A        STA   POINT
028   A648        LDA   #$48
02A   B71B        STA   POINT+1

02C   AE60        LDX   #$60

02E   BDB9        JSR   BCDBIN

030   BC80        JMP   START
```

List 10. Assembly language for Picotutor subroutine BCDBIN.

```
                      841 * BCDBIN - CONVERTS A 4 DIGIT PACKED BCD NUMBER IN
                      842 *          POINT TO 14 BIT BINARY, AND PLACES
                      843 *          RESULYT IN 0,X/1,X.  BCD NUMBER
                      844 *          UNALTERED. SETS CARRY IF A NON-DECIMAL
                      845 *          DIGIT ENTERED.
                      846 *
404 7F          431   847 BCDBIN CLR    0,X        CLEAR RESULT REGISTERS
405 6F01        432   848        CLR    1,X
407 131D        433   849        BCLR   1,BITSTR   CLEAR OVERFLOW FLAG
409 B61A        434   850        LDA    POINT      PUT 1000'S DIGIT IN POINTS
40B 44          435   851        LSRA
40C 44          436   852        LSRA
40D 44          437   853        LSRA
40E 44          438   854        LSRA
40F B71C        439   855        STA    POINTS
411 AD47        440   856        BSR    BCDCHK     CHECK DIGIT IS <=9
413 270A        441   857        BEQ    BCB2       BRANCH IF DIGIT = 0
                      858 *
415 A603        442   859 BCB1   LDA    #3         ADD H'300' TO RESULT
417 FB          443   860        ADD    0,X
418 F7          444   861        STA    0,X
419 A6E8        445   862        LDA    #H'E8'       ADD H'E8' TO RESULT
41B AD32        446   863        BSR    BCDADD     (TOTAL ADD=H'3E8', 1000 DEC)
41D 26F6        447   864        BNE    BCB1       BRANCH IF 1000'S NOT ZERO
                      865 *
                      866 *
41F B61A        448   867 BCB2   LDA    POINT      PUT 100'S DIGIT IN POINTS
421 A40F        449   868        AND    #H'F'
423 B71C        450   869        STA    POINTS
425 AD33        451   870        BSR    BCDCHK
427 2706        452   871        BEQ    BCB4       BRANCH IF DIGIT = 0
                      872 *
429 A664        453   873 BCB3   LDA    #H'64'       ADD H'64' (100) TO RESULT
42B AD22        454   874        BSR    BCDADD
42D 26FA        455   875        BNE    BCB3
                      876 *
                      877 *
42F B61B        456   878 BCB4   LDA    POINT+1    PUT 10'S DIGIT IN POINTS
431 44          457   879        LSRA
432 44          458   880        LSRA
433 44          459   881        LSRA
434 44          460   882        LSRA
435 B71C        461   883        STA    POINTS
437 AD21        462   884        BSR    BCDCHK
439 2706        463   885        BEQ    BCB6
                      886 *
43B A60A        464   887 BCB5   LDA    #H'A'        ADD H'A' (10) TO RESULT
43D AD10        465   888        BSR    BCDADD
43F 26FA        466   889        BNE    BCB5
                      890 *
                      891 *
441 B61B        467   892 BCB6   LDA    POINT+1    ADD 1'S TO RESULT
443 A40F        468   893        AND    #H'F'
445 AD13        469   894        BSR    BCDCHK
447 AD06        470   895        BSR    BCDADD
                      896 *
                      897 *
449 98          471   898        CLC
44A 031D01      472   899        BRCLR  1,BITSTR,BCB7 BRANCH IF NO ERROR
44D 99          473   900        SEC               SET CARRY AS NON-DECIMAL NO.
44E 81          474   901 BCB7   RTS               RETURN, CONVERSION COMPLETE
                      902 *
                      903 *
                      904 *
44F EB01        475   905 BCDADD ADD    1,X        ADD NUMBER IN A TO RESULT
451 E701        476   906        STA    1,X
453 A600        477   907        LDA    #0
455 F9          478   908        ADC    0,X        PASS ON CARRY
456 F7          479   909        STA    0,X
457 3A1C        480   910        DEC    POINTS     DECREMENT THE DECIMAL DIGIT
459 81          481   911        RTS
                      912 *
                      913 *
                      914 *
45A A109        482   915 BCDCHK CMPA   #9         SET ERROR FLAG IF DIGIT >9
45C 2302        483   916        BLS    BCDCH1
45E 121D        484   917        BSET   1,BITSTR SET FLAG
460 4D          485   918 BCDCH1 TSTA
461 81          486   919        RTS
```

List 7. Simulation of the 6800 DAA instruction included in the Picotutor.

```
                * DAA - THIS ROUTINE SIMULATES THE DAA INSTRUCTION OF THE
                *       6800 ETC.   IT SHOULD BE CALLED AFTER AN ADD OR ADC
                *       INSTRUCTION AS....   JSR DAA.
                *       UPON EXIT, A IS BCD CORRECTED AND C IS SET FOR
                *       MULTIPRECISION BCD ADD.
                *
386 B71E  DAA   STA    TEMPA     SAVE INPUT VALUE
388 BF1F        STX    TEMPX
                *
                * CALCULATE CORRECTION FACTOR
                *
38A 5F          CLRX             BUILD CORRECTION IN X
38B 101D        BSET   0,BITSTR SET CARRY STORE
                *
38D 2506        BCS    DAAH6
38F 111D        BCLR   0,BITSTR BUT CLEAR CARRY STORE IF CARRY ISN'T SET
391 A199        CMP    #H'99'
393 2302        BLS    DAALOW    INPUT <=H'99'
395 AE60        LDX    #H'60'      HIGH NIBBLE NEEDS CORRECTION
                *
397 2906  DAALOW BHCS  DAAL6
399 A40F        AND    #H'F'
39B A109        CMP    #9
39D 2304        BLS    DAADNE    NO LOW NIBBLE CORRECTION
39F 9F    DAAL6 TXA
3A0 AB06        ADD    #H'6'       LOW NIBBLE CORRECTION
3A2 97          TAX              TOTAL ADJUST BACK TO X
                *
                * CORRECT ACCUMULATOR NOW
                *
3A3 9F    DAADNE TXA             CORRECTION GOES INTO A
3A4 BB1E        ADD    TEMPA     AND IS ADDED TO ORIGINAL VALUE
3A6 BE1F        LDX    TEMPX
3A8 2504        BCS    DAA2      BRANCH OUT IF CARRY ALREADY SET
3AA 011D01      BRCLR  0,BITSTR,DAA2 OR IF IT WAS CLEAR ON ENTRY
3AD 99          SEC              BUT SET CARRY IF IT WAS ON ENTRY
3AE 81    DAA2  RTS
```

BCD-to-binary conversion

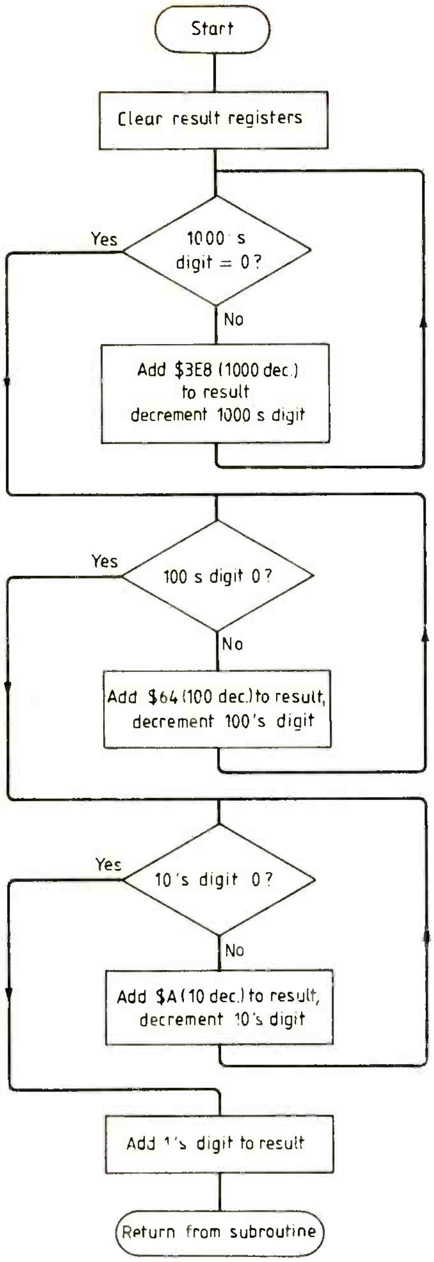


Table 1. System calls.

Add	Name	Function	Add	Name	Function
80	START	Re-enter monitor.	B6	BINBCD	Converts a 14-bit binary number in POINT/POINT+1 to a four-digit packed b.c.d. number in 0, X/1,X. Sets C if an overflow occurs.
83	DISKEY	Refreshes display with data in DISBUF then calls KEYIN.	B9	BCDBIN	Converts a four-digit packed b.c.d. number in POINT/POINT+1 to a 14-bit binary number in 0,X/1,X. Sets C bit if a non-decimal digit entered.
86	KEYIN	Scans keypad and returns with key code in A, 00 if no key pressed. Sets c.c.r. C bit if same key pressed, clears otherwise.	BC	BUILD4	Gets four hex. digits from keypad and packs them in POINT/POINT+1. Jumps to START if non-hex. key pressed.
89	DISGET	Repeatedly calls KEYIN until a new key is pressed, returns with key code in A.	BF	ADD	Adds two 16-bit binary numbers in POINT/POINT+1 and TEMPX1/TEMPX2. Result in POINT/POINT+1.
8C	DISHEX	Calls DISGET and converts key code to hex. if a 0-9 or A-F key and clears C bit. If non-hex., returns with original key code and sets C bit.	C2	SUB	Subtracts 16-bit number in TEMPX1/TEMPX2 from 16-bit binary number in POINT/POINT+1. Result in POINT/POINT+1.
8F	HEXCON	Converts key-code in A to hex (00-0F) and clears carry. If non-hex. key, returns with original code in A and sets carry.	C5	MUL	Multiplies two eight-bit binary numbers in TEMPX1/TEMPX2. 16-bit result in POINT/POINT+1.
92	BADDR	Builds three-digit address entered by keypad in POINT/POINT+1.	C8	DIV	Divides 15-bit binary number in POINT/POINT+1 by seven-bit binary number in TEMPX1, puts quotient in POINT+1, remainder in POINT.
98	THEX	Gets two hex. digits from keypad and combines in A. Puts seven-segment equivalent of two digits in 0,X/1, X. Non-hex. keys cause jump to START.	CB	DVM	Digital voltmeter program (see Jan. 83 issue)
9B	LSEG	Converts m.s. nibble in A to seven-segment code.	CE	VGEN	Voltage generator program (see Jan. 83 issue).
9E	RSEG	Converts l.s. nibble in A to seven-segment code.			
AD	ERROR	Puts 'Error' in display until any key pressed then jumps to START.			
B0	CLRDIS	Clears display buffer ram DISBUF.			
B3	DAA	Simulates the 6800 DAA instruction.			

List 9 is a program example for converting 2748 to binary for representation in hexadecimal form. First POINT and POINT+1 are set up with the decimal value then the index register is loaded to point to result location 60. Subroutine BCDBIN is then called to convert the number to decimal and return control to the monitor. Examination of locations 60 and 61 using the memory-open key should reveal the result 0ABC. List 10 is the b.c.d.-to-binary program in Picotutor. Try modifying the program to convert from binary in hexadecimal form to b.c.d. using Picotutor subroutine BINBCD.

System calls

Because of limited ram in Pictotutor a collection of useful subroutines, or system calls, such as BCDBIN are included in the monitor eprom, Table 1. By linking these to your programs fairly complex programs can be used despite the small ram. Included are the routines for addition, subtraction, multiplication and division already described. Other routines will be described later; the list is included now to allow you to experiment.

Addresses of each call are only three bytes apart because the address merely contains a jump instruction which causes a jump to the actual routine address. There are two reasons for this. Firstly all these jumps can be contained in page zero eprom locations which allows direct addressing and saves memory space. Secondly minor program modifications which alter address locations may be made without altering the jump addresses. An area of ram reserved for use by the monitor is also used by some of the system calls, indicated in Table 2.

Table 2. Reserved memory.

Address	Bytes	Name	Function
10	6	DISBUF	Store for seven-segment codes for each digit of display.
16	1	TIMEV	Timer interrupt vector. Program will jump to the direct address given here when a timer interrupt occurs.
17	1	IRQV	Same as TIMEV but for hardware interrupt.
18	1	LASKEY	Used by DISKEY.
19	1	POINTP	Used by monitor
1A	2	POINT	Used by monitor and for arguments of some system calls.
1C	1	POINTS	Used by monitor.
1D	1	BITSTR	Single bit flag store. Bit 0 used by DAA, bit 1 used by BINBCD and BCDBIN. Bits 2 to 7 reserved for future use.
1E	1	TEMPA	Used by monitor.
1F	1	TEMPX	Used by monitor.
20	1	TEMPX1	Used by monitor and for arguments of some system calls.
21	1	TEMPX2	Used by monitor and for arguments of some system calls.

Bob Coates concentrates on the 6805 and reveals some of Picototors secrets in his next article.

LETTERS

DESIGN COMPETITION

In case anyone who has entered your design competition is still undecided about what to do, I would like to make a suggestion.

In a noisy environment the normal ear can shut out the unwanted sound, enabling a conversation to be carried on without much difficulty.

Interpose a hearing aid or any microphone – amplifier – receiver combination for that matter and the ability to discriminate is lost. All we hear is the loudest noise.

Anyone who can overcome this will earn the undying gratitude of the hard of hearing.

D. Wattson
Hayfield
Derbyshire

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 are 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 department, especially with the increasing emphasis on community care.

I hope this will be taken up.

E. M. Cohen
Southend-on-Sea

'WASTE' OF A RESOURCE

May I suggest a new cause that *Wireless World* with its new-found sense of social responsibility may care to take up?

This is the almost incredible waste of a precious natural resource – the radio spectrum – on what can only be described as pap at its mildest and sheer rubbish at its worst. If one tunes across the medium-waveband in any part of this country today, all that can be heard is the same type of "chat-show, DJ, phone-in", repeated ad nauseam from what seems to be hundreds of stations, all identical except for their names and the occasional reference to some local event or other. Some put out adverts for local businesses and call themselves "independent" stations, others advertise themselves and claim to be the BBC. Radio 4 has absconded to long-wave, Radio 3 has been relegated to a single frequency and ruined by continuous fading even in daylight, and the scene is not even enlivened by the occasional "good music" station, as in the USA. In fact, as a frequent visitor to the USA, it seems to me that from a situation 20 years ago where we could be rightly proud of what the BBC was doing, we have completely degenerated to the point where almost any large American city has more real choice than we do.

What I object to is the sheer waste of frequencies. We have been told repeatedly over many years whenever some new form of public service broadcasting was suggested that the real problem was lack of frequencies, so they never came to anything, yet now we seem to have found (by magic, apparently) that there are in fact huge numbers of channels totally unoccupied and just waiting for another pap station to occupy them.

I have in mind, particularly, continuous weather broadcasting of the "Airmet" variety. "Airmet", you may remember, was a long-wave station that transmitted continuous weather reports for a large number of stations throughout the UK, interspersed with interpretation by a forecaster. Nominally for the benefit of aircraft, it was chased off the air in 1950 by, supposedly, the Copenhagen Plan, which re-allocated its frequency (245 kHz) to Copenhagen. There was a considerable outcry at the time, quietened down somewhat by the reassurance that as soon as an alternative frequency could be found it would be re-instated. Needless to say it has not been.

Now this was a particularly useful bit of true public service broadcasting. Being in plain language, on an easily accessible frequency, it needed no specialised equipment and eliminated all the business we now have of trying to remember at what time on what channel the weather forecast is. Unless you happen to have specialised knowledge and can use the h.f./s.s.b. civil and military weather broadcasts, there is still no way to get up-to-date actual weather reports country-wide. And yet, how many disasters do we still have attributed to some poor chap's lack of knowledge of how the weather was developing? A continuous broadcast on the medium waveband might just prevent some of those hikers or sailors starting out in the first place, and save the expenditure of large sums by the rescue services.

Of course, none of the existing broadcasters would want to organise it – it is unglamorous and might not pay – but how about the Government itself doing it?

This is only one example, but there are many others. Come on, *Wireless World*, this one might even have a better chance of success than some of your other causes!

W. Blanchard
Dorking
Essex

TELECINE SCANNING

Is it not time that, even now, after all these years of the growth of tv, something could be done to adjust more sensibly the 35mm telecine scanners of both BBC and the IBA companies. I have the impression that for a large number of years the SMPTE standard has been used, but unfortunately this results in excessive underscanning of the film frame, titles becoming far too close to the picture edges, in some cases even being partially cut off. Credits such as "irected by" at times being the result. Even famous names have been "shortened" on occasion.

In cinemas in pre-CinemaScope days when screens were all 4 × 3 ratio this problem did not arise. When one considers that domestic tv receivers almost always overscan the picture tube (all the ones I've seen – except mine – do) the present excessive underscanning by the broadcasting authorities telecines is completely unwarranted.

Surely the solution is to line up to the traditional scanning area of standard 35mm projectors. This will result in correct framing and compostion as intended by the original film makers. Incidentally there would be an added bonus (albeit only marginal) in that the definition would be improved.

Who will pursue this?

Arthur Dungate
Hounslow
Middlesex

BINAURAL RECORDING

I want to give some comment on Mr Kirkham's letter in *WW* June, 1983. First of all I want to deal with the "oddities" he discovered in the schematic diagram given in my article in *WW* November, 1982.

Driver stage for the 600Ω load

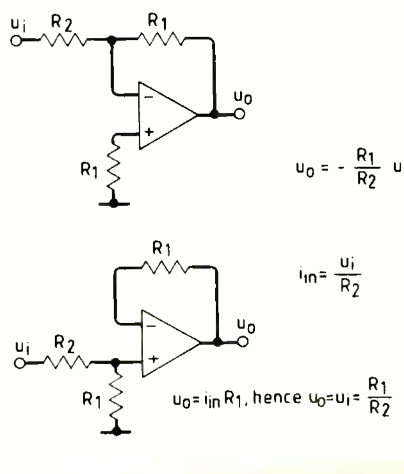
This stage was designed to operate with $1V_{peak}$ input voltage, with an overload margin of some 10 dB, and a flat frequency response up to 50 kHz. Therefore the output can make excursions between the power supply-lines. This requirement cannot be met by most op-amps, hence the class-B output stage. This opened the way to the use of a somewhat "funny" amplifier, the LM 3900, which is a Norton amplifier. This reduces the number of switch contacts, and reduces the number of resistors. The a.c. analysis of a typical Norton amplifier is given below.

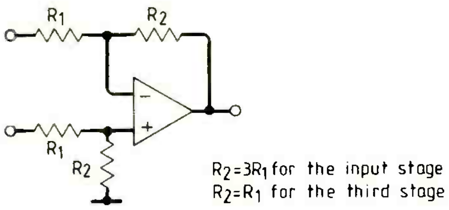
This shows that the amplification of the first stages is 3 in both modes, and that the third stages are 1×amplifiers in both modes.

Second amplifier stage

The second amplifier has to have the following characteristics: low noise, because the output of the cross-feed circuit is 0.01× the input signal; frequency characteristic flat up to 50 kHz. These demands are met by the LM387, which has an equivalent noise voltage of $7nV/\sqrt{Hz}$. This single supply amplifier however has a somewhat peculiar behaviour. The input presents a 1.2V d.c. level, which by means of d.c. feedback controls the d.c. output level. This explains the split between d.c. and a.c. feedback, and the 1μ capacitor on the input. Mr Kirkham is correct however, when he indicates that the switch was wrongly positioned. This was corrected in *WW* of January 1983.

The circuit as published in my article (*WW* Nov 1982) can be approved upon by using TL074 (or equivalent) because LM3900 is prone to high frequency instability, which generates noise. However, the circuitry has to be changed considerably, else you will end up with





wrong amplification factors. Part of the circuit is given below.

Now about the use of the circuit described in *WW* November, 1982. It is intended to give loudspeaker-like reproduction on headphones, or headphone-like reproduction on loudspeakers. This is something totally different from what Mr Kirkham is looking for. He is looking for some "gadget" that enlarges the stereo-base. The circuit he provides does just that, and nothing more.

When Mr Kirkham suggests that a simple roll-off at 1kHz would very likely generate the same audible effect as my circuit, I think this will not be the case. This is caused by the fact that no account is given to the difference in arrival-time of the sound of a single source on the left and right ear, and that no account is given to the high frequency lift generated by the presence of the head. Because of the cross-feed circuit used by me (and developed by Mr Bauer of CBS in 1961) does just that, one ends-up with a good reproduction of dummy-head (*kunstkopf*) recordings via loudspeakers, and loudspeaker-like reproduction of conventional stereo via headphones. These are facts that the circuit given by Mr Kirkham cannot achieve.

J. H. Buijs
Huizen
Holland

WAVES IN SPACE

I refer to the correspondence in the August issue concerning Catt's "Waves in Space", (March, 1983).

Ivor Catt has, for some years, been proposing new explanations of electrical phenomena which many regard as already fully explained by classical e-m theory; theory which unfortunately has become dogma because few have bothered to question its tenets in those areas where its teachings give rise to curious and unexplained paradoxes.

Correspondents who try to put Catt down generally throw up a dogmatic smokescreen whilst often failing competely to address themselves to the apparently paradoxical events he has attempted to explain. The latest correspondence concerning "Waves in Space" is no exception. R. T. Lamb's letter gives no real explanation of the phenomena that Catt discussed and simply fluffs the issue of pulse duration with a remark about the charged line being an energy storage device rather than a source of e.m.f.

Timothy C. Webb's letter puts a finger on one important issue when he asks why Catt's contra-moving waves are not destroyed by line losses, but he fails to ask whether conventional energy dissipation due to line loss applies to these contra-moving waves. I suspect Catt thinks otherwise and it would be interesting to have his views.

In other respects Mr Webb's letter falls into the dogma trap. There is a resounding bit about "The great body of scientific and engineering knowledge that has amply demonstrated . . ." etc., etc. Dr Catt has quite reasonably asserted that the great body of scientific and engineering knowledge has singularly failed amply to demonstrate some of the things it purports to explain! At the end of his letter Webb gives what I found to be an incomprehenisble explanation of the pulse duration problem and then rounds this off with a remark about the "pleasing aspect of this argument . . ." etc. I was not very pleased because I could not make head nor tail of it!

Hodge's letter is perhaps more thoughtful but again it does not seem to explain the phenomena which Catt discussed in his article.

Catt's theories may be wrong but he is certainly right to shine lights into some of the dark and deceiving corners of classical e.m. theory. One would like to see more reasoned arguments advanced in refutation and less reliance on the "dogma must be right" approach which, incidentally, rather neatly mirrors the discussion on the "closed loop arguments", (said to be used to support relativistic dogma), given in an unrelated letter from A. H. Winterflood in the same issue of *Wireless World*.

Anyone who thinks he knows all about electricity should also read Professor Jennison's article on making a charge from a radio wave!

M. G. T. Hewlett
Midhurst
W. Sussex

CRAFT AND TECHNOLOGY

In your July issue, under the above heading, Dr Smith purports to "discuss the role of the industrial designer". As a craftsman myself, with some experience in engineering and industrial design, I was disappointed to find that the discussion amounted to one paragraph, where he says that "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 (but) many mass-produced goods disguise themselves in poor design, however good the technology incorporated in them".

The main body of the article is entirely devoted to a "bracket clock of modern design, with fine traditional metalwork mounted in a handcrafted case of amber-tinted transparent acrylic (with) silvered chapter ring, brass spandrels and finials . . . finely engraved and hand finished . . . (giving) the impression of being a traditional English timepiece while using modern materials.

The maker of this article, which is shown in an illustration said, in answer to a question: "Contemporary artists and craftsmen must use modern materials and mould them to give a message of what we are doing now". The author justifies the printing of this article in *Wireless World* by saying that the clock "although it originated in a cottage industry established by a craftsman, uses a very up-to-date quartz drive . . . (and) bridges the gap between fine individually made objects and anonymous mass-produced (although highly technological goods". He says "the success of this design encourages me".

Well, it doesn't encourage me! What if someone were to make a modern electric locomotive look like a steam loco. Or an automatic washing machine like an old dolly-tub, or a steam smoothing iron look like the old flat-irons?

As a matter of contemporary fact, mass-produced pseudo-traditional clocks very like this handcrafted piece are the most astonishing feature of a modern city shopping centre. Industrial design seems to have by-passed clocks, except for the occasional pocket digital alarm-cum-stop-watch-cum-almost-everything in precision timing.

An instrumentation engineer myself, with somewhat disused craft skills of my own, I just love old clocks and measuring instruments, and the fine old instrument work that still lingers in a few old college laboratories. But this kind of modern mechanism deliberately dressed up in old clothing is the very antithesis of real craftsmanship, which in every age has always used the very best techniques and materials available at the time, and allowed the craftsman to express himself superbly without a single note of falseness or deference to an archaic traditionalism.

Does anyone suppose that clocks and other artefacts like the one described in this article will be admired by connoisseurs, or reproduced by artist-craftsmen one or two hundred years hence?

I am sure we are in for a resurgence of fine craftsmanship (if we survive long enough), if only to fill in the time of our structural unemployed. But I am equally sure it will not be dissipated in copying antique objects of beauty, or clothing high technology in resurrected 'traditional' forms.

R. Gill
Derby

RECORDING TELETEXT

Speaking recently by telephone to one of your technicians doubt was expressed about the possibility of recording teletext pages and subtitles on a domestic video recorder.

I thought that it might be of interest that I have quite successfully recorded using a teletext decoder from Ayr Viewdata of Byfleet, who advertise in your journal, this being simply tuned through a spare channel on my Toshiba V8600 video recorder.

There is a slight reduction in quality by using an adaptor rather than a teletext tv and, though pages are in full colour, subtitles are in black and white to save cost on the decoder. Results are pretty good and quite acceptable to the viewers.

This facility is valuable to people who are suffering from hearing problems and particularly those who would like to record a subtitle programme being shown at an unsociable hour or clashing with one on another channel.

Since it is available at approximately one third of the current price of a 22 inch teletext tv, I am amazed that manufacturers and dealers are not pressing sales of the decoder for people who already have a modern tv without the teletext facility.

N. Gibson
Burgess Hill
W. Sussex

IMPOSSIBLE LOYALTIES

Referring to your May editorial, the ethical problems of conflicting loyalties may have come to *Wireless World*'s attention only in 'the perilous 1980s', but people have been grappling with these questions for some thousands of years. To make a useful contribution, *Wireless World* should perhaps give them rather more careful thought than is evident in the editorial.

There seems no case for saying that loyalty can exist only between people. Loyalty is given to ideas and principles, not to people as structures of flesh, bones and hair nor to organizations as management structures. Ideas and principles may be embodied by organizations as much as by people: surely an organization such as The Red Cross must be allowed as an example of this.

The argument that organizations are motivated only by self-interest can be applied equally to people. One can say that any person's good action is done ultimately for the resulting glow of self-satisfaction, but this is a sterile line which puts an end to any useful debate.

Wireless World seems very ready to judge for us whether our loyalties are worthy or not. Are you, or is anybody, really in a position to dismiss as unacceptable the possible loyalty of a wife to her mass-murderer husband? In any case you are really suggesting only the replacement of conventional allegiances by loyalty to the concept of 'Engineers Against Evil.' If some engineers decided to uphold their principles with action rather than just words, you might even find yourselves advocating loyalty to a terrorist group!

D. P. Leggatt
Farnham,
Surrey.

DEATH OF ELECTRIC CURRENT

I believe Ivor Catt bases his theory on Heaviside's "the current in the wire is set up by the energy transmitted through the medium around it."

Chapter ten of Hertz's book 'Electric Waves' is a reprint of his paper 'On the Propagation of Electric Waves by Means of Wires' first published in 1889, a year after the experiments which made him famous. The purpose behind the experiments described in this later paper was to test Heaviside's and Poynting's theory that, as Hertz wrote, "the electric force which determines the current is not propagated in the wire itself, but under all circumstances penetrates from without into the wire. . . ." Hertz went on to say "As a matter of fact the theory was found to be confirmed by the experiments which are now to be described; and it will be seen that these few experiments are amply sufficient to support the conception introduced by Messrs Heaviside and Poynting."

Hertz then described a set of experiments which used his invention of the coaxial cable and the balanced feeder or transmission line, and concluded his paper, "On studying the experiments above described, the mode in which we have interpreted them, and the explanations of the investigators referred to in the introduction, one difference will be found especially striking between the conception here advocated and the usually accepted view. (Weber's theory of electricity carried by charged particles acting instantaneously at a distance.) In the latter, conductors appear as the only bodies which take part in the propagation of electrical disturbances – non-conductors as bodies which oppose this propagation. According to our conception, on the other hand, all propagation of electrical disturbances takes place through non-conductors; and conductors oppose this propagation with a resistance which, in the case of rapid alternations, is insuperable. We might almost feel inclined to agree to the statement that conductors and non-conductors should, according to this conception, have their names interchanged . . . "

Hertz was even more specific in his Supplementary Note No. 24. "By the experiments in the following paper it is pretty plainly proved that in the case of rapid variations of current the changes penetrate from without into the wire. It is thereby made probable that in the case of a steady current as well, the disturbance in the wire itself is not, as has hitherto been assumed, the cause of the phenomena in its neighbourhood; but that, on the contrary, the disturbances in the neighbourhood of the wire are the cause of the phenomena inside it."

Catt's critics have a choice: either Hertz was a crank and a crackpot, or he was, as an experimenter and detective, in the same class as Faraday. If Hertz's diagnosis of his experiments with a transmission line is correct, the effect we call a current is caused by "the disturbances in the neighbourhood of the wire," what, in the neighbourhood of the wire, is being disturbed? Maxwell's ether?

M. G. Wellard
Kenley Surrey

ELECTROMAGNETIC DOPPLER

If two objects have a relative velocity then the distance between them is changing (by definition). Anything that travels from one object to the other at regular intervals will travel different distances on successive trips. If the two objects are travelling away from each other then each trip will be longer (in distance) and will take longer (in time) unless the thing making the trip (wave crest, photon, bullet, or jogger for that matter) increases its speed to compensate for the increased distance. The fact that consecutive trips take longer (in time) means that consecutive arrivals are further apart (in time) than the corresponding departures. This is called the Doppler effect.

Special Relativity and Newtonian physics predict different values for the Doppler effect: they do not invoke different mechanisms. The mechanism is that unless you increase your speed you'll take longer to travel a greater distance.

You don't have to like Special Relativity but you must accept that it "explains" Doppler shift just as well as Newtonian physics does – indeed, the "explanation" is the same for both systems.

In your July issue, S. Kennaugh derives a formula for the magnitude of the Doppler effect. He describes his derivation as commonsense, elegant, but heretical. His derivation is Newtonian and relies on two assumptions (velocities can be added like pure numbers, and wavelength of a electromagnetic wave is constant to all observers) that are valid for Newtonian but not for special Relativistic physics. Neither of these assumptions is needed – I offer the following: Observer B is receiving radio signals transmitted by A at frequency f. A is moving at velocity v relative to B. "Wave crests" are transmitted at intervals of 1/f, during which time the distance from A to B increases by v/f. This extra distance is covered in time v/fc (c being the velocity of radio waves measured, like v, relative to B). Wave crests arrive at B at intervals of (1/f + v/fc) which corresponds to a frequency of fc/c+v – a Doppler frequency shift factor of c/c+v.

This derivation is correct for both Newtonian and Special Relativistic physics – provided that all values are observed by B. Note that (aside from the symbol 'c' for speed of wave propagation) there is nothing specific to electromagnetic Doppler in this derivation; it is equally correct for sound waves, or for any periodic transmission across an increasing distance.

In your July issue, J. Kennaugh raises another aspect of Special Relativity: suppose that the same radio wave is observed by two observers who are moving relative to each other. They each observe a different frequency for the wave but they observe the same propagation speed (c). Since $V = f\lambda$ holds good for all observers, these two observers obtain different wavelengths for the same wave. The two observers disagree about the length of the same physical "object". J. Kennaugh, it seems, does not like this prediction of Special Relativity. Although I can only agree with JK that Newtonian physics is simpler in many ways than Special Relativity, that doesn't make it correct.

In case your readers should think that I'm trying to avoid discussing the more disturbing predictions of Special Relativity, let me return briefly to the question of observed wavelengths. Special Relativity predicts (as pointed out by JK) that two observers of the same wave will see different wavelengths. Imagine now that one observer measures the time taken by the radio wave to travel between two objects at a distance of say in wavelengths apart. The other observer times the same radio wave travelling between the same two objects. Now Special Relativity predicts that the two observers measure a different distance (between the same two objects) traversed by the same wave at the same speed. They measure a different amount of time for the same physical event!

Predictions like these may be hard to understand and even harder to believe but it is important to realise that they are not contrary to logic. I'm sure that nothing I can say will shift JK (and many many others) from his view that Special Relativity contains some basic logical flaw, but if you are happy to continue publishing our letters then I am happy (for a while, at least) to continue defending Special Relativity.

Before I finish this letter I must challenge two things raised by James L. Smith also in your July issue. Firstly he suggests that the existence of a wave propagation medium (ether) changes the observed Doppler effect; as I've already explained, this is not true. Secondly he offers a choice between "Einsteinian" and "Non-Einsteinian" systems; this is a ludicrous oversimplification – Einstein proposed at least two systems (Special and General Relativity) and there are almost unlimited alternative (non-Einsteinian) systems – some predict an "ether", others do not.

S. J. Hobson
Hampton
Middlesex

HERETICS' GUIDE

It is reassuring to hear that the idea of the wave/particle duality or complementarity of light, "current half a century ago" (and chosen by Niels Bohr as his motto when knighted by the King of Denmark), is no longer a required belief in modern physics. Yet Mr Coleman (July 'Letters') continues to rely on the duality concept, even in this letter. In his fifth paragraph he refers to Doppler shift, a wave phenomenon (incidentally, is it really the ordinary conductivity electrons that radiate with this Doppler shift, and how is it measured, please?); then he speaks of "a photon hitting the surface of a metal" and of "an area comparable with the square of its wavelength" in the same sentence. Duality may be dead but it seems reluctant to lie down!

I asked earlier why it was that only one of these (millions of) electrons is ejected by the impact of a single photon. Mr Coleman says the answer is simple, but he does not supply it. The work function (escape energy of a conductivity electron) from a metal surface is measurable, and no visible or ultra-violet photon carries more than a few times this escape energy. If that energy were distributed equally or even thermally among millions of electrons not one of them would have enough energy to escape – yet one of them does. Why? The quantum theory does not try to explain this but, characteristically, side-steps the real question by *assuming* the observed result.

The bunching of visual photons measured by Dontsov & Baz' (*WW* Letters, May, 1983) may perhaps assist in accounting for the interference phenomenon, but it is not required in order to explain the so-called "diffraction" of electrons or gamma-rays. (I have not felt entitled to ignore such facts – indeed, the early articles were concerned with little else!). The mechanism need not be wavelike. In a pin-ball game the ball bearings follow preferred tracks and finish up in preferred places that are predictable statistically but unpredictable individually. This is just what is observed when electrons and photons pass through crystals and are "diffracted". A pintable doesn't look much like a diffraction grating to me.

W. A. Scott Murray
Kippford-by-Dalbeattie
Galloway

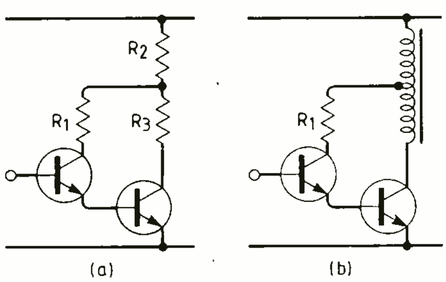
Dr Scott Murray on page 35 of the May 1983 issue of *Wireless World* uses the seepage of water through sand as an analogy for the tunnel effect. A more satisfactory analogy is that of frustrated total internal reflection of light waves.

N. A. de Bruyne
Princeton
New Jersey
USA

DARLINGTON DEVIATION

Mr Gray has pointed out (*WW*, March, 1983, p.62) the limitation of the Darlington in saturation and the advantage of the independent emitter-follower drive. When the main transistor is a power switch, and more especially when it is one of the devices which is operated at $I_b = I_c/5$, an intermediate configuration offers advantages.

The general form is shown in Fig. (a), and (b). In Fig. (a), R_2 and R_3 form the load to be heated. It is obvious that R_2 carries the total current in the two transistors. Provided that the first transistor is robust enough to accept a wide



(a) (b)

tolerance of current, the drop in R_3 need only be ($V_{CE\ Sat\ 1} + V_{BE2} - V_{CE\ Sat\ 2}$), about half a volt, and the load current is then, for the typical case, increased by some 10-15%. The introduction of R_1 gives better control at the price of lower efficiency.

When an output transformer is used, the circuit of Fig. (b) allows the drive transistor to be limited to anywhere between V_{CC}, for the emitter follower form, and $2V_{CC}$ for the Darlington.

T. Roddam
Arundel
W. Sussex

SATELLITE TV AERIAL ALIGNMENT

I must agree with all the difficulties that N. L. H. Cresdee describes in directing a satellite aerial dish. The problems are especially acute using the 12GHz band, with necessarily large dishes at present in use. In addition, if the receiving lens or reflector is slightly off-focus or boresight, the lobe pattern of the aerial is quite disturbed and you can easily end up optimising for a false or poor maximum.

However, there is one invaluable aid, both to directing and focusing that was not mentioned, and that is the sun. Far from the rarity it would appear to be in the UK, a visual sighting of the sun reflected on to your receiver lens will give you a positional fix close to that of the satellite orbit. The accuracy of this fix depends solely on your ability to know or calculate the local Solar Time.

J. Emmett
Supervisory Engineer
Thames Television

Sundials: Their Theory and Construction. A. E. Waugh, Dover.

RECHARGEABLE H.T. BATTERY

OVER recent months it has been my task to sort over the "debris" of 60 years of life of one family in the one house. One particular item that I have "found" is a Milnes rechargable h.t. battery (6×120 volt) that I know for fact has not been recharged or used in any way at all since 1956 – and almost certainly was last charged not later than 1952. Imagine my astonishment when a quick check with a multimeter revealed that several of the individual cells still – after 30 years or so – show a potential of at least one volt. I am writing to your journal because I know that your circulation penetrates those institutions where the "brains" are. Someone, somewhere – possibly engaged in storage battery research – could well be interested in this Milnes unit. I feel it would be criminal of me to cast it onto the rubbish heap without first making the effort to put it where it perhaps could be of use. I had over 35 years in radio communication and I only ever saw just two Milnes in my life – this one that my father bought sometime in the 1930's and one other where I first worked in 1943 at Somerton Radio Station: there cannot be very many in existence. I feel that a high percentage of those engaged in radio and electronics today would not even know what it was if one showed it them – hence my approach to you.

W. B. Pash
Somerton
Somerset

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 comparision 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, if 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

BBC ENGINEERING

May I reply to R. G. Brown (June 'Letters') whose letter I certainly take as constructive criticism rather than abuse.

First of all, most non-news recording in the BBC today is effected on 1 in helical machines, the earlier 2 in quadruplex equipment being progressively phased out. The technical quality obtained with the 1 in helical system is unquestionably superior to that on quadruplex.

Secondly, a lower standard of recording quality is sensibly accepted for e.n.g. work, in the interest of portability. But e.n.g recording quality could not possibly be matched by a domestic video recorder.

So equipment and engineering standards can certainly not be blamed for Mr Brown's dissatisfaction.

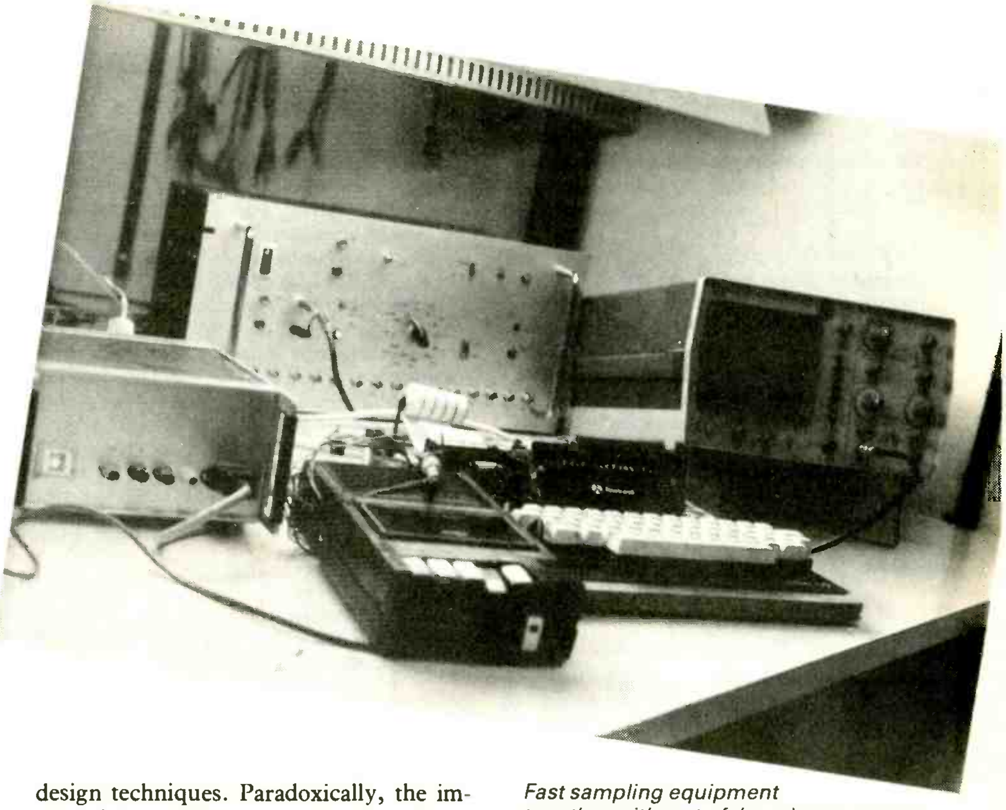
On the other side of the coin, programme makers will always push their technical facilities to the limit. Any improvements in effective sensitivity (ie signal/noise ratio) or other technical parameters will tend to be exploited to give additional programme flexibility in the way of darker or higher-contrast scenes, even more multi-generation dubbing for editing purposes, and more complex special effects. This push for flexibility is very proper and it is the business of engineering to continue with improvements which offer it; but of course a balance must be struck between programme flexibility and technical quality, such that the major part of our audience is pleased with the former and content with the latter. I'm sorry if to Mr Brown's eye we have overstepped the line at times but the final judgements are subjective.

As engineers we remain continually vigilant to see that the flexibility/quality balance is about right. Comments such as those of Mr Brown are useful aids to this vigilance.

D. P. Leggatt
Engineering Information Department
BBC
London

Process control by personal computer

Although most of the general-purpose process control systems still use proportional-integral-derivative algorithms, control techniques which have been too expensive or too complicated to implement not long ago are now made possible using a microcomputer.



Fast sampling equipment together with rest of the microcomputer system – Rockwell Aim 65 keyboard, external memory, power supply and oscilloscope.

This article covers the operation, design procedures and the applications of a microcomputer-based digital dynamic control system (d.d.c.) and underlines how the addition of a simple analogue interface on a small personal computer allows the designer to be come familiar with the digital dynamic control techniques in a real (not simulated) environment. The system described consists of an eight multiplexed input a-to-d converter, a d-to-a converter with power outputs and a six input adder. Thus multiple feedback controlling only one output variable is possible. Alternative interfaces are also described; their object is acquiring data and simplifying the software which the microprocessor needs to make data conversion.

Digital process control ousts analogue

The history of automatic control, from the use of ingenious pneumatic controllers to the present-day d.d. control systems, has spanned almost half a century. This evolution has not been the result of a continuous transformation but the consequence of an acceleration-stop process which has been technology's main characteristic since the second World War.

Neither has this evolution occured without controversy: the technological changes have originated many and sometimes serious polarizations in the designer's opinion. They can be classified into two main controversial groups, the first being an immediate consequence of the technological change. Concerning the control hardware selection, it is generally solved assuming that the ultimate decision is purely a marketing decision. Innovations in hardware often act like perturbations in the decision system.

The theory-practice gap evident in many applications constitutes the second controversy and is the most relevant characteristic in the recent history of automoatic control. On the other hand, theory and technology have evolved side by side; from the idea of feedback as a starting point, control theory has developed powerful analytical tools and efficient controllers design techniques. Paradoxically, the impact of these achivevments has been almost insignificant in the field of industrial applications. Thus p.i.d. action – which has been the main process control algorithm since the beginning of automatic control – still has worldwide acceptance. An inquiry made in USA in 1978 into the control type used by the analogue controllers then in use revealed that 34 out of 37 listed controllers were p.i.d., either exclusively or with options for proportional-integral or proportional actions. Satisfactory performance in the properly tuned p.i.d. controllers caused other control options to be relegated, whereas electronic technology could have made them possible.

by E. Bertrán, L. Martinez, J. Miguel and I. Munilla

It has not been exclusively a problem of mistrust in the theoretical proposals; an algorithm more sophisticated than p.i.d. implies a more complex and expensive analogue controller. The close relationship between algorithm and hardware complexity didn't allow the practical application of most theoretical models until the introduction of the digital computer. But not until few years ago could designers count on a real, economical and flexible alternative to the use of p.i.d. analogue controllers. Thus microcomputer-based digital control is competitive even in the area of small applications.

In a direct digital control system the microprocessor performs the controller tasks. The control becomes control by program instead of hardware control by analogue filter. Algorithm complexity is no longer related to the system price but to the computation time, namely to the output delay which constitutes a basic parameter in closed-loop systems. Neither does control sensitivity depend on filter component tolerance, but on computation accuracy (round-off, number of bits representing every coefficient, etc.). Old restictions disappear while new design factors arise. And finally, software flexibility allows selection of the appropriate algorithm, adoption of a control strategy which allows alternatives (for instance, starting and

Professor Bertrán and colleagues are in the Department de Sistemas de Control, Escuela Téchnica Superior de Ingenieros de Telecomunicación, Barcelona, where they teach circuit theory and systems control.

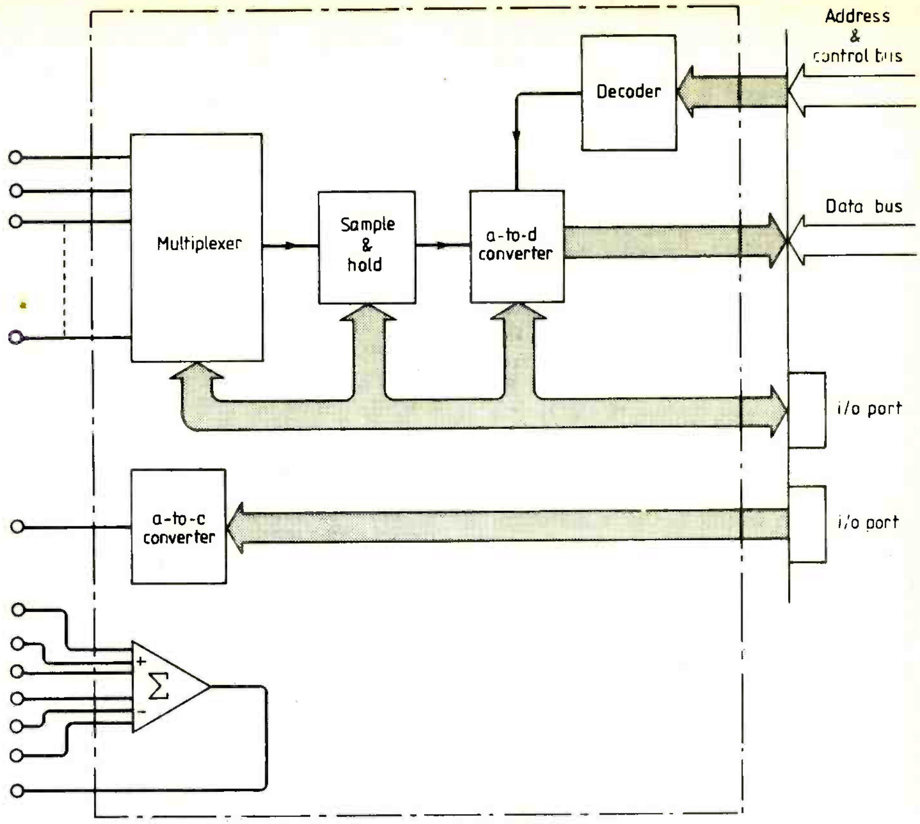
steady-state), program linearization of transducer characteristics, etc.

The small personal computer is a very useful tool for designers' practical initiation into d.d.c. techniques and it is mostly used for running either standard programs (e.g. video-games, file-handling) or the users program. Its outer communication is basically limited to the input and storage of data and programs, and to the display. By adding appropriate input/output devices and by means of a special program, this computer can perform the real-time control of anv outer device. The small personal computer can therefore be used as a calculator (analysis or design programs), as a simulator (simulation programs with graphical results), and as a controller (real-time control programs).

Equipment scheme and performance

An analogue control interface for the Rockwell Aim-65 microcomputer system has been implemented though the design is easily adaptable to any other computer. It uses eight multiplexed inputs and one output, and has been designed to control low-power devices. Its structure corresponds to the very general functional scheme of Fig. 1.

The analogue input consists of several modules whose performance is controlled by the microcomputer through an input/output port. The multiplexer selects one of its input signals and applies it to the sample and hold circuit whose aim is holding a sample at a fixed voltage during the a-to-d conversion time interval. The converter provides a digital representation of the value of every sample by using a limited number of bits (eight in this case). A decoder allows the microcomputer to read the digital samples through a specific memory address which belongs to the memory space not occupied by rom, ram or other addressable devices. The analogue output consists basically of a d-to-a converter. The microcomputer writes the digital values in an output port which is connected to the above-mentioned d-to-a converter. Finally, an analogue adder

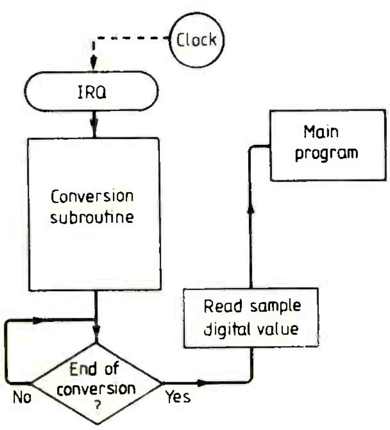


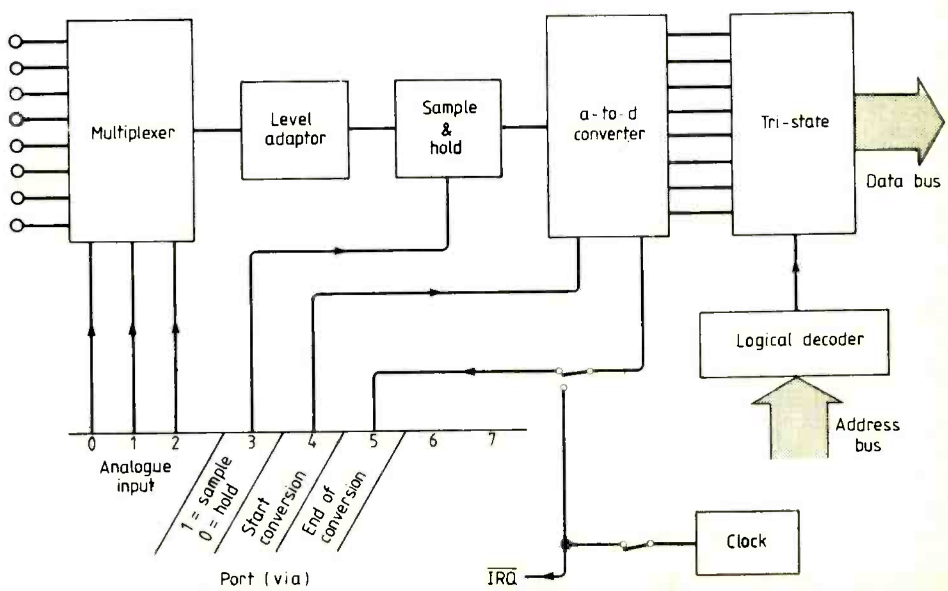
***Figs 1 & 2.** Functional scheme of the analogue interface (above) together with its detailed system performance (below).*

(Σ)with three adding and three substracting inputs has been incorporated.

The microcomputer system performs the control of the analogue input through the so-called v.i.a., a set of programmable input/output ports, owing to the use of the AIM-65 system. The sequence of tasks for the acquisition of one sample is given below:

1 *Programming of v.i.a. port A,* implies that PA_0, PA_1, PA_2 and PA_4 will be the outputs and $PA_5$the input.
2 *Selection of an analogue input.* According to the binary combination PA1, PA_0, PA_2, one of the eight possible inputs is chosen.
3 *Order of sampling:* A 'one' is loaded in PA_3.
4 *Acquisition time.* A minimum time t_A of 5μs is needed to ensure that the sample and hold output be equal to the input.
5 *Order of holding.* A '0' is loaded in PA_3.
6 *Delay of opening.* A minimum time t_H of 1μs is required to ensure a fixed voltage in the sample and hold output.
7 *Beginning of conversion.* Once the input signal analogue sample is obtained, i.e., t_H microseconds after the 'hold' order, the microcomputer gives the order 'begin of conversion' to the a-d converter by loading a '0' in PA_4.
8 *End of conversion.* The microcomputer remains in a waiting state until the end of digitization, indicated through PA_5. Therefore it will test either continuously that bit state. By varying the jumper position, the microcomputer may execute other program tasks without making any test since it would receive the end of conversion indication as if it were an interrupt request.





9 *Reading of the sample.* Once the end of a-to-d conversion is verified, the microcomputer reads the results in a memory position whose address is determined by the logical decoder. This decoder also activates the tristate buffer connected between the a-d converter ouput pins and the data bus. Fig. 2 shows the system performance when the sampling period is fixed by an external clock and the jumper applies the signal 'end of conversion' to PA_5. Port A is assumed to be initially programmed. Whenever a new clock edge is applied, the task (main program) is interrupted to execute the a-to-d conversion subroutine. As regards the analogue output, the R-2R d-a converter is directly coupled to v.i.a. port B which is output-programmed. Therefore, an analogue signal extracting program is an instruction or a set of instructions that can modify the contents of Port B. A detailed scheme of the acquisition and extracting modules for analogue signals is shown in Fig. 3.

Design alternatives

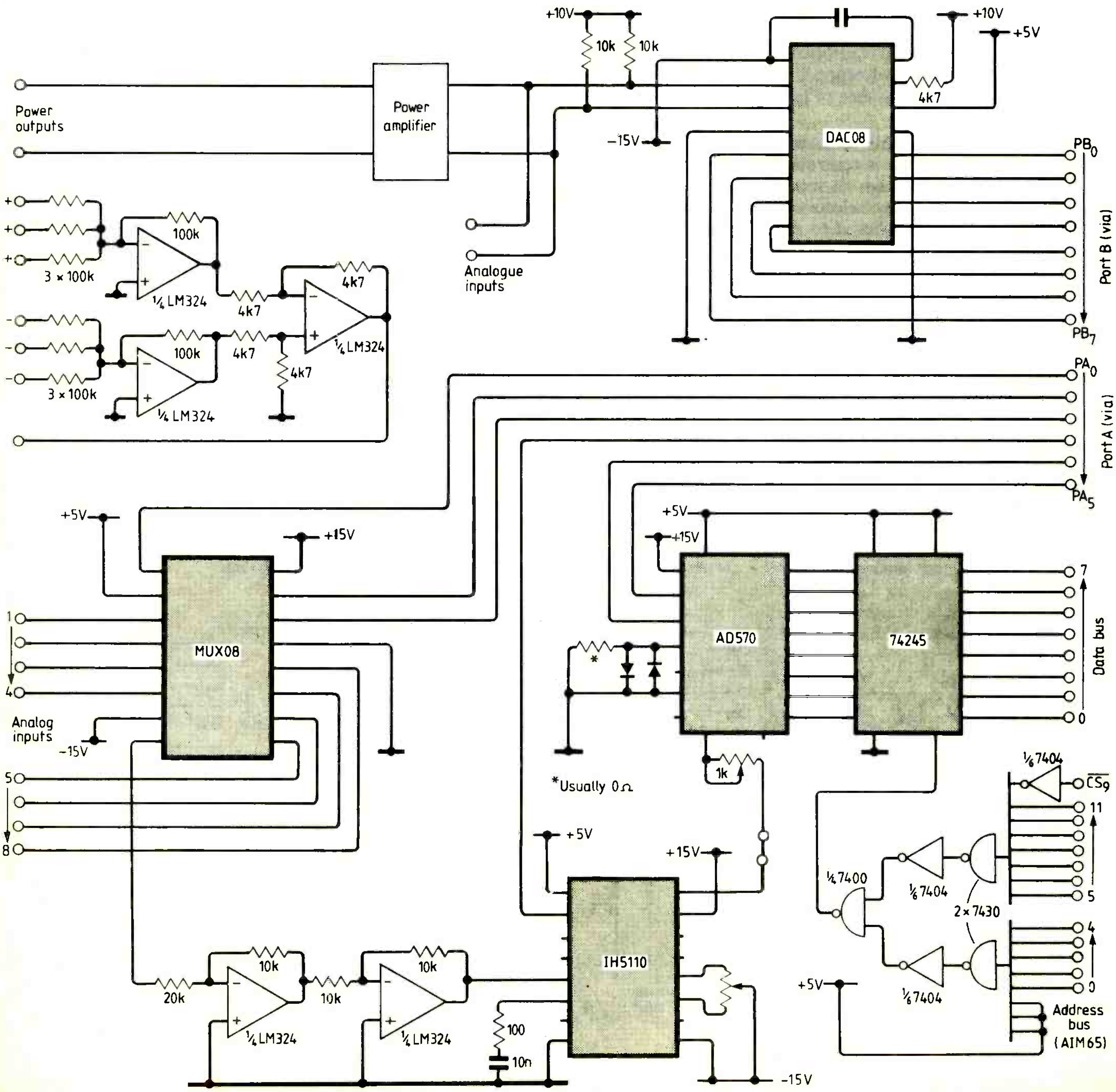
A similar equipment incorporating two cascaded monostables is shown in Fig. 4. Once the microcomputer gives the order of sampling, the orders 'hold' and 'beginning of conversion' are automatically generated after the necessary opening and holding times. This solution however, is not always optimal. In fact, in many cases it can be much more interesting not to use the monostables even at the cost of generating successively all the orders by microcomputer.

Fig. 3. Under control of port A, analogue input signals are processed by the multiplexer, amplifier and sample and hold circuit, and digitized by the AD570. Sample digital codes reach the data bus through the three-state 74245. DAC-08 performs the d-a conversion. An error adder is built separately with standard op-amps (LM324).

Another contribution of this equipment is the presence of a programmable gain amplifier which offers greater versatility by conforming the optimal range of the sample and hold performance to different possible multiplexor inputs.

Reading the digital code corresponding to the input analogue signal can be made in different ways. Fig. 5 describes the two most important ones, consisting either in the reading of the data as though it were a ram position, or in the reading through an i/o port. Choice of the method will depend on the application and, above all, on the limitations of the microcomputer.

In some applications, like supervision or processes identification, it can be interesting to dispose of a sampling unit with specific services. Fig. 6 shows the functional block diagram of an equipment for fast sampling which has been developed in the Department of Systems Control (E.T.S.I.T., Barcelona). Its performance also differs from the former because the



microcomputer initializes a counter by loading the number of consecutive wanted samples from the input signal. These samples are stored in the consecutive positions of a ram at the maximum speed allowed. While the input signal is being sampled, a d.m.a. controller carries the microcomputer to a state of waiting, this taking place only if the computer tries to accede to the ram, which is shared both by the computer and the acquisition system. Thus the information loss coming from the multiplexer is avoided.

With this equipment the rate of sampling can also be selected either automatically or by hand. It also allows sporadic transient phenomena to be registered in the ram, and pulse trains as well as different analogue signals to be generated.

Real time control constitutes the most stringent demand of the afore-described equipments. Computation lags, conversion times and operation accuracy now acquire a relevant design significance. So the basic criteria determining the microcomputer assignment can be classified as follows:

Precision grade – is proportional to the number of bits representing samples and coefficients. Quantization is modelled like an added noise to the

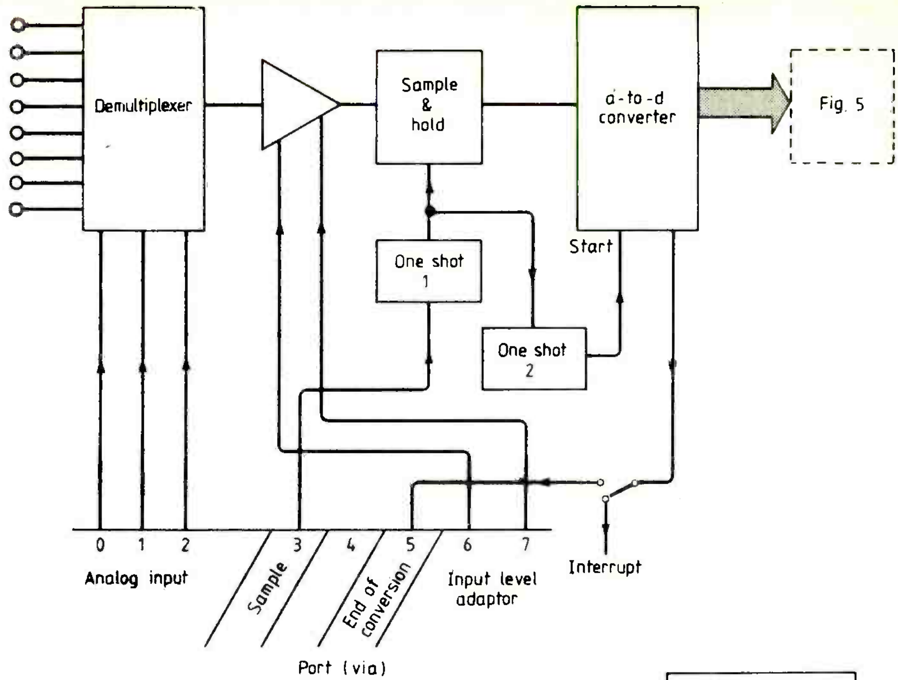


Fig. 4. Modified acquisition system automatically provides the delayed hold and beginning of conversion signals which follow the microcomputer sampling order. Two options of end-of-conversion indication can be switch-selected: a flag (bit 5) in the i/o port or an interrupt generation.

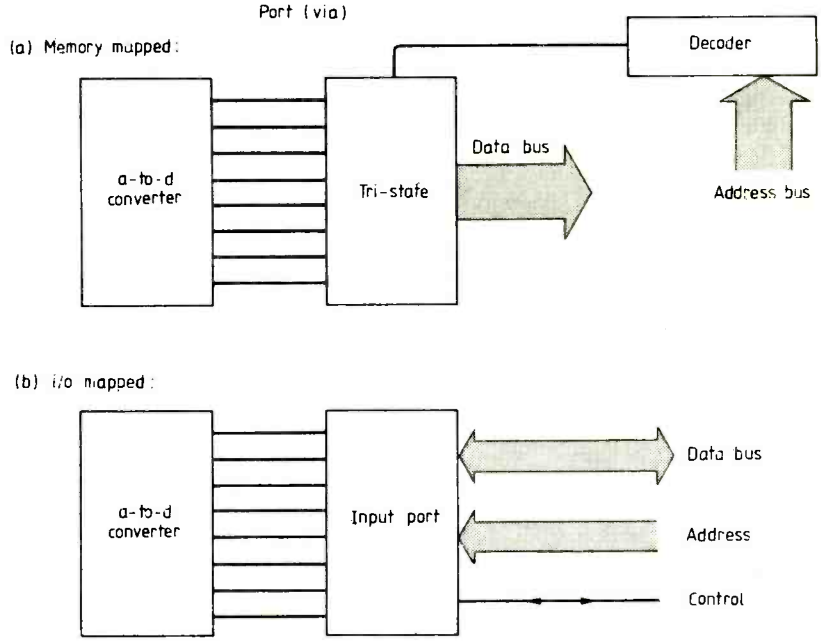


Fig. 5. Digital code-reading options: memory mapped or i/o mapped.

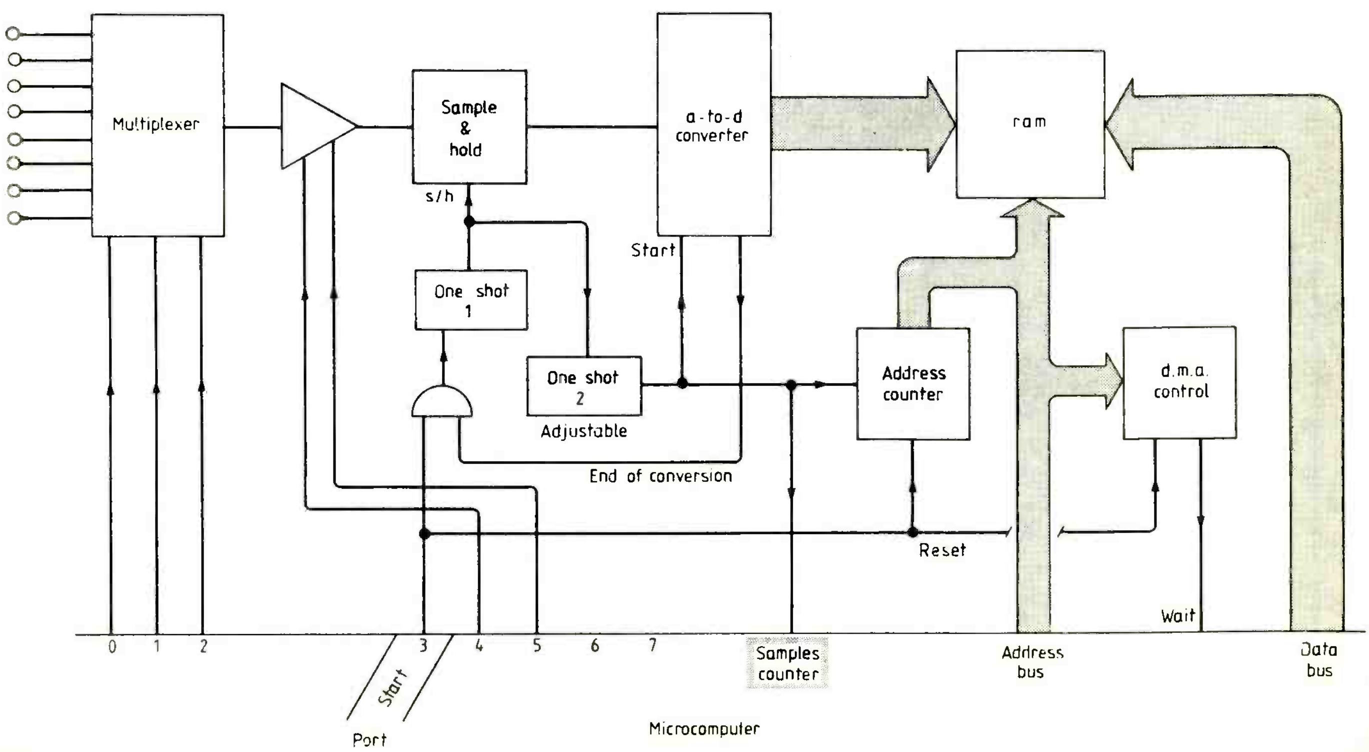


Fig. 6. This fast sampling equipment exploits the automatic generation conversion signal shown in Fig 4. The samples can be acquired by blocks of selectable length under control of the direct memory access arbiter.

designed ideal filter. It represents the round-off and truncation, both from calculations and from the filter coefficients effective value.

Maximum processing speed – is the inverse of the minimum possible sampling period. This period is calculated by considering the a-to-d conversion time, the control algorithm computation time and the d-to-a conversion time.

Precision criteria

By assuming a uniform distribution of the input samples along the whole amplitude range, an equation can be derived by relating the number of bits (n) used in the a-to-d conversion to the quantization signal-to-noise ratio in the input filter:

$$S/N_q \approx 6n \text{ (dB)}.$$

This equation applies exactly to an eight-bit converter. In general, the noise caused by internal operations can be neglected because calculations are usually made with a bigger precision (number of bits) than that used in converters. As regards the filter coefficients, if these have been calculated with a Q digits precision, P bits must be used to maintain that precision. This yields the following condition:

$$P \geq 3.3Q.$$

To express the sign, a supplementary bit is used so coefficients internally will need P+1 bits.

If a high-order filter is implemented, then it will be useful to decompose it into second-order sections, either series or parallel-coupled. Thus, global filter behaviour will be less sensitive to quantization errors in computations or in coefficients.

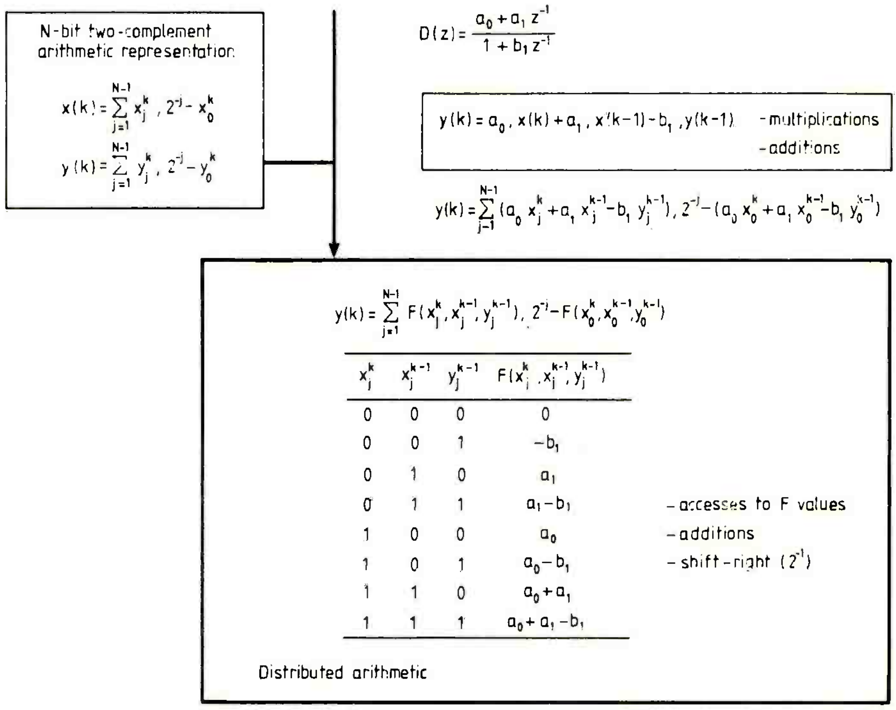
Speed criteria

By using a high-level language (Basic, Fortran, PL1, Pascal, etc.) internal operations are made with great accuracy, and as a consequence processing speed is reduced. On the other hand, using assembler language makes the speed increase at the expense of implementing operations with large arrors. This is due to the limitation to eight or 16 bits in the internal representation, which simplifies the operations; otherwise, speed would be also reduced.

A high processing speed without loss of precision can be obtained by means of a distributed arithmetic. Multiplications are substituted by accesses to table containing calculated values and additions, Fig.7. Therefore, the best services of an eight-bit standard microprocessor can be obtained at the expense of employing a great memory space (look-up tables). Thus, the antonym speed-precision changes into memory occupation-precision while maintaining the speeds. An example of the effective minimum sampling times with the AIM 65 and the equipment of Fig.1 are

- 0,2 seconds (Basic and conventional arithmetic)
- 1 millisecond (assembler and eight-bit distributed arithmetic).

These times include the conversions and the internal processing of a second-order correcting filter.



x_j^k	x_j^{k-1}	y_j^{k-1}	$F(x_j^k, x_j^{k-1}, y_j^{k-1})$
0	0	0	0
0	0	1	$-b_1$
0	1	0	a_1
0	1	1	$a_1 - b_1$
1	0	0	a_0
1	0	1	$a_0 - b_1$
1	1	0	$a_0 + a_1$
1	1	1	$a_0 + a_1 - b_1$

Fig. 7. From the digital filter specification, D(z), its corresponding recurrence equation can be obtained. This equation can be written in a more convenient form, substituting each digital sample by its N-bit twos-complement representation. Computations will be greatly simplified using preculculated values of F as a function of x_j^k, x_j^{k-1}, y_j^{k-1}, (x_j^k being the j-bit of the digital sample x(k), etc.).

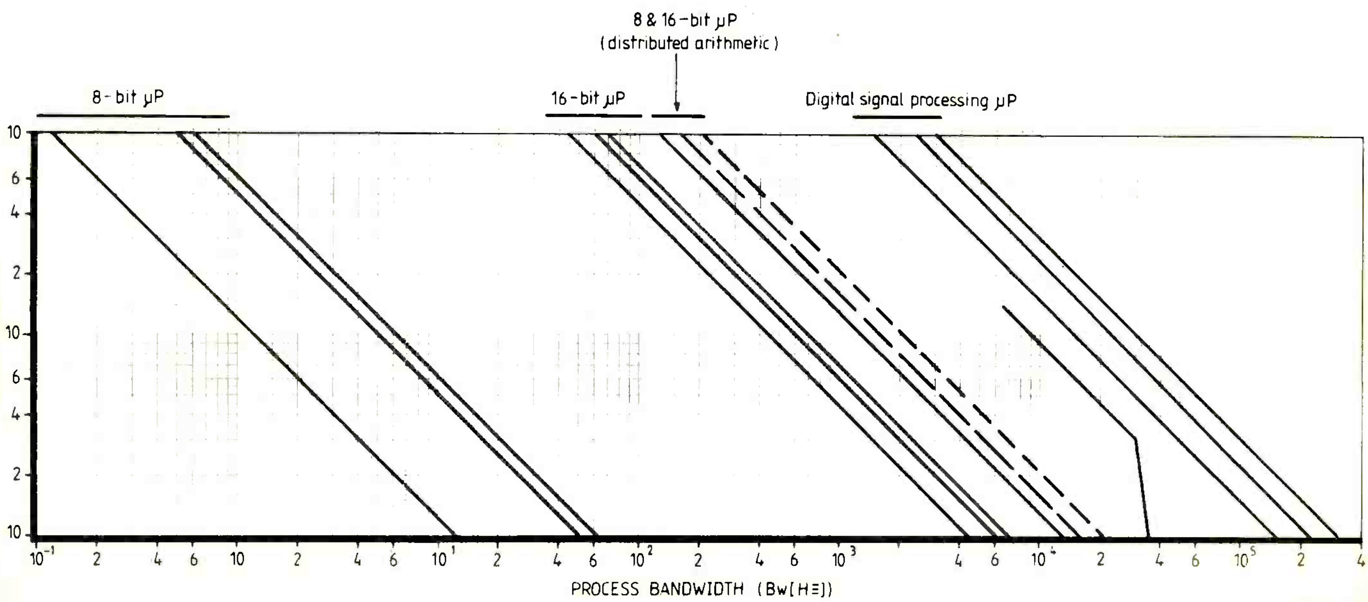


Fig. 8. Using distributed arithmetic, the processing speed of an 8-bit microcomputer can be easily multiplied by a factor of 100. 16-bit microcomputers normally include a powerful set of instructions that reduces the differences between the distributed and conventional arithmetic processing. Digital signal processing microprocessors are devices specially suited to signal processing, reaching thus the highest possible speed.

The microcomputer services can be evaluated when implementing a second-order filter; on the other hand, the microcomputer maximum processing speed for an nth-order filter will result from extrapolation as follows:

$$T_n \approx \frac{n}{2} \cdot T_2.$$

This equation means that the processing time of an nth-order filter (T_n) will be approximately n/2 times the processing time of a second-order filter (T_2). Decomposition in second-order sections, which is reasonable from the point of view of sensibility, justifies this estimation.

The process bandwidth (B) is a particularly useful parameter in the analysis of the microcomputer applicability to a particular case. This gives a measure of the process response speed to the control signal; a response time of 1 second implies $B \approx 1Hz$; 1 millisecond corresponds to $B \approx 1kHz$. According to the sampling theorem, this bandwidth will be related to the processing time as

$$B < \frac{1}{2T_n} = \frac{1}{nT_2}.$$

This condition allows the maximum bandwidth to be determined once the processing time of a second order filter (T_2)and the correct order are known. Figure 8 shows the results obtained in an approximate evaluation for different microprocessors. An important factor in the evaluation of B is the margin for the Nyquist's condition. For instance, $B < 1/10nT_2$ implies that the consequences of the delay computation on the controlled-system performance can be neglected.

Application examples

The main connections in the equipment in Fig. 3 are used for position control of a d.c. servomotor in Fig.9. Position feedback is obtained through the potentiometer transducer.

Fig.10 represents the functional block diagram of the control system. By using the bilinear transformation a lag-lead controller has been programmed in the microcomputer, with the transfer function

$$G_a(s) = K\frac{s+c}{s+p}.$$

Finally motor responses to a six-volt step in the set-point have been obtained for different values of p, Fig.11(a), and K, (b). In spite of the simplicity of this system, it has not been difficult to verify the importance of the computation time which must be reflected as a transport lag in the system. In fact, if the mechanical time constant of the motor is 0,38 seconds and the controller program execution time 0,16 seconds, Nyquist's condition will be only strictly accomplished. By comparing the real with the simulated response plots, it can be verified that only one of those simulated is correct – the one considering computation delay.

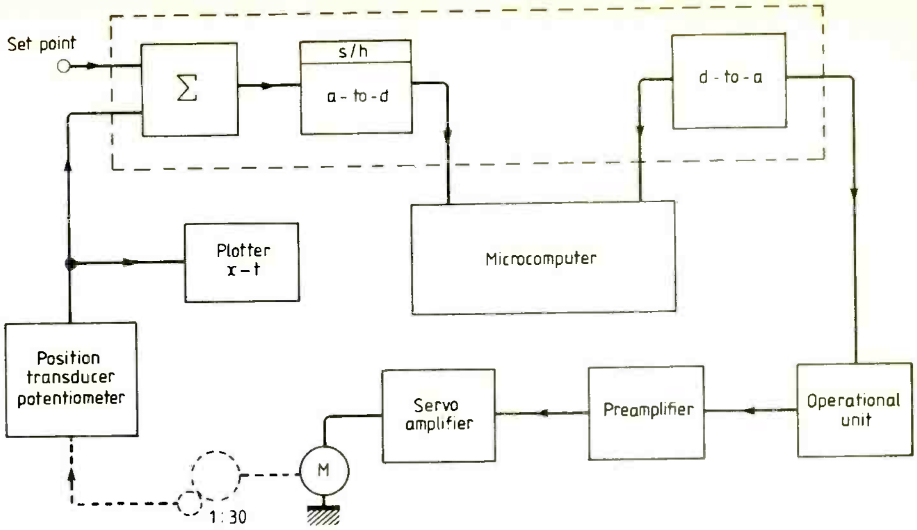
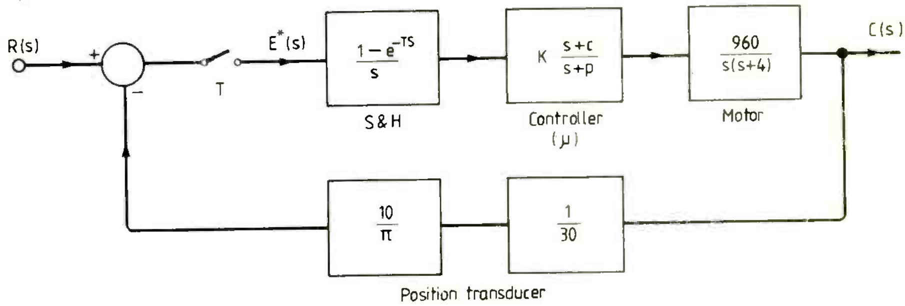


Fig. 9. Schematic representation of a laboratory experience intended to test the performance of the equipment described in Fig. 3 in the position control of a d.c. servomotor.

Fig. 10. Functional model block diagram of the control system implementation of Fig. 9(a).



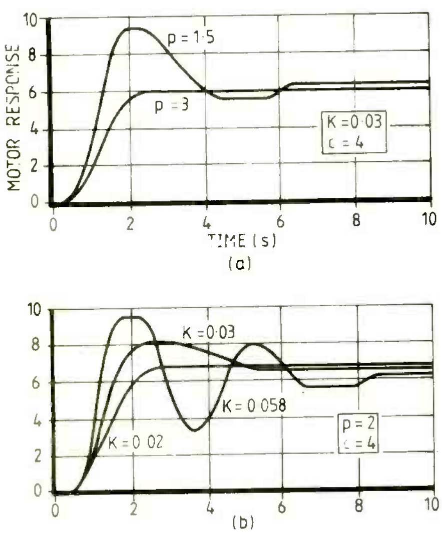


Fig. 11. Motor responses to a six-volt step in the set-point (p=1.5;3) – (a) compared with (k=0.02, 0.03, 0.58) – (b).

EVENTS

August 25-28
Acorn Computer Show (including the launch of the Electron); Cunard International Hotel, Hammersmith Broadway, London. Details from Susan Phipps, Telephone: 01-390 1612.

September 2-4
September Satellite Weekend: organised by the Institute of Broadcast Sound at the BBC Engineering Training Department, Evesham. Details from Jeff Baker, 14 Meadow Close, Marlow, Bucks.

September 2-11
Funkausstellung 83: International audio and video fair. Exhibition grounds and International Congress Centre, Berlin. AMK Berlin, Postfach 1917 40, Messedamm 22 D-1000 Berlin 19.

September 5-9
Many local further education colleges are enrolling for Radio Amateurs' Courses during this week.

Radio Spectrum Conservation Techniques: IEE International conference, University of Birmingham. IEE, Tel: 01-240 1871 Ext 222.

September 6-8
Electronic Displays, Exhibition and conference, Frankfurt Intercontinental Hotel. Network Exhibitions. Tel: 028 02 5226.

September 6-10
Inteltec 83/Swissdata 83. Two exhibitions at the Swiss Industries Fair Halls, Basle, on industrial and technical electronics and on data processing in technical applications: SMB, CH-4021 Basel, Messeplatz, Switzerland.

September 13-15
Testmex 83: Test and measurement instrumentation technology, exhibition at the Grosvenor House Hotel, Park Lane, London. Details from Evan Steadman Communications, Tel: 0799 22612.

Continued on page 72

Merriman reports

More public accountability is needed in the allocation of slices of the radio spectrum. This is one of the conclusions of the Independent Review of the Radio Spectrum, chaired by Dr James Merriman. The main conclusion of the Merriman Report is that there should be a more positive approach to the regulation of the spectrum and this has already resulted in the transference of the Radio Regulatory Division (RRD) to the Department of Trade and Industry from the Home Office.

One of the main reasons for having the enquiry was to find extra space for land mobile bands and the Report says that although there is enough room to cope up to the late 1980s, problems thereafter are likely to become acute unless significant use can be made of other bands and/or use of 'new technology'. No mention is made of where these other bands may be found although the earlier, interim, Report reallocated Bands I and III to land mobile use after the demise of the 405-line tv service.

For broadcasting it is recommended that the demand from the "enlarged community of programme makers" should be taken into account in policy formulation, and that the broadcasters should be encouraged to make the maximum use of the existing bands to accommodate their ancillary requirements. But there is "no justification for the provision of additional spectrum for terrestrial tv or sound services . . . in the light of the undoubted emergence of alternatives" [i.e. cable and satellite]. (Public broadcasting in the UK has the smallest allocation of frequencies in Europe.)

Despite outside criticism that the military are somewhat profligate with their frequency allocations, the Review body finds that "there is little scope for the reduction in defence spectrum usage".

Facing that saturation point is likely to be reached soon for fixed services, the Report recommends that early special arrangements be made with all parties concerned to review the policy and practice of frequency spectrum management so that an overall strategy may be developed.

In general the Report concludes that there is no prospect of any significant reserves of unused or underused spectrum being identified in the 30 to 960MHz range and reallocated, so any fundamental decisions need to be taken early on the relative priorities to be given to different services.

In the public accountability and information area the main recommendations of the Review are to:

- produce an RRD annual report reviewing spectrum policy and management together with explanatory material
- institute regular reviews related to specific user groups
- publish the frequency allocation table
- establish a high-level advisory committee
- use spectrum costing and cost/benefit analysis in management decisions
- review defence usage by a small committee of Privy Councillors
- adjust licence fees periodically to give financial incentive to use more efficient equipment in less congested bands
- allocate adequate resources to spectrum monitoring to aid efficient usage and effective management.

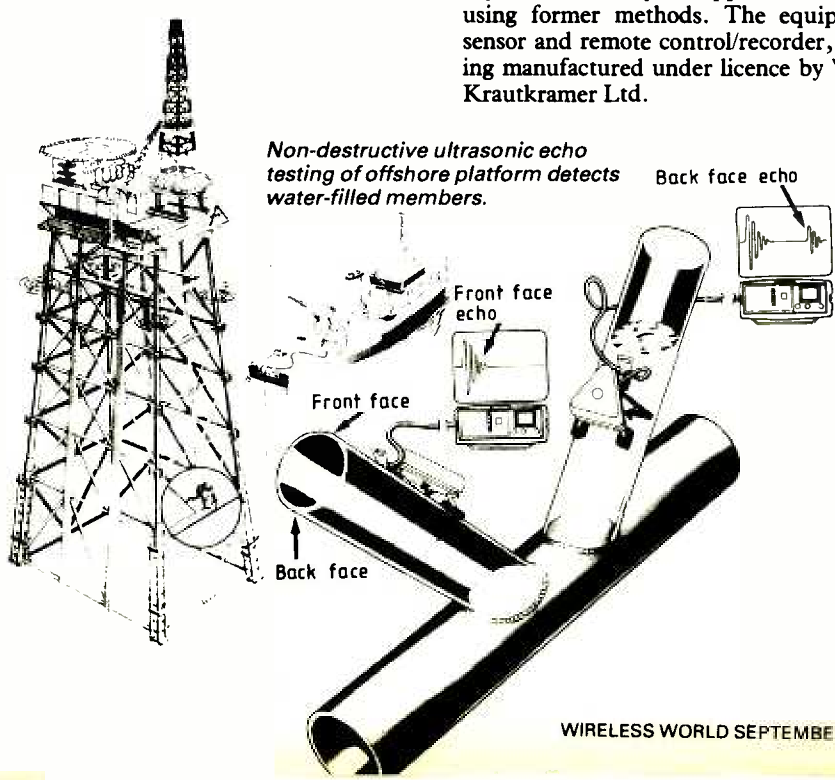
Decisions of responsibility, wherever practicable, should be delegated to common interest groups, reporting back to the RRD. Services should have some priority over individuals and fixed-term assignments could be adopted, as could short-term provisional assignments, to increase planning and development efficiency.

Because the RRD is understaffed and overworked, according to the Report, it is recommended that sufficient resources be made available for the Division so that it may carry out its duties, especially those activities in cooperation with the Science and Engineering Research Council and the Specially Promoted Programme into Radio Communications Systems.

Finally, the report recommends that radio regulation remains within Government, rather than being made the responsibility of a non-government body. There should be a separate ministerial department responsible for telecommunications or, failing that, responsibility for telecommunications be concentrated in a distinct unit with its own Minister, within an existing Government department.

Crack detection in offshore rigs

A method of testing for cracks in offshore platforms has been developed by British Gas at their Engineering Research Station. Hitherto it has been necessary clean back to the bare structure; removing all marine life and mineral deposits, but a new approach considers that important cracks are only those that let in water. To test if a rig member is full of water, an ultrasonic probe is clamped to the member magnetically and pulses transmitted by cable from a remote controller on the surface. In a normal air-filled structure the only echo received is from the nearest surface. But if water is present inside, a second echo will be received from the opposite wall. The method requires the minimum of cleaning from the surface of the steel structure and can be handled by divers with no previous experience of n.d.t. Each test takes about a minute and a whole structure can be surveyed in a few days as opposed to months using former methods. The equipment, sensor and remote control/recorder, is being manufactured under licence by Wells-Krautkramer Ltd.



Non-destructive ultrasonic echo testing of offshore platform detects water-filled members.

Book-size computer growth 'exponential'

Portable computers – those that fit into a carrying case with a keyboard, display and internal memory with stand-alone ability – are going to have an exponential increase in sales, according to a market research study by Venture Development. The provision of hard-copy as a built-in or add-on printer will be an important factor in differentiation between products, as will the operating system. The amount of memory storage is also considered to be important and yet users are demanding all this in as small a space as possible. This has resulted in the production of 'book-size' computers, the first of which on the market has been the Epson HX20. Many similar types will be introduced soon, but as they get smaller, users will need to choose between size and ease of use.

The survey found that the majority of users were in the scientific and engineering fields. A large proportion also used them for word processing, although portable computers with their inherently small displays do not seem to be particularly suitable for this. Business users like graphics displays for bar graphs and pie charts and the demand for graphics capabilities will increase. The use of electronic mail on portable computers is forecast to increase rapidly over the next five years. The full report, *The portable briefcase computer and terminal industry: A strategic analysis*, is published by Venture Development Corporation, 1 Washington Street, Wellesley, Massachusetts 02181, USA.

News in brief

The opening of a £1M factory marked the culmination of a business that started nine years ago in a kitchen sink. Brian Howard and John Edwards started by making small batches of printed circuit boards. As business expanded they moved to larger premises and eventually acquired Circuit Techniques Ltd. The new factory at Ashford, Middlesex, has two computer-aided design systems for the plotting and designing of multi-layer p.c.b.s. The plant also includes n.c. drilling equipment and the mechanical and optical devices needed to photo-print, align and bond all the layers. The company claims to produce a prototype single-layer board from a designer's sketch in 72 hours, and a 50-off preproduction set of boards within four weeks.

Button cell manufacture in Washington, Tyne & Wear, will no longer be carried out by the Timex Corp, as they have sold the factory to Ray-o-Vac, the US manufacturer of miniature batteries for use in electronic watches, calculators and hearing aids. Much new equipment is to be installed and the jobs of 85 employees are secure, say Timex.

The 1983 recipient of the Marconi International Fellowship is Francesco Carassa, professor of electrical engineering at the Polytechnic of Milan. The award recognises his 'outstanding contribution to radio-frequency communications, including both land and satellite communications using microwaves'. His experiments in v.h.f. satellite communications culminated in the launch of the Italian Sirio satellite which led to the use of new satellite technologies.

An agreement on basic specifications for magnetic discs to be used in electronic still-picture cameras has been reached by 20 companies in electronics, camera and magnetic tape industries. Over three quarters of the companies involved are Japanese but the alliance includes 3M, Philips and RCA and the specifications are being considered for submission to international organizations.

More US-UK cable tv bids

A bid for a major share in the cable tv market in Britain has been launched by Plessey Scientific-Atlanta with the introduction of a so-called multistar distribution system designed to meet Government requirements for both 12 and 20-year franchises. The system is based on the conventional tree architecture, but can be upgraded to switched-star if required.

The basis of PSA's network is a three-tier hierarchy of switching nodes capable of servicing various sized groups of homes. A key element in the switched-star version is a new subscriber switch capable of delivering to 20 households as many as three simultaneous tv channels plus the entire 88-108MHz f.m. broadcast band. The three television channels are carried as system I PAL signals in the band 5 – 88MHz, the lower portion of which is allocated to two-way data communications and a 'reverse' video channel allowing contributions to be fed back to the head-end. With some reconfiguration, the switch could also carry the C-MAC transmission format developed by the IBA.

Besides radio-frequency equipment, the unit incorporates a number of microprocessors – one for every three households for control purposes, plus another to relay information from the cable system's central computer. Subscribers can be billed automatically for the 'pay-per-view' programmes and access to individual channels can be permitted or denied. Non-payers may be cut off instantly against loss of revenues through unauthorised use of the system without the signal degradation often associated with scrambling devices. The computer software for the switch is capable of handling a variety of additional services such as home banking and 'teleshopping'.

In view of the signal radiation problems experienced with some cable systems abroad, PSA's choice of frequencies for the subscriber drops should go some way towards allaying the fears of other spectrum users. The method of construction of the company's demonstration system may be reassuring too: the electronic modules and their switched-mode power supplies are enclosed in separately screened boxes and the outer casing of each unit is sealed with an r.f.-tight gasket.

Upstream from the subscriber switch would be a further node capable of handling 160 households; and above that in a full switched-star system there would be a 1500-point switch. Coaxial cable is to be used for the feeders initially, though the company envisages a change-over to optical fibre when costs have fallen. The capacity of the switching nodes is dictated by typical housing densities in the United Kingdom.

It is expected that the Government will award first batch of cable franchise during the autumn and PSA hopes to have system components ready for the successful applicants from the end of the year onward. The first networks could begin operation in mid-1984.

Plessey Scientific-Atlanta Ltd is owned jointly by Plessey Telecommunications and the American corporation Scientific-Atlanta, from which many of the system's components will at first be imported. However, the company intends to transfer production of the distribution equipment to England, leaving only a few specialised items for the network head-ends to come from the United States.

● Another Anglo-American alliance in the cable tv field has been formed by GEC-McMichael and the Jerrold division of the General Instrument Corporation. GEC Jerrold's activities are to include the design and supply of both switched-star and tree-and-branch systems. The new company will also be concentrating on business users, with products such as a video teleconference system which uses data-rate compression to obtain bandwidth reduction of up to 40:1.

NEWS

Oric springs Forth

After what seems an interminable wait, some useful software has been published for the Oric-1 computer. There are the inevitable arcade games involving shooting things in space, though some of these do demonstrate the high-resolution colour graphics and high quality sound available. One package which caught our attention is an Oric Forth cassette program with an operation handbook. With it, the Basic-based system runs Forth. Standard FIG Forth is implemented with some additional words specific to the Oric. Programs may be stored in blocks of memory called screens, and a screen editor program is provided. When completed programs can be compiled into the Forth 'dictionary' or list of instructions and executed; they are not separate entities but part of Forth itself. Each instruction is linked to its component parts, which in turn are linked to their component parts, down to the machine-code primitives. This is why Forth is called a 'threaded interpretive language' – each instruction is threaded to others.

In addition to the Forth core and the screen editor, the cassette includes a machine-code assembler to create primitive Forth words from assembly language mnemonics. This incidentally illustrates the efficiency of Forth; the assembler, written in Forth, occupies less than 4K of memory and yet includes all the 6502 mnemonics, allows the use of labels and macro-assemblies.

A further addition is the 'extension' program which is mostly concerned with specific commands for high-resolution graphics and three-voice music. This is extended by a music demonstration program, Tunesmith, which enables music to be entered very easily and includes a demonstration tune in three-part harmony.

Loading from tape is slow but only a temporary discomfort as Forth is really designed to be run on disc and a 3in, 100K drive is to be added to the range.

Another addition is a £160 printer/plotter based on the Alps ball-pen mechanism. This has limitations; it is slow (eight character/s) and uses 120mm-wide paper. But it is low cost, has four colours and has a very clear print-out even in the tiny 80 characters/line mode.

Standardisation in gate arrays

Although semi-custom i.cs are all individual many of them have certain elements in common. Professor Carver Mead and Lynn Conway of Xerox's Palo Alto Research Centre devised an approach to v.l.s.i. design which has been adopted in many universities and in the (American) technical press. The system treats parts of a design as building blocks which may then be arranged to produce the required design. The building blocks themselves are given hierarchical values and are arranged topologically to keep interconnections to a minimum. In a report on the *Mead-Conway approach and other routes to user-designed i.cs*, the analogy is drawn that designing an i.c. is like designing a house; in a conventional custom i.c, the aim would be to get all the rooms into the least possible space and the first items to be designed would be the bricks and fittings. As a number of designers might be involved, the rooms could be of quite different styles and there may be no immediate connection between the dining room and the kitchen. Services and drains may be spread all round the house. By contrast, the Mead-Conway 'house' would start with blocks to represent the main rooms, as functional blocks and then move these around so that there is minimal interconnection, with the services together. Device manufacturers are largely ignoring these methods but the report points out that with the appropriate c.a.d, design is passing into the hands of the customers who can use the structured methodology introduced by Mead and Conway. The report was prepared by Mackintosh Consultants Ltd, and is published by Benn Electronics Publications, Luton.

Full-page cable teletext

A version of their full-channel teletext system has been developed by Jasmin Electronics for use on the switched-star multi-channel cable tv system designed by Rediffusion. The use of a full channel rather than the unused lines of a tv raster enables the transmission of 500 pages per second. Another advantage is a very large database capacity. The system can accept pages from Prestel and other data services and can decode the Ceefax/Oracle signals that would be transmitted by the public networks. A subscriber scheme is envisaged and the service would provide at least 1000 pages.

Computer display for partially-sighted

The portable reading aid for the partially-sighted, Viewscan, has been extended to include an information handling system. Viewscan has been coupled to an Epson HX20 portable computer. The system may be used, as before, to scan printed text and produce an enlarged image on the screen (News, March 1982). The improvement means that the text so displayed may also be stored in the computer memory and text may also be entered through the keyboard, viewed on the screen, and edited and stored. The system would seem to be particularly useful to those wishing to gather information from libraries. The combined unit can be carried in a briefcase and can operate from battery or mains. Wormald International, 7 Musters Road, West Bridgford, Nottingham.

Better stereo

The article scheduled for this issue on increasing low-frequency spatial impression in stereo reproduction by Y. Hirata has unavoidably been held over. We received further information in particular details of a circuit applying Dr Hirata's technique too late to include in the article.

Did WW get it right? In Alan Chester's study of the statistical background to the Morse code on pages 62-64 of the August issue, two lines were inadvertently not typeset. So in line 14 of column 2, following 'eight bits', please insert: "On this basis a bit count for all letters of the . . .", and in line 13 of the text on page 64, column 1, after 'sending the passage normally', insert "in a given time. For random code letters are . . ." Finally, in line 14 of column 3 on page 62, 1 word/min=50/60baud, and not 50 to 60.

Crossword solution

	$E'C'A'$	$E'C'A$	$E'CA'$	$E'CA$	$EC'A'$	$EC'A$	ECA'	ECA
$F'D'B'$	4	2				1	1	
$F'D'B$		3	1		1	2	1	
$F'DB'$		3	1					4
$F'DB$	1		1		2	2	2	
$FD'B'$			5			3		
$FD'B$	2			1	1		1	3
FDB'				6			1	1
FDB	1			1	4		2	

Clues

$B'D'E'F' = 6$ $A'BDF' = 6$

$B'DE'F = 4$ $B'DE = 6$

$BDEF' = 6$ $AD'EF' = 3$

$BDEF = 6$ $CEF = 8$

N. Darwood's numerical crossword appeared on page 62 of the August issue.

Typewriter printer

In the July issue Neil Duffy showed how an electronic daisywheel typewriter could be fitted with an RS232 interface to enable it to double as a printer for a computer. This article describes a few simple changes to the circuit to provide it with a Centronics-compatible parallel interface so that it can be used with micros that don't provide a serial output port.

by Neil Duffy

The design described in the July edition can be readily adapted to enable the typewriter/printer to be driven from a Centronics-compatible parallel port on a personal computer. The connection between the computer and the interface is designed to use a 26-way ribbon cable with alternative wires grounded to prevent cross talk between the signal cores. A 26-way insulation-displacement connector at the interface end is used rather than the more conventional Amphenol 36-way plug because of its lower cost and its compatibility with the Centronics port on the BBC Micro. As with the RS232 interface, correct operation of the handshake between the computer and the typewriter relies on the computer outputting both a line feed and carriage return character at the end of each line.

The main change to the original circuit consists of replacing the uart and the data rate generator (IC_2 and IC_3) with octal buffer IC_{12} to buffer the incoming parallel data from the computer before feeding it to the existing eprom. The clear-to-send signal originally generated by Tr_2 is no longer needed and the handshake timer circuitry associated with IC_5 is modified to handle the strobe and acknowledge signals associated with the Centronics interface.

Circuit operation

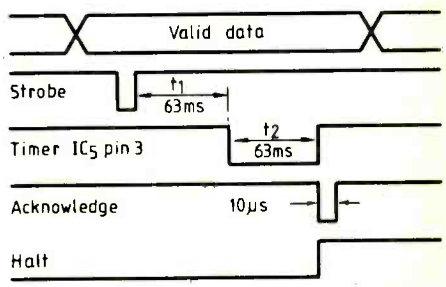
The interface described here is Centronics-compatible, that is, it uses a minimum subset of the signals available on a full Centronics port. The signals actually used are

- seven data lines D_0 to D_6 which are active high and which carry data from the computer to the interface
- a strobe line driven from the computer and which pulses low to indicate that valid data is available
- an acknowledge signal sent from the interface to the computer. This signal pulses low to indicate that data has been received and that the typewriter is ready for the next data strobe.

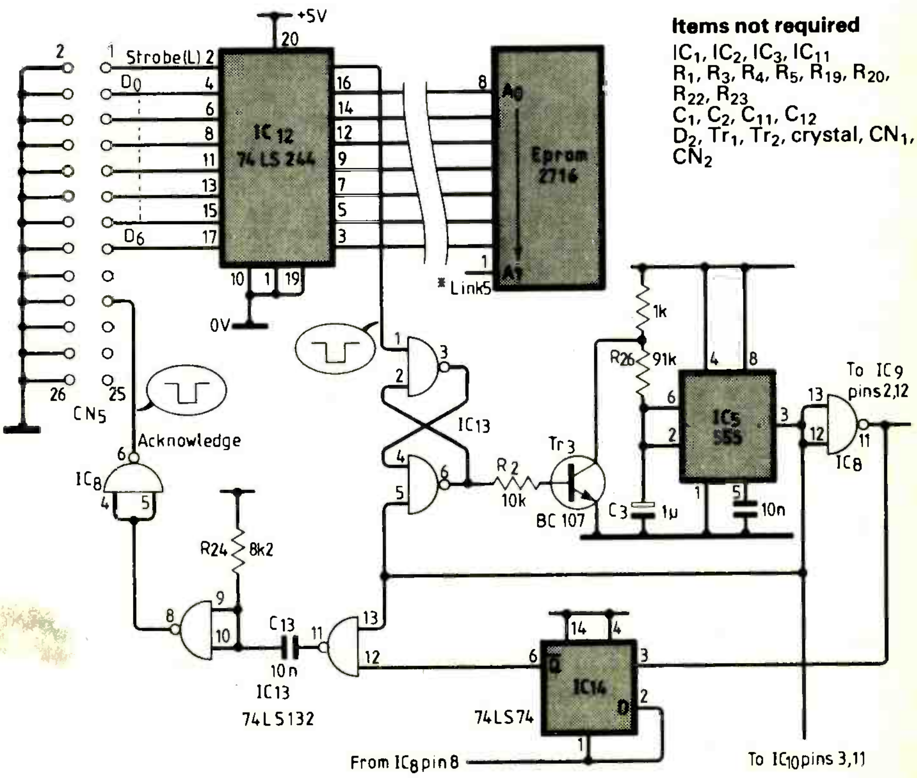
Relationships during a data transfer to the typewriter are shown in the timing diagram. When a strobe pulse is received from the computer the latch formed by IC_{13} is set and Tr_3 is turned off. After approximately 63ms (t_1) capacitor C_3 charges up to the threshold level of timer IC_5 causing its output to go low and reset the latch. Transistor 3 is now turned on again and discharges C_3 through R_{26}. After a further period of 63ms (t_2) the voltage on C_3 falls below the trigger level of the timer and its output goes high again. This causes R_{24} and C_{13} to generate a 10µs pulse which is buffered by one of the gates of IC_{13} and sent to the computer as the acknowledge signal.

Latches IC_{10} in the original circuit generate a halt signal during a typewriter carriage return or when the paper has run out. These latches are now clocked on the rising edge of the timer output signal. The halt signal is fed to flip-flop IC_{14} which delays it until the next data word (a line feed) is transferred from the computer. The delayed signal on the output of IC_{14} is used to prevent the subsequent acknowledge pulse from being generated until the halt condition is removed. This happens when the line-feed-complete switch on the typewriter operates or when the paper-out condition is removed.

Period t_1+t_2 in the timing diagram determine the maximum speed of data transmission between the computer and the typewriter. Because of the tolerance of C_3 it may be necessary to change the value of R_5 to set the speed to around eight characters per second.



In a Centronics parallel interface a strobe pulse from the computer signals that valid data is available. The computer must receive an acknowledge pulse from the peripheral device before any further data transfer can take place.



Items not required
IC_1, IC_2, IC_3, IC_{11}
R_1, R_3, R_4, R_5, R_{19}, R_{20}, R_{22}, R_{23}
C_1, C_2, C_{11}, C_{12}
D_2, Tr_1, Tr_2, crystal, CN_1, CN_2

Forth computer

Exceeding Brian Woodroffe's earlier expectations, his 6809-based Forth computer can be used with disc drives requiring high data-transfer rates – including Sony's microdrive and 8in floppy-disc drives. Access times for standard drives can also be reduced using a minor hardware modification.

After using the computer for a while I became discontented with the disc system because the software caused a one second delay each time access to the disc was required. This waiting time is needed to allow the drive to reach its operating speed – the software doesn't know whether the disc is running or stopped before access – and much of the benefit of the virtual memory system is lost because of this delay. Forth keeps data from a number of disc sectors in memory. When data from a sector that is not in the main memory is requested by the program, Forth overwrites one of the buffers with the required data. But if data in the buffer has been changed Forth first sends the data back to the disc so there can be two 1s delays for one disc call.

Keeping the disc constantly rotating is the easiest way of avoiding this delay but this was rejected because it shortens the life of the drive even though the motor is a brushless d.c. type. The method chosen relies on the fact that disc access operations are not uniform in time i.e., they are likely to come in bursts, especially when loading or listing screens from a disc and as a result of the virtual-memory buffer replacement algorithm described above. Keeping the drive running for a short while after a disc access is made means that it is likely that the disc will be running when the next disc access is required.

Normally, the disc-drive motor is turned off by the disc-select signal going false (p.i.a. A port, D_6, 0 to 1) when the program finishes using the drive. In the modification the drive motor enable signal is held true for five seconds after the drive-select signal goes false by a monostable multivibrator triggered by the trailing edge of the p.i.a. signal. As the software always assumes that the drive is up to speed and available, even though the monostable i.c. might have completed its cycle, a means of ensuring that the WD1793 controller doesn't try to access the drive during the motor start period is required. During this period the ready signal is held false by a further monostable multivibrator fired by the drive-motor start signal. A low-pass filter after the NOR gate combines the two sources of motor-on signal to allow for the set-up time of the 5s monostable.

This small hardware modification, consisting of two s.s.i. devices relieves the software of all considerations of motor-start latency. To prevent erroneous triggering the two monostable multivibrators should be grounded separately.

by B. Woodroffe

Brian Woodroffe works in research and development at Hewlett Packard.

Interfacing 8in drives

I found it galling that my 1.5MHz 6809 Forth system could not be interfaced with faster 8in drives, especially as these are often available second-hand at bargain prices. I have not yet got an 8in drive but I have been fortunate enough to try one of the sub-5in drives from Sony which has the same data rate as 8in drives. There is as yet no *de jure* standard for microfloppy-disc drives[1] but within Hewlett Packard, the Sony drive is the *de facto* standard. The first problem is to build a data-service routine that services the disc at a rate better than 11μs/byte. Although nominal disc-data transfer normally takes 16μs/byte, Western Digital specify 11 and 13μs worst-case service times for write and read respectively.

The previously used software loop (*Wireless World,* June 1983) achieves far worse than 11μs, even with the M6809 direct-page register modified to make the controller i.c. accessible through direct addressing. Analysing the software loop shows that two functions are being carried out – a byte is transferred between the WD1793 controller and ram, and bytes are counted to determine when the sector operation is completed. If the second function could be dispensed with the remaining loop would be much smaller and faster. There would be a small penalty in that the ability to read from and write to consecutive sectors would be lost as no byte count is kept. The problem now is how to break out of the disc-service software loop. Fortunately the controller gives hardware help here in that the IRQ line is activated on completion of every command; the DRQ line is activated for each byte transfer. DRQ, connected to the M6809 FIRQ line, is used in the data transfer loop to make the processor clear its SYNC state, thus synchronizing controller/processor transfers operations.

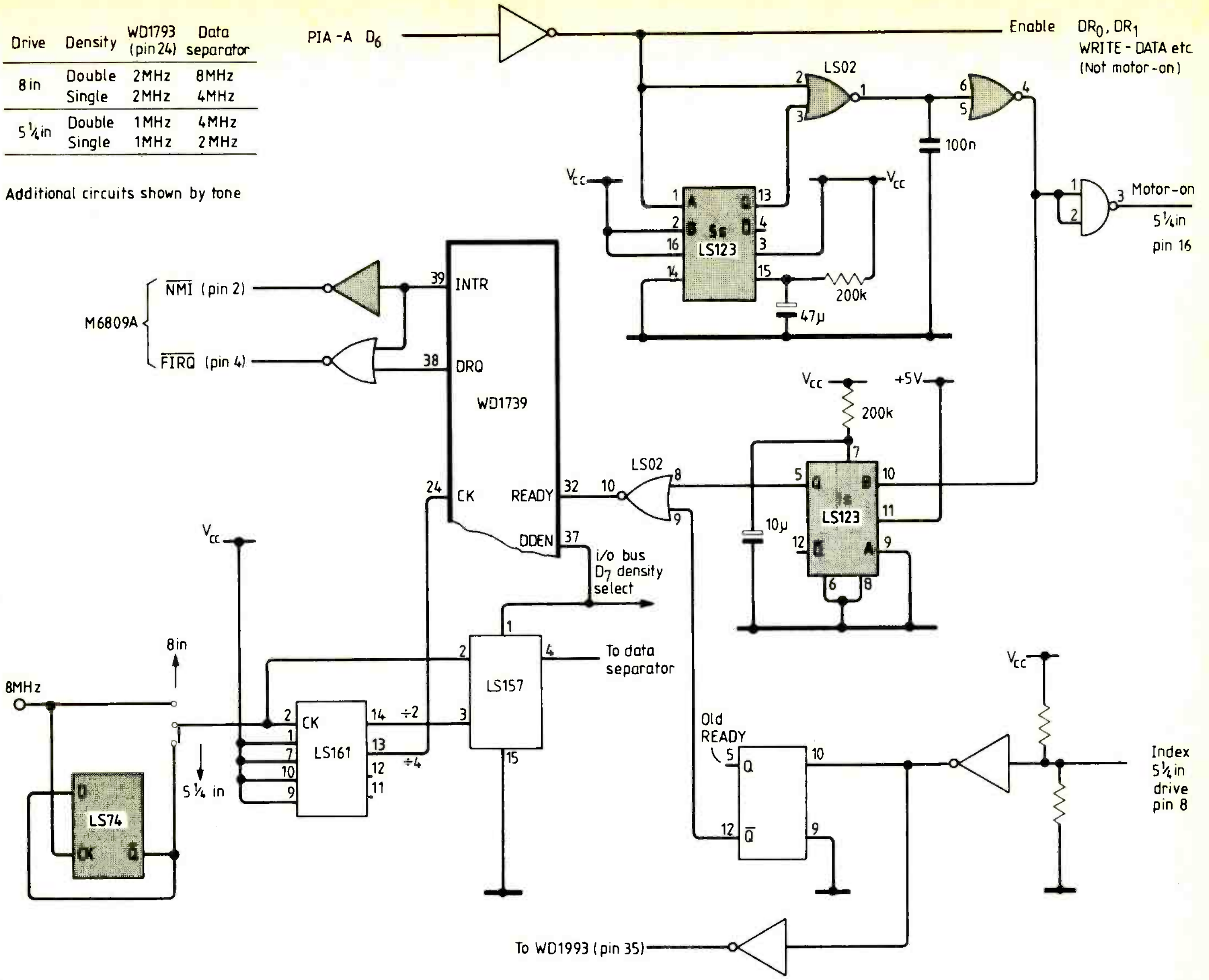
Interrupt request IRQ is tied to one of the other M6809 interrupt lines so that when a read or write-sector command is complete the processor aborts its current data-transfer loop activity and commences the interrupt routine. On application of the FIRQ signal the processor does not abort the data transfer loop and carry out the FIRQ routine because the program inhibits the FIRQ interrupt by holding the FIRQ mask bit in the condition-code re-

List 1. In this design the following Forth words are available.

LIT	EXECUTE	BRANCH	0BRANCH	(LOOP)	(+LOOP)
(DO)	I	J	K	DIGIT	(FIND)
ENCLOSE	EMIT	KEY	?TERMINAL	CR	CMOVE
U<	U*	U/	AND	OR	XOR
SP@	SP!	RP!	;S	+	D+
MINUS	DMINUS	1+	2+	1-	2-
M*	*	M/	/MOD	/	MOD
*/MOD	*/	M/MOD	ABS	DABS	S->D
+-	D+-	0=	0<	LEAVE	>R
R>	R	OVER	DROP	SWAP	DUP
+!	@	C@	!	C!	TOGGLE
<BUILDS	DOES>	:	;	CONSTANT	VARIABLE
0	1	2	3	BL	C/L
FIRST	LIMIT	USER	+ORIGIN	S0	R0
TIB	WIDTH	WARNING	FENCE	DP	VOC-LINK
BLK	IN	OUT	SCR	OFFSET	CONTEXT
CURRENT	STATE	BASE	DPL	FLD	CSP
R#	HLD	COLUMNS	HERE	ALLOT	
,	C,	-	=	<	
>	SPACE	MIN	MAX	-DUP	
TRAVERSE	LATEST	LFA	CFA	NFA	PFA
!CSP	?ERROR	?COMP	?EXEC	?PAIRS	?CSP
?LOADING	COMPILE	[	]	SMUDGE	HEX
DECIMAL	(;CODE)	COUNT	TYPE	-TRAILING	"
("	(."	."	DEPTH	?STACK	?FREE
ROT	EXPECT	QUERY	X	FILL	ERASE
BLANKS	HOLD	PAD	WORD	(NUMBER)	NUMBER
-FIND	(ABORT)	ERROR	ID.	CREATE	[COMPILE]
LITERAL	DLITERAL	INTERPRET	IMMEDIATE	VOCABULARY	DEFINITIONS
(	QUIT	ABORT	COLD	WARM	#DR
USE	PREV	+BUF	(LINE)	.LINE	MESSAGE
LOAD	-->	'	FORGET	BACK	BEGIN
ENDIF	THEN	DO	LOOP	+LOOP	UNTIL
END	AGAIN	REPEAT	IF	ELSE	WHILE
SPACES	<#	#>	SIGN	#	D.R
.R	D.	.	?	LIST	INDEX
DUMP	VLIST	B/BUF	B/SCR	SCR>BLK	USEBLK
DR0	DR1		DRIVE	R/W	;CODE
UPDATE	EMPTY-BUFFERS	BLOCK	FLUSH	FORTH	TASK
NOOP					

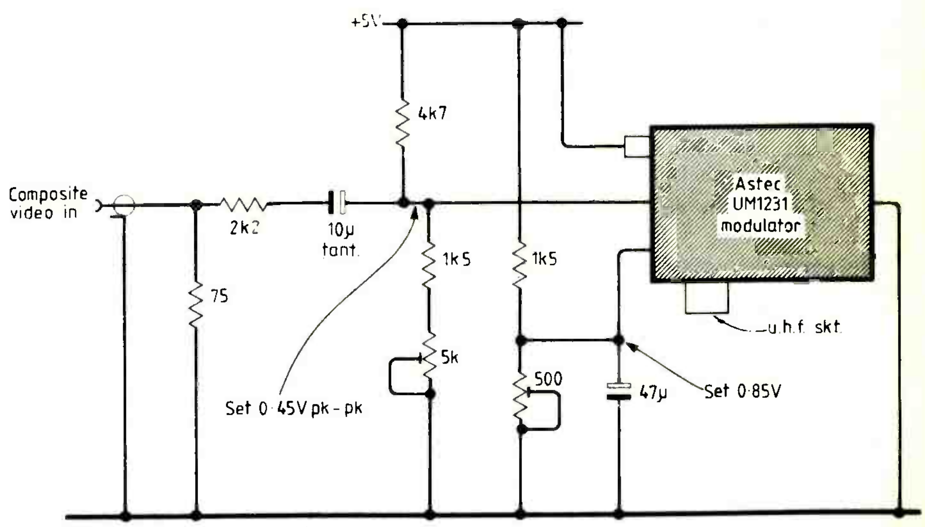
Drive	Density	WD1793 (pin 24)	Data separator
8in	Double	2MHz	8MHz
	Single	2MHz	4MHz
5¼in	Double	1MHz	4MHz
	Single	1MHz	2MHz

Additional circuits shown by tone



▲ *Disc interface modification speeds up overall access time by keeping the drive motor running for five seconds after the computer tells it to switch off. This significantly reduces the effect of a one second delay required for the motor to start up since disc-access operations tend to come in bursts.*

U.h.f. modulator connects to the video-controller circuit output (see June issue) so that the computer can be used with a standard tv set. ▶



gister set. The controller interrupt-request line IRQ, being connected to the processor's non-maskable interrupt input NMI, can never be masked so when this line is true the processor must be interrupted and goes to the routine requested by IRQ. The processor IRQ interrupt-request input could have been used but I wanted to leave it free for expansion.

For sector read and write operations the disc controller interrupts on transfer of the last byte. In the case of a sector-write operation the data-transfer routine is finished when the last byte is written into the controller. In sector read operations the data transfer routine is finished not when the last byte is read from the controller, but when it is written into the ram sector buffer. So when a sector is written the controller interrupts after all data transfers have taken place but when sectors are read the controller causes a jump out of the software loop before the last memory-storage operation is carried out. Worse still, latency before the controller interrupt is variable so when an interruption is made, whether or not the memory has been updated remains in doubt. The solution I chose was to code the data-transfer loop so as to maximize the time between reading data from the controller and writing it into the memory. Inclusion of a no-operation, NOP, increases the data-transfer loop time to just under the allowable maximum of 13μs to ensure that the controller always interrupts before the processor can write the byte into memory; the first operation of the interrupt routine is to write that byte into memory. Unfortunately this writing operation done outside the data-transfer loop means that the interrupt routines for sector reading and writing must be different.

```
MEMORY              SOURCE
ADDRESS  CONTENTS   LINE
  000C              154 VECTOR6 RMB 2                          NMI   used by disc

E02A 6E 9F000C      298 VECTOR6E JMP [VECTOR6]      NMI   hw uses NMI for disc

F873 7D C000        1745 SAFE      TST FDC                      any read of the FDC kills any IRQ
F876 8E F87C        1746           LDX #SAFNMI
F879 9F 0C          1747           STX VECTOR6
F87B 39             1748           RTS
F87C 7D C000        1749 SAFNMI    TST FDC                      read the status register to kill
F87F 3B             1750           RTI                          FDC NMI and return

                    1875 * BLOCK-READ, BLOCK-WRITE accept the following parameters
                    1876 * sector  - where to start reading from
                    1877 * side    - which side
                    1878 * addr    - memory address where the data is to be read from / written to
                    1879 * addr,side,sector BREAD/BWRITE
                    1880 * On return if no problem B=0
                    1881 *                  else    B= status register value
                    1882 * for 8in  double density must acheive the following times:
                    1883 * 13.5µS READ,    11.5µS WRITE

FA4D FA4F           1889 BREAD    FDB $+2             addr,side,sector -- 0=good, <>0 status error
FA4F 8E FA64        1890          LDX #RNMI
FA52 C6 82          1891          LDB #082H           single side, single record, side 0
FA54 34 08          1892          PSHS DP             save DP
FA56 8D 1E          1893          BSR CMNDSET         read sector start
                    1894          SETDP 0C0H          tell assembler value of direct page pointer
                    1895 * this loop reads bytes from the FDC, X=pointer to storage
                    1896 * maximum NMI latency is 3µs, so loop is arranged to give maximum time
                    1897 * betwenn FDC read and the store to memory. The hanging write to RAM
                    1898 * is done outside the loop
FA58 D7 00          1899 BREAD1   STB FDC             set FDC going by o/p command
FA5A 20 02          1900          BRA BREAD3          jump into middle of loop
FA5C A7 80          1901 BREAD2   STA 0,X+     7      store it away
FA5E 13             1902 BREAD3   SYNC         2      wait 'til interupt
FA5F 96 03          1903          LDA FDC+3    4.25get the data
FA61 12             1904          NOP          2      this nop to allow FDC to NMI
FA62 20 F8          1905          BRA BREAD2   3      loop          =18.25cycles @ 1.5MHz=12.2µS
                    1906 * will exit by NMI to NMIVECTOR which pushes status onto return stack
FA64 A7 84          1907 RNMI     STA 0,X             hanging write, store last byte away
FA66 32 6C          1908 WNMI     LEAS 12,S           delete saved parameters
FA68 D6 00          1909          LDB FDC             get status
FA6A 35 08          1910 BREDEX   PULS DP             restore DP
                    1911          SETDP 000           tell assembler what DP is
FA6C 4F             1912          CLRA                B=set=error flag
FA6D 36 06          1913          PSHU D              push flag
FA6F BD F873        1914          JSR SAFE            get a safe nmi vector
FA72                1915          NEXT
                    1916 *                            user stack=addr,side,sector
FA76 86 C0          1917 CMNDSET LDA #0C0H
FA78 1F 8B          1918          TFR A,DP            set up DP
                    1919          SETDP 0C0H          tell assembler what value of DP to use
FA7A 0D 00          1920          TST FDC             clear any FDC irq
FA7C BF 000C        1921          STX VECTOR6         fixup nmi vector
FA7F 33 41          1922          LEAU 1,U            delete sector msb
FA81 37 02          1923          PULU A              get sector number
FA83 97 02          1924          STA FDC+2           store in FDC
FA85 AE C1          1925          LDX 0,U++           test for side
FA87 27 02          1926          BEQ CMNDST2
FA89 CA 08          1927          ORB #8              set for side 1
FA8B 37 10          1928 CMNDST2 PULU X               get the ram pointer
FA8D 39             1929          RTS

FFFC E02A           2523          FDB VECTOR6E   NMI
```

Through

This code executes an indirect jump

To

And jumps to

On application of n.m.i., M 6809

- Pushes all registers onto 'S' stack
- Fetches jump address from

Notes - By changing contents of location 'vector6' the write routine exits from its loop to location 'WNMI'

- Vector6 is in ram, all other locations are eprom

Diagram of program flow during a sector read on the Forth computer.

The processor starts its interrupt sequence by pushing appropriate registers onto the stack and jumping to code pointed to by a vector in high memory. In this Forth system high memory is eprom so the interrupt vectors cannot be changed to point to different routines. I remedied this by making the interrupt vectors point to code which executes a jump to a location determined by a value stored in ram. By changing data in the ram location the non-maskable interrupt vector can be altered during program execution. This practice is unstructured and therefore unfashionable, but it is highly effective.

Normally an interrupt routine is completed by a return-from-interrupt instruction which restores processor register values to those prior to the interrupt, i.e. restore context. In this case the interrupt vector is being used as a jump instruction to jump out of the data-transfer loop so the first operation in the NMI routine is to delete saved registers (LEAS 12,S). As the controller is connected to the non-maskable interrupt line there is the potential for the occurrence of an interrupt when one is not required. To prevent this the NMI vector points to a safe routine when not in use which reads the controller status register, clearing the cause of the interrupt before carrying out a more normal return from interrupt, RTI, operation.

Extra signals to the disc drives, e.g. track 42, should be inverted and buffered using standard t.t.l. open-collector drivers (7438) as used for the WGATE signal. Extra input signals from the drive such as READY should be buffered using say two LS14 gates, and terminated as previously shown. I should have used the drive's ready signal, eliminating one of the monostable multivibrators connected to the index line but I did not. Also I connected my motor-on signal (5.25in drive, pin16) to the Sony drive head-load line, pin 14, whereas I should have used hold, HLD on pin 28 of the controller. These minor modifications were made because I still intend to use 5.25in drives as they currently offer better value for money than the Sony drives at one-off prices.

The matter of write-precompensation has not yet been resolved. I found by trial and error that for the Sony drive at least write-precompensation is not mandatory. It might be necessary for older 8in drives, and in commercial products to minimize the number of attempts to read the disc. Details of precompensation circuits are given in the Western Digital handbook and reference two.

For drives that keep the disc rotating, such as Sony's and most 8in drives, the disc speed-up hardware previously described should not be fitted but the drive should be connected with the motor-on

List 2. Forth words specific to this system.

```
Note the movement of data onto and off the stack is shown thus
        s1 s2 ..ABC.. r1 r2 r3
  Forth word 'ABC' takes two values off the stack (s2=top of stack) and produces
  three results (r3=new top of stack).
  VEMIT,VKEY,V?TER    - a user variable containing the execution vector for
                        EMIT,KEY, ?TERMINAL respctively
                        ..VEMIT..addr    ..VKEY..addr      ..V?TER..addr
  DPMAX               - a user variable containing the maximum address for the
                        dictionary.
                        ..DPMAX..addr
  SMAX                = a user variable containing the maximum depth of data
                        stack allowed for this user
                        ..SMAX..addr
  P!,P@               - a WORD to store a byte to, read a byte from one of the
                        user ports
                        data addr..P!..             addr..P@..data
  DENSITY             = a constant =0 for single density; -1 for double density
                        ..DENSITY..boolean
  DR-SEL              - a WORD to select the drive value top of stack
                        value..DR-SEL..
  DE-SEL              = a WORD to deslect the disc drives
                        ..DE-SEL..
  VERIFY              = a variable which if true causes a read after write
                        verify of disc writes
                        ..VERIFY..addr
  SIDE/DISC           = a constant returning the number of sides per disc
                        ..SIDE/DISC..value
  SEC/TRK,TRK/SIDE    = constants returning the number of sectors per track and
                        tracks per disc respectively.
                        ..SEC/TRK..value       ..TRK/SIDE..value
  SIDE                = a WORD to select the side of the disc depending on the
                        value at top of stack
                        value ..SIDE..
  ?WRITE              - if disc is write-protected issue error message 10 and
                        abort execution to return to terminal mode
                        ..?WRITE..
  CMND                - a WORD to execute [illegible] command at top of stack
                        value ..CMND..
  RATE                - a CONSTANT which equals the disc drive stepping rate as
                        coded for the WD1793
                        ..RATE.. value
  SEEK                = steps the floppy drive to seek the track that is at top
                        of stack
                        value ..SEEK..
  STEP                = a WORD to step the floppy disc, IN if TOS=1
                                                        OUT if TOS=-1
                                              same direction if TOS=0
                        value ..SEEK..
  R-ADR               = reads the address mark off the disc, either returns
                        a/ flag-true if unsuccessful (=status of WD1793)
                        b/ sector_type, sector, side, track , false flag
                        ..R-ADR.. type sector side track 0         or
                        ..R-ADR.. true
  BREAD,BWRITE        = similar to FORTH BLOCK_READ, BLOCK_WRITE except
                        additional parameters are included, sector within a
                        track.
                        returns WD1793 status 0-succesful
                        address side sector ..BREAD.. status
  SEC-R/W             = similar to FORTH R/W except no limit checking is done.
                        Returns to top of stack a flag. 0=successful operation
                                                        1=crc error
                                                        2=seek error
                                                        3=not ready
                        addr sector flag ..SEC-R/W.. status
  TRK-WR              - a WORD to write a whole track to disc, used in formatting
                        a disc. Takes from the stack the address of the track
                        immage. Return WD1793 status, 0=successful
                        addr ..TRK-WR.. status
  TRK-BLD             - a WORD to build in memory a byte image of a track prior
                        to be written out by TRK-WR. Takes as input the side and
                        track number whose image is to be formed and produces
                        the address of where the image is.
                        side track ..TRK-BLD.. addr
  ?DISC               - a WORD to find out what sort of disc is on the drive.
                        sets CONSTANTs B/BUF,DENSITY,SEC/TRK to suit.
                        ..?DISC..
  MS                  - a WORD to delay execution by the number of milliseconds
                        that is top of stack
                        value ..MS..
  SKEW                  currently a no operation word, that canbe patched to
                        allow interleaving of the sectors when formatting a disc.
                        Intended usage is that it will modify the sector number
                        currently at top of stack
                        sector_no ..SKEW.. sector_no
```

signal permanently true, i.e. grounded.

Software issued (first revision) assumes the presence of disc speed-up hardware and includes the faster data-transfer loop. I will supply a drive pin connection list and format program for the Sony drive that can be modified for 8in drives to readers sending an s.a.e. to me at 632 Queensferry Road, Edinburgh. The Forth word BLD-TRK in eprom is only suitable for mini-floppy disc drives.

Thanks to Hewlett Packard for the use of their test equipment and Sony for the loan of a microdrive. Software used, based on the FIG model, was prepared on an HP64000 microprocessor development system.

Integrated circuits 87 and 88 were missing from last month's components list. They are 2114 static rams. In the photograph of power-supply spikes, vertical sensitivity for all but the clock signal is 0.5V/div.

References

1. J. Bovin, Floppy incompatibility, *Systems International*, May 1983, p.61.
2. J. Hoeppner and L. Wall, Encoding/decoding techniques double floppy disc capacity, *Computer Design*, Feb. 1980, pp. 127-135.

Brian Woodroffe plans to describe the Forth language in a subsequent series.

Wireless World Forth computer
Introduction, c.p.u. and memory circuits, May 1983, pp. 53-8.
Circuit description, video-controller circuit and peripherals, June 1983, pp. 55-8.
Software, disc controller and power supply circuits, July 1983, pp. 58-61.
Construction tips, August 1983, pp.44,45.

Complementary current mirror

Current mirrors with transistors of the same type of conductance are well known[1] and widely used in integrated circuits[2]. It is possible to create the configuration with similar properties using complementary transistors also, Fig. a. Accepting the usual assumptions[2] that

$$I_{C1}=I_{S1}\exp|V_{BE1}|/V_T$$
$$I_{C2}=I_{S2}\exp V_{BE2}/V_T$$
$$I_{B1}=I_{C1}/\beta_{F1}$$

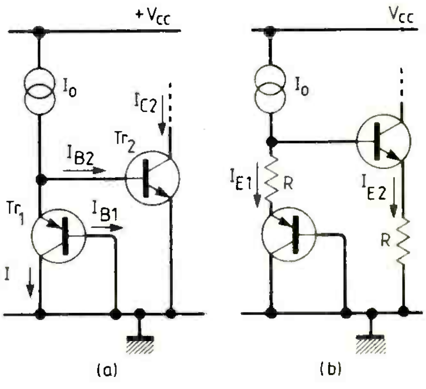
and $I_{B2}=I_{S2}/\beta_{F2}$, the output current is

$$I_{C2}=\frac{I_0}{\left(1+\dfrac{1}{\beta_{F1}}\right)\dfrac{I_{S1}}{I_{S2}}+\dfrac{1}{\beta_{F2}}}$$

with $|V_{BE1}|=V_{BE2}$. If the technology allows two complementary transistors with $I_{S1}=I_{S2}$, then

$$I_{C2}=\frac{I_0}{1+\dfrac{1}{\beta_{F1}}+\dfrac{1}{\beta_{F2}}}\approx I_0\left(1-\frac{1}{\beta_{F1}}-\frac{1}{\beta_{F2}}\right)$$

as in the ordinary current mirror. Usually n-p-n and p-n-p transistors in an integrated technology are produced by different methods and parameters I_{S1} and I_{S2}



Complementary transistor current mirror with matched transistor (a) and matched emitter resistances (b).

are not matched. But the discrete current mirror with matched resistors in emitter circuits works reasonably well, Fig. b. In this circuit

$$I_{E1}R+|V_{BE1}|=V_{BE2}+I_{E2}R$$

and

$$I_{E1}=I_{E2}+\frac{|V_{BE1}|-V_{BE2}}{R}.$$

If transistors are designed for complementary operation, say 2N4401 and 2N4403, and emitter resistors are matched to within 1% the error is 2 to 3% without preliminary transistor matching. The gain β_{F1} of a discrete p-n-p transistor is usually high and the collector currents happen to be matched also. – I. M. Filanovsky, University of Alberta.

1. F.J. Lidgey. Looking into current mirrors. *Wireless World*, October, 1979, vol. 68, pp. 51-58.
2. P. Gray, R. Meyer. Analysis and design of analog integrated circuits. Wiley, 1977.

CIRCUIT IDEAS

555 mark/space control

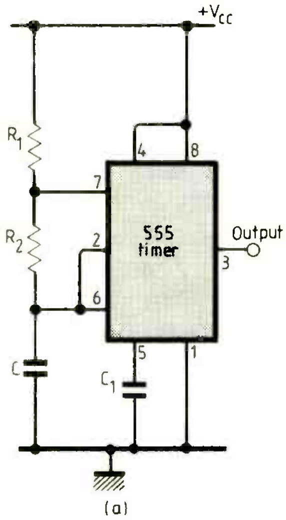
The frequently used 555 astable circuit[1] with one capacitor (a) has the disadvantage that the capacitor C is charged through R_1 and R_2 and is discharged through R_2. Any variation of R_2 will change both the charge and discharge time.

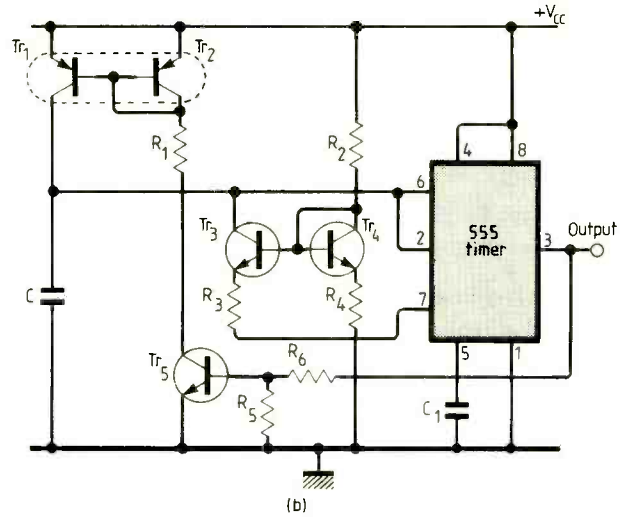
A circuit where the same capacitor is charged and discharged by independently controlled currents is shown at (b). In the first quasi-stable state C is charged by the current source Tr_1, Tr_2 when the switch Tr_5 is closed and the transistor Tr_3 of the discharging current source is off (the inner switch of the 555 timer is open). Charge current is $I_c \approx (V_{cc}-0.7)/R_1$ and the mark duration is $T_1=V_{cc}C/3I_c$. Capacitor C will be charged up to $2V_{cc}/3$. Then the inner switch of the 555 timer (pin 7) closes. Simultaneously the switch Tr_5 opens and the circuit flips to its second quasistable state. Potential on pin 7 becomes close to 0V. Capacitor C starts to discharge. The discharge current

$$I_d \approx \frac{(V_{cc}-0.7)}{(R_2+R_4)} \cdot \frac{R_4}{R_3}$$

and the space duration is $T_2=V_{cc}C/3I_d$. When C discharges to $V_{cc}/3$ the circuit returns to the first quasistable state.

This circuit can be used without matched transistors in the current source





Tr_1,Tr_2. In this case we have to introduce resistors[2] in the emitter circuits of Tr_1 and Tr_2 as in Tr_3 and Tr_4 (the emitter resistor of Tr_1 in this case can be used for frequency control as well). For the current source Tr_3,Tr_4 the resistor R_3 and R_4 are necessary to compensate for the saturation voltage of the 555 inner switch (this voltage can be as large as 0.1V).

Mark/space ratio for this circuit is $T_1/T_2=I_d/I_c$. It is easily controlled, and T_2/T_1 of the order of 10^{-3} can be achieved without difficulty, taking into consideration practical limitations for transistor currents.

I. M. Filanovsky, V. A. Piskarev
University of Alberta
Canada

1. J.L. Linsley Hood 555-Type integrated circuits. *Wireless World*, April 1982, pp. 41-43.
2. U. Tietze, Ch. Schenk. Advanced Electronic Circuits. Springer-Verlag, 1978.
3. F.J. Lidgey. Looking into current mirrors. *Wireless World*, October 1979, pp. 57, 58, 68.

Predictable relay oscillator. Switch S of this circuit in the August issue was the one at the top of the diagram.

Acoustic timer with bargraph display

Devised to monitor the response time of an acoustic impulse system, the start pulse in this circuit is derived from the stimulation and the stop pulse from a pressure sensor. As several supposedly identical sources were triggered simultaneously, and the important parameters were output phase and reapeatability rather than absolute delay, a multiple bargraph display gave the best visual readout.

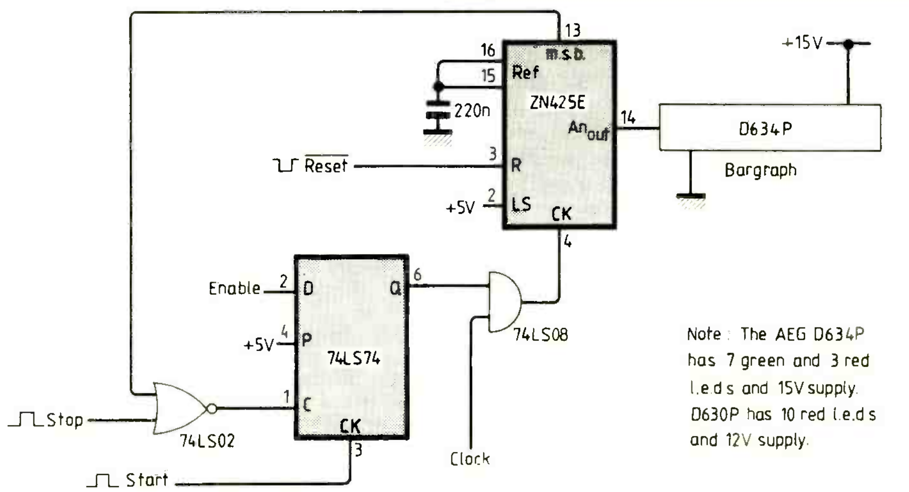
The most attractive feature is that only one control wire is needed to each bargraph display; no current-limiting resistors are needed and each display takes only 40mA of current irrespective of the number of segments lit. Calibration is unnecessary, device tolerances being well within the 10% display resolution.

The ZN425E is used in the counting d-to-a mode, and will accept clock rates of up to 1MHz. Using the internal 2.55V reference, one clock pulse gives an output step of 10mV. With full scale on the D634P needing 1.0V, this corresponds to 100 clock pulses; a 100kHz clock gives a full scale of 1ms, and the scale can be changed merely by changing the clock frequency.

The m.s.b. output will go high at a count of 128 (=1.28V). By or-ing this with the stop input, the display will always give a "full house" reading when the stop pulse is missing or outside the pulse window.

For measuring such items as pulse jitter about a mean, the effective accuracy of the display can be increased by introducing a fixed delay in the start pulse to bring it closer to the stop pulse, and increasing the clock frequency.

Trevor S. Smith
Stag Electronics
Hebden Bridge
W. Yorkshire



Don't waste good ideas

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

Submissions are judged on originality or usefulness – not excluding imaginative modifications to existing circuits – so these points should be brought to the fore, preferably in the first sentence. Minimum payment of £20 is made for published circuits, normally early in the month following publication.

Simpler combination lock

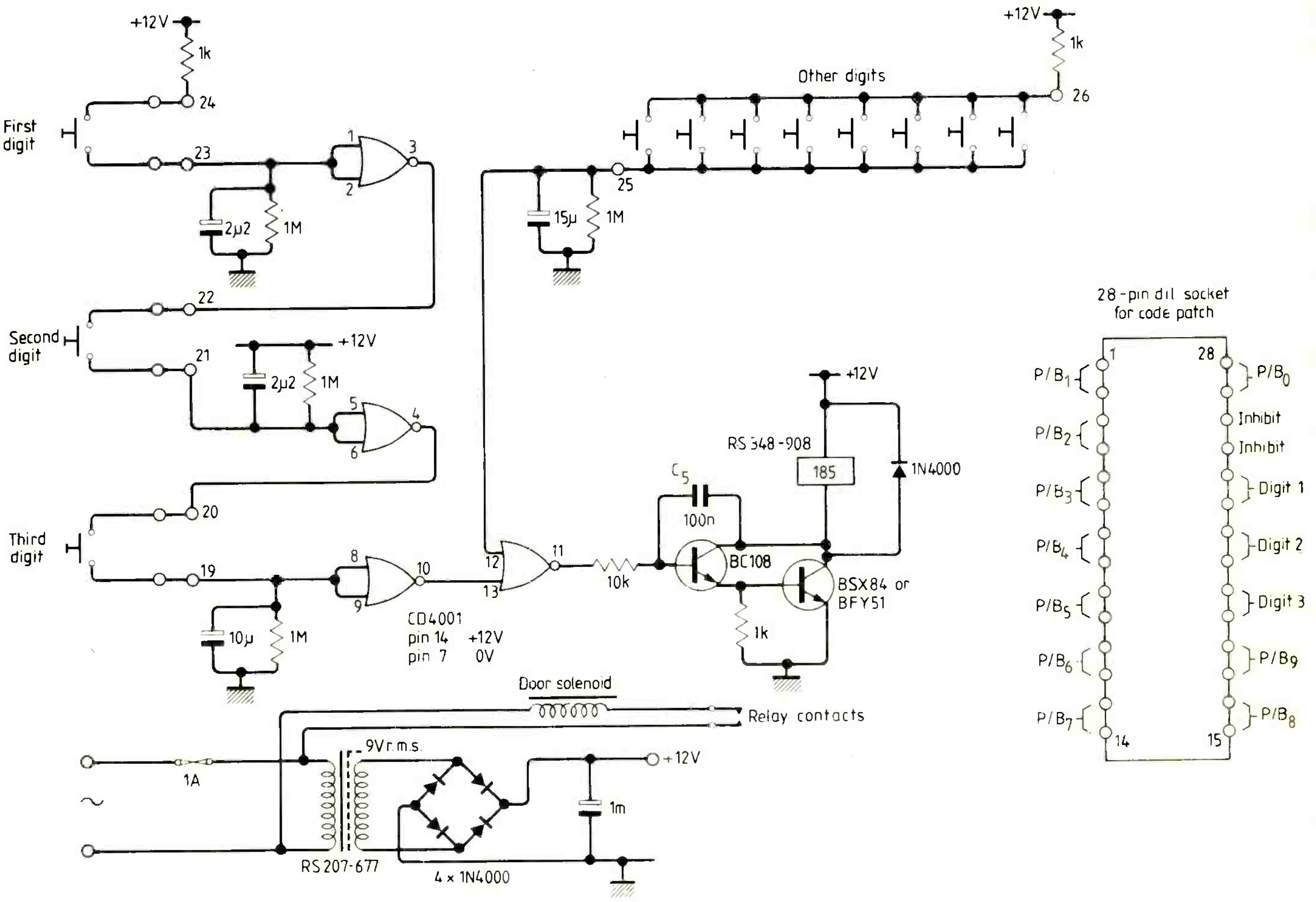
This simple and cheap circuit has been in use for over three years on an entrance door to a clean-room and has suffered only one breakdown caused by "infant mortality" of a leaky BC108 transistor.

Three push-buttons have to be operated in sequence to open the lock. Pressing an incorrect button inhibits lock operation for approximately 20 seconds. A person trying to gain access without knowing the combination would not know how long to wait between attempts, and therefore might miss the successful combination. There are 700 possible combinations of 3 different keys from 10, so waiting 20 seconds between entries will take approximately 10 hours to try them all. If an authorized person hits a wrong key, the 20 seconds is not too long to wait until a new attempt can be made. Of course, the time delays or even the number of keys can be altered as appropriate for the security level required.

The code for the lock can be hard-wired by connecting the push-buttons directly to the circuit, or can be changed as shown in the circuit diagram by routing the connections through a 28-pin d.i.l. socket or any other appropriate patch plug. The three active push-buttons are jumpered across the first, second and third digit inputs, and the remainder are wired in parallel to the inhibit input. Note that push-buttons with separate access to both switch contacts must be used, and not the encoded matrix arrangement used on calculators etc.

The circuit could be extended for greater security by adding further push-buttons across the inhibit input, or by adding another quad nor-gate for up to four more keys in the code chain.

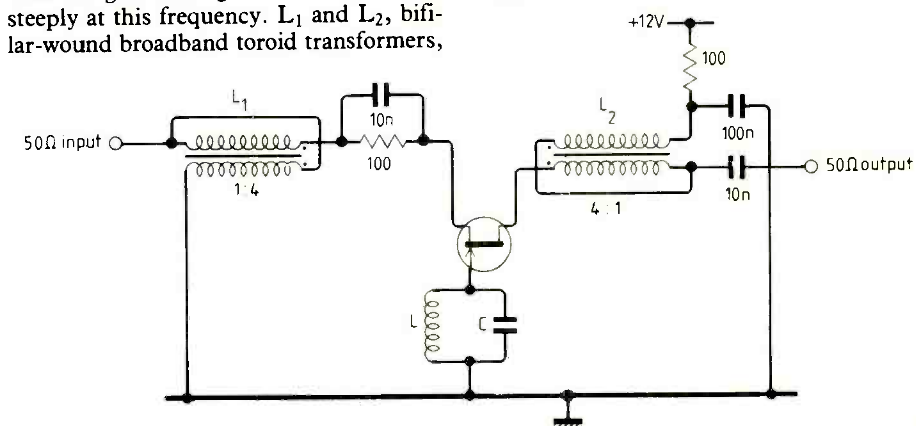
A. F. Abbey
Stoney Stanton, Leics



RF notch filter has wide range

Designed to operate from the low to the high radio-frequency range, this notch filter provdes −76dB stopband attenuation. Basically a common-gate amplifier, at the notch frequency $f = \frac{1}{2\pi}\sqrt{LC}$, the parallel-tuned LC circuit effectively isolates the gate from ground and gain falls steeply at this frequency. L_1 and L_2, bifilar-wound broadband toroid transformers, can be replaced by simpler resistive coupling. Attenuation and Q are dependent on choice of fet, LC characteristics and circuit layout. A Q of 30 and stopband attenuation of −76dB were obtained at a cut-off frequency of 30MHz using an MPF102 field-effect transistor.

A. Achong
University of the West Indies
Trinidad



General-purpose microcomputer board

Designed to perform secondary tasks in a larger system, this single-board microcomputer based on the 8085 processor has serial i/o through a uart – data rates up to 9600 baud are selected by software.

by Michael Shragai

As presented, this single-board microcomputer transmits and receives characters for teleprinters and other terminals using a usart but the board has numerous applications including modem, c.r.t. and instrument control. Test software given demonstrates sending and receiving of characters in RS232/20mA loop form and proves the hardware construction. The board's first application was in traffic control: data on traffic received by telephone in four-bit hexadecimal form is converted and sent to a remote terminal in serial 300 baud ASCII code or binary form at RS232 levels.

Four main elements of the circuit are c.p.u., memory, serial i/o and timer sections. Features of the 8085 processor are five interrupt levels, integral clock, two serial i/o lines (SID and SOD), seven registers and 71 instructions, 69 of which are 8080 compatible. An 8251 universal synchronous/asynchronous receiver/transmitter, or usart, was used for serial i/o instead of the serial capability of the processor to keep software to a minimum and reduce the load on the processor, but apart from this there is no reason why the 8085 serial i/o lines shouldn't be used.

Most of the control bus is buffered to provide extra drive necessary when the computer is connected to external systems. Decoder 74LS142, connected to the high-order byte of the address bus, is used for selecting ram, eprom, usart and the timer. Four additional external devices may be selected using spare capacity of this decoder. Memory devices may be 2-8K static ram and 2-8K eprom, and their start address may be either 0 and 20000 octal or 20000 and 0 respectively. Usually, eprom uses addresses 0 to 20000 and ram starts at 20000.

Restart interrupt inputs RST 5.5 and RST 6.5 of the processor are connected to the usart transmitter and receiver-ready outputs. Alternatively polling may be used to test the status word of the usart. The receiver/transmitter can work in synchronous and asynchronous modes; in this application the device is used to receive or transmit data at rates up to 9600 baud which are determined by software using only six instructions. Initiation of the usart and timer are included in the program example, List 1, and values of control words used to set the data rate assuming a 6.144 MHz clock are given in Table 1. Data can be transmitted or received in RS232 or 20mA current loop form using

Table 1. Values used with software control words to determine data rates

Rate (baud)	Number loaded CNTR1	CNTR2
110	163	10
300	40	3
600	140	1
1200	200	0
2400	100	0
4800	40	0
9600	20	0

Michael Shragai works in R&D Laboratories as a senior electronics technician at the Chief Scientists Office of Israel's Ministry of Communications, Tel Aviv.

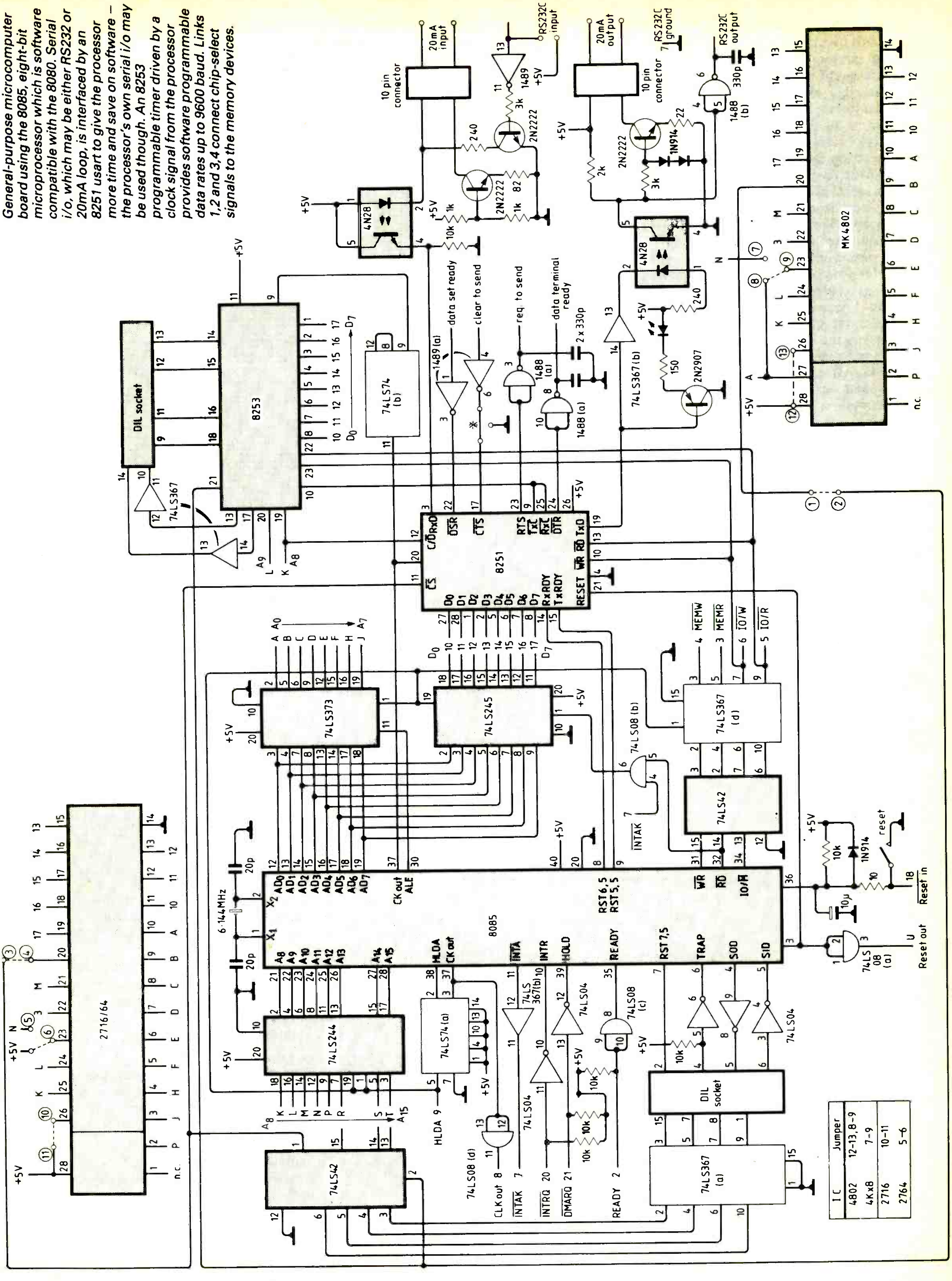
Test program for transmitting to a teletype terminal

```
[illegible]
```

Test programs for transmitting data to teleprinter terminal, left, and for receiving then transmitting characters, right.

Echoing program

```
         MVI   77,A     ;[illegible] mode of time
         OUT   43
         MVI   CNTR1,A  ;Load timer
         OUT   40
         MVI   CNTR2,A  ;with appropriate data rate
         OUT   40
         MVI   214,A    ;[illegible]
         OUT   1
         MVI   [illegible],A ;receiver and transmitter
         OUT   1
         MVI   17,A     ;Disable [illegible] restart
         SIM
TTYIN:   IN    1        ;[illegible]
         ANI   [illegible]  ;[illegible]
         JZ    TTYIN    ;[illegible]
         IN    0        ;Input character
TTYOUT:  MOV   [illegible]  ;Transmitting subroutine
TTYO:    IN    1
         ANI   [illegible]
         JZ    [illegible]
         MOV   [illegible]
         OUT   [illegible]
         JMP   TTYIN
         .END
```



I C	Jumper
4802	12–13, 8–9
4K×8	7–9
2716	10–11
2764	5–6

General-purpose microcomputer board using the 8085, eight-bit microprocessor which is software compatible with the 8080. Serial i/o, which may be either RS232 or 20mA loop, is interfaced by an 8251 usart to give the processor more time and save on software – the processor's own serial i/o may be used though. An 8253 programmable timer driven by a clock signal from the processor provides software programmable data rates up to 9600 baud. Links 1,2 and 3,4 connect chip-select signals to the memory devices.

opto-couplers, data transmission being indicated by an led.

The prototype was connected to the outside world using four connectors – a 44 pin edge connector for address, data and control signals, a 16pin dil socket connected to the decoder, a 26 pin flat-cable connector carrying status signals and a 10pin connector for RS232/20mA signals. Automatic power-on reset is included, i.e. the program always starts from the beginning when the computer is switched on.

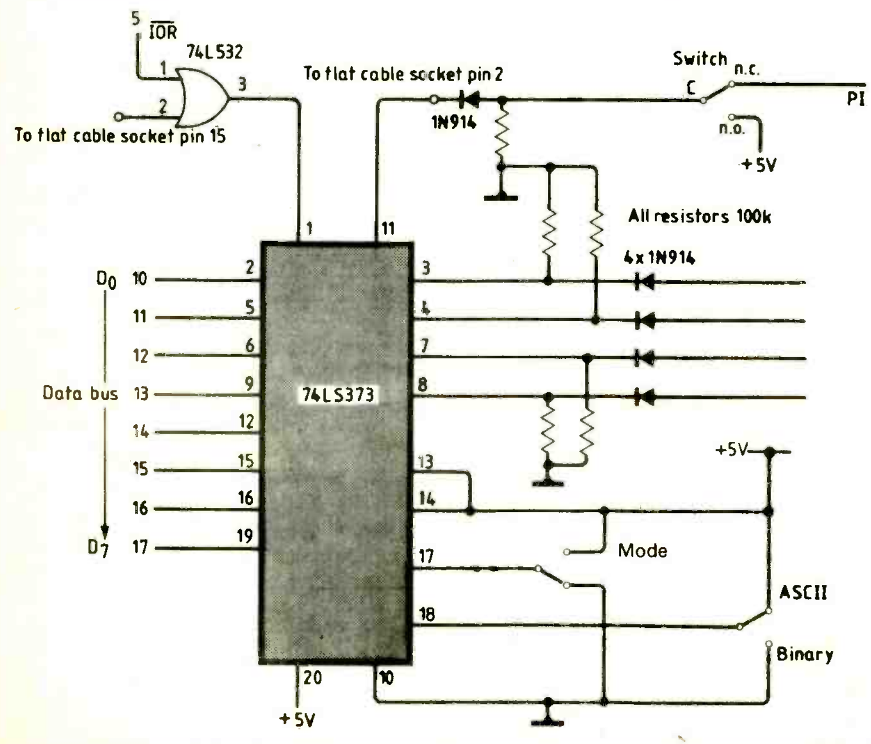
Software was developed on a PDP11/40 minicomputer and translation to machine code carried out by a MAC80 cross assembler. In my application ram is loaded from the host computer using a 'front panel' system. Loading is done in direct memory access mode after defining the memory region and the file name of the program to run in real time on the target microprocessor. The front panel has tracing and breakpoint capabilities to help debugging of the program.

```
        LXI     24000,SP
        JMP     INIT
        .BLK    66              ;Blank til address 74 oct.
INTR:   JMP     MSG             ;Restart 7.5 address
INIT:   MVI     77,A            ;Set time for 300x16 baud
        OUT     43
        MVI     40,A
        OUT     40
        MVI     3,A
        OUT     40
        MVI     372,A           ;Set uart for even parity
        OUT     1
        MVI     41,A
        OUT     1
        MVI     13,A            ;Enable restart 7.5 only
        .BYTE 60
        EI                      ;Enable interrupt
        LXI     HEADER,H        ;Print header
        CALL    TTYO
        JMP     CRLF            ;Print CR and LF
EOM:    DCR     B               ;LF & CR every 80 char.
        MOV     B,A
        JZ      CRLF
        MVI     113,A           ;SOD low (ready signal)
        .BYTE 60
        HLT                     ;HALT: wait for interrupt
        JMP     EOM
MSG:    IN      1               ;Ready to transmit?
        ANI     001
        JZ      MSG
        MVI     313,A           ;SOD high (not ready)
        .BYTE 60
        IN      100             ;Input status
        RAL                     ;Rotate m.s.b. to check carry (switch pos.)
        JC      ASCII           ;Jump according to switch position
        JNC     BINAR
ASCII:  IN      100             ;Input parallel word
        ANI     17              ;and transmit serial ASCII
        ADI     60
        OUT     0
        EI
        RET
BINAR:  IN      100             ;Input parallel word
        ANI     17              ;and transmit serial binary
        OUT     0
        EI
        RET
CRLF:   IN      1               ;Print CR and LF
        ANI     001
        JZ      CRLF
        MVI     12,A
        OUT     0
S2:     IN      1
        ANI     001
        JZ      S2
        MVI     15,A
        OUT     0
        MVI     80.,B
        JMP     EOM
HEADER: .BYTE 12,15             ;Header transmit subroutine
        .ASC /TRAFFIC MEASUREMENT DEVICE/
        .BYTE 12,15
        .ASC /TELECOMMUNICATION RESEARCH CENTER/
        .BYTE 12,15
        .ASC /***********************************/
        .BYTE 12,15,0
TTYO:   IN      1
        ANI     001
        JZ      TTYO
        MOV     M,A
        OUT     0
        INX     H
        ANA     A
        RZ
        JMP     TTYO
        .END
```

Data-conversion application

This software and interface developed for the general-purpose microcomputer board were used to convert four-bit hexadecimal telephone traffic-control data into 300 baud RS232 serial data for sending to a remote terminal in ASCII or binary.

Inputs to the conversion interface are four bits representing a hexadecimal word, punch-instruction select signal, ASCII/binary select and a signal representing operating mode, set using the unmarked switch.



EVENTS

Continued from page 59

September 16-17
Television tomorrow – costs and quality. Royal Television Society Convention, Kings College, Cambridge. RTVS Tel: 01-387 1970.

September 17-25
The great home entertainment spectacular: home entertainment electronic show. Olympia, London, Montbuild, Tel: 01-486 1951.

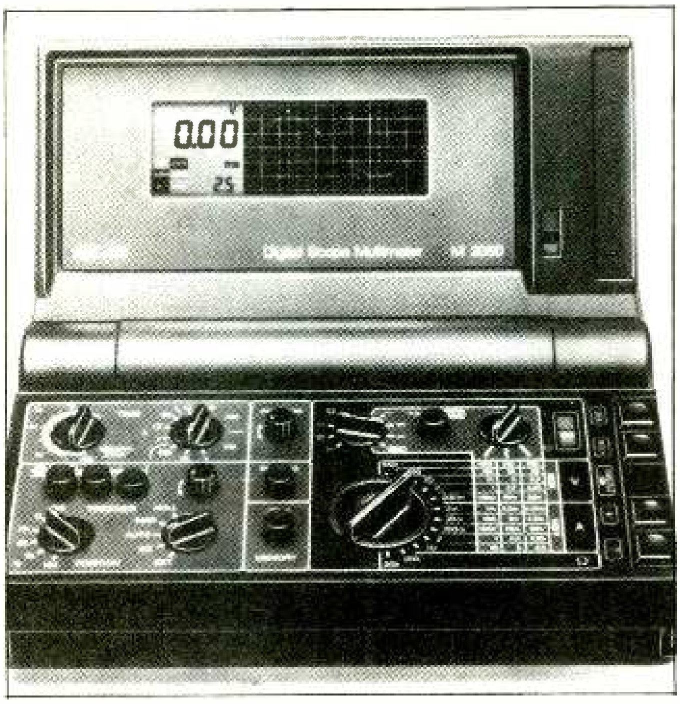
September 20-22
Sensors and their applications: European conference and exhibition at University of Manchester Institutes of Science and Technology. Organised by the Institute of Physics, Tel: 01-235 6111

September 26- 28
International electrical, electronics conference and exposition; Automotive Building, Exhibition Park, Toronto, Canada. Sponsored by the Canadian Region of the IEEE, 1450 Don Mills Road, Don Mills, Ontario M3B 2X7, Canada.

NEW PRODUCTS

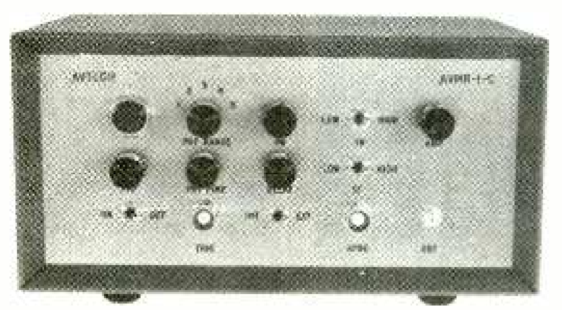
BRITISH PRINTER FOR SCHOOLS AND SHIPS

Walters WM200 dot-matrix printer incorporates many of the features that make printers emanating from the Far East attractive. It has 9 by 9 dot-matrix printer head that prints in either direction at a speed of 120 characters/s. Four character sizes are available and much thought has been put into the design of the typeface which is very clear and legible. Sprocket-fed paper can be up to 254mm wide. The printer is provided with a Centronics, RS232 or IEEE488 interface and may be easily converted from one to another by changing a slot-in p.c.b. a 750-character internal buffer is supplied which may be expanded to 1800 characters. The printer's development was partly funded by the Department of Industry's Microprocessor Applications scheme and has been selected for use in schools as part of the extension to the 'micros in schools' project, and by the Ministry of Defence. £395 from Walters Microsystems International Ltd, Cetec House, Lincoln Road, Cressex Industrial Estate, High Wycombe, Bucks HP12 3QU.
WW 301


WW305

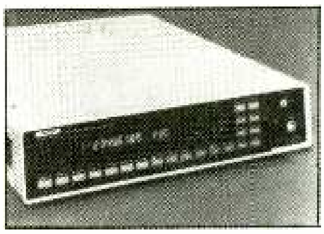
FAST-RISE PULSE GENERATOR

Rise and fall times of 150ps are provided in Avtech pulse generators. AVMR-1 has a pulse width variable between 10 and 200ns and a repeat frequency of 5MHz which may be increased to 10MHz with a rise time of 1ns. AMVR-2 is similar but provides high pulse amplitude to 20V with 300ps rise time at 5MHz or 3ns at 10MHz. Both models are available as a bench instrument with internal clock, a line-powered instrument with external trigger or a compact module requiring 24V direct power and an extenal trigger. Prices start at £700. Lyons Instruments, Hoddesdon, Herts.
WW 302


WW302

MAGNETIC HYSTERESIS MEASURED

A B-H meter which can be used directly to check the quality of magnetic recording tape and discs is the 7500A meter which can be used for process control by manufacturers of magnetic media. The microcomputer-controlled meter may be programmed (though two floppy discs) for a variety of applications. Analogue B and H measurements are digitised, stored, sorted and scaled in order to measure the desired parameter. A 50 or 60Hz magnetizing field is applied to the sample and a graphical plot of the Hysteresis curve is displayed on the c.r.t. along with the computed parameters. The curves and data may be stored for later use or printed out on the optional printer-plotter. All fits into a convenient desk-sized unit. LDJ Electronics Inc. Unit 2, The Midlands, Holt, Trowbridge, Wilts BA14 6RU.
WW 303


WW304

MICRO-CONTROLLED D.V.M.

A digital voltmeter with an 8½-digit readout with a resolution down to 10nV has been announced by Solartron. The heart of the system is a patented pulse-width modulated a-to-d converter. The scale length can be selected to give five or eight significant digits, each with a different integration time. On d.c. ranges the meter is claimed to have an accuracy to within 1.2 p.p.m. over a 24-hour period. The performance has been achieved, say Solartron, by close attention to the ageing of such components as zener diodes and resistors, with compensation circuits to allow for temperature stability of the zeners. True r.m.s. alternating voltages can be measured with six significant figures, resistances from 10μΩ to 1400MΩ. The lowest ohms range has the means of measuring any spurious e.m.f. and then compensating for this to give a 'true ohms' reading. The control circuitry allows eight different ratio measurements and 17 data processing programs to calculate such parameters as the mean, standard deviation and variance of measurements, or for checking results against pre-defined limits. 1500 results may be stored and used for analysis or display. The meter has IEEE488 and RS232 interfaces and calibration may be carried out through these. The makers see the meter as of use in calibration labs and in automatic test gear as well as general lab and workshop use. The 7081 is from Solartron Instrumentation Group, Victoria Road, Farnborough, Hants GU14 7PW.
WW 304

FLAT-SCREEN SCOPE WITH DVM

A combination of the functions of an oscilloscope, a transient recorder and a digital multimeter are all fitted into one portable unit. The 3½-digit multimeter has 32 ranges of current, voltage and resistance measurement. A flat screen liquid crystal display oscilloscope can run for up to eight hours on the internal battery. The transient recorder uses the integrated l.c.d, and there are two independant 0.5K-byte memories. Folding for carriage and storage the instrument is useful in the laboratory, workshop or for the field engineer. The M2050 costs £975 and can be provided with a printout when it would cost £1150. John Minster Instruments Ltd, 137 Sandgate Road, Folkestone, Kent CT20 2DE.
WW 305

REMOTE CONTROL

A four-channel infra-red remote control costing £38.50 for both receiver and transmitter is available. The control provides a latched push-on/push-off function which may be used to operate several functions. Power switching relays may be added if required. Maximum operating range is 20m. The receiver preamplifier is fitted into a screened box mounted on to a p.c.b. with the remaining components, and a stabilized power supply which operates from 12 to 14V alternating supplies. Immunity from interference is provided with the use of coded signals. The transmitter uses four power infra-red l.e.ds with reflectors and is powered by a 9V battery, all fitting into a hand-held case. The Velleman control is available from Electronic and Computer Workshop Ltd, 171 Broomfield Road, Chelmsford, Essex, CM1 1RY.
WW 306

MICRO PRODUCTS

16-BIT FORTH

A Forth implementation for the Sage II computer includes an assembler for the 68000 processor which enables machine code languages to be developed through Forth. The versatility of Forth is illustrated by the development of the package; "To write this version of Forth we had to use an assembler that had certain shortcomings," says Tim Moore of Kuma. "We wrote a verbosely coded Forth and then used it to write a real assembler. Using that, we wrote the final version of Forth". Kuma intends to implement the Forth on as many different 68000-based computers as popular demand requires and are willing to undertake 'custom' versions for such applications as industrial robotics. The kernel conforms to FIG-Forth standard, the 68000 assembler uses standard mnemonics, a screen editor is provided and the system is supported by a tutorial manual. Kuma Computers Ltd, 11 York Road, Maidenhead, Berks SL6 1SQ.
WW 307

C-MOS 8086

A world first c-mos 16-bit processor is claimed for the Harris 80C86, a c-mos version of the Intel 8086. The 80C86 is completely compatible with its pattern and has the added advantages of lower power requirements, greater reliability and a wide temperature-operating range. The operating current of 10mA compares with 340mA for the 8086. This means that high speed portable computers may be manufactured with the full facilities of standard computers. The operating frequency of 5MHz is available now for versions with commercial, industrial or military temperature range requirments. 8MHz versions will be introduced toward the end of the year. Harris Systems Ltd, 153 Farnham Road, Slough, Berks SL1 4XD.
WW 308

8085 COMPUTERS USE Z80 SOFTWARE

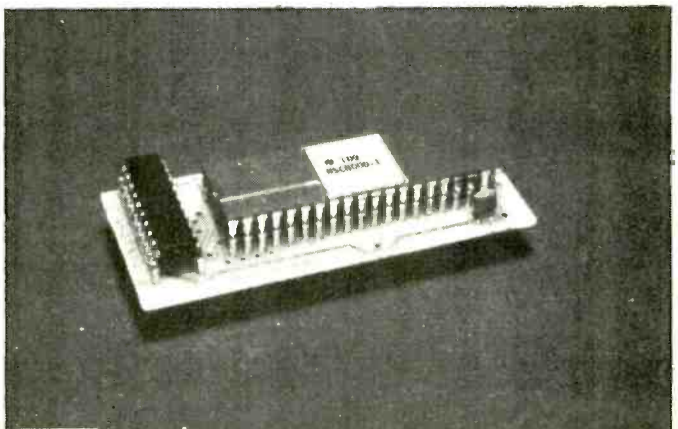
. . . if a simple adaptor is used to replace the 8085 microprocessor with an NSC800 and a matching circuit. The plug-in unit fits the 8085 socket and itself has a socket for the NSC800. One drawback is that the serial input and serial output pins of the 8085 may not be used. The adaptor costs £12.90 from F. Braunschmid, Inzerdorferstrasse 119, A-1100 Vienna, Austria.
WW 309

WW310

MICRODRIVE – AT LAST

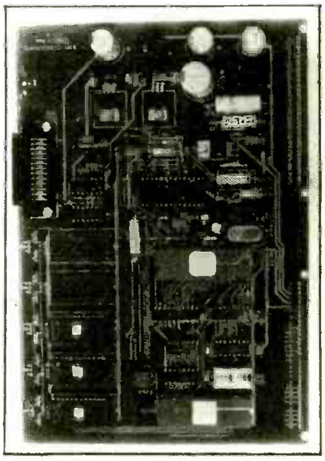
Announced as 'coming soon' when the Sinclair ZX Spectrum was launched, the ZX Microdrive has just been launched, about a year later. The recording medium turns out to be a continuous loop of tape sealed in a removeable cartridge. Each cartridge can store over 85Kbytes with a typical access time of 3.5s and the Microdrive behaves rather like a miniature floppy disc drive. It interfaces with the computer through ZX Interface 1, which contains the control circuitry for up to eight Microdrives, giving a total storage capacity of 680K-bytes. Interface 1 also provides an RS232 interface so the Spectrum can communicate with other networked Spectrums, or with other computers or peripherals. Transmission rates are software-selectable up to 19200baud. The local area network can link up to 64 Spectrums; it transmits at 100baud. Each transmitting terminal can select a receiver or broadcast to all open receivers. File exchanges and peripheral (i.e. printer) sharing are allowed for.

The ZX Microdrive costs £49.95, Interface 1 is £29.95 if bought with Microdrive or £49.95 on its own. Each cartridge costs £4.95. There is unlikely to be any available in the shops for a while; they are being offered, mail order, to the owners of ZX Spectrums in the order in which they were purchased. Sinclair Research Ltd, 25 Willis Road, Cambridge CB1 2AQ.
WW 310


WW309

HIS MAESTRO'S VOICE

The speech synthesiser chip used in the BL Maestro car is now available to design engineers as an evaluation and support package. The Europcard Speechpak board is based on the Hitachi HD61885 speech synthesiser and includes an audio amplifier. Words and phrases can be input through a keyboard, or through an RS232 data link. It costs £180. There is also a software development service available and the distributors can provide production-quantity boards with the on-board rom mask-programmed to any requirement. Dialogue Distribution Ltd, Watchmoor Road, Camberley, Surrey GU15 3AQ.
WW 311


WW311

FAST FORTH FOR Z80

A CP/M disc version of Forth for the Z80 processor claims to be the only version which can compile high-level threaded code definitions into machine code primitives. This gives a two- to five-fold increase in speed according to the Quanta Corporation, who developed Q4TH. The standard Forth-79 set is implemented along with an interpreter, screen editor, assembler (using Zilog mnemonics) and the machine code compiler. The system is available in a number of disc formats and is supported by an update and newsletter scheme. A package of various utilities is included. Quanta Corporation, 2510 Sunset Boulevard, Los Angeles, California 90026, USA.
WW 312

If you would like more information on any of the items featured here, enter the appropriate WW reference number(s) on the mauve reply-paid card bound in this issue. Overseas cards require a stamp.

EuroCUBE 6502/6809—EuroBEEB—BEEBEX
The expanding range of CUBE control boards

BBC BASIC now on Eurocard

EuroCUBE is just one small 100×160mm Eurocard–but it is a single-board computer of exceptional power and versatility.

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- Four memory sockets, each 28 pin. Supports RAM, ROM, EPROM–from 2KB to 32KB each.
- Battery Back-up for CMOS RAM
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- VIA provides 20 digital i/o channels.
- ACIA provides a bi-directional RS-232/423/422 serial port. On-board programmable baud-rate generator.
- PROM address decoding.
- Machine Operating System included free of charge.

EuroBEEB–EuroCUBE with BBC BASIC–The MOS included on EuroCUBE, provides an environment in which languages can be run, and is available in two main versions:

MOS A – supports ATOM BASIC
MOS B – supports BBC BASIC

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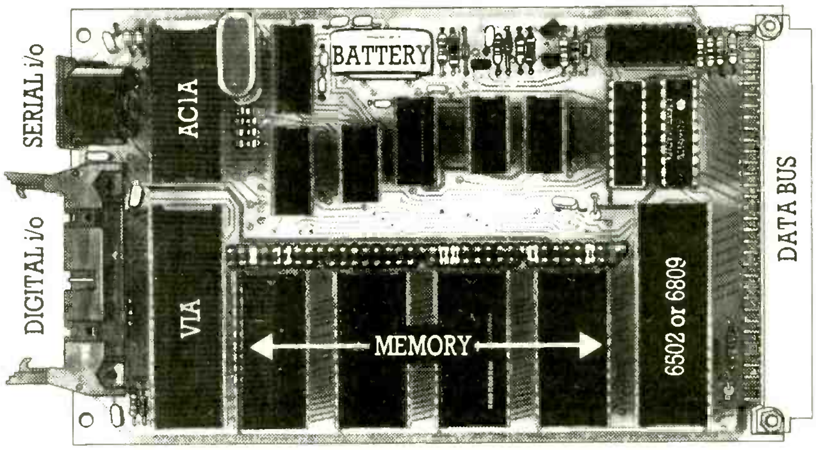

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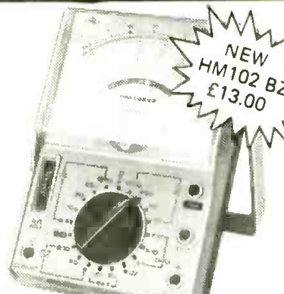

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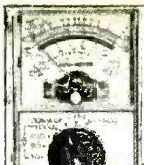

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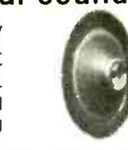

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AUDITORIUM	15	8-16	60	HI-FI	£37	£2
GROUP 45	12	4-8-16	45	PA	£16	£2
DG 75	12	4-8-16	75	PA	£20	£2
GROUP 100	12	8-16	100	Guitar	£26	£2
DISCO 100	12	8-16	100	Disco	£26	£2
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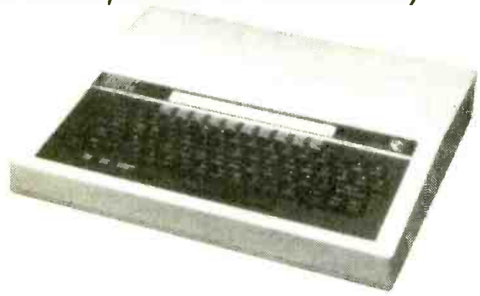

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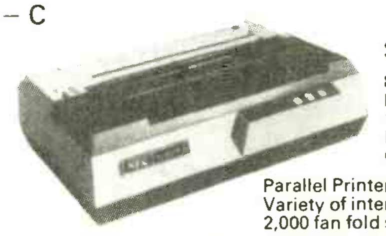

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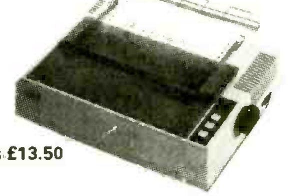

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20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No. of ways	9	15	25	37
MALE				
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Angled	150p	210p	250p	365p
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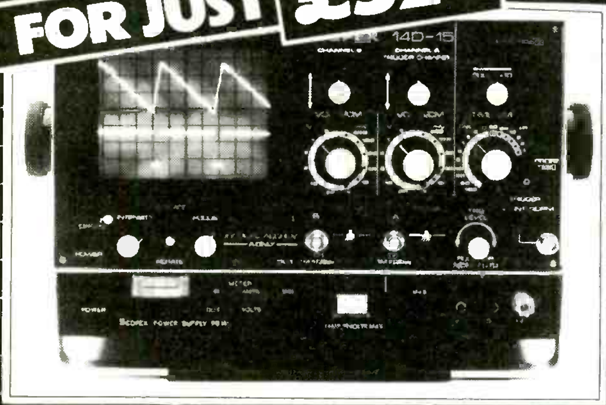

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SOFTWARE DEVELOPMENT ENGINEER

A programmer is required to join our development team involved with software development of our automated broadcast television products (including processor-controlled broadcast studio colour television cameras). You should be experienced in writing assembly language programs for process control/automation applications using the NSC800 (a CMOS Z80) series of processors or similar. Experience in the use of higher level languages would also be an advantage.

TELEVISION SYSTEMS SALES ASSISTANT

An assistant with a sales engineering background who has the ability to progress into the area of writing and costing proposals and quotations for the design and construction of broadcast television systems (studios and outside broadcast vehicles) is required to join our sales team. You should have a knowledge of television broadcast engineering, a technical writing ability and a financial awareness.

Competitive salaries are offered together with free permanent health insurance, contributory pension scheme and generous relocation assistance where necessary.

Please telephone our Personnel Department on Andover (0264) 61345 for an application form or alternatively, write to us giving us full details of your background and experience.

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ELECTRONICS

Walworth Industrial Estate, Andover, Hampshire, England
Telephone: Andover (0264) 61345

(2216)

P & E LTD

RECRUITMENT

We have been successful in filling both senior and junior vacancies from our comprehensive file of applicants who have registered with this Company. We now wish to extend our file to meet future demands and are seeking application for registration mainly from those whose qualifications and experience fall into the following categories:

Management staff with engineering qualifications and experience in Television and Radio broadcasting or related technologies.

Transmitter installation or operations and maintenance engineers and technicians for Broadcasting and Telecommunications services.

Television Studio and Outside Broadcast engineers and technicians.

Graduates with Electronics degree but without material practical experience.

Vacancies occur both for UK based and overseas posts.

If you believe your skills or qualifications meet the above broad requirements please contact:

PERSONNEL & ELECTRONICS LTD.
Triumph House, 1096 Uxbridge Road
Hayes, Middlesex
UB4 8QH, England, UK
Telephone: 01-573 8333. Telex: 934271

(2222)

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DIGITAL, MICROPROCESSOR, COMPUTER
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Design, Test, Sales and Field Service Engineers — to use our free, confidential service and improve your salary and career prospects. UK and overseas, contact:

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11 Westbourne Grove, London W2. Tel: 01-229 9239

(1935)

LASER-SCAN LABORATORIES LIMITED

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We are a leading manufacturer of precision computer controlled laser-deflection systems, located on the Science Park.

Our range of products includes laser-based displays, plotters and digitisers.

Due to Company expansion we invite applications for:

IN-HOUSE COMMISSIONING ENGINEER

Required to test and align the Company's precision laser plotters and digitisers. A working knowledge of TTL is required, and experience with microprocessors and/or laser optical systems would be an advantage. A minimum qualification of HNC in Electrical and Electronic Engineering or equivalent is required, coupled with at least two years' industrial experience of both digital and analogue circuitry.

To the successful applicant we can offer pleasant working conditions, competitive salary and a non-contributory sickness scheme.

Please apply to:

The Personnel Officer
Laser-Scan Laboratories Limited
Cambridge Science Park
Milton Road
Cambridge CB4 4BH
Telephone: (0223) 69872

1982

(2223)

INNER LONDON EDUCATION AUTHORITY
Learning Resources Branch
Television Centre
Thackeray Road
Battersea SW8 3TB

ENGINEER — ELECTRONIC MAINTENANCE

Salary range: (ST2) £7,035 to £7,974 plus £1,284 London Weighting Allowance.

The ILEA's Television Centre produces a wide range of educational programmes on video and audio cassettes.
The Maintenance section numbers four persons and a vacancy has arisen for an engineer with a sound knowledge of the principles of colour television, and preferably a working experience of maintaining broadcast type TV equipment. Applicants must wish to specialise on the video side (cameras, vision mixers, telecine, etc.), and will receive appropriate training.
An engineering degree, TEC or other equivalent qualifications are desirable.

Application forms from the Education Officer (EO/Estab. 1B), Room 365, The County Hall, London SE1 7PB. Please enclose a stamped and addressed foolscap envelope. Completed forms to be returned by May 4, 1983.
ILEA is an equal opportunities employer.

(2201)

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(2172)

COLOUR TELEVISION

If you have experience in television or test equipment engineering, there could be an interesting and rewarding future for you at Rediffusion Consumer Manufacturing Ltd. We are currently producing an advanced range of colour television receivers at our factories in County Durham and Cleveland and wish to make the following appointments:

PROJECT LEADER — Production Support

A senior engineer with a sound understanding of television systems and receiver circuits is required to lead a team of engineers and technicians responsible for ensuring that engineering standards are maintained during mass production of television receivers.
Responsibilities include investigation of any technical problems encountered in production, component fault assessment and origination of test/quality specifications. Close liaison is required with the design team to ensure that the product conforms to design specification.

PROJECT LEADER — Test Equipment

Effective testing of television receivers plays an important role in ensuring that our very high quality standards are maintained, and we now wish to appoint an experienced engineer of proven ability, to control a team of engineers and technicians responsible for all aspects of production test equipment.
Responsibilities will include the calibration and maintenance of a sophisticated range of test and signal origination equipment, employing both digital and analogue techniques. Although some test gear is designed and constructed locally, close liaison will be required with the design team, based at Chessington, Surrey, both to keep abreast of new development and influence the design of new equipment in the light of production experience.

Both positions are based at our factory in Bishop Auckland, County Durham, which is within easy reach of attractive countryside and has excellent road, rail and air connections. A wide range of good quality housing is available and assistance with relocation expenses will be made available where appropriate.

Attractive salaries will be offered, together with the benefits of a good pension scheme, free life assurance and 22 days' holiday with a choice of leave period.

If you are interested in either of these positions and would like more details, please write to or telephone:

Mr. D. Abbott
Engineering Product Manager
Rediffusion Consumer Manufacturing Ltd.
Fullers Way South
Chessington
Surrey KT9 1HJ
Telephone: 01-397 5411

REDIFFUSION

(2224)

Leeds Western Health Authority
THE GENERAL INFIRMARY AT LEEDS

Senior Electronics Technician (Grade III or IV)

Applications are invited from persons experienced in electronic maintenance, preferably with imaging and counting equipment, to work in our well-equipped Nuclear Medicine Department. Knowledge of computer systems particularly 8080A microprocessors would be an additional (or alternative) recommendation. The work is interesting, responsible and includes design and development of specialised electronic units. A less experienced person may be considered on the MPT IV Grade.

Minimum qualifications are H.N.C. in electronics or equivalent and N.H.S. experience is desirable.

Salary Scale: MPT III — £6,132 to £7,926 per annum
MPT IV — £5,171 to £6,798 per annum

Application forms and job descriptions are obtainable from The Personnel Officer, Leeds General Infirmary, Great George Street, Leeds LS1 3EX. Telephone (0532) 432799, ext. 3355.

Closing date: August 31, 1983.

(2218)

Television Broadcast Engineers
BBC Television centre, London.

"Our reputation... excellence!"

Television Recording requires Electronics Engineers to train in Broadcast Engineering, to support an expanding Video Tape and Telecine Operation, which includes complex digital and analogue equipment.

Applicants need not initially possess an in-depth knowledge of Television Engineering, as full training will be given, but previous academic training must be supported by enthusiasm for practical engineering.

After training, applicants will progress to work involving all aspects of Television Recording, including in-depth servicing, acceptance of equipment, design of modifications, and technical investigations.

These challenging posts offer excellent promotional prospects for the self-motivated and committed engineer capable of working at the forefront of today's technology. Salaries range from £8,129 to £9,200 – this includes an allowance for shift working. A higher salary will be considered in exceptional circumstances. Qualifications required are, a Degree in Engineering, HND, HNC, Full C&G. For further information please write, with details of your academic and work experience, to **Bob Neal, BBC, P.O. Box 2 BL, London W1 2BL.**

Please quote ref: 83.E.4055/WW/178

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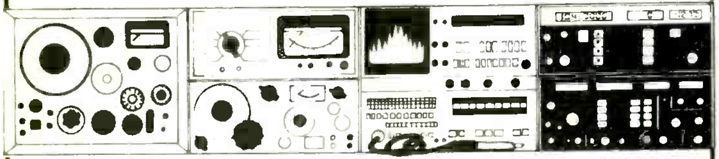
BBC
television recording

Appointments

Test & Calibration Engineers



Having introduced an extended new product range, many of which are microprocessor based, Marconi Instruments has once again confirmed itself as Europe's leading manufacturer of sophisticated test and measurement systems. Our products are selling throughout the world and we are naturally developing further new and innovative designs.

A key role in our organisation is that of our Luton based Service Division, where a group of Technicians satisfy a very wide range of customer needs in the repair and calibration of test equipment.

When you join our team you will quickly become individually responsible for work assignments involving many different kinds of propriety products.

Prospects are excellent. The Division is part of a large company with its main Instrument Design/Manufacturing Base at St. Albans, a Microwave Plant at Stevenage and a further substantial Design Manufacturing Group at Donibristle in Scotland. The Company is proud of its policy of promoting men and women from within, as future Salesmen, Managers and Engineers.

Salaries, which are dependent upon experience and ability are excellent and regular overtime is normally available. Progress for competent engineers and technicians can be rapid. Relocation assistance is available in approved cases. Special consideration is given to 'ex-forces' personnel.

Whatever your level of experience we would like to hear from you. Cut out the coupon and send it to John Prodger, Recruitment Manager, Marconi Instruments Limited, FREEPOST, St. Albans AL4 0BR. Tel: (0727) 59292.

Name Age

Address

Tel. No.

Years Experience

Present Salary:	£6,000 – £7,000	£7,000 – £8,000	£8,000 – £9,000	Over £9,000

Qualifications

Present Job

(2143)

marconi instruments

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Telecommunication Technical Officers

Two levels of entry providing two salary scales: £5980-£8180 and £8065-£9085

Minimum qualifications are TEC/SCOTEC in Electronics/Telecommunications or a similar discipline or C & G Part II Telecommunications Technicians Certificate or Part I plus Maths B, Telecommunications Principles B and either Radio Line Transmission B or Computers B or equivalent: ONC in Electrical, Electronics or Telecommunications Engineering or a CIE Part I Pass, or formal approved Service technical training. Additionally, at least four years' (lower level) or seven years' (higher level) appropriate experience is essential in either radio communications or radar, data, computer or similar electronic systems. At the lower entry level first line technical/supervisory control of technicians involves "hands-on" participation and may involve individual work of a highly technical nature. The higher level involves application of technical knowledge and experience to work planning including implementation of medium to large scale projects.

Radio Technicians

£5232-£7450

To provide all aspects of technical support. Promotion prospects are good and linked with active encouragement to acquire further skills and experience. Minimum qualifications are a TEC Certificate in Telecommunications or equivalent plus two or more years' practical experience.

Cheltenham, a handsome Regency town, is finely-endowed with cultural, sports and other facilities which are equally available in nearby Gloucester. Close to some of Britain's most magnificent countryside, the area also offers reasonably-priced housing. Relocation assistance may be available.

For further information and your application form, please write to

Recruitment Office
GCHQ Oakley, Priors Road
Cheltenham, Gloucestershire GL52 5AJ
or phone 0242 21491, Ext. 2269.

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Hanslope in Buckinghamshire is, we admit, an unlikely backdrop for high technology research and development.

Yet a mere stone's throw away from this delightful rural village the men and women at HM Government Communications Centre are applying the very latest ideas in electronics to the development of sophisticated communications systems and installations, designed to meet special Government needs both at home and overseas.

For graduates and near graduates with real ability and a genuine passion for creative electronics design (the kind of enthusiasm that may already have prompted you to design and build your own communications equipment), this is a superb career environment.

Technically challenging projects cover a wide range of interests including radio (HF to microwave, advanced modulation, propagation studies and micro-circuitry applications); acoustics; magnetics; signal analysis; systems engineering.

The majority of these projects are directed towards specific ends, and we have our own production facility. So, unlike many other R&D establishments, HMGCC offers you the satisfaction of seeing your work right through from conception to manufacture.

With such a broad spectrum of work and training facilities at your disposal, HMGCC is an ideal environment in which to develop the potential you've gained by studying an electronics-biased course. What's more, we think you'll find the working conditions and location very much to your liking.

Please write to us for further details on the work and the remunerations offered at the Centre. As our careful selection process takes some time, it would be particularly helpful if you could detail your qualifications, your personal fields of interest and practical experience, and describe the type of working environment most suited to your career plans.

Dr. D. Orr, Recruitment Officer,
HMGCC, Hanslope Park, Hanslope,
Buckinghamshire MK19 7BH.

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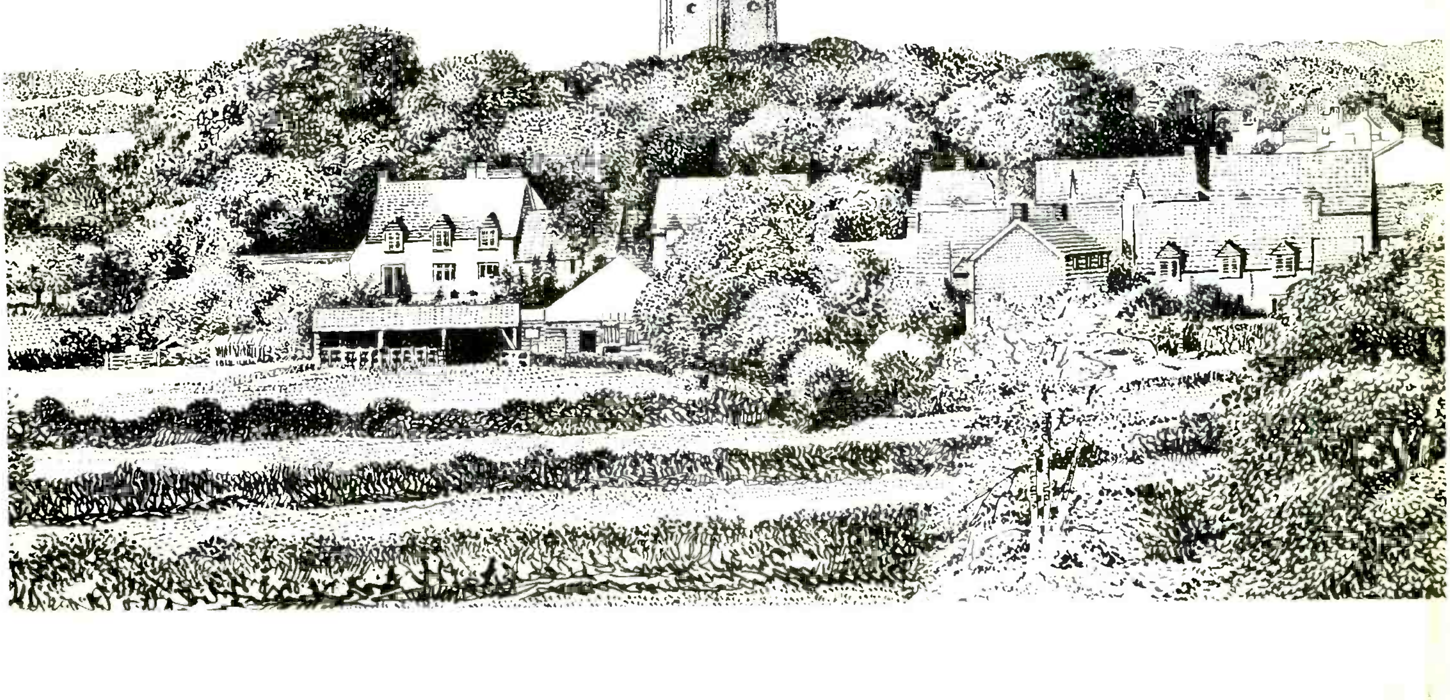

Electronics Engineers

Aviation Systems Planning

IAL you will find worldwide, wherever there is a need for Aviation, Meteorological, Communications or Medical Services.

The continuing expansion within our Aviation Division enables us to offer further opportunities to career minded electronics engineers. These engineers will be based at our headquarters, near Heathrow Airport, and will undertake the systems planning of ground electronics projects for new and existing commitments. Dealing with these projects will entail an element of overseas travel.

You should be qualified with a degree, HND or HNC and preferably be a corporate member of a recognised professional institution. As well as systems planning your experience should cover at least one of the following:

* Radio navigation aids — ILS, VOR, DME.
* HF, VHF and UHF radio and line communications for civil and military aviation.
* Primary and/or secondary radar systems for airfield control, terminal and long range applications.
* Computerised data handling systems for radar display, automatic message switching and meteorological applications.

Salary will be in the range of £8,500 to £11,500 commensurate with experience.

Apply to the Senior Recruitment Officer, IAL, Aeradio House, Hayes Road, Southall, Middlesex, UB2 5NJ. Tel. 01-574 5134. Please quote Ref. K120.

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(2219)

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We have many clients interested in employing ex-service fitters and technicians at sites throughout the UK. Phone for details

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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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Roger Howard, C.Eng., M.I.E.E., M.I.E.R.E.

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Windsor (07535) 58022 (5 lines)

(1640)

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Salary scale: £9898-£11,395 p.a. inclusive

An appointment exists in this modern teaching hospital, which carries responsibility for the day-to-day administration of the technical staff in the Medical Electronics Department.

The main duties are associated with medical 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 preferably have experience of running 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.

Application form and job description from the Unit Personnel Dept, Brandenburgh House, 116 Fulham Palace Road, London W6. Tel: 01-748 2040, ext 2992.

Closing date: 14 September, 1983.

(2225)

RADIO ENGINEER : LATIN AMERICA

To work as a technical adviser with a Latin-American organisation for education by radio, with 40 affiliated radio stations in 17 countries.

The engineer will initially be based in Quito, Ecuador, and will later travel to radio stations in other countries. The job consists of planning and running training courses for local technicians in maintenance of mainly small, short- and medium-wave transmitters, aerials and studios.

Applicants should have radio engineering experience, gained in a broadcasting environment; the post will demand skills in training people with non-technical backgrounds and in planning and improvising equipment. Spanish speakers especially welcome, but language training can be provided.

The post is initially for three years on a basic salary. Because of extensive travel, it is unlikely to suit applicants with families. CIIR will provide orientation and language training, insurance, air fares and various allowances.

For a job description and application form, please send a brief c.v. to CIIR Overseas Programme, 22 Coleman Fields, London N1 7AF, quoting Ref. WW3.

(2212)

BOX NOs.

Box number replies should be addressed to:

Box No......................
c/o Wireless World
Quadrant House
The Quadrant
Sutton, Surrey, SM2 5AS

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ILP

Over the past ten years we have become one of the country's foremost leaders in the field of audio pre and power amplifier modules. We now wish to extend the existing range together with launching new and unassociated products. In order to fulfil this expansion programme, our Research and Development Department have the following vacancies:

AUDIO ENGINEER

The successful applicant must have previous experience in the Hi-Fi field and will be required to tackle all aspects of design, development and preproduction of new products (from conception through to launch).

Salary: Negotiable.

R.F. ENGINEER

We require an R.F. Engineer to be involved in a number of new and interesting projects. Suitable applicants are expected to be qualified to degree level and have some relevant experience in the design of low-power R.F. transmission and receiver circuitry from VHF upwards.

Salary: Negotiable.

Apply in first instance with full c.v. to: Mrs. Johnson, Personnel Manageress, ILP Electronics Limited, Graham Bell House, Roper Close, Canterbury, Kent CT2 7EP.

(2213)

Test Engineers and Technicians –Wembley, Middlesex

Racal-BCC are members of the highly successful Racal Electronics Group and are world leaders in the design and manufacture of tactical radio communications equipment. We require a number of test technicians and test engineers to fill a variety of grades within the Test Department on both the day and night shift. The department is responsible for the manual and automatic testing and fault finding of the Company's equipments at various stages of manufacture.

Applicants should be qualified to HNC/HTC level and have experience of radio communications equipment.

We offer excellent conditions of service including good basic pay and all the benefits you would expect from an internationally successful company.

Please apply in writing to:
Mr. A. Charman,
The Personnel Officer,
Racal-BCC, South Way,
Wembley, Middlesex.

Racal-BCC

RACAL

World leaders in electronics

(2217)

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drake

Philip Drake Electronics Ltd is a growing, successful company that has established itself as a leading supplier of studio communications equipment, programme quality sound distribution modules and special "one off" designs to the Broadcast Industry.

Our continuing expansion has led to a requirement for bigger premises and we are moving from London to Welwyn Garden City in the autumn of this year. We are looking for suitable people to fill the following positions which have become vacant or are being created to handle our increasing business.

As well as attractive salaries, the Company offers a pension scheme and BUPA membership and the new premises being constructed at Welwyn Garden City will provide a pleasant working environment when completed.

SALES MANAGER

A manager with proven sales experience in the broadcast field and/or sales management experience of professional capital products is required. An engineering background is desirable for handling quotations and customer's enquiries.

The manager is responsible for the efficient running of the sales department including control of staffing, preparation and monitoring of department budgets, monitoring of quotation and invoice procedures and direct involvement with customer visits, preparation of quotations, and checking of quotation output from the department.

The manager will also be involved with exhibitions, and sales literature in collaboration with the marketing manager. Applicants must possess a clean driving licence.

SALES ENGINEERS

The Sales Department requires extra staff to cope with the increasing amount of work. The department is involved in defining customers' requirements, preparing quotations, order acknowledgements, invoices, securing sales and briefing projects engineers on new orders. Experienced staff handle all aspects of the work but we would consider applicants with only quotation experience or sales experience who are able to progress to fulfilling the complete task. An electronic engineering qualification would be an advantage.

WIREMEN

We require wiremen/women able to interpret circuit diagrams and wiring schedules and with a minimum of construction detail to build and wire control panels, racks and bays neatly and quickly to a high standard. Good references are essential but those wishing to work under contract need not apply.

PROJECTS ENGINEER

An additional engineer is required to join our projects team. The department deals with system design of talkback and intercom equipment, including software updates of standard microprocessor controlled systems, one-off system designs to customers' requirements, and modifications to customers' audio and control equipment.

The work involves liaison with customer engineers, detailed system design, one-off circuit design, preparation of production and handbook documentation and support for manufacturing and test departments.

Applicants should have a recognised electronic engineering qualification and two years' experience of system/project engineering of professional equipment. Previous experience of systems involving software control would be an advantage but not essential.

TEST ENGINEERS

We are looking for suitably qualified test engineers with probably four to five years' experience in testing analogue (preferably audio) circuits, who will be involved in varied testing, from small batch produced modules to complete communication systems, and who are able and willing to adapt to digital technology as this is introduced to the Company.

PRODUCTION MANAGER

A person with a good background in production is required to manage our wiring shop and to organise the production of metalwork, printed circuit boards and assembly work using subcontractors. The person will also be expected to oversee the introduction of printed circuit assembly in our factory utilising suitable assembly aids including flow soldering equipment.

TRACER/JUNIOR DRAUGHTSMAN

A tracer/junior draughtsman is required to assist engineers with system designs. The work involves close liaison with engineers and production staff and production of metalwork, circuit and wiring drawings for both manufacturing and customer documentation. The ideal applicant would be self-motivated and capable of adding finer details to the work passed on by the engineer. The work is interesting and challenging and provides scope for advancement as experience is gained.

TEST DEPARTMENT MANAGER

A suitably qualified person with a successful record in testing both analogue and digital equipment is invited to take on the full responsibility of running this department. As well as scheduling and controlling the work of a small team of test engineers, the successful applicant will be required to design test methods and jigs, maintain test records and investigate the introduction of ATE to the department.

AUDIO ENGINEERS

We have vacancies for experienced audio engineers to join our Development Department. Candidates should have a relevant degree and will probably have worked in a design environment. The person will be responsible for all aspects of development from initial concept to production, and will therefore become involved in a variety of tasks. An ability to produce innovative but practical designs with minimum supervision is essential.

All posts are open to men and women. Successful applicants may be asked to work at our London premises until we move to Welwyn Garden City at the end of September, but this is not an essential requirement.

Applications in writing and including an up-to-date CV should be addressed to **The Personnel Officer, Philip Drake Electronics Ltd., 23 Redan Place, London W2 4SA or phone Jill Humphreys on 01-221 1476 for an application form. Please quote ref: JH5**

drake

(2226)

Appointments

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.

ELECTRONIC ENGINEERS

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.

ELECTRONIC DESIGN/DEVELOPMENT

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.

SOFTWARE PROGRAMMERS & ENGINEERS

Engineers or mathematicians required for development of commissioning and design proving programmes from assistant to team leader level. Salaries up to £12,000 p.a.

Please contact by telephone, or letter, to discuss companies and possibilities. Watford 49456 anytime. (2146)

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Advanced Engineering Applications

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The progress of the electronic revolution is now heavily dependent on the interfacing of real world analog signals to digital processing. The complexities of current and future LSI circuitry demands highly sophisticated computer controlled **AUTOMATIC TEST EQUIPMENT** in all phases of design and manufacture.

Our Client, an established world leader in LSI Test Systems has created exciting career opportunities for 2 talented Engineers to contribute to their success in taking responsibility for the complete application support of an interesting and varied client base.

You will ideally

- Be currently employed in the Telecommunication or Semi-Conductor industries.
- Be performing a Design/Testing or Applications role.
- Be experienced with Digital Signal Processing, Digital/Analog LSI circuits and/or Testing techniques.

A high degree of customer contact providing consultancy advice on future applications and problem solving demands good presentation, communication and organizational abilities.

The benefits include 3 months product training in the U.K. and U.S.A.; a full relocation package where necessary; company car with petrol expenses; company profit share and share purchase plan; 23 days holiday; family BUPA and Life Assurance.

For an initial confidential discussion please telephone Bob Rae or write to him in strict confidence to: –

ARCHIBOLD RAE CONSULTANTS LIMITED.
(High Technology Search and Selection)
7, London Road, Newbury, Berkshire.
Tel: Newbury (0635) 33445.

ARC

(2240)

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VIDEO RECORDING & STUDIO ENGINEER

£9,060-£10,539

Urgently required to join an experienced and enthusiastic team making educational training and distance learning video and audio programmes. The standard is high (mastering on 1" C-Format) and the variety wide (studio, mobile and V.T. editing).

Further details and application forms from the Deputy Head of Personnel, Brighton Polytechnic, Moulscoomb, Brighton BN2 4AT. Tel: Brighton 693655 Ext. 2536. Closing date, 16th September.

(2229)

UNIVERSITY COLLEGE CARDIFF
Department of Physiology

ASSISTANT EXPERIMENTAL OFFICER/EXPERIMENTAL OFFICER

The department, which has an active neuroscience-based research programme, requires a person with design experience to work in collaboration with the academic staff in the development and maintenance of equipment for research laboratories. Degree in electronics an advantage. This post offers a challenging opportunity for those interested in developing the latest electronic technology in a biomedical environment.

Salary range: OR IB £6,310-£9,875/£10,250-£11,615 p.a. Duties to commence as soon as possible.

Applications (two copies), together with the names and addresses of two referees, should be forwarded to the Vice-Principal (Administration) and Registrar, University College, P.O. Box 78, Cardiff CF1 1XL, from whom further particulars may be obtained. Closing date 14th September, 1983. Ref: 2660.

(2232)

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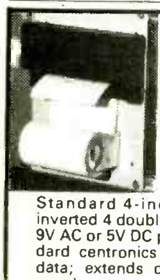

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