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Pseudo pen-recorder for Apple

CIRCLE 1 FOR FURTHER DETAILS

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July 1986
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REGULARS

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Technical Editor
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01-661 3039 or 8637 (lab.)
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01-661 8648
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01-661 8649

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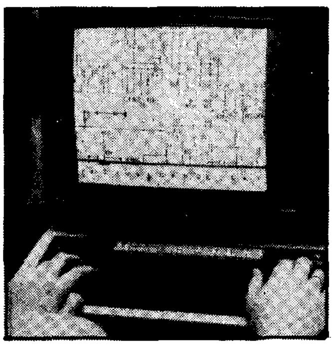

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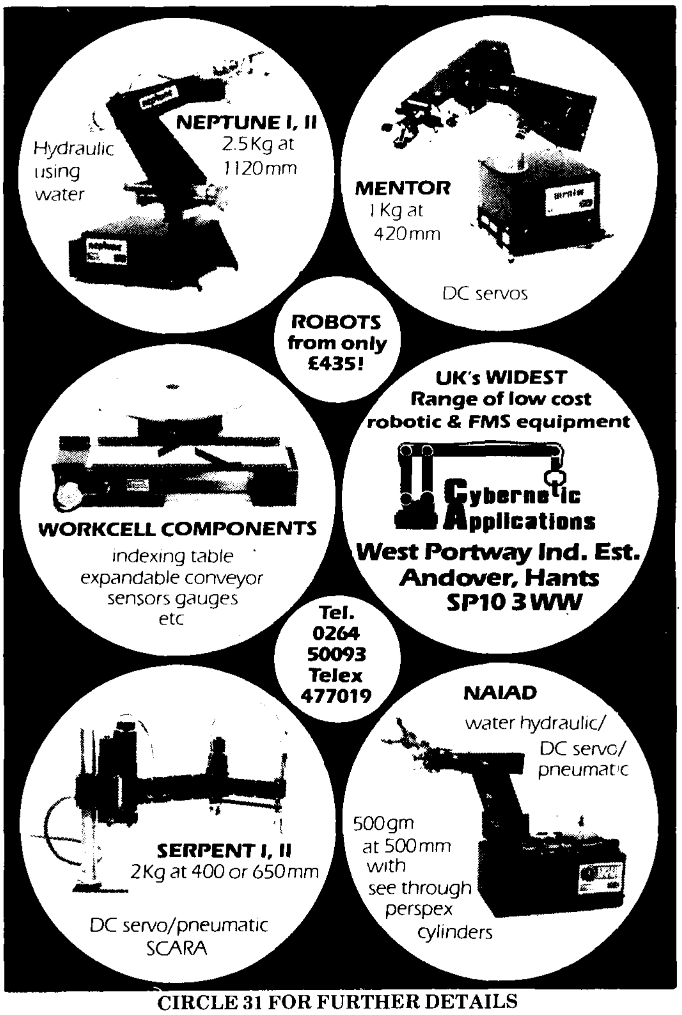

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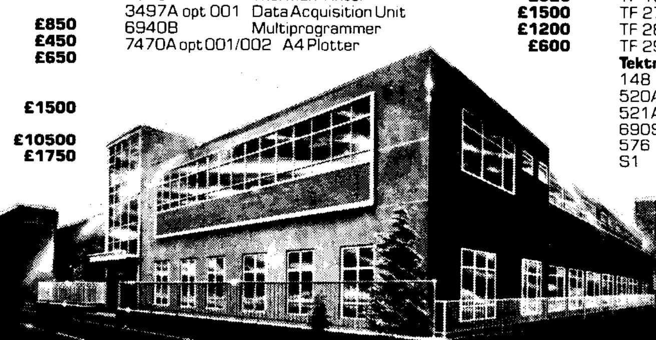

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CIRCLE 49 FOR FURTHER DETAILS

NEWS COMMENTARY

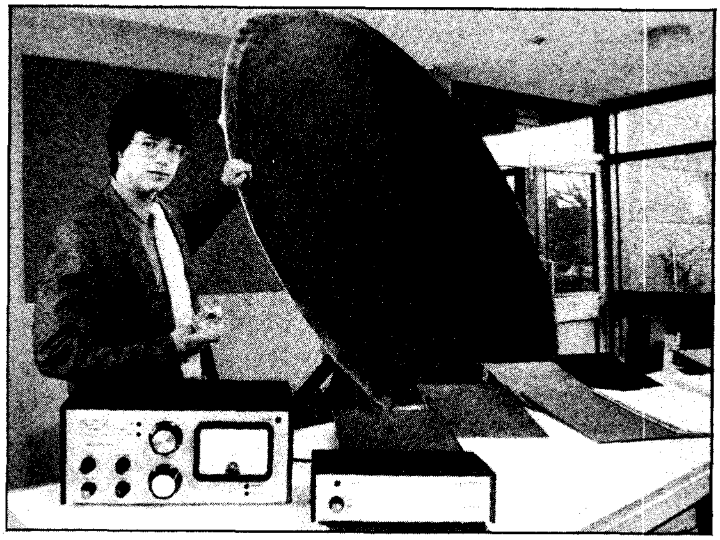
Industrial control from BT

Process control and instrumentation applications can be automated with the use of Martello, a control system developed by BT Research Labs, Martlesham. Martello has claimed for it independence from any specific manufacturer; with many single-board control computers, the purchase of a proprietary system locks the user into that manufacturer's range of products. As well as the modules provided, users can incorporate hardware from any manufacturer as long as it is compatible.

Compatibility with a wide range of equipment is assured by the use of the STE bus (IEEE P1000). The bus works on a master/slave concept in which a master terminal can control many slaves. The slaves can also communicate with each other by means of an asynchronous interlocked protocol. The particular advantage of this system is that it enables communication between devices of widely varying speeds. STE bus is supported by more than 15 manufacturers.

Software for the system uses Forth-83, which is particularly suited to control applications. Multi-tasking and communication with other computers is incorporated into this version of the language.

Martello can be used as a development system and be embedded into target products. Physically it consists of a rack of standard Eurocard boards, an 8085 c.p.u. card and twin 3.5in disc drives. Four modules are available at present; development system, c.p.u. card, disc controller and floppy disc sub-system. The disc filing system, screen editor, assemblers and debugging tools are written entirely in Forth. Many more modules introduction in the near future. Full documentation and customer support are included in the package, which is distributed by Dean Microsystems.



Just back from the finals of the Philips European Young Scientists Contest in Oslo are Andrew Randle of Hewett School, Norwich, with a merit certificate worth £350 for his A-level satellite tv receiving equipment, and Stuart Quick and Andrew Johnson, both of Dr Challoners Grammar School, Amersham, with their high-speed cellular radio data processing system, also awarded a merit.

Andrew Randle's initial problem was finding a suitable alternative to glue and aluminium foil for the dish covering. With the help of the school's microwave system, he tested various surfaces for relectivity, finding a nickel-based aerosol still worked well after subjecting a sample to alternate boiling and freezing water temperatures for 15 cycles and then exposing it to real weather. Base for this skin was glass-reinforced plastics moulded over a concrete paraboloid, shaped using a computer-generated profile, and topped with a 5mm layer of plaster, french polish.

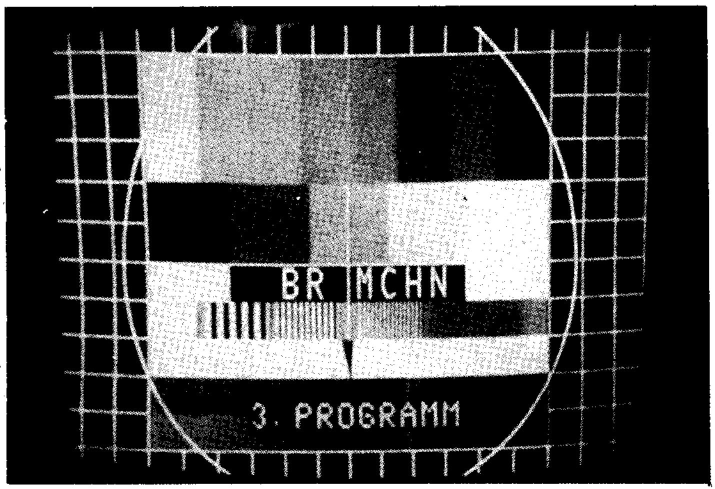
Mark Brownfield has passed his Radio Amateurs' Exam: no mean feat for a boy who is both blind and deaf. He receives all messages through his Casio portable computer, linked to a morse transmitter which sends a highly amplified signal to the headphones. He doesn't so much hear as feel the signals. He has also passed the International Telecommunications Morse Examination. No concessions were made to Mark for the examination and he had to achieve the same standard as any other candidate.

Adjustable aluminium skin aids maser mapping

An improvement of an order of magnitude in surface flatness of Jodrell Bank's Mk II radio telescope antenna allows the telescope to map water-vapour masers in regions of star formation. Each of the 206 panels was required to follow a paraboloid shape to within 1mm r.m.s. to achieve sufficient sensitivity at 14mm (22GHz); in fact the panels have turned out to be accurate to within 0.5mm r.m.s. Racal Antennas, who installed the panels, say this is due to their new manufacturing technique: "We can now make panels quickly and accurately at much lower cost than before" says m.d. John Hirst, though the company won't divulge their method. "It obviously opens up new areas for us and we see Jodrell Bank as being the first of many to take advantage of this new technology".

Researchers at Manchester University's radio astronomy department have already used the dish at 6GHz where most of their work is done with noticeable improvement.

"What is important" Professor Sir Francis Graham Smith told us "is that the dish deflects under gravity, and detailed measurements for difficult elevations are needed. When the surface profile over a range of elevations has been determined using microwave holography, we can then adjust the profile and assess the antenna at the 14mm (22GHz) wavelength."



D.J. Standen, North East Satellite Systems.

A clear view to the Eastern horizon and a Ku-band satellite receiver could allow four further stations to be received from the g.s.o. (further, that is, to those in last November's issue, page 61). Four German stations are transmitted on the 57° Intelsat V to cable networks at a look angle of around 6° in Eastern England: ARD1, WDR, BR3 and the German Music Box. Off-screen photograph was taken using a low-noise block of 2.2dB noise figure and a 1.6m dish antenna.

Factory and technical networks

A new initiative from the DTI will enable a large number of manfuacturing plants to communicate technical information between computers. Two branches of the scheme are planned; MAP (manufacturing automation protocol) and TOP (technical office protocol). Over 45 companies are taking part.

The work will concentrate on interconnecting locally many different types of machinery such as machine tools, cad installations and robots.

There are US models for these systems. MAP is being installed by General Motors; TOP comes from Boeing. MAP is a communications system using broadband taken bus local area networks and the Open System Interconnection model established by the ISO. TOP is a comparable specifically protocol using a base-band, local-area network and is concerned specifically with technical office activities.

The systems and their associated equipment are to go on show at a DTI-sponsored exhibition – Factory Communication in the 1990's – to be held in December, so the companies have only until then to develop working models of the systems.

In brief

The tape levy row grumbles on. The Tape Manufacturers' Group commissioned a survey from National Opinion Polls that showed that over half of all blank tape purchasers used them to record their own records. They make back-up copies to preserve their discs and to be able to listen in the car or on their personal cassette players. A further 18% record broadcast music. In both cases copyright fees had already been paid. If the proposed 10% levy on audio cassettes were be raised, 70% of tape buyers would be paying twice for the same music. Of the remaining 30%, a high proportion use the tapes for dictation machines and for recording lectures. So the proportion remaining, those who pirate recorded material, is very small. The survey also showed that those who bought the most tapes also bought the most recorded music. So the levy would penalize those who are already contributing more than average to the copyright owners.

Electronic nose for drugs

A new device could help in the prevention of drug smuggling and terrorism. British Aerospace have announced the production of an electronic detector which can be tuned to be sensitive to particular substances, especially illegal drugs or explosives. Condor (Contrabrand Detector) is an electronic sniffer which uses mass spectroscopy to detect the vapour given off by the substances and is sensitive enough to find them even when wrapped in polythene sheeting. The spectroscope is programmed to detect specific chemicals by their spectral characteristics and will find them even in the presence of other strong smells.

Condor can analyse the sample within two minutes.

Alternative energy

Following the accident at the Chernobyl nuclear power station in the Ukraine, interest has been re-aroused in alternative sources of energy. Perhaps a leaf can be taken from Sweden's book: 100,000 households in Sweden are to have district heating supplied from a floating heat pump with a capacity of 100MW.

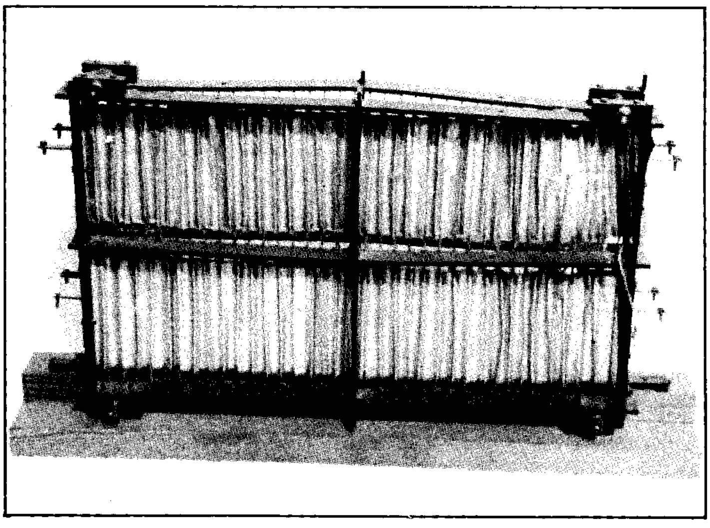
Heat pumps work like refrigerators in reverse. Instead of using energy to extract heat from an area, they gain energy by extracting the latent heat energy from the environment, in this case the sea.

The structure is 100M long by 20M. Eight to nine cubic metres of sea water will be pumped into the station's machine and evaporation rooms. Thermal energy from the water is transferred to the refrigerant in the heat pump evaporators, the temperature and pressure of the refrigerant being raised with the aid of two-staged turbo compressors. The refrigerant subsequently heats the water in the condensers to 60 to 80°C. The sea water is returned to the sea.

This heat station follows many others that have been installed in the Stockholm area that use lake water.

The pump station is expected to cost about £36M to put into operation but will save about 230M gallons of oil in a year.

Does this home-made electrostatic speaker jog any memories? It is beautifully constructed from wood, mica, and foil taken from condensers. It was donated to the Wireless Museum on the Isle of Wight, but nothing is known of its origins or design. Quad engineers deny all knowledge of it! Any information that can throw light on it would be gratefully received by Douglas Byrne, 52 West Hill Road, Ryde, Isle of Wight PO33 1LN.



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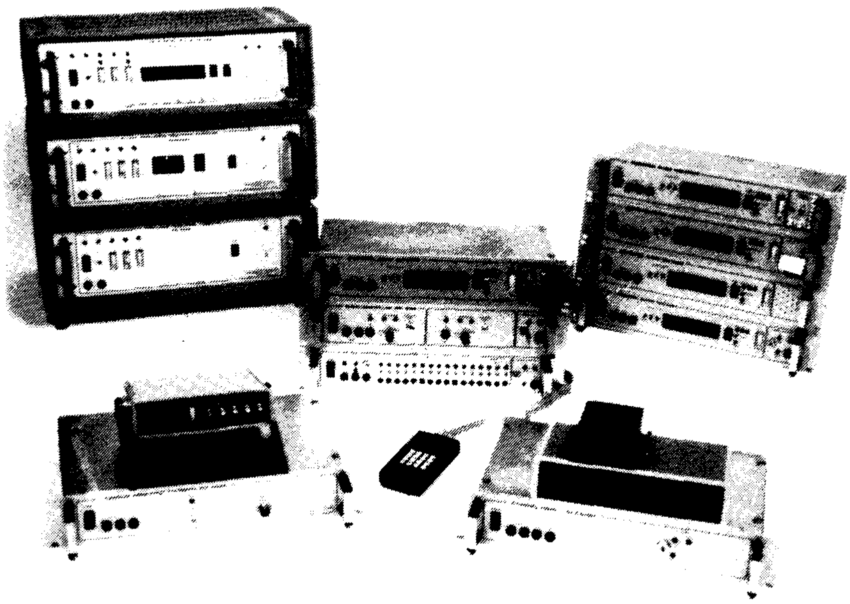

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(*A Circuit Services Associate Co.)

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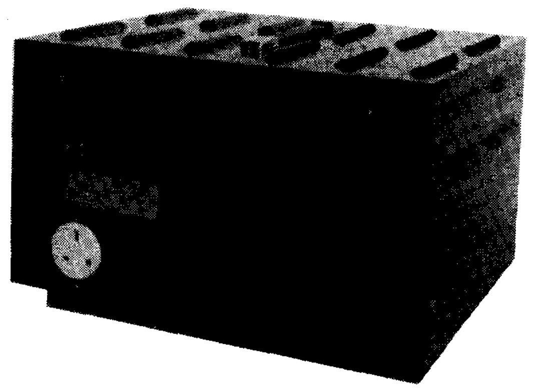

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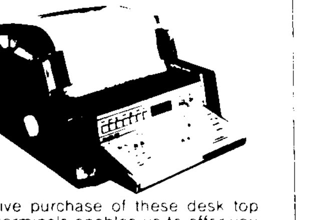

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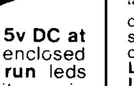

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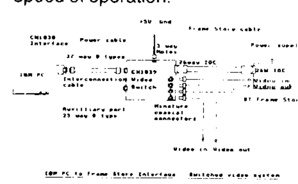

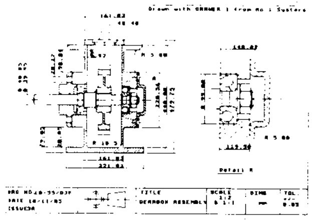

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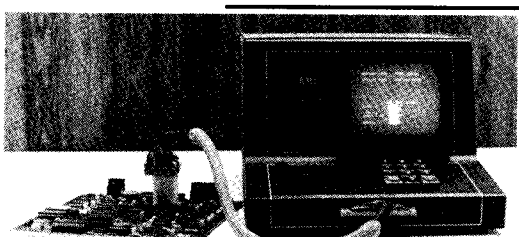

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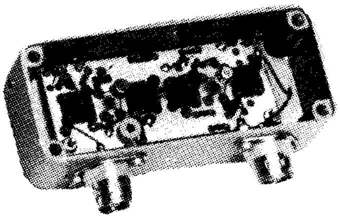

TYPE 9006

TYPE 9002

GASFET RF PREAMPLIFIERS. Aligned to your specified frequency in the range 30–1000MHz. Masthead or local use.

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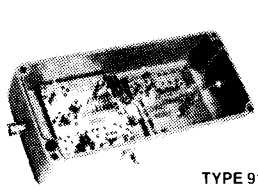
TYPE 8034



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TYPE 9113 PHASE LOCKED LOOP FREQUENCY CONVERTER. Converts your specified input channel in the range 30–1000MHz to your specified output channel in the range 30–1000MHz. 1mV input, 10mW output (+10dBm). Gain 60dB adjustable −30dB. Will drive transmitting amplifiers directly ...... £295 + £5 p&p
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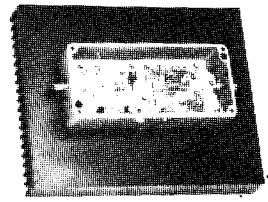
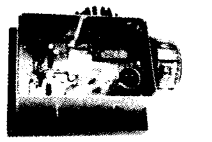
TYPE 9263 2/3 watts input, 15 watts output ...... £330 + £20 p&p
TYPE 9235 Mains power supply unit for complete system ...... £120 + £15 p&p



TYPE 9155



TYPE 9158 WITH P.S.U.

TMOS RF LINEAR POWER AMPLIFIERS. Tuned to your specified frequency in the range 10–250MHz. Power 24V. + DC.

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TYPE 9155 1 watt input, 30 watts output ...... £270 + £15 p&p
TYPE 9158 5 watts input, 70 watts output ...... £370 + £20 p&p
TYPE 9235 Integral mains power supply unit for above amplifiers ...... £120 + £15 p&p

TYPE 9051

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TMOS LINEAR WIDEBAND POWER AMPLIFIERS 4/20 watts RF output. Without tuning. Power gain 13dB (×20) 24V. + DC supply.

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TYPE 9235 Integral mains power supply unit for above amplifiers ...... £120 + £15 p&p

CIRCLE 69 FOR FURTHER DETAILS

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TEKTRONIX 465 Dual Trace 100MHz Delay Sweep	£900
TEKTRONIX 454 Dual Trace 150MHz Delay Sweep	£550
TELEQUIPMENT D75 Dual Trace 50MHz Delay Sweep	£350
GOULD OS300A Dual Trace 40MHz Delay Sweep	£350
TELEQUIPMENT D67 Dual Trace 25MHz Delay Sweep	£250
COSSER CDU150 Dual Trace 35MHz Delay Sweep	£200
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TEKTRONIX 434 STORAGE Dual Trace 25MHz	£500
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WAVETEK FUNCTION GEN 162 0.001Hz-30MHz	£500
H.P. TEST OSCILLATOR 651A 10Hz-10MHz	£100
RADIOMETER SMG40 STEREO GEN	£300
LEADER FM STEREO GENLSG231	£125
FARNELL Moldular Pulse Generator system 1Hz-10MHz	£50

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MARCONI 'Q' Meter TF1245 with TF1246 or TF1247	£500
H.P. POWER METER 431C with Thermistor Mount 10MHz-10GHz or 12.4-18GHz	£250
MARCONI RF MILLIVOLTMETER TF2603 50KHz-1,500MHz	£150
MARCONI VALVE VOLTMETER TF2600 10Hz-10MHz 1mV-300V FSD	£40
MARCONI INSITU UNIVERSAL BRIDGE TF2701	£75
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MARCONI AF SIGNAL SOURCE TF2000 20Hz-20KHz	£200
H.P. RF MILLIVOLTMETER 411A 500KHz-500MHz	£60
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H.P. TRUE RMS VOLTMETER 3400A 10Hz-10MHz	£400
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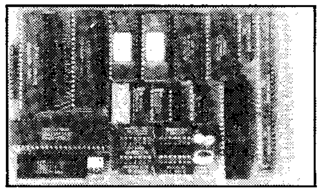

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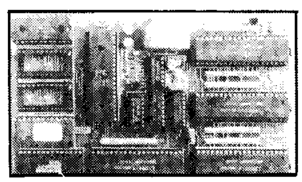

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TBA480Q	1.25
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TBA510Q	2.50
TBA520	1.10
TBA520Q	1.10

TBA530	1.10
TBA530Q	1.10
TBA540	1.25
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TBA651R	2.50
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TBA800	0.89
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556	0.60
723	0.50
741	0.35
747	0.50
748	0.35
7805	0.65
7808	0.60
7815	0.65

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AAY12	0.25
AC125	0.20
AC126	0.45
AC127	0.20
AC128	0.28
AC128K	0.32
AC141	0.28
AC142K	0.45
AC176	0.22
AC176K	0.31
AC187	0.25
AC187K	0.28
AC188	0.25
AC188K	0.37
ACY17	1.15
AD142	0.79
AD143	0.82
AD149	0.70
AD161	0.39
AD162	0.39
AD161/2	0.90
AF106	0.50
AF114	1.95
AF115	2.95
AF116	2.95
AF117	2.95
AF121	0.60
AF124	0.65
AF125	0.35
AF126	0.32
AF127	0.65
AF139	0.40
AF150	0.60
AF178	1.95
AF239	0.42
AFZ12	3.75
ASY27	0.85
AU106	4.50
AU107	3.50
AU110	3.50
AU113	4.50
BC107A	0.11
BC107B	0.11
BC108	0.10
BC108A	0.11
BC108B	0.12
BC109	0.10
BC109B	0.12
BC109C	0.12
BC114	0.11
BC116A	0.15
BC117	0.19
BC119	0.24
BC125	0.25
BC139	0.20
BC140	0.31
BC141	0.25
BC142	0.21
BC143	0.24
BC147A	0.12
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BC148A	0.09
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BC157	0.12
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BC159	0.09
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BC174A	0.09
BC177	0.15
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BC182	0.10
BC182LB	0.10
BC183	0.10
BC183L	0.09
BC184LB	0.09
BC204	0.10
BC207B	0.13
BC208B	0.13
BC212	0.09
BC212L	0.09
BC212LA	0.09
BC213	0.09
BC213L	0.09
BC214	0.09
BC214C	0.09
BC214L	0.09
BC237B	0.09
BC238	0.09
BC239	0.12
BC251A	0.12
BC252A	0.15
BC258	0.25
BC258A	0.39
BC2284	0.30
BC300	0.30
BC301	0.30
BC303	0.26
BC307B	0.09
BC327	0.10
BC328	0.10
BC337	0.10
BC338	0.09
BC347A	0.13
BC461	0.35
BC478	0.20
BC527	0.20
BC547	0.10
BC548	0.10
BC549A	0.10
BC550	0.14
BC557	0.08
BC557B	0.80
BC558	0.10
BCY33A	1.60
BD115	0.30
BD124P	0.59
BD131	0.42
BD132	0.42
BD133	0.40
BD135	0.30
BD136	0.30
BD137	0.32
BD138	0.30
BD139	0.32
BD140	0.30
BD144	1.10
BD150C	0.29
BD159	0.65
BD160	1.50
BD166	0.55
BD179	0.72
BD181	0.45
BD182	0.70
BD183	0.70
BD201	0.83
BD202	0.65
BD203	0.78
BD204	0.70
BD222	0.46
BD223	0.59
BD225	0.48

BD232	0.35
BD233	0.35
BD234	0.35
BD236	0.49
BD237	0.40
BD238	0.40
BD242	0.65
BD246	0.75
BD376	0.32
BD410	0.65
BD434	0.65
BD437	0.75
BD438	0.75
BD520	0.65
BD538	0.65
BD597	0.95
BD589	0.45
BD701	1.25
BD702	1.25
BD707	0.90
BDX32	1.50
BF115	0.35
BF119	0.35
BF119	0.65
BF127	0.39
BF154	0.20
BF158	0.22
BF160	0.27
BF167	0.27
BF173	0.22
BF177	0.38
BF178	0.26
BF179	0.34
BF180	0.29
BF181	0.29
BF182	0.29
BF183	0.29
BF184	0.28
BF185	0.28
BF194	0.11
BF195	0.11
BF196	0.11
BF197	0.11
BF198	0.16
BF199	0.14
BF200	0.40
BF241	0.15
BF245	0.30
BF257	0.28
BF258	0.28
BF259	0.28
BF271	0.26
BF273	0.18
BF336	0.34
BF337	0.29
BF338	0.32
BF355	0.37
BF362	0.38
BF363	0.65
BF371	0.25
BF394	0.19
BF422	0.32
BF457	0.32
BF458	0.36
BF459	0.36
BF467	0.68
BF494	0.45
BF495	0.45
BF595	0.23
BF597	0.25
BFR39	0.23
BFR81	0.25
BFR88	0.30
BFR90	1.50

BFR91	1.75
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BU125	1.25
BU126	1.60
BU204	1.55
BU205	1.30
BU208	1.39
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TIP41C	0.45
TIP42C	0.47
TIP47	0.65
TIP120	0.60
TIP125	0.65
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2N2905	0.40
2N3053	0.40
2N3054	0.59
2N3055	0.52
2N3702	0.12
2N3703	0.12
2N3704	0.12
2N3705	0.20
2N3706	0.12
2N3708	0.12
2N3733	9.50
2N3733	2.75
2N3792	1.35
2N4427	1.95
2N4444	1.15
2N5294	0.42
2N5296	0.48
2N5298	0.60
2N5485	0.45
2N5496	0.95
2SA715	0.60
2SC495	0.80
2SC496	0.80
2SC1096	0.80
2SC1106	2.50
2SC1172Y	2.20
2SC1173	1.15
2SC1306	1.40
2SC1307	1.75
2SC1364	0.50
2SC1449	0.80
2SC1678	1.25
2SC1909	1.25
2SC1945	2.65
2SC1954	0.95
2SC1957	0.80
2SC1969	1.95
2SC2028	1.15
2SC2029	1.95
2SC2078	1.45
2SC2091	0.85
2SC2098	2.95
2SC2166	1.95
2SC2314	0.80
2SC2371	0.36
2SD234	0.50
3N211	2.95
3SK88	0.95

DIODES

AA119	0.80
BA115	0.13
BA145	0.16
BA148	0.17
BA154	0.06
BA156	0.15
BA157	0.30
BAX13	0.04
BAX16	0.06
BB105B	0.30
BT151	0.79
BY126	0.10
BY127	0.11
BY133	0.15
BY164	0.45
BY176	1.20
BY179	0.63
BT182	0.55
BY184	0.35
BT199	0.40
BY206	0.14

BY208-800	0.33
BY210-800	0.33
BY223	0.90
BY298-400	0.22
BY299-800	0.22
BYX10	0.20
BYX36-150R	0.20
BYX38-600R	0.60
BYX55-600	0.30
BYX71-600	1.10
BZY95C30	0.35
CS4B	4.50
CS10B	8.45
OA47	0.09
OA90	0.05
OA91	0.06
OA95	0.06
OA202	0.10
IN21DR	5.00
IN23B	5.00
IN23C	5.00
IN23ER	5.00
IN23WE	5.00

IN4001	0.04
IN4003	0.04
IN4004	0.05
IN4005	0.05
IN4007	0.06
IN4148	0.02
IN4448	0.10
IN5401	0.12
IN5402	0.14
IN5403	0.12
IN5406	0.13
IN5407	0.16
IN5408	0.16
ITT44	0.04
ITT923	0.15
ITT2002	0.10

ZENER DIODES

BZX61 Series	0.15
BZY88 Series	0.10

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THORN 8000	23.50
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CME2024W	45.00
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CME3132GH	45.00
CME3155W	45.00
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CV2191	19.00
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CV5119	85.00
CV5320	85.00
CVX389	55.00
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D10-210GH	45.00
D10-210GH68B	65.00
D10-230GH	35.00
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D13-600GM	59.00
D13-610GH	59.00
D13-511GH	59.00
D13-611GM	59.00
D13-630GH	59.00
D14-150GH	75.00
D14-150GM	75.00
D14-162GH/84	59.00
D14-172GR	55.00
D14-172GV	55.00
D14-173GH	55.00
D14-173GM	53.00
D14-173GR	55.00
D14-181GH/98	65.00
D14-181GJ	55.00
D14-181GM	53.00
D14-181GM50	59.00
D14-182GH	59.00
D14-200BE	89.00
D14-200GA/50	85.00
D14-200GM	75.00
D14-210GH	75.00
D14-270GH/50	75.00
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5T01A	15.00
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SANYO ORIGINAL PART NUMBER	MODEL	DESCRIPTION	
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4-527T-23501	VARIOUS	Motor Assy	9.75
4-527V-51000	5150	Capston Motor	29.95
143-0-4904-00900	FVHP615	Gear Idler Assy.	5.95
143-2-457T-05900	VTC9455	Stopper Reel Base	0.55
143-0-545T-01701	VARIOUS	Pinch Roller Assy.	8.95
143-0-545T-01700	VARIOUS	Pinch Roller Assy	1.95
143-0-551T-VTC9300		Idler Assy	0.95
143-0-661T-03800	VARIOUS	Loading Roller	0.95
143-0-662T-01201	VTC5150	Reel Drive Pulley	8.50
143-0-9974-00100	FVHP615	Mod Kit IC BA6304A	1.95

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THORN 3000/3500	7.57
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VA1056S	0.23
VA1104	0.70
VA8650	0.45
VA1097	0.25

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DF92	0.60
DF96	0.65
DF97	1.00
DH63	1.20
DH77	0.90
DH79	0.56
DH149	2.00
DK91	0.90
DK92	1.20
DL35	2.50
DL63	1.00
DL70	2.50
DL73	1.50
DL92	0.95
DL93	1.10
DL94	2.50
DL96	2.50
DLS10	13.50
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DM70	1.95
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ECC85	0.75
ECC86	2.75
ECC88	0.95
ECC91	2.00
ECC180	0.72
ECC189	1.95
ECC801S	3.50
ECC803S	4.95
ECC804	0.60
ECC2000	12.00
ECF80	1.15
ECF82	1.15
ECF86	1.70
ECF200	1.85
ECF202	1.85
ECF801	0.85
ECF805	2.50
ECF806	10.25
ECH3	2.50
ECH4	3.00
ECH35	3.50
ECH42	1.50
ECH81	1.00
ECH83	1.00
ECH84	1.00
ECH2000	1.50
ECL80	0.60
ECL82	0.79
ECL83	2.50
ECL84	0.74
ECL85	0.69
ECL86	0.95
ECL805	0.69
EF37A	2.50
EF39	1.50
EF40	4.50
EF41	3.50
EF42	3.50
EF50	2.50
EF55	4.95
EF70	1.20
EF71	1.50
EF72	1.20
EF73	1.00
EF80	0.55
EF83	3.95
EF85	0.50
EF86	2.25
EF86 Mullard	4.50
EF89	1.50
EF91	1.95
EF92	2.15
EF93	0.95
EF94	0.95
EF95	1.95
EF97	0.90
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EF183	0.65
EF184	0.65
EF730	1.80
EF731	3.50
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EF806S	14.50
EF812	0.65
EFL200	1.50
EH90	0.72
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EL33	5.00
EL34	2.25
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EL42	2.00
EL81	6.95
EL83	5.95
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EL86	1.25
EL90	1.75
EL91	6.00
EL95	1.75
EL153	12.15
EL183E	3.50
EL18P	3.50
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EL509	5.25
EL519	6.95
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EL821	8.50
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EM80	0.70
EM81	0.70
EM84	1.65
EM85	3.95
EM87	2.50
EN32	15.00
EN91	1.95
EN92	4.50
EY51	0.80
EY81	2.35
EY83	1.50
EY84	5.95
EY86/87	0.50
EY88	0.55
EY91	5.50
EY802	0.70
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EZ80	0.75
EZ81	0.75
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KT44	4.00
KT45	4.00
KT61	5.00
KT63	2.00
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KT66 USA	9.95
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KT67	9.00
KT77 Gold Line	10.95
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KTW62	2.50
KTW63	2.00
KTZ63	2.50
L102/2K	6.95
L102/2K	12.00
LB7-20	95.00
LS9B	6.95
M502A	60.00
M537A	60.00
M5143	155.00
M8079	6.00
M8082	7.50
M8083	3.25
M8091	7.50
M8096	3.00
M8098	5.50
M8099	5.00
M8100	5.50

M8136	7.00
M8137	7.95
M8161	6.50
M8162	5.50
M8163	5.50
M8190	4.50
M8195	6.50
M8196	5.50
M8204	5.50
M8223	4.50
M8224	2.00
M8225	3.95
ME1401	29.50
ME1402	29.50
ME1501	14.00
MH4	3.50
MHL6	4.00
ML4	4.50
MS4B	5.50
MU14	3.50
MZ1-100	125.00
N37	12.50
N78	9.85
OA2	0.85
OA2WA	2.50
OA3	2.50
OB2	0.85
OB2WA	2.50
OC2	2.50
OC3	1.50
OD3	1.70
OM4	1.00
OM5B	3.00
OM6	1.75
ORP43	2.50
ORP50	3.95
P61	2.50
P41	2.50
PABC80	0.50
PC86	0.75
PC88	0.75
PC92	3.50
PC97	1.10
PC800	1.10
PC900	1.25
PCC84	0.40
PCC85	0.55
PCC88	0.70
PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	0.40
PCF200	1.80
PCF201	1.80
PCF800	0.40
PCF801	1.35
PCF802	0.60
PCF805	1.25
PCF806	1.00
PCF808	1.25
PCH200	1.50
PCL82	0.85
PCL83	2.50
PCL84	0.75
PCL85	0.80
PCL86	0.85
PCL800	0.80
PCL805	0.90
PE1-100	69.00
PEN25	2.00
PEN40DD	2.50
PEN45	3.00
PEN45DD	3.00
PNE46	2.00
PE06-40N	42.00
PFL200	0.95
PL21	2.50
PL36	0.95
PL38	1.50
PL81	0.72
PL81A	0.72
PL82	0.60
PL83	0.52
PL84	0.78
PL88	1.00
PL95	1.75
PL302	1.00
PL345	12.50
PL500	1.10
PL504	1.15
PL508	1.75
PL509	4.85
PL519	4.95
PL802T	3.50
PL820	2.95
PL5557	29.50
PY32	0.60
PY33	0.50
PY81	0.70
PY82	0.70
PY83	0.70
PY88	0.65
PY500A	1.95
PY800	0.79
PY801	0.79
QB3-300	54.95
QB3-1750	139.50
QB5-3500	495.00
QE03-10	4.95
QE08-200	145.00
QF40	65.00
QP25	1.00
QQE02-5	19.50
QQE03-12	7.95
QQE03-20	35.00
QQE06-40	45.00
QQV02-6	19.50
QQV03-10	5.50
QQV03-10 Mullard	15.00
QQV03-20	25.00
QQV03-20B	32.00
QQV06-40A	27.50
QQV06-40A Mullard	45.00
QQV07-50	63.50
QQZ03-20	42.50
QS75/20	1.50
QS75/40	3.00
QS92/10	5.00

QS95/10	4.85
QS108/45	4.00
QS150/15	6.95
QS150/30	1.15
QS150/45	7.00
QS1200	3.95
QS1202	3.95
QS1203	4.15
QS1205	3.95
QS1206	1.05
QS1207	0.90
QS1208	0.90
QS1209	3.15
QS1210	1.50
QS1211	1.50
QS1212	3.20
QS1213	5.00
QS1215	2.10
QS1218	5.00
QU37	9.50
QV03-12	5.75
QV05-25	1.75
QV06-20	29.50
QV08-100	145.00
QV2-2500	45.00
QY3-125	65.00
QY4-250	70.00
QY4-400	76.00
R10	4.00
R16	12.00
R17	1.50
R18	2.50
R19	2.50
R20	1.20
R1169	55.00
RG1-125	4.95
RG1-240A	14.50
RG3-250A	3.50
RG3-1250A	35.00
RK2K25	62.50
RK-20B	12.00
RL16	1.50
RPL16	12.00
RPY13	2.50
RPY43	2.50
RPY82	2.50
RR3-250	15.00
RR3-1250	35.00
RS613	45.00
RS685	54.95
RSS688	52.15
S6F17	5.95
S6F33	28.95
S11E12	38.00
A30/2K	12.00
S104/1K	10.00
S109/1K	15.00
S130	5.59
S130P	5.95
SC1/800	5.00
SC1/1100	6.00
SC1/1200	5.00
SC1/1300	6.00
SC1/200	9.00
SP41	5.00
SP42	3.00
SP4B	4.95
SS501	35.00
ST11	1.50
STV280/40	11.95
STV280/80	19.95
SU42	4.95
TB2.5/300	85.00
TB2-300	45.00
TB3-2000	395.00
TD1-100A	25.00
TD03-10F	35.00
TD3-12	4.00
TDD4	5.50
TP25	1.50
TSP4	7.00
TT11	1.50
TT21	45.00
TT22	45.00
TT100	57.00
TTR-31MR	65.00
TY2-125A	85.00
TY4 400	85.00
TY8-600W	365.00
TYS2/250	375.00
U18-20	2.75
U19	11.95
U24	2.00
U25	0.90
U26	0.90
U37	9.00
U41	6.95
U50	2.00
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	2.25
UBC81	1.50
UBF89	1.00
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	2.50
UCH42	2.50
UCH81	1.00
UCL82	1.75
UCL83	2.50
UF41	1.15
UF42	1.15
UF80	1.75
UF85	1.20
UF89	2.00
UL44	3.50
UL84	1.50
UL85	0.85
UU5	3.50
UU7	8.00
UU8	9.00
UY41	3.50
UY85	0.70
V235A/1K	250.00
V238A/1K	295.00
V246A/2K	315.00

V2406/1K	225.00
V241C/1K	195.00
V339	3.50
V453	12.00
VLS631	10.95
VP4B	4.50
VP133	2.00
VR75-30	3.00
VR101	2.00
V105/30	1.50
VR150/30	1.15
VT52	2.50
VU29	4.50
VU39	1.50
W21	4.50
W77	5.00
W729	1.00
W739	1.50
X24	4.50
X66/X65	4.95
X76M	1.95
XC24	1.50
XC25	0.50
XFW47	1.50
XFW50	1.50
XG1-2500	50.00
XG2-6400	135.00
XG5-500	22.50
XI1-5V	1.50
XL628FT	7.50
XNP12	2.50
XR1-1600A	49.50
XR1-3200A	79.50
XR1-6400A	115.00
Y502	25.00
Y65	6.95
YD1100	75.00
YJ1060	265.00
YL1020	29.00
YL1070	195.00
YL1071	195.00
YL1290	65.00
Z77	1.20
Z302C	12.00
Z359	9.00
Z505S	15.00
Z520M	4.00
Z521M	8.00
Z700U	3.00
Z749	0.60
Z759	19.35
Z800U	3.00
Z803U	18.95
ZA1000	12.50
ZA1001	1.50
ZA1002	1.50
ZM1005	8.00
ZM1020	6.00
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1082	9.00
ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
ZM1612	3.00
1A3	4.50
1AC6	1.20
1AE	43.50
1B3GT	1.95
1B22	10.00
1B27	55.00
1B35A	45.00
1B63A	75.00
1C1	2.50
1C5GT	2.50
1FD1	2.50
1G3GT	2.50
1J3GT	2.50
1N2	4.50
1N5GT	2.50
1P28	25.00
1P39	19.50
1R5	0.90
1T4	1.00
1U4	1.75
1U5	1.00
1X2B	1.40
1Z2	8.95
2AS15A	11.50
2B7	1.50
2B22	69.50
2C39A	32.50
2C39BA	39.50
2C40	37.00
2C42	29.50
2C43	60.00
2C51	0.75
2CY5	1.50
2D21	1.95
2D21W	2.50
2E22	49.00
2E26	7.95
2J42	93.00
2J55	350.00
2K25	35.00
2K25 Raytheon	75.00
2K26	95.00
2K29	250.00
2K48	140.00
2K56	250.00
3A5	4.50
3A/107B	12.00
3A/108A	9.00
3A/109B	11.00
3A/110B	12.00
3A/141K	11.50
3A/147J	7.50
3A/167M	10.00
3A/2	3.95
3A3A	3.95
3A4	1.10
31L5	0.95
3AT2	3.35
3B2	3.00
3B4	4.95
3B7	4.50
3B24	10.00
3B26	24.00
3B28	15.00
3BZ6	1.50
3C4	1.00
3C23	19.00
3C45	24.00

3CB6	1.50
3CN38A	2.50
3CS6	0.95
3CX3	2.50
3CY5	1.50
3D6	4.50
3D21A	29.50
3E22	49.50
3EH7	1.95
3EJ7	1.95
3V4	1.75
3W4GT	2.50
4B5518	115.00
4-65A	59.00
4687A	9.50
4-125A	72.50
4-250A	79.50
4-400A	87.50
4-1000A	425.00
4B32	35.00
4BQ7A	1.75
4BZ6	1.95
4C27	25.00
4C28	25.00
4C35	145.00
4C86	1.95
4CX1000A	425.00
4CX4000A	1100.00
4CX250B	49.00
4CX250B EIMAC	59.50
4D32	125.00
4CX250BN	75.00
4CX250K EIMAC	95.00
4CX125C EIMAC	125.00
4CX350A	95.00
4CX350F	79.50
4XC1500B	393.50
4E27	195.00
4GS7	2.25
4J52	75.00
4JC6A	2.95
4X150A	35.00
5A/102D	9.50
5A152M	9.00
5A163K	10.00
5A170K	6.25
5A-180M	9.00
5A-206K	10.00
5AMB	2.15
5ANB	1.20
5AR4	2.00
5AU4	1.50
5B 110M	10.00
5B-254M	14.50
5B-255M	19.50
5B-256M	15.00
5B-257M	15.00
5B-258M	14.50
5C22	125.00
5J180E	2500.00
5R4GB	3.50
5R4GY	3.50
5T4	5.95
5U4G	2.95
5U4GB	4.50
5V4G	1.50
5Y3GT	1.95
5Z4GT	1.50
6/30L2	0.70
6A/203K	9.00
6A7	4.95
6A8G	1.50
6AC7	2.00
6AG5	1.50
6AG7	1.95
6AH6	2.50
6AJ4	2.00
6AJ7	2.00
6AK5	1.95
6AK6	2.50
6AL5	0.60
6AM4	3.25
6AM5	6.00
6AM6	1.95
6AN8A	3.50
6AQ5	1.75
6AQ8	0.85
6AR5	5.95
6AR8	3.95
6AS5	1.50
6AS6	2.50
6AS7G	4.50
6AT6	0.75
6AT8	1.75
6AU4	2.00
6AU5GT	4.50
6AU6	0.95
6AV6	0.75
6AW8A	2.50
6AX4GT	1.95
6AY3B	1.95
6AZ8	4.50
6B7	2.80
6B8G	1.50
6B10	1.95
6BA6	0.95
6BA7	4.50
6BA8A	3.50
6BE6	0.95
6BG6G	3.00
6BH6	1.95
6BH8	1.50
6BJ6	1.50
6BK4	4.00
6BK7A	1.95
6BL6	85.00
6BL8	1.15
6BM6	115.00
6BM8	0.58
6BN4	1.65
6BN6	1.65
6BN7	4.50
6BN8	3.95
6BQ5	0.75
6BQ7A	0.72
6BL7GTA	3.95
6BR5	0.70
6BR7	4.95
6BR8	2.15
6BR8A	2.15
6BS7	5.50

6BW4	1.50
6BW6	5.35
6BW7	1.50
6BW8	4.00
6BX6	0.48
6BX7GT	3.50
6BZ6	2.50
6BZ7	2.95
6C4	1.25
6C5	1.95
6C6	2.50
6C8G	1.50
6C11	2.50
6C18	2.50
6CA4	4.95
6CA7	3.50
6CB5	3.95
6CB6	1.95
6CD6GA	4.50
6CF6	1.50
6CG7	2.25
6CH6	6.95
6CL3	3.95
6CL6	3.25
6CL8A	1.50
6CN5	1.60
6CM7	2.95
6CS6	0.75
6CW4	6.50
6D6	2.50
6DC6	2.35
6DJ8	0.95
6DK6	1.50
6DQ5	5.95
6DQ6B	2.50
6DT6A	1.50
CDW4	2.15
6E5	3.95
6EA4	4.95
6EA7	2.50
6EA8	2.50
6EAB8	1.75
6EM5	2.50
6EM7	2.50
6EU7	1.95
6EU8	1.75
6EV7	2.95
6EW6	2.95
6EW7	4.50
6F1	2.00
6F5	4.95
6F6	2.50
6F6G	2.00
6F7	5.50
6F12	1.50
6F13	3.00
6F14	1.00
6F17	2.75
6F21	2.50
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F32	1.25
6F33	17.00
6FG5	1.95
6FQ7	2.95
6G6G	5.50
6GE5	3.95
6GH8A	0.80
6GK5	1.50
6GK6	1.95
6GS7	2.15
6GV7	2.50
6GW6	2.50
6GY5	3.95
6H1	9.50
6H3N	2.50
6H6	1.95
6H6GT	1.95
6HF5	5.50
6HF8	2.50
6HS6	4.95
6J4	2.15
6J4WA	3.15
6J5	2.50
6J6	2.00
6J7	4.15
6JB6A	4.50
6JE6C	5.50
6JU8	2.50
6JS6C	4.95
6J7G	4.15
6K7G	2.00
6K8G	3.00
6KD6	5.50
6KM8	2.50
6KT8	2.95
6L1	2.50
6L15	3.15
6L19	3.95
6L6GC	2.95
6L6GC(GE)	4.50
6L6GT	1.95
6LD20	1.15
6LF6	7.50
6LJ8	2.50
6LQ6	5.50
6N7	2.50
6N7GT	2.50
6P15	1.50
6P25	4.00
6P26	4.00

6P28	2.00
6Q7	1.75
6Q7GT	1.20
6R7G	3.15
6S4A	1.50
6SA7GT	1.35
6SC7	1.50
6SG7	2.50
6SH7	1.35
6SJ7GT	1.20
6SK7	1.35
6SK7GT	1.35
6SL7GT	0.85
6SN7GT	1.35
6SQ7	1.50
6SS7	1.95
6U4GT	1.75
6U6WA	3.50
6U8	1.15
6U8A	1.50
6V6G	1.25
6V6GT	1.50
6VGG	1.00
6X2N	1.00
6×4	1.50
6×5GT	1.00
6×5GTY	1.00
6×8B	2.25
7A6	4.50
7A7	2.00
7AD7	1.75
7AU7	1.50
7B6	3.50
7B7	2.50
7C5	3.50
7C6	2.50
7E7	2.50
7H7	3.50
7J7	5.50
7Y4	2.50
8B8	2.50
8B10	2.50
8BQ5	1.95
8FQ7	1.95
10D2	1.25
10DE7	2.50
10EW7	2.95
10F1	0.75
10GK6	1.95
10P14	2.50
10P18	0.78
10LD12	0.65
11E2R	45.00
11E3	55.00
11R3	5.50
12A6	3.95
12AD6	1.50
12AL5	1.00
12AT6	1.25
12AT7	1.15
12AT7WA	2.50
12AU6	1.50
12A17	0.65
12AV6	1.95
12AV7	2.50
12AX7GT	1.00
12AX7	0.65
12AX7WA	2.50
12AY7	3.95
12AZ7A	1.95
12B4A	4.50
12BA6	1.50
12BE6	1.95
12BH7A	2.50
12BL6	1.75
12BY7A	2.75
12C8	2.50
12CA5	1.95
12CX6	1.20
12DQ6B	3.50
12DW4A	3.50
12E1	17.95
12E14	38.00
12GN7	3.95
12HG7	4.50
12HG7A	4.50
12J5GT	3.95
12J7GT	3.50
12JZ8	2.95
12K5	1.95
12K7GT	1.50
12K8	1.95
12SA7GT	1.95
12SG7	4.75
12SH7	1.95
12SK7	1.95
12SJ7	1.50
12SQ7GT	1.95
12SN7GT	1.85
12SR7	2.50
12X4	1.95
13D3	3.20
13D7	3.20
13D9	3.20
13DE7	2.50
13DR7	2.95
13E1	145.00
13EM7	3.50
14S7	1.95
16GY5	2.95
17BE3	2.50
17DW4A	2.95
17EW8	0.95

17JZ8	4.50
18D3	6.00
18GB5	3.50
19AQ5	3.50
19AU4GT	2.50
19G6	9.00
19G3	17.00
19H4	35.00
19H4R	25.00
19H5	33.50
19Q6	9.00
20A2	10.50
20D1	0.70
20LF6	7.95
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.95
20P5	1.15
21LU8	2.50
24B1	39.50
25DQ6B	2.95
25L6GT	1.75
25BQ6	1.75
29C1	19.50
29KQ6	6.50
30C17	0.40
30C18	1.48
3F5	0.95
30FL1	1.00
30FL2	1.35
30FL12	0.95
30FL13	1.10
30FL14	1.25
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30PL1	2.50
30PL13	0.60
30PL14	1.75
31JS6C	5.50
33A/158M	19.50
35A5	4.50
35L6GT	2.00
35Z3	1.85
38HE7	4.50
40KD6	5.50
42	6.95
47	6.00
50A5	1.50
50C5	0.95
50CD6G	1.15
50EH5	1.50
50JY6	2.95
52KU	2.00
53CG	15.00
61SPT	4.50
75B1	3.50
75C1	2.50
80	4.50
83	8.50
84	3.00
85A1	6.50
85A2	1.95
90AV	15.00
90C1	3.50
90CG	13.50
90CV	12.50
91AG	9.00
92AG	19.50
92AV	15.00
95A1	6.50
100E1	10.00
108C1	1.50
150B2	6.50
150C2	2.50
150C4	2.15
155UG	25.00
185BT	1.50
211	33.50
274A	15.00
307	5.00
328A	15.00
388A	17.50
425A5	8.00
431U	4.50
572B	55.00
705A	8.00
708A	8.00
715C	45.00
724A	275.00
726A	75.00
803	14.95
805	39.00
807	1.95
810	85.00
811A	15.00
812A	35.00
813	23.50
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6072	4.20
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6132	10.50
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CIRCLE 57 FOR FURTHER DETAILS

64180 computer board

by J.H.Adams M.Sc.

This 64180-based microcomputer board is a significant improvement over its Z80 predecessors, and plugs directly into SC84.

There are now 16 and 32bit microprocessors but eight-bit devices can still give high performance and they can be far cheaper to use. If one were to criticize eight-bit processors such as the Z80, it would be for their limited address range and for their lack of an integrated structure. But there is now an eight-bit processor that renders this criticism untrue.

Processors such as the 8086 and 68000 have increased address ranges and 16bit processing. The high-integration concept was introduced with 80186-series devices where peripheral and processing functions are integrated onto one chip. But these features are not, as some think, intrinsically 16bit attributes as Hitachi has proved by producing a high-integration version of the Z80.

This eight-bit processor, the HD64180, allows all of the Z80 instructions to be used, and some new ones. It includes a 512Kbyte address range, a clock generator, a programmable wait state generator and a semi-asynchronous refresh generator. It also has a memory-management unit, two d.m.a. controllers, three serial interfaces, extra interrupt lines, two programmable timers and control signals for interfacing both Z80 and 6800 peripheral devices.

Described here is a high-performance replacement for the current SC84 processor board using the HD64180. The Eurocard board contains so many peripheral functions though that it is also suitable for use as a complete microcomputer or as the basis of other multi-board systems. The core of the design is the processor itself so before detailing the circuit, I'll give you an overview of the 64180 — both its good points and bad points.

64180 features

Some extensions to the normal Z80 instructions are included in the 64180. Most of these are associated with the extra control registers inside the 64180 which are arranged to be programmed using some new i/o instructions. Main additions to the instruction set are a set of non-destructive And instructions and a group of eight-by-eight bit multiply functions.

Actually, the total number of instructions is smaller than that of the Z80 as none of the undocumented instructions which process the 16bit index registers as two separate 8bit registers appears to be executed by the 64180. This is unfortunate but should not affect most software.

What is noticeably different is the speed at which these instructions are executed. Some are executed markedly faster but all benefit from the semi-asynchronous refresh generator. In the Z80 a refresh operation is appended to each fetch of an op-code. As these may be fetched at the rate of 1.5MHz, refreshing may be carried out 20 times faster than is strictly necessary.

The 64180 treats refreshes as a form of bus request such as might be required in a multi-processor system. A programmable counter clocked at the processor clock rate generates refresh requests in a semi-asynchronous manner and these are inserted as bus cycles between processor or d.m.a. cycles.

Tests have shown a speed increase of approximately 10-15% over the equivalent Z80-based system. This semi-asynchronous behaviour should be borne in mind when debugging the processor or devices driven by it as the time taken to execute a string of instructions is not well defined as a result of refresh activity.

The HD64180 has a 512Kbyte (19bit) addressing capability and yet has an instruction set designed for use in a 64Kbyte (16bit) address evironment. It is the function of the memory management unit to provide the means of exploiting the full 512Kbyte.

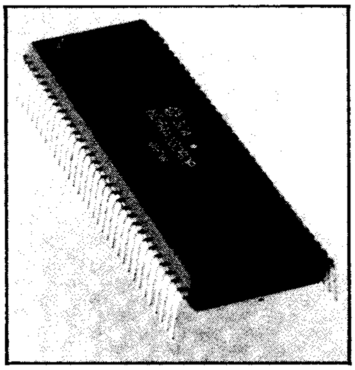
This could be done by simply appending three bits from an internal register to the 16 generated by the software — a technique called paging — so that there would be eight 64Kbyte pages in the memory area.

The 64180 implements a more sophisticated system where the entire memory is segmented into 4Kbyte blocks and the 64Kbyte logical memory is then made up from up to three independent segments of memory. Each independent segment is a multiple of 4Kbytes in size and can be located almost anywhere in the physical 512Kbyte processor address range, the only restriction being that if all three segments are in use at once, the lowest segment must start at the bottom of physical memory.

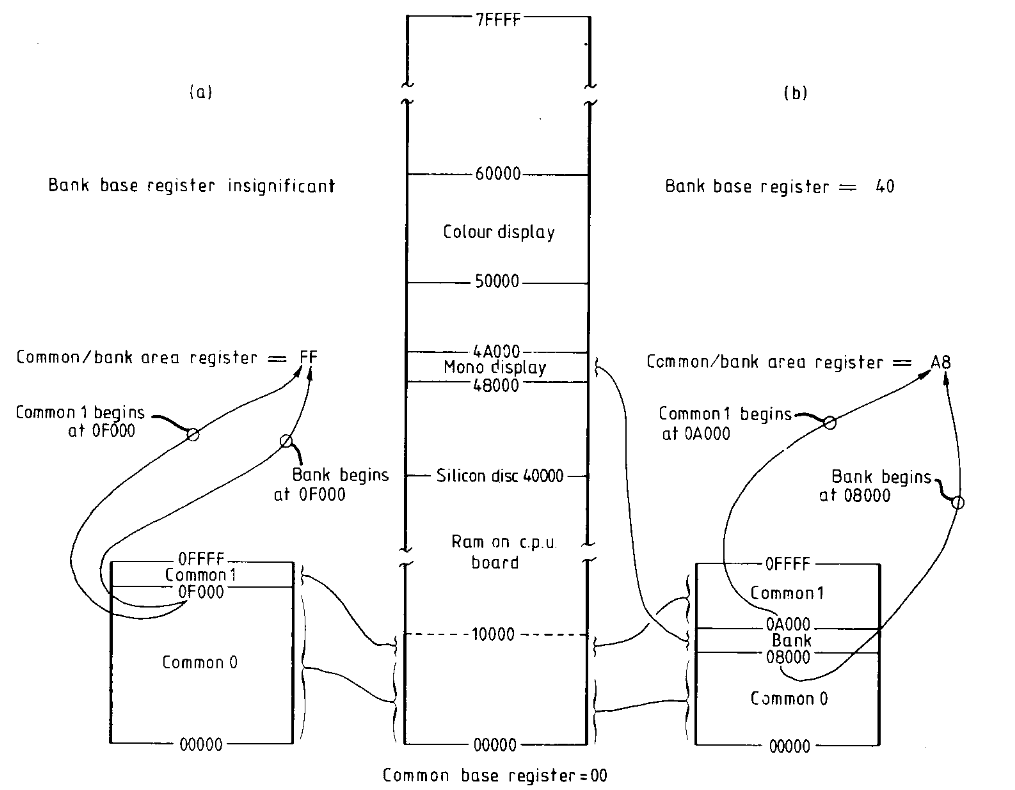
This technique allows peripheral devices with on-board memory to be inserted into the processor's logical workspace under software control rather than by the hardware paging system used in SC84. As a result devices such as the character v.d.u. or sili-

64180-board features

Up to 32Kbyte eprom onboard.
256Kbyte zero waitstate ram.
Decoding memory blocks.
6.144MHz clock.
Two high-speed d.m.a. channels.
Two asynchronous serial channels.
One synchronous serial channel.
Two programmable timers
Eurocard format.



The 64-pin c-mos 64180 runs Z80 code and despite being an eight bit processor, it can access up to 512Kbyte of memory. Picture courtesy of Dialogue Distribution.



Examples of memory mapping with the 64180

Section (a) shows a standard memory map. No aperture for bank memory is allowed so content of the bank base register has no significant meaning. Both common areas have a physical base address of zero and the changeover from common-zero to common-one occurs at F000. In section (b), a monochrome display is mapped into the memory by defining the base of the bank segment at physical address 40000 and then creating an aperture between logical addresses 8000 and 9FFF through which the corresponding part of the bank segment can be accessed.

con disc can be made to appear anywhere in logical memory.

Memory allocation for the new processor board is such that the lower 256Kbyte of memory are provided on the processor board and that a select line is produced for each of the four 64Kbyte memory pages not catered for by this memory. Conventional 16bit address devices such as the character v.d.u. can use one of these select lines with the lower 16 address lines for their addressing whereas ones such as the silicon disc can decode the 19 bit address bus directly and can thus be located on any 2Kbyte boundary. Software control of the memory is discussed later.

D.m.a.

Direct-memory access (d.m.a.) controllers are used to transfer data between memory locations or between memory and peripheral devices without the need for processor intervention. The advantage of d.m.a. as a means of data transfer is that, as no instructions have to be fetched or executed to make the transfer happen, data can be transferred at a very high rate.

The disadvantage of d.m.a. is that, as the d.m.a. controller has to take control of the address, data and control buses during the transfer, an external d.m.a. device requires quite a complicated interface when fitted to a bus-oriented system. This disadvantage disappears of course when the d.m.a. controller is actually within the processor.

There are two d.m.a. controllers in the 64180, one optimized for memory-to-memory transfers and one for peripheral-to-memory transfers. Transfer rates can be as high as 1.5Mbyte per second.

Up to 64Kbytes of data can be transferred in one operation through d.m.a. channel zero. In memory-to-memory mode the controller can be made to transfer that data in a continuous burst or alternately with normal processor cycles. The controller can transfer data from and to any location in the 512Kbyte memory range and so can be used as an alternative to the memory-management unit when it is inconvenient to map a device into the logical space. During the transfer, both the destination and source addresses can be independently set to increment or decrement.

The same d.m.a. channel can also be programmed to pass data between memory and either memory-mapped or i/o mapped devices. In these cases the mapped device address does not change and transfer is controlled by a d.m.a. request input to the processor which can be set to trigger a single transfer on each falling edge at this input or to continue transferring while the input is active.

Direct-access offers channel one similar facilities for i/o mapped transfers only. Its programming is slightly different to channel zero which has source and destination registers whereas channel one has a memory register, an i/o register and a direction register.

These two options add to the flexibility of the d.m.a. system. Both channels signal the end of the transfer by a hardware output, a bit in a control register and, optionally, by a processor interrupt.

Serial communication

The 64180 contains three serial communication devices. There are two bidirectional, asynchronous channels each of which can work in full-duplex, i.e. can send and receive simultaneously. Each has double-buffering, which means that there are temporary buffers between the receive/transmit mechanism and the bus interface so that the processor does not have to wait for the instant when a character has just been sent or received.

Each communication device has its own programmable bit-rate generator for rates between 50 and 38 400 baud. There are facilities for selecting either an external clock or output of the rate generator. Implementation of this feature has an unfortunate side-effect as, despite having 64 pins, the 64180 has to share functions on some pins. The two pins used for clock i/o are also used for external control of d.m.a. channel zero.

Presumably, this combination has been chosen since when d.m.a. channel zero is used for memory-to-memory transfers only, its handshake lines are not used. Since d.m.a. channel one is available for i/o transfers, channel zero may only be needed for memory-to-memory transfers and so the clash of pin functions is avoidable.

Each channel has parity checking, standard frame structures, error flagging, a multi-processor communication mode and programmable interrupts. Serial channel zero has three hand-shaking signals. Output RTS is just a programmable bit and CTS is an input which can mask the internal flag which prompts the system for more transmit data. Input DCD resets the receiver, masking the flag which prompts the system to read data from the receiver buffer and holding all error flags inactive whatever is actually happening in the receive buffer itself.

Channel one has only a CTS input line and this pin is shared with another function (see Timers). As such its primary application would be as a printer port. In this mode the CTS line would be the control for hardware handshaking but, being a bidirectional port, software handshaking (e.g. by XON/XOFF signalling) would also be possible.

The third port is a simple half-duplex synchronous port. Basically, it is just a programmable bit-rate generator, an eight bit shift register and some control logic. If a byte is written to the shift register then it is immediately shifted out and eight clock cycles appear on the clock pin synchronous with this process.

If a byte is requested then eight clock cycles are output and data is clocked into the same register. Using the same register means that transmission and reception may not occur at the same time and, as there is no buffering, the system must monitor the transmit process and not write data to the shift register until the current transmission is finished.

Use of this port is compromised by the sharing of its receive data input by the CTS line for asynchronous channel one. Nevertheless it is of some use as a transmit channel only, for use with peripheral devices such as frequency synthesizers programmed by serial input like the Plessey NJ88C30.

Timers

Two 16bit timers are provided. Each has a 16bit holding register which reloads into the counting register every time the counter reaches zero, and so the timer may be used to provide a regular interrupt.

The timer may be read as it is counting. As the 16bit timer has to be read in two processor cycles the timer access is arranged so that whenever the lower eight bits of a timer are read, the upper eight bits are latched into a temporary register which can then be read later.

This technique prevents any errors which might occur should the counter go through a multiple of 256 in between the two eight bit accesses. Interrupts are available for end-of-count indication. The timers are clocked at one twentieth of the system clock frequency, which gives a lowest end-of-count frequency of about 5Hz.

One of the timers can toggle an output pin and so act as a programmable signal generator. Unfortunately this is another shared pin and its second function as an address line is not available in this design.

Interrupts

The 64180 includes all of the interrupt facilities associated with the Z80, and some new ones — 12 in all. Seven interrupts are associated with peripheral functions already described. Two more maskable hardware interrupts are provided through external pins. These nine functions operate in interrupt-mode two, an internal register pointing to a 18byte relocatable table of service-routine addresses in the processor interrupt-vector page. Two more interrupts are the Z80-like INT and NMI.

The last is TRAP which is an interrupt generated by the processor itself. This particular trap is triggered whenever an undefined op-code is fetched, the action being to make a call to logical address zero. This function can be used to provide extra protection against coding errors or to provide user-defined extensions to the instruction set.

When a TRAP occurs the program counter is pushed onto the stack and bits in a control register are set so that the system can determine that this was a trap and not just a hardware reset, and how far into the op-code fetch that the error was detected. This latter feature is necessary as the error may only become obvious after the second or third fetch and so some means of knowing how far back the program counter needs to be stepped is required.

Timing and control

Various system timing facilities are provided on the 64180 chip. First is a clock generator. This runs at twice the system clock frequency, the latter being available on a buffered output. As the system clock is often used as the timebase for the serial channels, it is advisable to pick a frequency which provides standard data rates on division. For a 6MHz processor this usually means a 12.288MHz crystal.

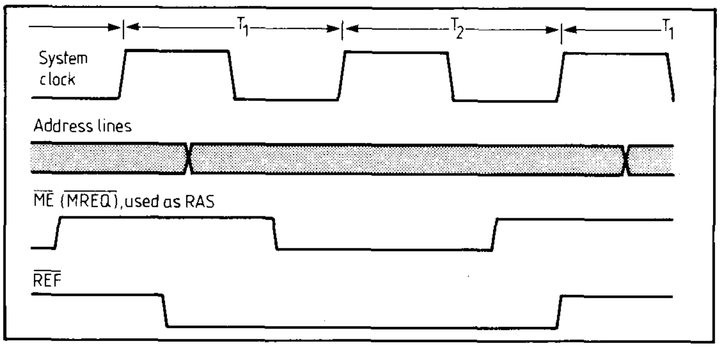
As with the Z80, an extra wait state is inserted into i/o cycles. Over and above this the processor may be programmed to insert up to three extra cycles in all memory functions and, independently, up to

Bus connector signals

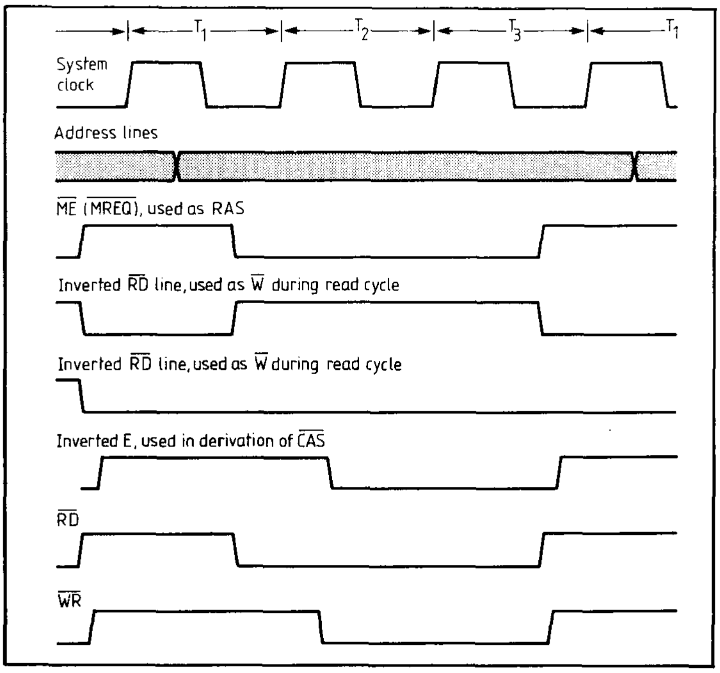
Row A	Pin number	Row C	Function
GND	1	GND	
+5	2	+5	
D_0	3	$\overline{\mathrm{ST}}$	processor status
D_1	4	$\overline{\mathrm{INT2}}$	maskable interrupt
D_2	5	$\overline{\mathrm{INT1}}$	maskable interrupt
D_3	6	$\overline{\mathrm{INT0}}$	maskable interrupt
D_4	7	$\overline{\mathrm{NMI}}$	non-maskable interrupt
D_5	8	$\overline{\mathrm{HALT}}$	processor halted
D_6	9	$\overline{\mathrm{ME}}$	memory enable
D_7	10	$\overline{\mathrm{IOE}}$	i/o enable
A_0	11	$\overline{\mathrm{RD}}$	processor reading
A_1	12	$\overline{\mathrm{WR}}$	processor writing
A_2	13	$\overline{\mathrm{WAIT}}$	request for proc. wait
A_3	14	$\overline{\mathrm{BUSRQ}}$	request for proc. bus
A_4	15	$\overline{\mathrm{BUSAK}}$	processor bus relinquished
A_5	16	$\overline{\mathrm{RESET}}$	20μs reset pulse
A_6	17	$\overline{\mathrm{LIR\ (MI)}}$	proc. fetching an op-code
A_7	18	E	proc. is using data bus
A_8	19	$\overline{\mathrm{DREQ1}}$	d.m.a. request to cont. 1
A_9	20	$\overline{\mathrm{DREQ0}}$	d.m.a. request to cont. 0
A_{10}	21	$\overline{\mathrm{REF}}$	memory refresh cycle
A_{11}	22	$\overline{\mathrm{SELTRK}}$	i/o strobe from i/o board*
A_{12}	23	–	unused
A_{13}	24	$\overline{\mathrm{TEND1}}$	last d.m.a. transfer on ch. 1
A_{14}	25	$\overline{\mathrm{TEND0}}$	last d.m.a. transfer on ch. 0
A_{15}	26	$\overline{\mathrm{PAGE4}}$	address 4xxxx $_{16}$ decoded
A_{16}	27	$\overline{\mathrm{PAGE5}}$	address 5xxxx $_{16}$ decoded
A_{16}	28	$\overline{\mathrm{PAGE6}}$	address 6xxxx $_{16}$ decoded
A_{17}	29	$\overline{\mathrm{PAGE7}}$	address 7xxxx $_{16}$ decoded
+12	30	−12	
+5	31	+5	
GND	32	GND	

* addresses xxEC to xxEF

Refresh cycle timing showing how ME is used as the d-ram row-address strobe signal.



General c.p.u. timing.



three extra cycles into all i/o functions.

This is one area where the 64180 and Z80 differ as, immediately after reset, the Z80 runs with no extra wait states whereas the 64180 runs with three. This can be quite alarming if one is expecting the 64180 to outstrip a Z80B!

Refresh cycles are normally two microcycles long but these may also be programmably extended, or suppressed all together. Note that the 64180 provides eight-bit refresh addresses and that refresh cycles may actually occur in the middle of multi-byte instructions.

Note also that the refresh address is incremented on every refresh cycle not on every instruction fetch. This means that if some condition occurs which suppresses or delays the granting of a refresh operation, the refreshing addresses are still in sequence.

The R register functions as in the Z80, incrementing on every op-code fetch. As such it may run out of synchronisation with the refresh address but, more importantly, is still available as a pseudo-random seed for software such as Basic interpreters which rely on it for functions such as RANDOMIZE.

Externally, the 64180 has two extra control lines. Signal ST is driven low during the fetch of the first byte of an op-code, during all types of interrupt acknowledge, during HALT and during internal d.m.a. operations. Output E is a signal which is driven high during periods when the data bus is expected to be driven. Its intended function is to allow 6800 and 68000 peripheral devices to be easily interfaced.

Several limited modes of operation are possible with the 64180. The common one with the Z80 is HALT mode where the processor cycles waiting for an unmasked interrupt or hardware reset. The SLEEP mode is a new function which discontinues most processor activities, except for the interrupt structure and the on-chip i/o functions.

An alternative mode is IOSTOP where the processor continues but the on-chip i/o and timer facilities are shut down. Mode SYSTEM STOP is a combination of these two modes in which power consumption is reduced from 75 to 20mW.

To exit from IOSTOP it is only necessary to reset a bit in a control register. To exit from modes involving SLEEP the usual exit is through a reset or an interrupt. In the latter case an interesting option is offered in that if the global interrupt-control bit is reset and an individual unmasked interrupt occurs, then execution immediately proceeds to the instruction following the SLEEP one. This must give the possibility of almost the fastest microprocessor interrupt response.

Inside the 64180 there is a 64byte register block used to control all peripheral and system functions incorporated in the processor. These are accessed by i/o instructions which output zero on the upper half of the i/o address bus.

The register block may be relocated into any 64byte boundary in that i/o page, the default being zero to $0003F_{16}$. Single and multi-byte i/o instructions which implicitly access these registers are provided. An internal i/o operation activates the external control lines but without any programmed wait states.

Not all aspects of the 64180 are positive. There are some odd timing skews which make the 64180 less than straightforward to apply in circuits containing Z80 peripheral chips. The first timing problem is during the return from Z80 interrupt, i.e. during the fetch of op-codes for the RETI insteruction.

Although it is not documented, it is apparently necessary that the LIR control signal (M1 on the Z80) be high at the start of the fetch of the second op-code byte in order that the code will be recognized. In this way, the internal 'in-service' flag for that particular interrupting channel will be reset and the internal and external priority chain will be settled correctly.

The Z80 provides for this whereas the 64180 uses the clock edge which signals the start of the fetch to drive the LIR line low. There will be a delay before the LIR line actually goes low at the peripheral's M1 pin and this may match the

Previous articles

SC84's original **c.p.u.** board described in the May 1984 issue, pp. 37-40 & 51, uses a Z80 microprocessor and 64Kbit dynamic rams. Further articles were
Disc and i/o board, June 1984 pp. 39-42
V.d.u. board, July 1984 pp. 31-34 & 64-66
Power supply, September 1984 pp. 39-41
Construction, September 1984 pp. 51-53 & 63
Bubble memory, September 1985 pp. 32-33
Silicon disc, October 1985 pp. 35-36 & 93
Eprom programmer main circuit, November 1984 pp. 43-46
Eprom programmer p.s.u., December 1984 pp. 51-55
Eprom programmer software, February 1985 pp. 33-36

hold time of the peripheral; but this is a close race and may cause problems unless $\overline{\text{LIR}}$ is actively delayed.

There also appears to be a problem associated with the handling of this return-from-interrupt mechanism while the d.m.a. controller is active. The cause of this is not clear but may be associated with the interruption of the fetching of the two byte RETI instruction by a d.m.a. cycle. This seems to make the peripheral device skip the resetting of the interrupt sequence.

Neither of these problems affects the MK3801 used on the i/o board as it is an asynchronous device which is programmable for a mode where the in-service flag is reset immediately after the interrupt-acknowledge sequence.

Delay between the address bus being set up and $\overline{\text{ME}}$ (the Z80 $\overline{\text{MREQ}}$) becoming active is very short. At 6MHz it can be as short as 10ns and after resetting or a return from a BUSRQ sequence it may be −15ns, i.e. $\overline{\text{ME}}$ becomes active *before* the address is stable.

Dynamic and pseudo-static rams often use $\overline{\text{ME}}$ as $\overline{\text{RAS}}$ and this close timing may cause problems. On reset, access is normally made to static memory (a rom) and so this does not matter.

Experience with 4 and 6MHz devices has shown that the address is set up typically 60ns before $\overline{\text{ME}}$ is driven low so with the delay through address multiplexers and the minimal set-up time required for row addresses, no correction should be needed, even after a BUSRQ sequence.

When asynchronous channel zero is programmed for internal clock mode and the processor enters the SLEEP mode, the pin which can be the d.m.a. request input line for channel zero functions as an output irrespective of the programming of the line.

This could result in damage due to both the processor and the external d.m.a. driver trying to drive each other. It can be avoided by connecting a current limiting resistor between the two.

The final problem is that when the timer output pin is used instead of as A_{18}, noise spikes of various amplitudes can occur as address lines switch. ■

Operation of the board is discussed next month. A Eurocard p.t.h. board for this microcomputer will be available toward the end of July at £19 inclusive from Combe Martin Electronics, King Street, Combe Martin, North Devon EX34 0AD.

BOOKS

Newnes Radio and Electronic Engineer's Pocket Book 16th edition, by Keith Brindley. Newnes Technical Books, 170 pages, hard covers 95mm by 196mm, £5.50. Fact-packed vade mecum for the engineer. A few examples picked at random from its contents are tables of SI units; conversion factors; physical laws and formulae; BS component and diagram symbols; data on common diodes and transistors; pinouts of logic i.cs; glossaries; the phonetic alphabet and the international Q code; radio emission designation; world time differences; and details of UK broadcasting stations.

Land Mobile Radio Systems edited by R.J. Holbeche. Peter Peregrinus Ltd for the Institution of Electrical Engineers, 229 pages, hard covers, £28 in UK, £30 elsewhere. Contributors are drawn from Philips, British Telecom, the DTI and the universities. Chapters cover fundamentals of v.h.f. and u.h.f., propagation in urban areas, aerial and base-station design, modulation methods (including the newer ones), data systems, regulatory control in the UK, paging, the telephone network and radiophones, trunked systems and cellular radio.

The text is reproduced from typescript, with some diagrams and formulae entered by hand.

The Mobile Communications Guide 1986 edited by Adrian Morant. IBC Technical Services Ltd (56 Holborn Viaduct, London EC1A 2EX), 120 A4 pages, soft covers, £25. The current radio communications scene in the UK is surveyed in a score or so of articles contributed mainly by industry sources. Topics covered include p.m.r., voice messaging, data services, community repeaters and of course cellular telephones (with marketing men from both sides explaining why we should choose theirs). An extensive directory section lists products and suppliers.

Wiring up the Workplace by Roger Camrass and Ken Smith, with a foreword by Prof. Bryan Carsberg of Oftel. IBC Technical Services, 172 A4 pages, soft covers, £55. Practical handbook on implementing the new office technologies, aimed at corporate planners and managers. How to assess your communications needs, how to evaluate different network technologies and future trends, how to plan power supplies and wiring schemes and so forth. Plenty of realistic-looking advice. Nine out of ten times, say the authors, your network will malfunction during initial tests, and will take many weeks beyond the time of going live to be sorted out. The cost of a typical high-tech office system is reckoned to be about £10,000 per worker.

Advanced Signal Processing edited by D.J. Creasey. Peter Peregrinus Ltd for the Institution of Electrical Engineers, 297 pages, hard covers, £33 in UK, £36 elsewhere. Proceedings of an international seminar held at the University of Warwick in September 1984. Aspects of radar, sonar and communications are examined in 33 contributions from government research establishments, industry and the academic world. A few examples: diversity techniques in communications receivers; acousto-optical receiver techniques; digital filters; c.c.d. processors for sonar; designing in silicon; biological echo-ranging systems; satellites; display ergonomics; very high performance i.cs; the Ada language; speech processing and recognition; real-time image-processing.

A Practical Reference Guide to Word Processing on the Amstrad PCW8256 and 8512 by F.A. Wilson. Bernard Babani (Publishing), 181 pages 195mm by 263mm, soft covers. Amstrad's own user guide is notoriously hard going and so this book should find a ready market. The text is a good advertisement for these low-cost systems: it was prepared camera-ready on an PCW8256. It's easy to follow and explains many useful tricks. But an index would have been helpful.

The Radio Hacker's Code Book by George Sassoon. Duckworth, 239 pages, soft covers, £6.95. The somewhat flip title creates the impression that this is merely a directory of code-words, which it isn't. It begins with a practical guide to receiving confidential data transmissions on the short waves, with much detailed information on modulation methods and signalling protocols, and suggested methods of implementing them on a microcomputer. Then follows a consumer's guide to codes and ciphers, describing principal varieties from far back into classical antiquity and even biblical times, via Enigma, right up to the RSA public-key cipher of the present day. Weak points of each code are pinpointed; and possible approaches to breaking them are in many cases illustrated with listings in Basic and Z80 machine code. As one reads, an aura of mystery starts to surround the author, who plainly knows a good deal more even than the very considerable amount he tells us. What little the publisher's blurb says about him sounds rather implausible.

An intriguing and very worthwhile introduction for the would-be cryptographer or cryptanalyst. There is an extensive bibliography.

Op-Amps, second edition, by J. Brian Dance. Newnes Technical Books, 102 pages, soft covers, £4.95. Recipe book for the constructor, covering a variety of i.c. types including some of the newer fet-input devices and op-amps for audio. Programmable op-amps such as the RCA CA3440 get a mention, but there is no sign of the chopper-stabilized sort (ICL7650 etc.) except in the glossary at the end.

FEEDBACK

ELECTROLYTICS AND DISTORTION

I am grateful to Mr Powell (*EWW* May 1986) for pointing out to those who may not have realised it that I am sitting on a fence over the use of specific kinds of capacitors, or none, in audio circuits. I think that this is an objective attitude to adopt in the light of what has been published so far in magazines, perhaps also in professional and technical literature, to which I do not have access. But yes, like Mr Self, I would require really sophisticated listening tests to accept the capacitor limitations spoken of by some, though my experience of amplifiers is neither that of Mr Self nor of Mr Powell. But I do know "different" from "better", and I can enjoy variety and choice in sound!

Scientific attitudes and experimental findings which seemed unchangeable may have their human limitations, as has been commonly found through the centuries. With this relatively recent recognition it is surely appropriate in these times to remain agnostic until there is no reasonable present doubt after effective enquiry on points at issue? And to make decisions for practical purposes on best available evidence, but which are recognised and admitted to be a matter of personal choice, and therefore possibly prejudiced.

My main objective in writing the letter of February 1986 was to make engineers aware, if they are not already, that there are also other criteria than engineering technicalities in human appreciation of reproduced sound. So when one is dealing with a technical manipulation of an art form it is essential to remember that one of the most basic human pleasures and needs is social communication in the widest sense – forgive the pun! What Mr Powell and I have both illustrated in different ways is that perfect received quality is by no means essential for such communication to occur meaningfully, as information theory confirms. Though I agree that the less the imperfections within detectable limits the easier it may be for some to become deeply involved in what is being, perhaps unwittingly, communicated, and I count myself among these.

I have certainly learnt from the contributions of Mr Self and others, though perhaps not always what they might have wished. Not everybody demands or recognises perfection, except perhaps professionals and the luxury market, where self-delusion seems widespread, and for want of realistic appraisal and self-criticism is too often encouraged by those who will gain most from it. And that is my view of the hi-fi market, where there need be little easily detectable difference to most ears between an expensively packaged and a much more moderately priced set-up.

So to accept market criteria as a substitute for good fundamental research results as Mr Powell seems to want to do appears to me to be setting up for the future another one of those reappraisals of accepted attitudes which would be better carried out now, but which, if market directed, will not be until the present sale initiatives are becoming exhausted, incidentally causing increasingly entrenched and bitter attitudes.

The possibly ironic aspects of the approach to absolute perfection of my earlier letter seem to have bypassed Mr Powell, who is probably obsessed with perfection, as amplifier designers have been for decades. Earlier sales drives seem to have been responsible for the introduction of this persistence into the public mind, fostered by designers as well as sales staff. Will capacitor types be equally widely and deeply lodged? We shall do well to examine and re-examine attitudes, both technical and human!

David White,
Gwynedd

I was interested to read Mr Powell's reply to my letter, on the vexed subject of 'capacitor distortion', in the May 1986 issue. It is refreshing to hear from a hi-fi manufacturer on the topic rather than reviewers.

I do not think I implied that there was any special value in implausible theories in this field. On the contrary, a plausible theory is always a tool that can be used with more confidence. The disabling difficulty that the 'Subjectivist' school of audio labours under is that in general it has no theories at all. It is a long, long, way from producing a hypotheses, such as "capacitors must affect the sound that goes through them" to constucting a theoretical mechanism that predicts some effect on electrical waveforms, an estimate of the magnitude of this effect, and proposes some means of measurement that would confirm this. One aspect that is almost always painfully obvious in its absence from subjectivist musing is a before-and-after waveform diagram, indicating just what sort of damage a typical waveform would suffer. In my more cynical moments I sometimes think that this is because such explicit information would render the demolition of a cherished theory all too easy if it happended not to be true. Keeping your hypotheses woolly is, sadly, an effective way of deterring serious critics.

To deal with Mr Powell's detailed points in order, it would be a nice tidy world if amplifier manufacturers (or indeed manufacturers of anything) could count on profits that increased with the quality of their product. In the case of audio in particular, this seems a claim fraught with difficulties, bearing in mind that the majority of the paying public buy relatively inexpensive systems that cause hi-fi reviewers to shake their heads more in sorrow than in anger. One could even postulated that if there were no subjective differences between competently-designed amplifiers, then manufacturers with an eye on optimizing their sales might be in some difficulty.

As to what Mr Powell calls my "implausible depolarization theory," here I must protest. It is not implausible; it is the cold truth. Anyone with a distortion analyser and an oscilloscope can prove to himself that the effect is exactly as I described. Perhaps Mr Powell has not tried the experimental himself. Whether depolarization or dielectric absorption is the primary culprit I leave as an open question; once more I invite a capacitor manufacturer to enlighten us to this point. It is quite true that my view of the mechanism involved leads me to suppose that capacitor action at low levels is effectively perfect in audio coupling applications.

As to verifying this at microvolt/nanoamp level. I have a few ideas on how this may be done, though I am not so naive as to suppose that even the clearest demonstration would lay the subject to rest. For the moment I simply remark that the vast majority of, if not all, microphone preamplifers use input coupling capacitors and one would suppose that any possible capacitor crossover distortion, or 'granularity' as it is sometimes called, would be mercilessly exposed by signal levels which are often as low as −80dBu (about 70 microvolts). I am prepared to state categorically that in my experience such is not the case.

Finally, to the mangling of music. It is true, as Mr Powell points out, that either severe phase distortion or linear low-pass filters will affect music without obviously impairing a suitably-chosen sinewave. (The filter is actually irrelevant as my letter did specify a sineware anywhere in the audio band) I was of course discussing non-linear distortions, and so Mr Powell's point hardly seems worth making. Just for the record, it is well established that phase distortion of speech is undetectable until the 5-8kHz band is delayed by at least 5m$ with respect to the 1-3kHz band, and the lowest octave (50Hz) can be delayed by more than 70m$. Since it would be a truly outrageous hypothesis that claimed that such an effect was possible inside a capacitor, I think that this point can be left there. Both phase distortion and unsuspected low-pass filters would of course be instantly exposed by simple square-wave testing.

In conclusion, I can only say that there is still no objective evidence that capacitors are in any way audible. However, one last thought. Back-to-back capacitors may or may not undergo cyclic depolarisation in a strict electro-chemical sense, but they *dd* generate distortion of the kind I have described in my previous letter. One hopes that Mr Powell might feel impelled to try some actual experiments on the subject.

D.R.G. Self,
Bow,
London E3.

Having read reviews of audio amplifiers attributing more musicality, depth, bass control etc. to some and not to others and now the correspondence in this magazine about the sound of capacitors, I recently carried out some practical tests. Various amplifiers were obtained, ranging from those classified by the hi-fi press as 'very good' down to 'cannot be recommended' (None of my friends was able to lend me a really prestigious 'excellent' amplifier)

A relay with four-pole, two-way, gold-plated contacts switched the stereo input signals and earths between pairs of stereo amplifiers, and potentiometers were provided exactly to match all four outputs at 1kHz. A similar four-pole relay was used to switch the outputs to the speakers, which were either Spendor BC1s or Gale 401s. All connections were of equal lengths for all the amplifiers and made with good quality wire.

Listeners took the stereo seat and at their leisure switched between pairs of amplifiers. They were asked: 1. can you hear a difference? and 2. what difference? The relay switch was marked A and B and the amplifiers 1 and 2 and they could be swapped, but it turned out not to matter as no one, young or old, could hear any difference between competently designed power amplifiers. A drop of 2dB at 20kHz was just heard by some and the difference in the sound between the others and the 'not recommended' amplifier was just audible but not marked.

No doubt it will be said that the input signal, from various CD players, and also white noise, did not provide the subtle nuances that excellent amplifiers pass but others ignore, and that long-grain-orientated wire should have been used as well as more awkward loudspeakers. Well, if someone will lend me these I shall be happy to repeat the tests and report the results.

What I found most interesting was that we had compared some of these amplifiers before by changing over all the connections and setting the levels by ear and had then ourselves attributed to them different quantities of musicality, depth, bass control etc., so it turned out to be a shock when they all sounded the same.

A. Halfhide,
Cambridge.

MATHEMATICAL RAKE'S PROGRESS

Where sine functions are concerned, Ivor Catt behaves like the proverbial hen with its beak to a chalk line. Witness his statement (A mathematical rake's progress, January issue) that 'the sinusoidal wave, which is a camouflaged circle, is Ptolemy's pure circular epicycles fighting back against Kepler's less pure, ...ellipse'. Now if you take a plumb bob, move it away from its rest position, and push it in a direction which misses the rest position, its subsequent motion is described by the two sinusoidal expressions

$$x=a.\sin(\omega t+\epsilon)$$
$$y=b.\sin(\omega t+\phi)$$

which define, of all things, an ellipse! Only in the degenerate special case where a and b are equal and the phase difference is exactly $\pi/2$ does this become a circle. Of course the variation of velocity of the plumb bob round its path doesn't match that of a planet round its orbit, but then the sine functions appear because the bob experiences a force towards its rest position proportional to its distance from that position, whereas a planet experiences a force toward the sun inversely proportional to the square of its distance from the sun.

Ivor Catt's chalk line traces out a circle round which a point moves uniformly, so that the projection of its motion on a diameter varies sinusoidally. Unfortunately students can be left, as he appears to have been, with the impression that this definition provides a full understanding of the nature of sine functions.

Three factors in combination account for the importance of the sine function in physics and engineering. They are

- the behaviour of any network of linear lumped components can be represented by a linear differential equation. The 'complementary function' of such an equation of order n is the sum of n terms, each of which is the product of a sine function and an exponential, the frequencies and the multiplying constants in the exponents being defined by the coefficients of the derivatives in the equation
- if a sinusoidal driving voltage is applied to the network all the currents and voltage which it generates vary sinusoidally at the same frequency.
- any driving voltage within reason can be expressed by a Fourier series or a Fourier transform as a sum of sinusoidal components.

Mr Kennaway's comments (May Letters) are also misguided. Why, if the Fourier transform of a single square pulse can represent the zero level before the pulse arrives, should the calculated output which it generates when applied to a low-pass filter begin before the leading edge of the pulse arrives? As for his remarks about partial differential equations, a mathematician may be satisfied with the general solution of the one dimensional wave equation, but this solution is not of much help to the physicist or engineer who wants to find a solution to a specific problem, and must take boundary conditions into account. By diving 'straight into separation of variables, superposition and Fourier transforms' the writers of those physics and engineering text books showed that they knew exactly what was required of them.

C.F. Coleman,
Grove,
Oxfordshire

INTENTIONAL LOGIC SYMBOLS

The old truth that the best way to learn a subject is to teach it hit me after you published my letter in July 1982.

A friend drew my attention to a book on the history of computing by Herman H. Goldstone in which he reveals that the simple and self-explanatory logic symbols that I was advocating had been invented by John von Neumann.

If any civil servants in the British Standards Institute are considering the long-festering problem of showing the functions of logic circuits symbolically, they could hardly do better than to go back to these early and elegant symbols and to elaborate on them as little as possible.

John C. Rudge,
Harlington,
Middlesex

TRASH PUSHERS

Ivor Catt's labelling of contemporary physicists and engineers as "maths pushers" (*E&WW*, January 1986) was disputed by Richard Kennaway (Feedback, May 1986). The latter correctly demonstrated that "physicists and engineers do not suffer from too much mathematics, but from too little, and too little understood".

In fact, the situation is much worse: what these people push is not merely incomplete or slightly inaccurate maths, but (whenever it suits their needs) it is patently incorrect maths. This was attested by a leading "maths pusher", Paul Dirac, who in 1975 felt obliged to declare:

> 'Most physicists are very satisfied with the situation. They say "Quantum electrodynamics is a good theory, and we do not have to worry about it any more." I must say that I am very dissatisfied with the situation, because this so-called good theory does involve neglecting infinities which appear in its equations, neglecting them in an arbitrary way. This is just not sensible mathematics. Sensible mathematics involves neglecting a quality when it turns out to be small – not neglecting it just because it is infinitely great and you do not want it! (P.A.M. Dirac, Directions in Physics, John Wiley & Sons, 1978, p 36).

Yet these people, instead of being exemplarily penalized, are scandalously awarded promotions and prizes – even Nobel prizes.

Actually the situation is even worse. What these people push is not only incorrect maths; when it suits their needs, they also push a badly confused set of ambiguous or meaningless concepts; an extraordinary collection of dubious or false theories; a blatantly sloppy and fallacious "logic"; and a dismally erroneous epistemology. All these allegations have of course been substantiated, to a small or great extent, by such eminent critics as Alfvén, Brilloin, Dingle, Essen, Landé, etc., not to mention the scores of less eminent ones.

To call these people "maths pushers" would indeed be a nice compliment to them – and a libellous slander to the genuine mathematicians. These people deserve to be labelled what they really are: *trash pushers*. And they should be held responsible for the harmful effects of their reckless actions: obstruction to progress and a stupendous waste in resources.

T. Theocharis,
Southfields,
London SW18

CABLE RADIO

When I drive north through the Dartford Tunnel, Wrotham v.h.f. f.m. fades out once inside the entrance, as might be expected, but when I drive south, it doesn't – I can hear Radio 4 all the way through.

Can any of the learned gentlemen who read *Wireless World* suggest why this might be so?

W. Blanchard,
Dorking,
Surrey

We are at present conducting an experiment to extend the coverage of BBC v.h.f.-f.m radio services to the southbound carriageway of the Dartford Tunnel. The three national radio services transmitted from the nearby high powered station at Wrotham, and BBC Local Radio services are received, amplified and retransmitted into a "leaky" feeder installed along the length of the tunnel.

Because the signals radiated inside the tunnel, from the leaky feeder, are on the same frequency as those receivable outside the tunnel, motorists should be able to continue listening on v.h.f.-f.m. without adjusting their sets when entering or leaving the tunnel.

We hope, if this experiment proves successful, to be able to extend coverage to the northbound tunnel as well. However, this is not likely to be done for about 18 months to 2 years as this tunnel is at present being refurbished.

Henry Price,
Asst. Head, Engineering Information Department,
BBC

For a further note on radio beneath the waters, see our report on the recent MRUA conference (page 17, June 1986). Ed.

By J.L. Linsley Hood, M.I.E.E., M.I.M.C.

An engineer's log – moisture measurement

Problem – solving in the industrial electronics environment, taking moisture measurement in a moving web as an example.

There are snags, it is said, with everything, and I think that most electronics engineers working in manufacturing industry would ruefully agree that this was conspicuously true for their jobs. For a start, one must choose between being an 'instrument engineer', which will not involve very much original electronic design work, but will largely consist of tracking down, and installing, appropriate pieces of commercially available hardware, or being an 'instrument development engineer', where one would normally work in some research or development laboratory.

If one chooses the latter, in say, some chemical or industrial manufacturing plant, one is likely to have a great deal of personal autonomy in the design field, as one of the few local experts in one's chosen line of activity. However, one is then likely, as an odd boffin of unusual skills, to have cut oneself off from any possible promotion ladder apart from that short path leading to the management of one's own small section in an environment filled with salesmen, accountants, and chemical and industrial engineers. Yes, I know that modern industry tends also to embrace specialists in other fields, such as systems analysts or market psychologists, but they are likely to be nearer the hub of management, and more likely to be noticed, than an electronics engineer working on abstruse problems in some remote out-station.

A further, slightly more subtle, problem is that, even in these days, electronics engineers with industrial or manufacturing experience do not find it too hard to get other jobs, unless they are no longer young. This means that one will find useful young staff being tempted away, the resulting vacancies then being left unfilled by an unaware management, who are principally anxious to keep their total head count as low as possible. In my own experience the so-called 'natural wastage' has a high incidence among young engineers in all industrial electronics labs, with the higher salaries and more secure prospects offered by government employment being the principle lure.

The final snag – though one may not always see it in this light – is that one is never likely to be asked to solve any process problem unless it is a very difficult one! If it was only fairly difficult, the chances are that there would already be some commercially available equipment which would meet the need, without incurring the cost and time penalties of the development of a new instrument, from scratch.

Of course, it is always possible that one's manufacturing plant produces some product of a very specialized nature, for which the potential sale of process instruments, of a kind necessary to solve its singular problems, is too small to attract the interest of commercial instrument manufacturers. However, one can see that there are snags with that situation too – if only because there is unlikely to be any useful amount of background literature upon which one can draw for guidance or inspiration.

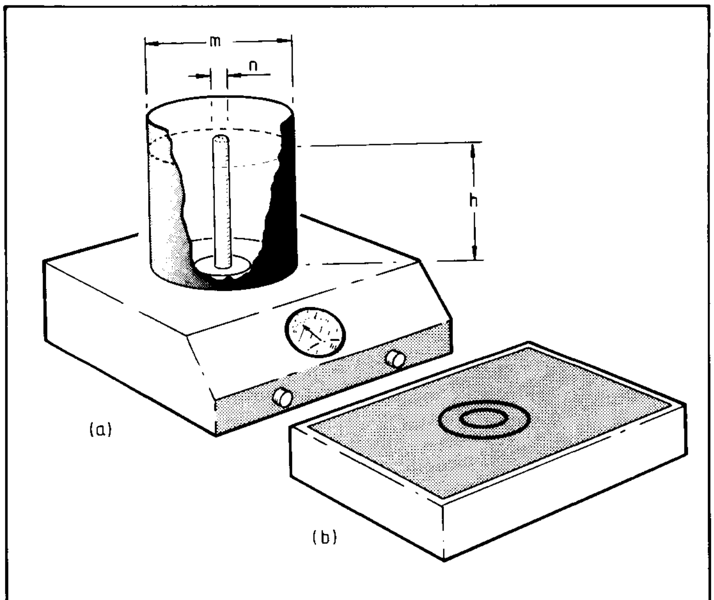


Fig. 1. Possible layouts of electrodes. Loose material could use method at (a), while for surface application, method (b) can be used.

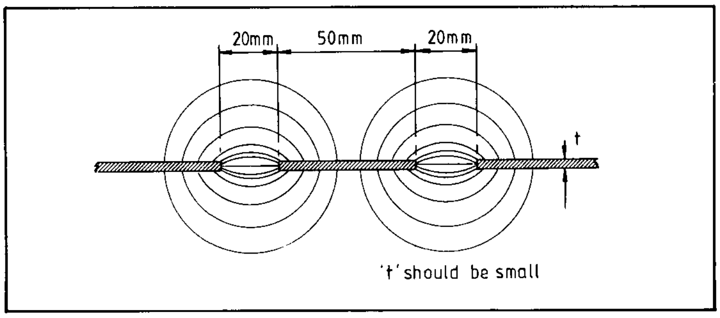


Fig.2 Electric field pattern produced by electrode layout of Fig.1(b).

A practical example

Looking back on my two years as an instrument development engineer, and the various kinds of instrument which we evolved, I think that the problems of the measurement of the moisture content of a continuous-flow product illustrate most fully the nature of the tasks which have to be done. In the particular case of one of the products made at my own place of employment – a continuous, tranparent web of regenerated cellulose film, used for packaging and adhesive tape applications – the actual water content was fairly critical, and was required to lie within the range of 6.5 – 7.5 percent, by weight, if the film was to avoid the problems of brittleness or limpness.

Because of the glossy, but easily marked surface of the web, and the high speed at which it was produced, it was desirable that one should not touch the moving surface, and for reasons of manufacturing technology, the film contained other 'softening agents' homologous to water, of which the quantity was not normally precisely known. Finally, since the material was typically only some 25 microns thick, there was not a lot of material to measure in the first place.

Possible methods

The methods which are available for this type of measurement would be based, generally, on some detectable physical change which was related to the water content. Ideally the measuring instrument should be non-contacting, and its output reading unaffected by other parameters. Possible approaches include electrical conductivity, specific heat, infra-red absorption, dielectric constant, dielectric loss and, bearing in mind the reasons for the need to know, physical stiffness.

There were, I admit, several moisture-measuring instruments on the market at the time that this work was commissioned, intended for in-line measurements on fast moving webs, but these were aimed at the much larger sheet paper market, and did not perform as well as was desired when used for regenerated cellulose film, which was much thinner, and of a more complex physical composition. The reasons for this performance shortfall were not known at the time, but it was hoped that an instrument could be developed which would be more accurate.

Some of the physical phenomena listed above could be dismissed from consideration without further ado. Into this category falls electrical conductivity, since, although it is directly related to water content, it is also greatly influenced by the presence of ionic solutes. Indeed, the very low conductivity of pure water is used as the basis for the determination of the purity of distilled or deionized water.

Since, in the case in point as in most other likely applications, the presence and proportion of ionic contaminants (which only need to be present in trace quantities to affect the result) could not be determined, conductivity could be dismissed as a possible basis for a working instrument.

Ionic conductivity, since it is dependent on ionic mobility, which is related to viscosity, is also strongly temperature-dependent, a further practical objection. These same objections would apply equally to the measurement of dielectric loss, though this, at least, could be made non-contacting, and therefore free from the problems of contact resistance.

With very thin material, the determination of specific heat, perhaps by way of a measurement of the ability of the material to transfer heat from one place to another, would be difficult, but not impossible. One might envisage an approach in which the extent of cooling which was required to maintain a following path roller, at a temperature differential of 1°C lower than a preceding one, was measured. The likely problem here would be the contribution to heating or cooling made by the ambient air conditions.

Infra-red absorption techniques would provide an ideal answer, and have been exploited commercially. The difficulty here lies in the thinness of the measured material. The most commonly chosen measuring wavelength, of about 2.8 microns, is associated with a rather weak absorption band and although sensitive and inexpensive IR photocells are available, which will operate at room temperature, it does not give a very strong absorption, even with computer enhancement.

This problem arises because a 2.5 cm diameter IR measurement beam, normal to the surface of the web, would intercept only some 19 microgrammes of water in the 25 micron-thickness web within its path.

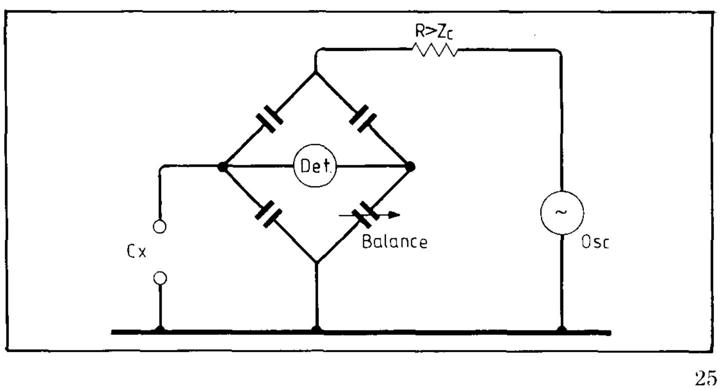
The alternative usable wavelength, in the 6.05 – 6.1 micron region (any good IR spectrophotometer will speedily identify the useful wavelengths within the target material), although highly sensitive to the presence of water, and not just -OH groups, suffers from the twin snags of expensive and complex photodetector systems, and high absorption by atmospheric moisture within the measuring path. Nevertheless, it is a sensitive technique for thin materials, and is exploited commercially.

The use of a dynamic stiffness measurement is an intriguing possibility, in that the parameter measured would be directly related to the quality in the material which it was desired to control, so that an increase in water content might be permitted to offset an inadvertent shortfall in the proportion of added glycol or glycerol type softening agents. Such a measurement might, perhaps, be made by contriving a pulsating air jet to be directed at one face of a travelling web of film, and then measuring the extend of the synchronous deflection of the other face.

The measurement of dielectric constant (K), is, superficially at least, an attractive approach to this type of instrumental determination, since free water has a very high value of dielectric constant, of about 80 at 20°C, whereas cellulose is only of the order of 5 – 6.

However, one should be wary of the effect of other ingredients in the material under test. For example, glycerol, which is a likely softening agent in cellulose films in imprecisely controlled quanti-

Fig. 3. Schering-bridge method of capacitance measurement.



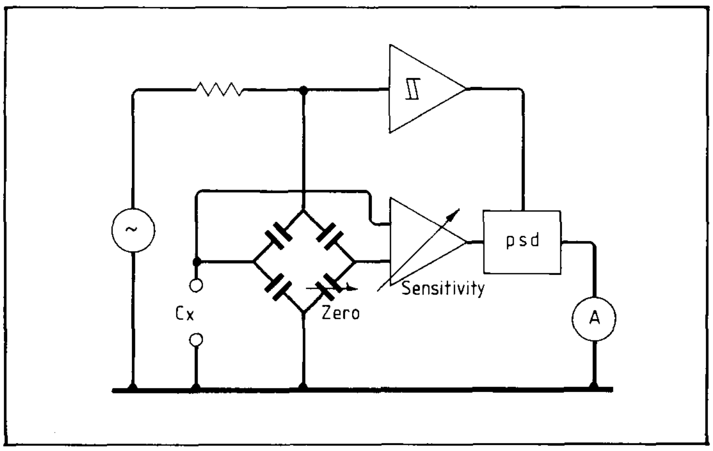
ties, has a dielectric constant of about 40 and some of the polyglycols have K values of the same order.

Other complicating factors, here, are that the dielectric constant of water is likely to be greatly reduced when it is in physical association on a molecular basis with some bulk material. In this case, depending on the type of material, and the way in which the water is associated with it, the dielectric constant will be much lower, in the region of 5 – 10. Moreover, in such a molecular association, the dielectric constant will have a strong positive temperature coefficient, of which both the value and the profile of its dependence on temperature will depend on the bulk material involved.

On the credit side, this is a fairly simple, non-contacting, system which is probably relatively unaffected by ionic contaminants. In the special case of cellulosic materials, in which water is held in two distinct molecular phases depending on whether the local cellulose substrate is crystalline or amorphous, the dielectric constant is anisotropic: having differing values in the length, breadth, and thickness dimensions, depending on the microscopic characteristics of the material. There is also, fortunately, a broad region of inflexion in the upward curve of dielectric constant with temperature, which occurs in the region of 30 – 35°C, and is associated with the second-order (crystalline/rubber) transition of the material.

Having said that, there is yet another source of difficulty, in that the contribution of the dielectric constant, due to water in a cellulose matrix, is

Fig. 4. Bridge with a phase-sensitive detector to measure components due to dielectric constant and dielectric loss.



dependent on whether the water is held in the crystalline region, where K is very low, or in the amorphous region, where it is higher. This causes problems in measurement, not only because of the variability of the composition of the substrate, but also because water is taken up and lost again much more readily from the amorphous than from the crystalline regions, so that there is a strong hysteresis effect in the wetting down/drying out graph.

Further requirements

Quite apart from the need to identify some feasible and accurate method of carrying out the measuring or control function required, additional constraints will also apply in any industrial environment in which it is desired to instal some new piece of equipment, due principally to physical hazards associated with moving 'nips', in which some unwary hand might be caught, and to flame hazards in a potentially inflammable or explosive atmosphere.

These latter problems might arise not only because of the stored electrical charges associated with the electrical equipment (in general, any inflammable or explosive atmosphere has a minimum ignition energy, measured in milli- or micro-joules, below which ignition will not normally occur), but also because of 'static' electrification effects through frictional contacts, which may entrap the unwary. I feel that it is wise for most industrial instrument engineers to have a reasonable working knowledge of static electrification phenomena, and the ways in which such charges are generated, in order to avoid such eventualities. A reasonable degree of familiarity with the legislation, or insurance requirements, involved in the installation of equipment in industrial environments would also be prudent.

Again, it is essential that equipment is both reliable and robust. A hard-bitten engineer of my acquaintance once observed, rather misanthropically, that any piece of equipment which one fitted on a machine must be strong enough to serve as a foot hold. If it gave way when trodden upon, one would be held responsible for the consequences!

The weakest link in the chain determines reliability, and might simply be a single wire pulled out of a multi-way socket or, more irritatingly, a critical control twiddled by foolish fingers. So a mixture of pessimism and perfectionism, coupled with practical experience, is essential in the design, construction, and installation of any equipment needed for the proper operation of any continuously running machinery.

If it does go wrong, the chances are that it will do so at three in the morning and that, due to some freak combination of circumstances, one is the only available person with the necessary skills and knowledge. Since the costs involved in down-time on a continuously operating plant are very high, quite apart from one's own costs in returning to one's factory at three in the morning, economies in material on any one-off instrument are unwise. However, one learns through experience where care is needed.

Of course, on any easily replaceable, off-line equipment the same considerations would not apply, and while reliability is just as desirable, it might be achieved at a lower cost by the provision of one or more substitute units. Prudence would also dictate that one makes sure that adequate, informative and intelligible documentation is provided at the same time as the instruments and that, if there are spares, their location should be well known – perhaps by a small advisory notice affixed to the unit in question.

Practical water-content measurement

Having outlined some of the possibilities and difficulties in the evolution of the piece of equipment for use in an industrial environment, I think that it might be of interest to consider the practical design of a simple water-content measurement apparatus, based on the measurement of bulk dielectric constant, which might be useful – depending on the type of electrode structure employed – in making this kind of determination on, for example, cereal grains, or the walls of a house.

The basic intention is that the material to be measured will influence the capacitance of some electrode assembly external to the electronic measuring instrument, and that these electrodes will be constructed so that, when filled to some predetermined depth with the material to be measured, or held in predetermined contact with a surface, there will be a measurable difference in the electrode capacitance in comparison with that which might occur for a dry material. The change shall be of sufficient magnitude to be displayed without excessive drift due to short or medium term electronic circuit effects.

Two suitable measurement electrode schemes are shown in Figs 1(a) and 1(b). In the first of these, a hollow cylindrical electrode, of diameter m, and effective height h, is mounted on the top plate of the measurement instrument, and a central insulated rod electrode, of diameter n, is arranged to stand centrally within this, upon an insulating bush.

Although there are end-effect phenomena, particularly due to the top plate of the instrument, which will affect one's calculations, the capacitance of such a structure may be (approximately) derived from the formula

$$C(pF) = (0.241Kp)/\log_{10}(m/n)$$

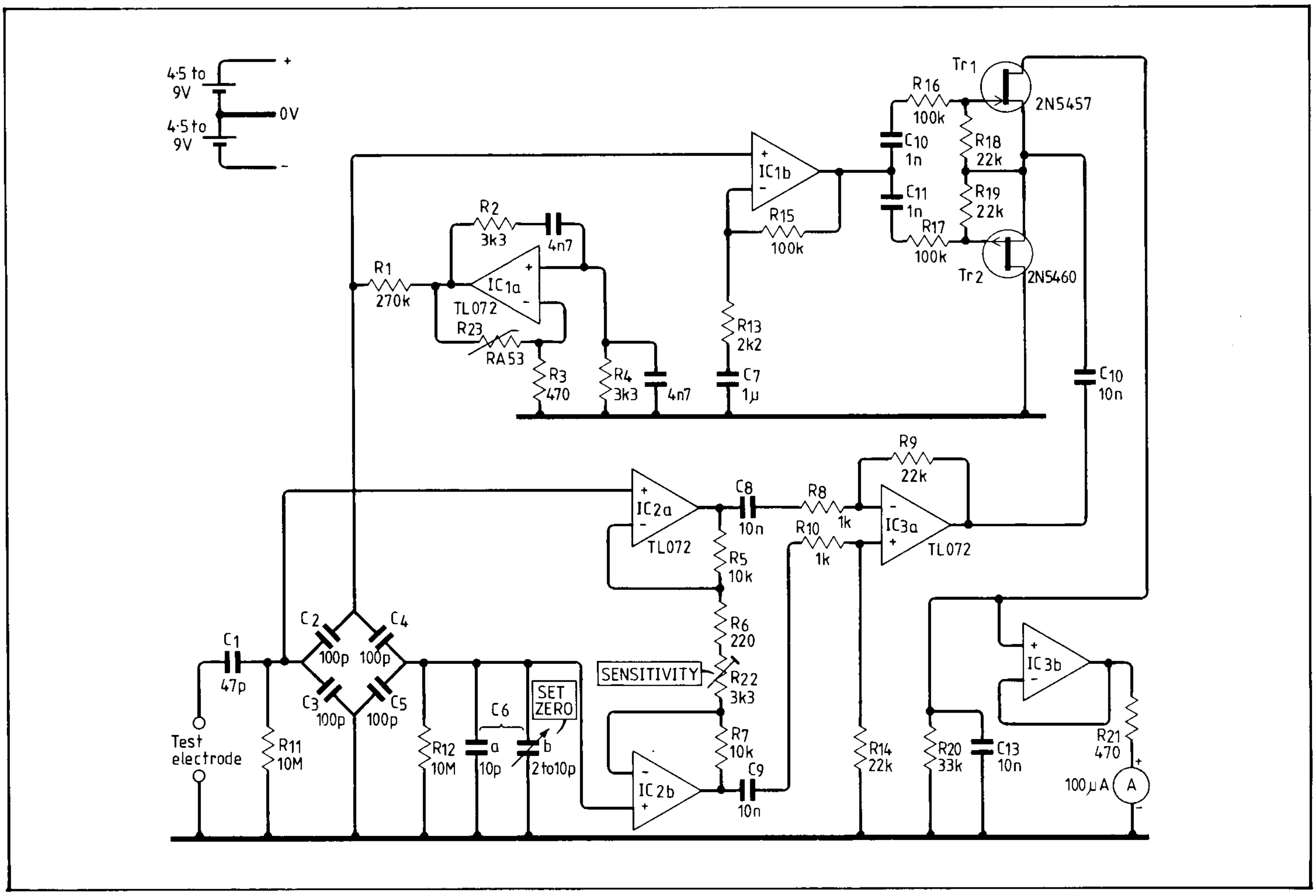
where all dimensions are in cm, so that for a cylinder with a i.d. of 7.5cm, housing an inner rod of 1cm o.d., and with an effective length of 7.5cm, the capacitance, when empty, will be approximately 2pF. If this measuring electrode were to be filled to 7.5cm depth with a cereal grain, having an effective dielectric constant of 4.5, the electrode capacitance would increase to 9.2pF. Now, the effective dielectric constant of the cereal grain is (notionally) made up from the 'dry' K of the grain, say 3.0, and, perhaps, a 15% content of water having a molecularly bound K of 10.

A 5% reduction in the water content, (to 10% total), would lead to a drop in the K of the grain to 4.0, and a change in the electrode capacitance from 9.3 – 8.26pF, or about 1pF.

In the case of the 'fringe-field' electrode shown in Fig. 1(b), the calculation of the electrode capacitance is somewhat less precise, in that a number of simplifying assumptions must be made, consequent upon the electric field pattern sketched in Fig. 2. If one assumes that the mean radius of the fringing field is 3cm (and this will depend on the annular gap between the inner and outer plate regions) then the effective mean diameters of the inner and outer electrodes will be 1cm and 12cm respectively and the effective capacitance between them, for a notional 10cm gap, will be 0.53pF in air, or 7.9pF when pressed against a damp, but smoothly plastered, house wall having an effective K of 15.

Since, in a 'dry' house, the K value for the plaster could fall to about 5 – 8, the expected capacitance change could be of the order of 4-5pF, which would be quite easy to measure. There are some practical problems, however, in that it would be preferable for the satisfactory operation of the

Fig. 5. Circuit diagram of moisture meter.



instrument that the electrodes should be mounted on the rear surface of a thin sheet of insulating material, such as Perspex. This will lessen the effective capacitative coupling with the plaster substrate being measured, as will the normal difficulty of getting good planar contact.

Also, the outer surface of the plaster will normally be drier than the inner bulk, and while the adoption of a fairly large annular gap, in the electrode structure, encourages the development of a more penetrating electric field, the practical nature of the field will be a lot more complex than my simple model suggests. All of these effects, in a less than ideal world, will tend to diminish both the extent to which the dielectric constant measurement penetrates the substrate, and also the observed capacitance change.

Still, one could well anticipate effective penetrations of 1-2cm, and capacitance changes of 1-2pF between 'dry' and 'damp' structures which will, in practice, allow a sensible survey of the extent to which the ravages of dampness have progressed.

Circuit design

Looking at the electrical requirements of the circuit to be used in association with both of these suggested electrode types to give a reading of change of capacitance, it would appear necessary to display as a full scale deflection a change of the order of 1pF, in a total capacitance of 5-10pF.

A number of methods have been proposed for this type of measurement, and used in commercial instruments, of which the most common is to apply the external electrode capacitance across an oscillator tuned circuit, so that a change in capacitance produces a change in output frequency, which could be determined by some frequency discriminator arrangement.

This arrangement suffers from the snag that the resonant frequency of the tuned circuit is likely to drift with changes in ambient temperatures, unless it is fairly carefully temperature compensated. Such drifts would be erroneously represented as changes in the dielectric constant of the material being tested, which would lessen its accuracy.

An alternative method, which I think is to be preferred, employs a modified Schering bridge, of the type shown in Fig. 3, in which the external electrode structure is connected across one of the limbs of the bridge, so that a change in external capacitance will alter the voltage developed across this limb. The components of this change in signal voltage due to changes in dielectric constant and to changes in dielectric loss can be resolved by the use of a phase sensitive detector, in the manner shown in Fig. 4. Once again, the system should be compensated for temperature effects, but this is now easier because all the bridge capacitors can be of identical type, and will therefore display similar temperature coefficients of capacitance.

A practical circuit design to exploit this system is shown in Fig. 5. In this, C_2-C_6 form the capacitance bridge, to which the external electrode is coupled by C_1. The static unbalance of the bridge, due to the external electrode, is trimmed out by C_6, so that there is normally a zero a.c. output from the differential amplifier array, IC_{2a}, IC_{2b}, and IC_{3a}.

The bridge is energised by a simple Wien-bridge osillator, operating at 10kHz, based on IC_{1a}, whose output, as applied to the bridge, is amplified and squared by IC_{1b}, and fed along with the output from the differential amplifier to the phase detector, which is built up from Tr_1 and Tr_2, acting as a synchronous rectifier. The overall sensitivity of the instrument can be trimmed by R_{22} or, if larger adjustment is needed, by alteration of the values of resistors 8,9,10 and 14.

For portable use, the instrument can be operated from a ± 4.5V supply, with a normally-off push switch in the battery supply lines to prolong battery life.

The use of a good-quality, low-distortion bridge oscillator is to be preferred, because the presence of oscillator harmonics will make a good bridge balance more difficult to obtain.

Calibration

Although the component values shown in Fig. 5 will give a reasonable performance when used with the electrode systems as dimensioned in Figs. 6 and 7, there is no really satisfactory substitute for the calibration of such instruments by external analytical means. This would normally be done by the use of test samples which are oven dried to the lowest feasible water content, and then re-wetted, following measurement on the instrument, to various precisely known incremental water contents.

For the reasons noted above, some time should be allowed to elapse following adjustment to the water content of a test or calibration sample, before the measurement is made, in order to allow any internal molecular rearrangements to take place. ■

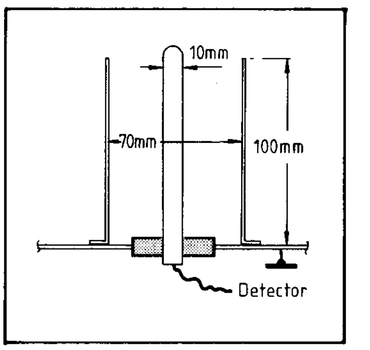


Fig. 6. Dimensions of electrode assembly used for loose material shown in Fig. 1(a).

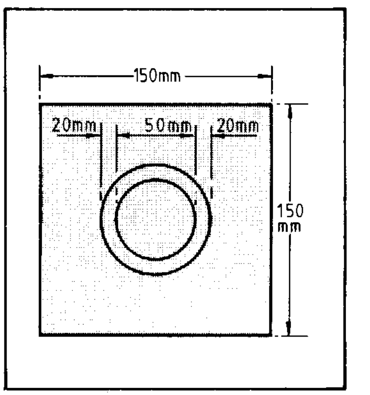


Fig. 7. Dimensions of 'fringe-field' type of electrode in Fig. 1(b).

S5/8 – the need and the solution

by Andrew Hardie

This simple serial interface puts an end to computer interconnection problems. BS approval is expected soon.

What standards exist for general-purpose, local interconnection between microcomputers and peripherals? Incredible as it may seem, the answer is none!

A couple of names are widely referred to when discussing interfaces of this class: RS-232 and Centronics. These feature on many devices and so might claim to be candidates for the title of General Purpose Local Interface Standard. How valid is their claim?

RS–232C

RS–232C, is a serial interface, transferring data in a bit-serial fashion, usually full-duplex. It is bit-rate independent, uses bipolar, unbalanced signalling at speeds up to 20 k-bits per second and is suitable for short range (15 metres recommended) operation in a point to point configuration. (Multi-drop and daisy chaining can be used, but they are not part of the RS-232C specification.)

On several points, RS-232C meets some requirements of a local, general purpose interface, but a number of problems are associated with it.

The RS-232C standard, published by the Electronic Industries Association (EIA), is defined for modems and terminals only.

An equivalent pair of recommendations is published by the International Telegraph and Telephone Consultative Committee (CCITT), V.24 and V.28, covering the same subject but it is not technically identical with RS-232C and uses different notation.

In physical terms, RS-232C is usually thought to mean a 25-way D-type connector but in fact does not actually specify a connector type at all. An appendix mentions the suitability of connectors meeting MIL-C-24308, and a new foreword refers to ISO-2110, which does specify a 25-way D-type; but neither is embodied in the actual standard. The list of defined circuits assigns pin numbers, up to 25, but to no specified connector. It does, however, specify that the modem (data communication equipment) shall have the female connector and that the terminal (data terminal equipment) shall have an extension cable with a male connector. Even that simple stipulation has been widely flouted by manufacturers and a whole variety of connectors have been used in addition to D-types, such as audio Din and miniature circular types.

Both the RS-212C and V.24 documents specify a large number of signals (20 for RS-232C, with two more reserved, and 43 for V.24) most of which are optional, leading to thousands of possible permutations. Also defined are a series of complex inter-relationships between these signals, all specifically for modem-to-terminal type applications, as are the names given to the signals themselves. For any other application, RS-232C and V.24 simply do *not* apply.

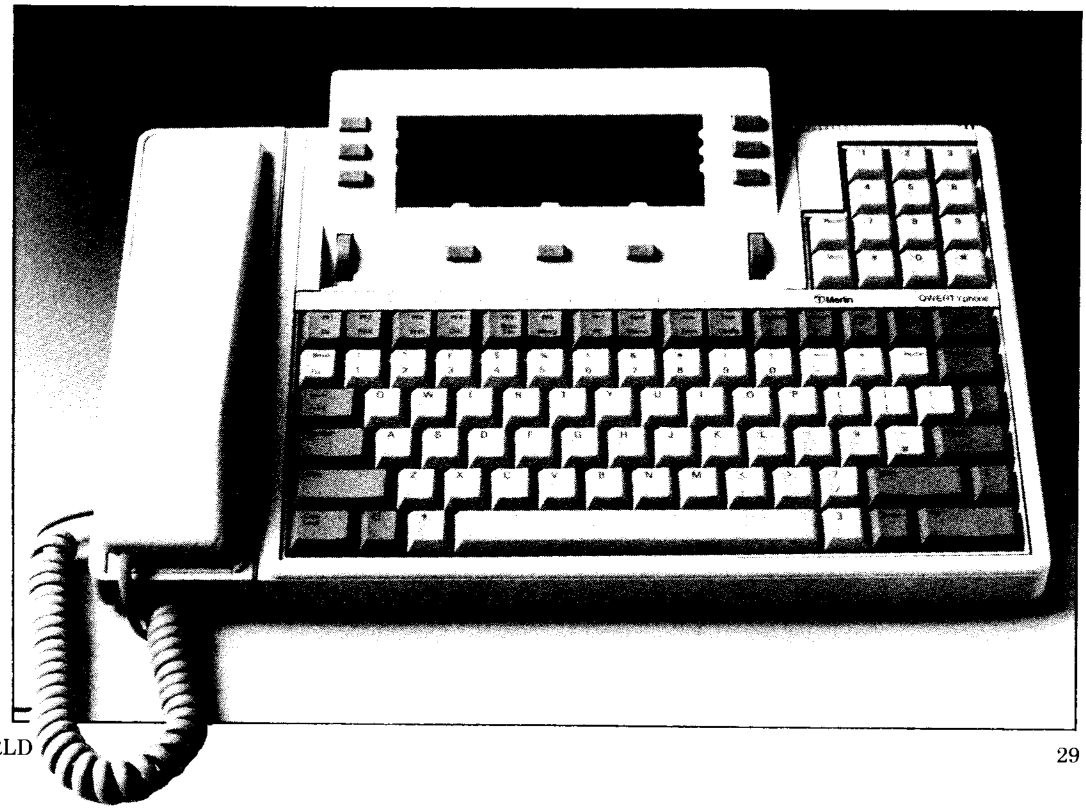
RS-232C and V.28 both specify obsolescent bipolar signalling voltages which are a historical hang-over from polarized teleprinter relays. They are quite unnecessary and inconvenient in modern equipment. The EIA and CCITT have both indicated that they wish in the long term to move to balanced electrical operation.

RS-232C and V24/28 are standards, but they are specific standards, mis-applied to local connections in general, for

Andrew Hardie is research director of Oval Automation Limited and is a member of a number of standards committees and user bodies, including the BSI committees IST/18/1 (text and office systems) and IST/6/7 (interconnection of equipment), a user group on Integrated Services Digital Networks (ISDN) and a manufacturers' group, the British Office Technology Manufacturer's Alliance.

In his role as technical consultant to the Public Services Working Party he advises on floppy disc standards and was responsible for devising the S5/8 interface. The common theme of his work on these various committees and bodies is to facilitate *data interchange*, whether by direct connection or off-line transfer.

Pioneering the S5/8 standard: British Telecom's Qwertyphone, a multi-function terminal-cum-featurephone.



S5/8: the need

S5/8 was designed to meet a need for an easy-to-use general-purpose standard for local interconnections between microcomputers and peripherals.

General Purpose means an interface not dedicated to a single device or class of device and not dedicated to a single function, in other words not application-specific. Such an interface should be capable of simultaneous bi-directional data flow, i.e. full duplex. It should preferably not be of the master-slave type and should not involve a polarization of devices. It should offer a transparent transfer of binary octets (bytes) and have the absolute minimum numbers of versions and variants.

Local means short range inter-connection between devices such as micros, printers, plotters, modems, terminals, LAN nodes, etc., in the region of 1 to 10 metres, covering the majority of home and office device inter connections.

which they were never intended and for which they are wrong. The result has been a progressive degradation and modification of the interface from its original purpose of terminal-to-modem connection.

Centronics

Turning now to the other possible contender, Centronics, this is a parallel interface, transferring data in a bit-parallel, byte-serial fashion. It is a one-way interface: data can flow only in one direction on any one inter-connection. It is independent of data rate, uses unipolar, unbalanced (open collector t.t.l.) signalling and is suitable for short range operation (three metres recommended) and can transfer data at rates up to a theoretical maximum of 143 k-bytes per second in a point-to-point configuration.

The problems with the Centronics interface are similar to those of RS-232C. It is a special purpose interface intended for printers and similar devices, unsuitable as a general purpose inter-connection, particularly as it only allows data transfer in one direction.

The Centronics interface is not a standard. It is a manufacturer's specification, devised to meet a product need; what is commonly referred to as a *de facto* standard.

Being more specific than RS-232C, Centronics has suffered less from degradation, but problems with different connectors still occur. The Centronics Engineering standard document specifies a connector only for the printer, not for the host device, but this is of no comfort to the user. The 36-way Amphenol type connector has been joined, at the computer end, by IBM flavour (25-way D-type), BBC flavour (26-way i.d.c.), MSX flavour, and a number of others.

Furthermore, timing variations have gradually crept into the implementation, particularly on the ACKnowledge signal, to the extent that some manufacturers have used a dip switch to set the timing flavour and yet others have abandoned the ACK signal altogether.

The original Centronics document only specifies, in addition to the eight data signals, strobe, acknowledge, busy, paper empty, select and external oscillator. One is reserved for +5V and four others are reserved for product-specific functions. All other signals found on such interfaces, or absences of the specified signals, are thus non-standard.

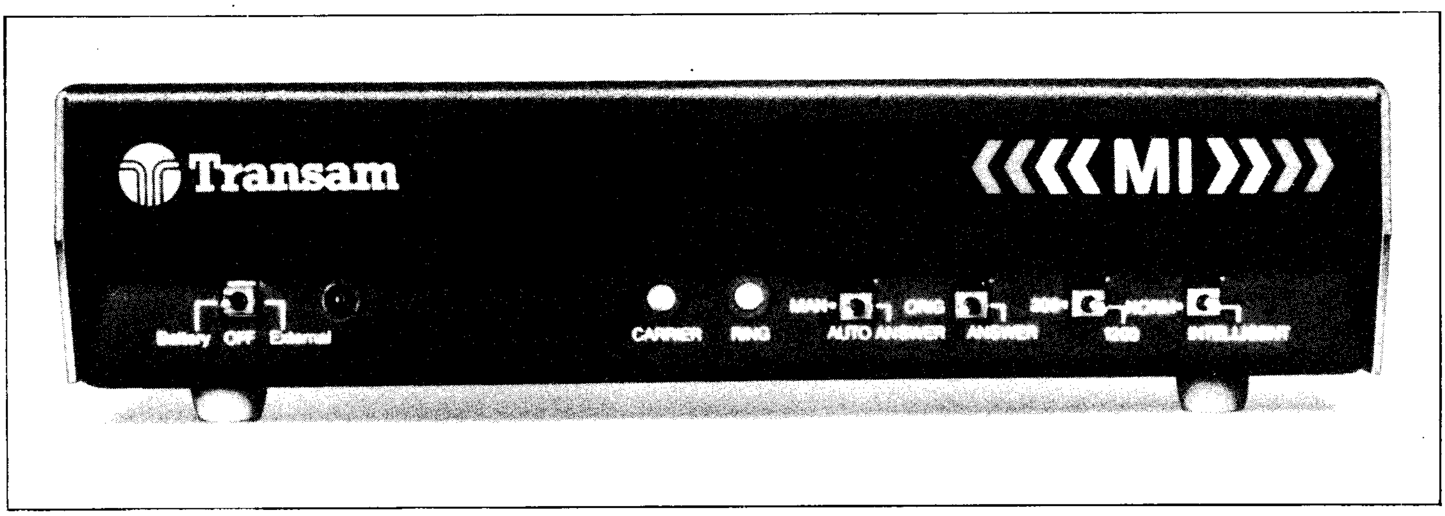
One must ask whether a parallel interface is nowadays appropriate to such a local inter-connection. The Centronics interface dates from an era when connectors were relatively cheap, t.t.l. buffer gates were very cheap and uarts were expensive, difficult to use, state-of-the-art p-mos integrated circuits. Today, the situation is very different; multi-pole connectors and cable are expensive, t.t.l. buffer gates are no longer as cheap by comparison but uarts cost less than £1.

For most local inter-connections, serial will serve just as well as parallel. The speed advantage of the parallel interface can seldom be used except, possibly, for print buffers. Applications requiring very high speed have a number of emerging specialized peripheral interfaces to choose from, such as SCSI, offering much higher speed and sophistication.

The problems

To effect a connection between two devices using RS-232C or Centronics interfaces, the connector type, sex and pin connections must be known and the behaviour of the flow control or handshake signals must be understood before an appropriate connecting cable can be chosen. RS-232C, additionally, requires the bit rate, framing and parity to agree in both devices.

Furthermore, if either of the devices is a character imaging device (such as a terminal or printer) then the data coding



First product to carry an S5/8 connector was Transam's intelligent modem for the cellular radio user.

must be considered; that is, what the data bytes actually represent. Neither RS-232C or Centronics addresses this question but it is still important for the user. The problem of bit 7 frequently arises with printers, as does the difficulty of coding inconsistencies with character sets. All these factors must agree in both devices before *meaningful* data interchange can take place.

The problem with the physical connectors has been aggravated recently with the arrival of lap-top portable computers. Here, space and weight considerations have forced a move away from the more traditional 25-way and 36-way connectors to a variety of other types. Another influence for the change is the severe cost pressures in the home and computer market which have dictated a move to cheaper connectors, often Din types, but also to telephone jacks and sometimes even no connector at all, just a row of p.c.b. fingers.

So far as the user is concerned, both RS-232C and Centronics have become elective non-standards, used and abused by the manufacturers, as they have thought fit, resulting in widespread confusion, delay and frustration. To the user this means wasted time and money. To the supplier it also means wasted time and money, but can also cause bad customer relations which can lead to lost business.

Who benefits from the current situation? Certainly not the users. To them it must often seem that every supposedly standard interconnection example requires a custom solution. And that is not so very far from the truth.

Suppliers, who are often not the manufacturers of the equipment they supply, also do not, on the whole, benefit. The user blames them for the problems of incompatibility. They are caught between manufacturer and user. Some end-user suppliers do seem to view inter-connection solutions almost as a legitimate consultancy spinoff to boost profits on the sale of equipment on progressively decreasing margins. However, to large scale suppliers, such as distributors, these incompatibilities are a stumbling block to sales requiring expensive multiple stocking to cover interface options, variants and cable permutations.

The Far East has driven prices down dramatically and has led to inferior products coming on to the market. Connectors such as the D-type and the Amphenol 36-way were never designed as ultra-low-cost products and manufacturing them as such has resulted in low reliability and mechanical performance characterized by bad alignment, poor tolerances, inadequate contacts and low grade materials.

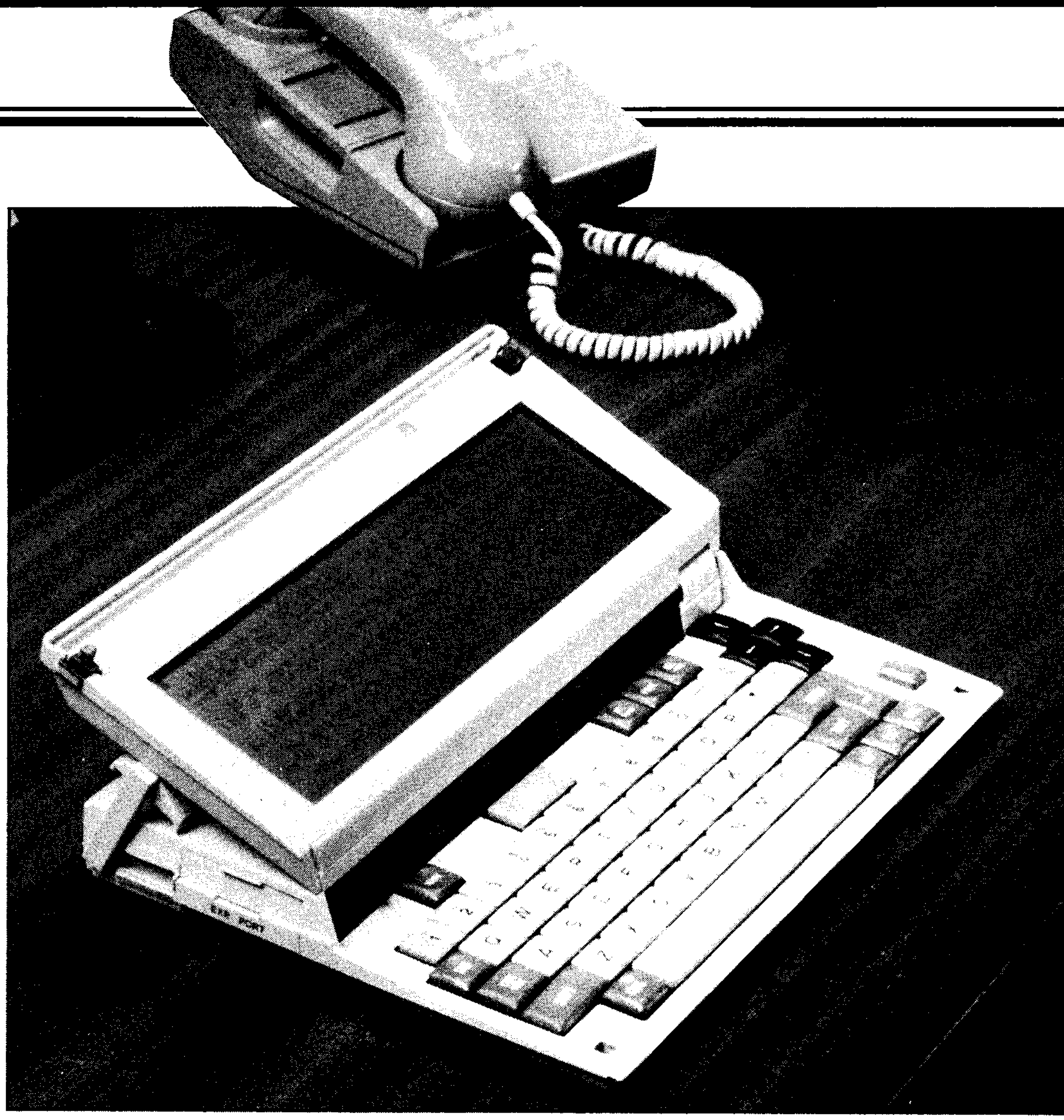
The one area of the market that has benefited from the situation is the fixit widget. Some catalogues of computer equipment suppliers are overflowing with reversing cables, gender-benders, null-modems, break-out boxes, smart connectors, interface converters, and so on. These are only necessary because of the lack of a properly defined standard.

The solution

A new serial interface which addresses these problems has already been published as a Public Services Standard and has been accepted by the British Standards Institution, with the first publication, in the form of a Draft for Development, scheduled for June this year.

The new interface is called S5/8 (pronounced Ess-five-eight) which stands for **S**erial **5**-volt **8**-pin, a reference to the voltage levels employed and the number of poles on the connector used.

The specification for such an interface must include the following:



The Liberator portable text processor by Thorn-EMI takes full advantage of the power and space savings of the S5/8 interface: it has two of them.

S5/8: the benefits

The advantage of S5/8 to the user is, first and foremost, simplicity: it is a plug-and-run inter-connection.

The S5/8 interface uses both old (the Din connector) and new (high-speed c-mos logic) technology, and is an example of applying the *right* mix of technologies to an area that has been plagued with non-standardization for far too long.

Its size and power advantages obviously favour portables, but the concept that it introduces has a much broader appeal. S5/8 is cheaper and simpler for manufacturers and end-users alike.

Users will be spared the confusion that exists at present and will pay far less for fewer cables. For portable computers, users will carry just one cheap and lightweight cable for all their interconnection requirements – the *one-cable concept*.

- interface configuration
- interface signals and functions
- electrical characteristics
- mechanical characteristics
- data structure
- signalling rate
- flow control
- data coding

When all these are fully specified and so agree in both devices, then meaningful data interchange can take place consistently.

Interface configuration

The S5/8 standard specifies two classes of device distinguished by their power supply provision. A D-device is a self-powered device, able to supply power to the S5/8 interface. An S-device does not have a power supply of its own but draws its power (up to 20mA) from the D-device, through the S5/8 interface.

The relationship between the devices in data transfer terms is equal. There is no "master" and no "slave": they are of equal rank and interchange is on a peer-to-peer basis. Neither is there any polarization with one device regarded as the sender and the other as the receiver.

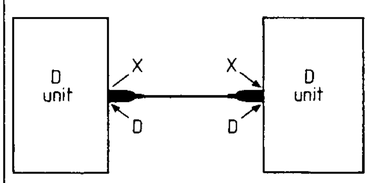


Fig.1. A D-device such as a computer or printer connects to another D-device through a plug-in lead. Optional extension leads can be inserted at the points marked X.

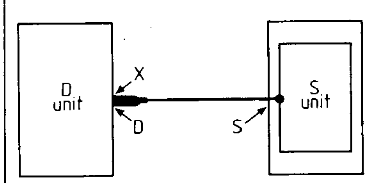


Fig.2. Devices with no built-in power supply, such as mice, joysticks or line-powered modems, are S-devices and are fitted with a captive lead. They draw a modest current from the D-device over the interface.

Physically, the S5/8 interface is defined around eight-pole connectors. The D-devices have an eight-pole fixed socket, so that D-device to D-device inter-connection is always effected with a plug-to-plug cable. S-devices, on the other hand, have a captive cable fitted with an eight-pin plug.

These two configurations permit D-device to D-device and S-device to D-device interconnection, but prevent S-device to S-device connection which would not work, as neither would be supplying the power the other expected. The allowed configurations are shown in Figs 1 and 2. The labels D and S indicate the points at which the electrical characteristics are specified and X indicates the points where optional extension leads may be inserted.)

The main beneficiaries of today's confusion are the makers of fixit widgets. But with a properly defined interface standard, such devices would not be needed.

Nearly all computers and peripherals are D-devices, having their own power supply, either mains or battery. Among S-devices would be mice, joysticks, trackballs, touch-pads, converter units (e.g. serial to parallel) and line monitors or testers. Any device that cannot be used on its own and requires only a small power supply is a potential S-device.

A particularly interesting application for an S-device is a line powered modem. It is now possible to make a modem where all the electronics is powered from the telephone line, in just the same way as modern electronic telephone. Instead of having an isolating transformer between the line and the modem electronics, the electronics floats on the telephone line and isolation is performed at the data interface by opto-couplers.

However, some power must be provided at the data side of the isolation barrier to drive the leds and feed the pull-up resistors of the opto-couplers. This means that either the line-powered modem must be fitted inside another, self-powered, item of equipment, such as a terminal or computer; or a separate power supply must be provided, which rather defeats the object of a line powered modem.

S5/8, however, provides a power supply suitable for the purpose and makes possible an in-line modem with no power supply or batteries. With miniaturization, using custom chips and surface-mounting, such a modern could be reduced to the size of a matchbox.

Physically, the S5/8 interface is defined around eight-

In the second part of his article, Andrew Hardie looks at electrical and mechanical aspects of the S5/8 interface and describes the data format and handshaking protocol.

PSWP

The Public Services Working Party was originally formed to define a standard for micro-floppy discs for use in the public services. It is organised by the government's CCTA and consists of representatives from the following organisations:

- *Central Computer and Telecommunications Agency (CCTA)*
- *Local Authorities Management Services and Computer Committee*
- *British Telecom*
- *National Health Service*
- *British Micro Manufacturers' Group*
- *Inter-Bank Research Organisation*
- *Information and Word Processing Association*
- *National Computer Users' Forum*

Following publication of part 1 of the Public Services Standard for micro-floppy discs, the working party has been giving its attention to standards for file structure and file data content for data interchange.

In light of the widespread confusion over RS-232, the PSWP turned its attention to proposing an alternative, more suited to present day equipment. The result was the S5/8 Public Services Standard.

Cad at the poly

Polytechnics and colleges that run degree-level courses in electrical and electronic engineering are to receive grants, from the Dept. of Trade and Industry, to buy computer aided design equipment. The silicon i.c. design systems are the same as those selected by the University Grants Committee for use in universities (*E&WW* News April 1986), with products from GenRad, Qudos, Racal-Redac, Silicon Microsystems and Silvar Lisco. The funding of £3M represents up to £75,000 to each of the participating institutions.

Computer interfaces for measurement

An exploration of the links needed between a physical quantity to be measured and the computer used to record, display and possibly react to the data collected.

Automation is not new. However, the tasks needed to automate a process in the past often called for a dedicated system which did that and nothing else; a c.n.c. lathe or a weaving loom are examples.

Now that the microcomputer has become ubiquitous, ways have been found both in equipment and in computer programs to undertake automatic test and measurement tasks. There is, however, a gap between the quantity being measured and the computer control of the application, which would be taken care of intrinsically in an industrial control system. We hope to explain how that gap can be bridged.

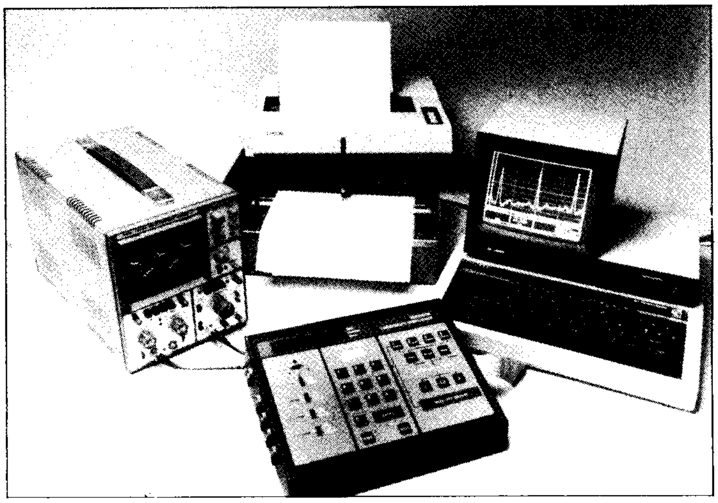
A variety of input devices are available to measure quantities in the real world; temperature probes, load cells and acceleration transducers; instruments to measure voltages, current, resistance and the like; analytical instruments and ultimately whole systems such as range finders, direction finders, radar, and artificial vision and hearing as might be used in robotics. To obtain records from such inputs, it is necessary to link them to a computer which, according to its program, can then react to the incoming information and produce a suitable output. It can store and display the data or it will switch controls, adjust parameters, move a robot or sound an alarm.

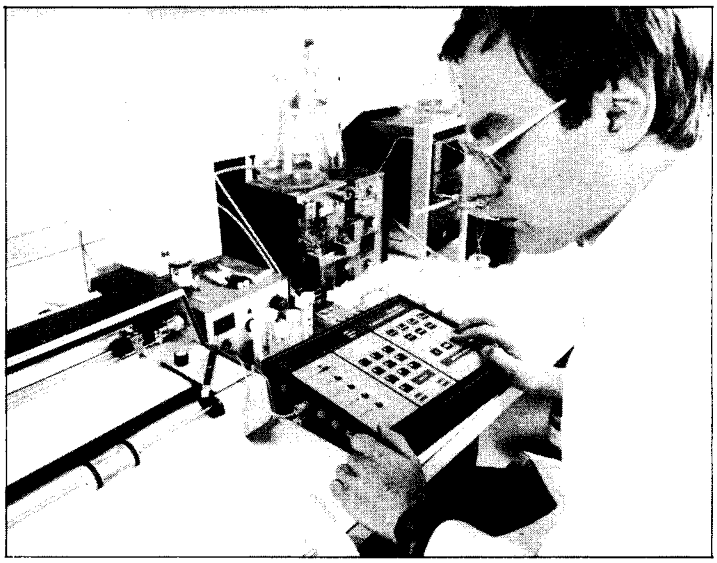
The problem is that the input transducers rarely communicate directly with the computer. Take, for example a thermocouple. It is a very low-voltage, constantly varying (analogue) output and its behaviour is rarely linear, i.e. it does not give the same voltage step for a similar temperature change in different parts of its range. So its information needs to be coded into a form that the computer program can understand before the data can be collected or acted upon. The signal from the probe needs to be amplified and converted into a digital format and calibrated, with its non-linearity allowed for to give an accurate reading. Thermocouples are provided with codes to indicate how they are calibrated.

Some computers do include analogue-to-digital converters, can be sensitive enough to receive the signal directly and use internal software to calibrate and linearize the source. However, this is only possible with a few computers and the technique would only apply to temperature probes; a different technique may be required for other input devices.

Signal conditioning and recording instruments might themselves be computers, dedicated to that task, or they may include some computing elements (as can be found in a digital storage oscilloscope or a waveform analysis instrument). These need to be able to communicate with the central recording and control computer. The computer also needs to recognise the nature of the data that is being transmitted to it and be programmed to record the data and respond to it.

So there is a combination of hardware and programming needed to complete the chain between transducer and computer. Luckily, there is a number of devices that enable all these things to happen so that quantities can be measured and control devices can be activated.





Applications for a general-purpose data logger: vibration analysis on a lathe bench; waveform capture and analysis; monitoring the output of a gas spectrum chromatograph.

Data logger

The Vela (versatile laboratory instrument) is given here as a example of an instrument that contains many of the elements described. It is a multi-function data logger for use in laboratories and on test benches. Data recording in industrial and electronics laboratories has often required specialized, high-cost

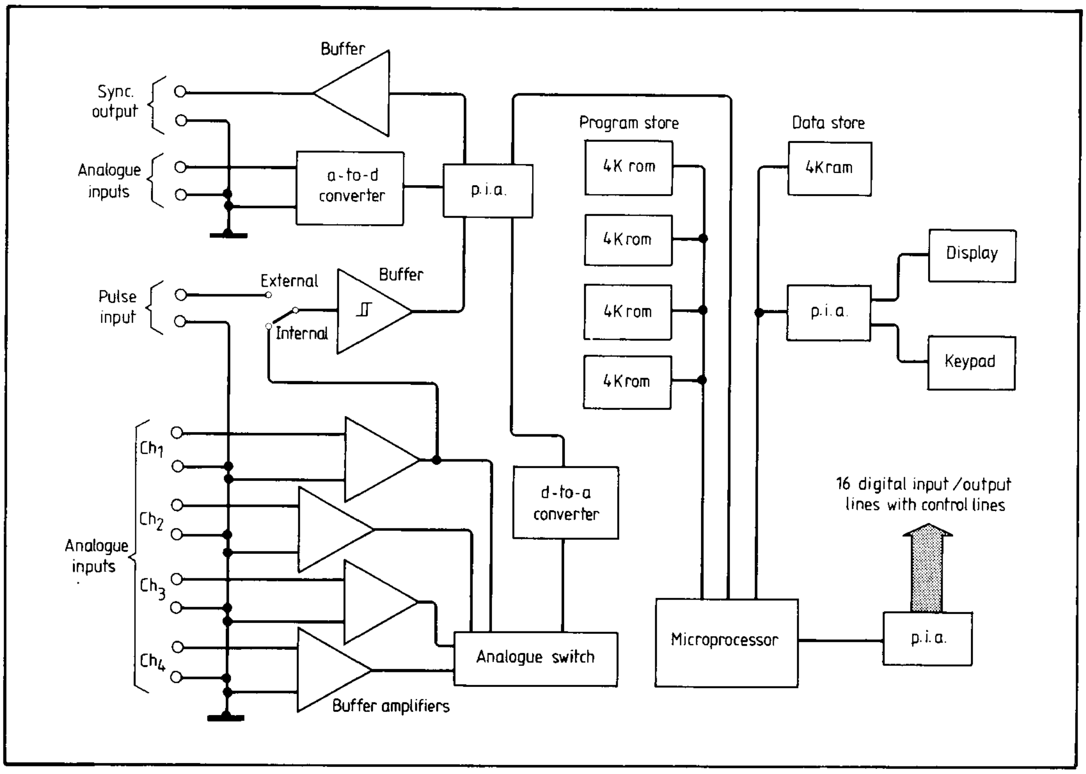


Fig. 1: Elements of a general purpose analogue and digital data logger.

Fig. 2: Screen dump of a captured pulse and (Fig. 3) the resulting spectrum analysed by f.f.t.

data loggers, dedicated and optimized to a specific task. Computers have also been used with rigged-up interfaces or commercial packages; however, this is not an ideal solution, since both hardware and software take development time and money. The gap between specialized data loggers and computer interfaces pointed to the need for a low-cost, pre-programmed logger that would be suitable for a wide variety of data capture tasks and which uses readily available display devices, such as an oscilloscope, a printer, chart recorders or through a microcomputer to a v.d.u.

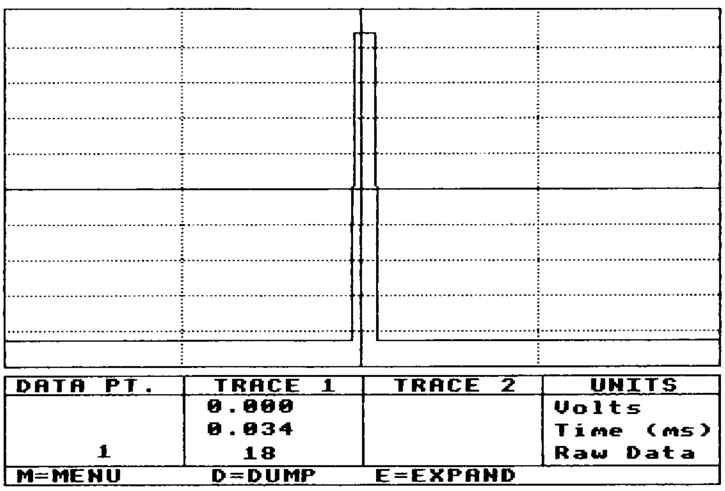
The building blocks of such a logger are shown in Fig. 1. All of the elements, such as on-board signal conditioning, multiplexers, a-to-d and d-to-a converters, battery-protected c-mos ram, and digital input-output ports, can be configured by rom-based software into the appropriate system for a specified task. For example, it is possible to use a single channel as a fast data logger (there is a trade-off between the speed and the number of channels used); a four-channel signal averaging meter with capture time up to ten days; a multi-channel events timer or a waveform synthesizer. The digital voltmeter program is used to check and display sensor operation before logging commences. The frequency display program can be used to evaluate the upper frequency limit of the signal prior to logging so that appropriate sampling rates are selected to avoid aliasing. Programs are called up from the front-panel keypad by a two-digit number. Parameters can also be entered in this way.

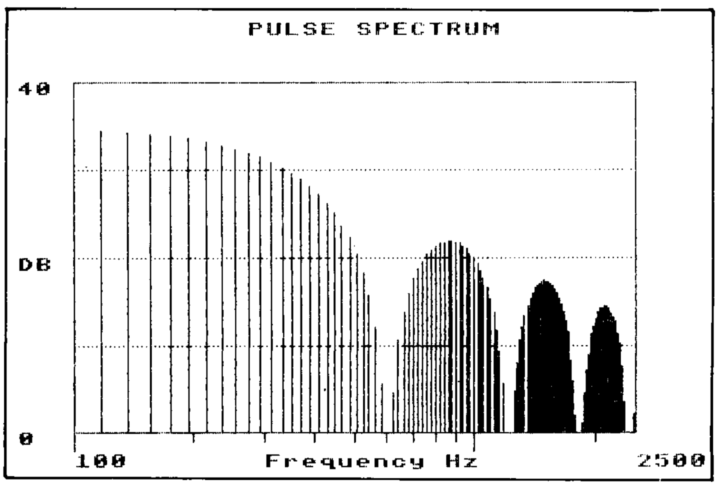
Data acquired through the instrument can be displayed in a variety of ways. At the most basic level the logger can operate as a four-channel sampling d.v.m. Therefore, it is possible to scan through the memory and the built-in digital display shows the channel number, sample number and recorded voltage.

Output to an oscilloscope of recorded waveforms is useful, as the logger adds the digital storage memory to an ordinary oscilloscope to convert it to a d.s.o. Data from the memory is continuously stepped through at a high speed to give an apparently static display, thus providing a 'frozen' image of a transient event. A bright cursor can be moved through the display and the instrument readout will provide the time and amplitude information relating to that point. Stepping through the recorded data also enables the trace to be transferred to a pen recorder. As the logger can capture events much faster than they can be plotted on a slow pen recorder, this effectively turns a normal one-channel plotter into a high-speed four-channel device.

The logger works independently of a computer but can be linked through a parallel port. The instrument includes communications software and hardware for data transfer with the usual handshaking protocols.

Once transferred to the computer, data can be displayed and processed further. For example, the latest waveform captured can be compared with a reference. Amplitude and time



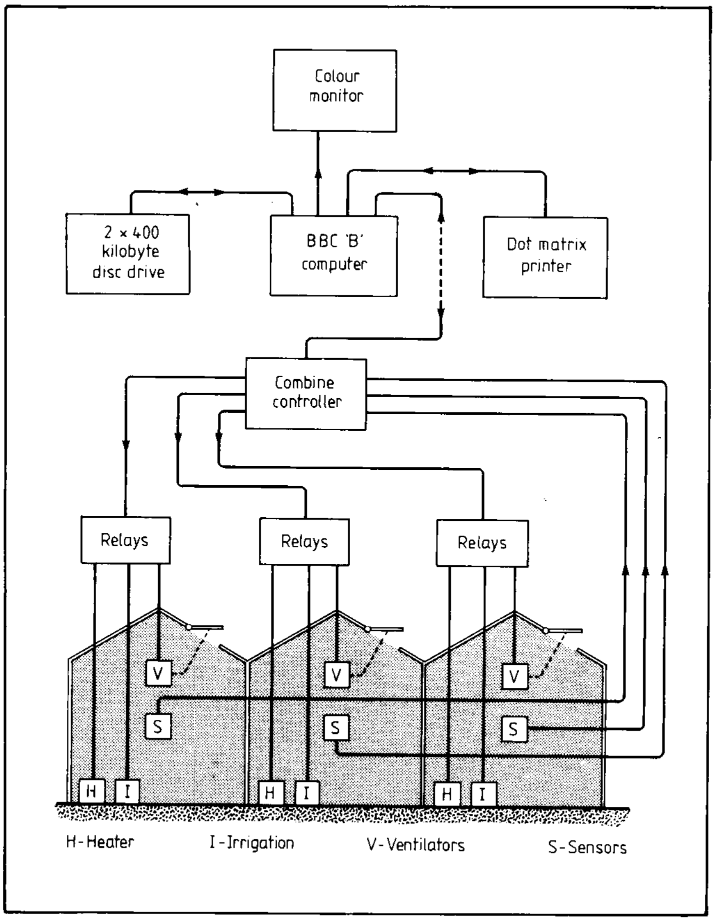


measurements can be taken with cursor control. Screen images can be output to a printer or plotter and the data can be stored on disc for later reference.

Computer software is available, such as a statistical analysis package or a fast-Fourier transformation (f.f.t) that extend the analytical capabilities even further. An f.f.t. package (typically under £200), together with the logger, converters the personal computer into a spectrum analyser suited to a range of vibrational analysis and acoustical monitoring tasks. For example, Fig. 2 shows the screen display of a captured pulse and Fig. 3 the resulting spectrum. Although not fast by digital signal processing standards, such a package can perform a 1024-point transform in under ten seconds. Digital readout, from a moving cursor, of amplitude and frequency are useful additional facilities. The eight-bit a-to-d converter gives a useable dynamic range of 48dB.

Although the cost of fast 12-bit a-to-d coverters is falling rapidly, the absolute accuracy of many transducers used in laboratories did not warrant this level of precision. An 8-bit converter gives adequate resolution on oscilloscope and monitor screens and 4K of data storage per channel (with 1K being available on screen at any one time) gives reasonable cost/performance trade-off. The link with the microcomputer is bidirectional, so programs can be generated and stored in the host computer and sent to the logger for execution. Data look-up tables for complex wave synthesis can be generated in the computer from a Basic program. The data can then be transferred to the instrument for reconstruction through the d-to-a converter into the selected waveform at a chosen frequency. The data is available both at the analogue output and in digital form, so that a slower output can create a different digital pattern and such a digital waveform with the appropriate time steps is, in effect, a control sequence. Each sequence can be up to 1000 samples long.

The instrument can also be used purely as a non-intelligent interface with the sampling of one to four channels and the



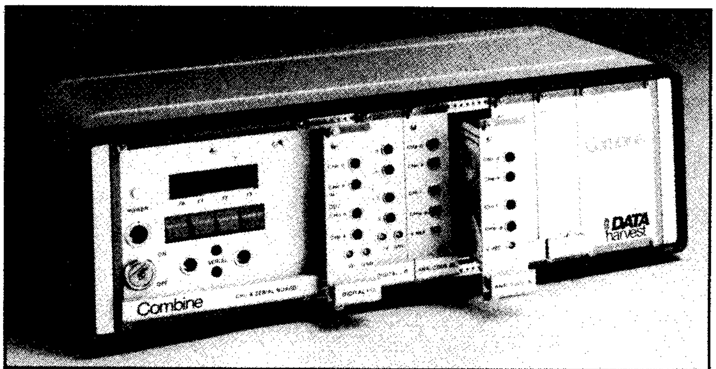
The Combine data logger and control system (below) was developed at Reading University where it was used to investigate plant growth under various tropical weather conditions simulated in three greenhouses as shown in the diagram.

real-time transfer of data completely under the control of the host computer. In practice, a combination of the internal programs on the logger and instructions from the host seem to offer the best performance.

For some applications it is necessary to add signal conditioning units to drive the analogue inputs of the logger. Such units are available from distributors such as RS Components. However an additional sensor system with added firmware in rom was developed specifically for the Vela which may be conveniently plugged together. Before the start of logging the user keys in a code for the sensor code for each channel which then selects the appropriate algorithm to translate the a-to-d reading into the correct physical quantity; °C, millibar, pH, or whatever. The battery back-up enables the instrument to be used for data collection in the field.

Altogether the instrument represents a comprehensive pooling of a variety of functions which will fit in with the existing equipment available in most laboratories.

One step up from the Vela instrument described is another, the Combine, from the



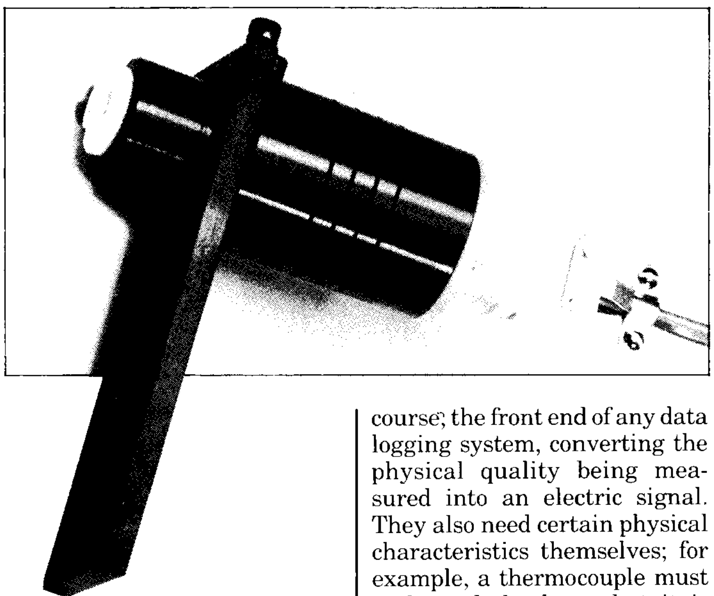
same manufacturer, Data Harvest. It was developed at the University of Reading, where it was used to control the operation of three greenhouse compartments designed to investigate the relationship between weather and the growth of tropical crops. The system can provide a complete simulation of the daily and seasonal thermal profile of a tropical location in each of the compartments and also provide irrigation and humidity control. All data is retained as a record and can be plotted on a chart recorder.

Combine works independently of a computer, relying on its own 6809 processor with built-in control Basic. Programs are stored in its memory. However a computer can be used to store programs and for additional

processing, displaying and storing of captured data. Communication with the computer is through a standard serial (RS232c) link and up to 16 Combines can be daisy-chained together through the link. Data Harvest Ltd, 28 Lake Street, Leighton Buzzard, Beds LU7 8RX.
EWW205 on the reply card.

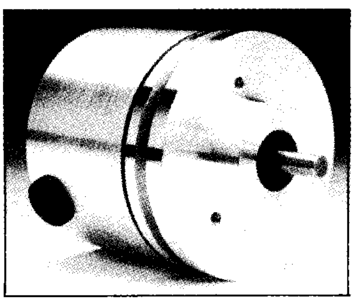
Transducers

Temperature probes were given as one example of the sort of input transducers that may be used in for collecting measurements. Transducers are, of



course, the front end of any data logging system, converting the physical quality being measured into an electric signal. They also need certain physical characteristics themselves; for example, a thermocouple must withstand the heat that it is measuring or an accelerometer has to be resistant to the vibrations on the test rig.

There is, for example, a thermcouple that is used to measure the temperature of moving surfaces. It has a range up to 250°C and can cope with a surface speed of 275m/s. The probe is in physical contact with the surface and can be used on rotating shafts or such flat surfaces as metal, plastics and some low-abrasion fabrics. The sensor is incorporated into a low-friction, spring-loaded detection head, incorporating thermocouple calibration codes K,T,J, and E and come from TC Ltd, PO Box 130, Uxbridge UB8 2YS.
EWW 206 on the reply card.



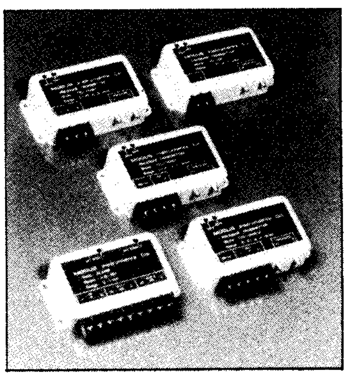
Some transduscers do already include signal conditioning elements, or they inherently give a machine-readable output. For instance, the shaft encoder from Sanchin gives square-wave ouputs for two channels and an index pulse. It can thus measure both rotation and direction of a shaft. The aluminium housing is liquid-proof and the hardened steel shaft is available in a variety of lengths and diameters. Several different version cope with the required resolution. Sanchin Ltd, 1 Gladstone Vila, Turners Hill Road, Crawley Down, W. Sussex RH10 4NW.
EWW 207 on the reply card.

Two pressure transducers are used together to transmit a pressure differential measurement for static and velocity air pressure measurement in filters and air-conditioning equipment. Non-linearity and hysteresis are included in the claimed accuracy of 1%. Various pressure differential ranges are available. Techmark (UK) Ltd, Sulby House, North Street, Sudbury, Suffolk CO10 6RE.
EWW 208 on the reply card.

Much higher pressures are measured by the aircraft grade transducer, made by Data Instruments. Ranges available are in 0 to 25, 50, 100, 200, 500psi. Accuracy is within 0.5%. Signal output 100mV at full scale which is sufficient to drive a panel meter without amplification. It needs a 5V excitation supply. Typical applications include the measurement of engine oil pressure, cabin air pressure or checking and controlling landing gear. Available through Control Transducers, North Lodge, 25 Kimbolton Road, Bedford MK40 2NY.

EWW 209 on the reply card.

Entran make a whole range of different transducers for pressure, load cells, strain gauges and accelerometers. An example is the EPN series high-sensitivity pressure transducer which may be used in fluid



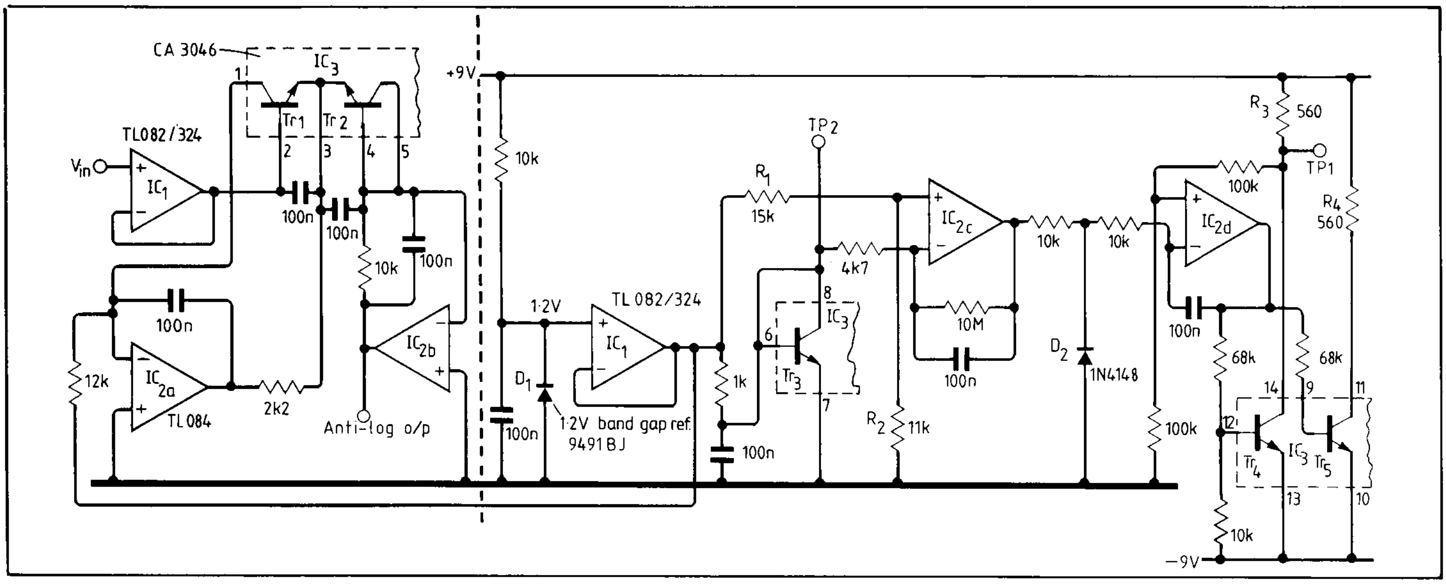
pressure monitoring and control, wind tunnel model testing, industrial processing and biomedical pressure studies. The sensing area is only 45mm^2. It has a stainless steel diaphragm which is corrosion resistant and may be used for studies in corrosive liquids. Different models cope with pressures up to 350bar. Entran Ltd, 5 Albert Road, Crowthorne RG11 7LT.
EWW 210 on the reply card.

Communications

Mention has been made of a serial interface through which our example instrument communicates with the computer. Such a system requires communications circuits on both the transmitter and receiver and these use a protocol program to speak to each other. One can only transmit when the other is ready to receive. One accepted standard serial interface is the RS232c or RS423. This specifies the number of wires needed between the devices and their configuration. Another system, about to be adopted as a British standard is the S5/8 interface; an article describing this is on p.29 of this issue. Serial systems communicate by sending the information down a single line coded in a computer equivalent of Morse Code. It is also possible for several lines to be used, so that the data can be sent in computer words, much faster, with less coding and decoding. Such a system is the General Purpose Interface Bus (GPIB) developed by Hewlett-Packard for their instruments to communicate with each other and with a host computer. This has been adopted in America as a standard with the title of IEEE-488 and is used widely. The addition of yet more hardware and software enables several computers and instruments to communicate serially or in parallel through a network either locally, for devices sharing a common site or even remotely through a wide-area network. Various standards are being studied and developed for such networking systems according to a set of rules drawn up by the International Standards Organization, designed so that computers of different manufacture and design can communicate through an 'open system'.

Continued on p.62

CIRCUIT IDEAS



Oven-controlled anti-log amplifier

This anti-log amplifier is part of an apparatus for determining the concentration of fluoride ions in a chemical solution. I found the basic circuit, to the left of the dotted line, to be very temperature sensitive on its own.

My temperature-compensated amplifier involves using a five-transistor array. Two transistors perform the anti-log function, two are heaters and one is a temperature detector.

A small current from the band-gap diode reference section feeds the temperature detection transistor. Voltage across this transistor base-emitter junction is compared with that at the junction of $R_{1,2}$; this voltage determines the chip temperature.

The value chosen for chip temperature is the highest ambient temperature anticipated plus the rise in chip temperature caused by the signal. Between 70 and 100°C should be adequate.

Remembering that the base-emitter voltage drops by about 2mV/°C, voltage at the $R_{1,2}$ junction is set to 150mV below the base-emitter voltage of Tr_3 (TP_2) at room temperature.

Voltage difference is amplified then passed to $Tr_{4,5}$. Diode D_2 ensures that the maximum power is dissipated in $Tr_{4,5}$ when the chip is cold and power is turned on.

An easy way to check the circuit is to place your finger on IC_3 and monitor voltage at TP_1. This voltage should fall, indicating that more power is being dissipated in the chip.

Values of $R_{3,4}$ determine the maximum power dissipated in the chip. Numerous 100nF capacitors stop the circuit from oscillating and even though IC_{2d} operates with very high gain, voltage at TP_1 is quite stable and does not interfere with signals in $Tr_{1,2}$.

Richard Beck
Iver Heath
Buckinghamshire.

Inexpensive combination lock

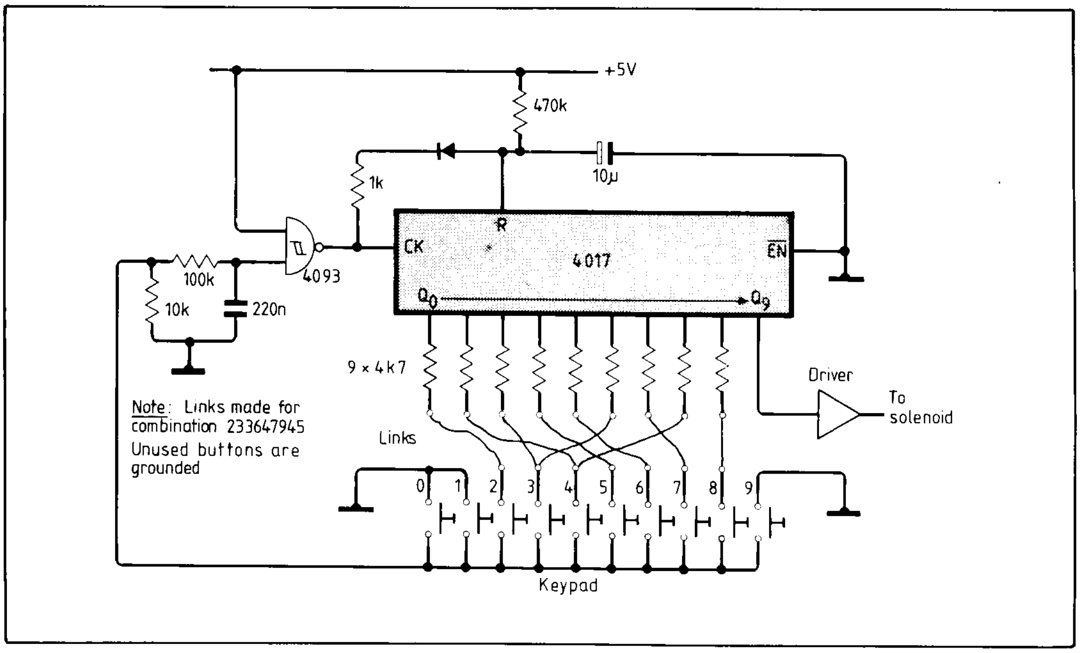
Using only two standard i.cs, a lock with up to 10^9 combinations can be made.

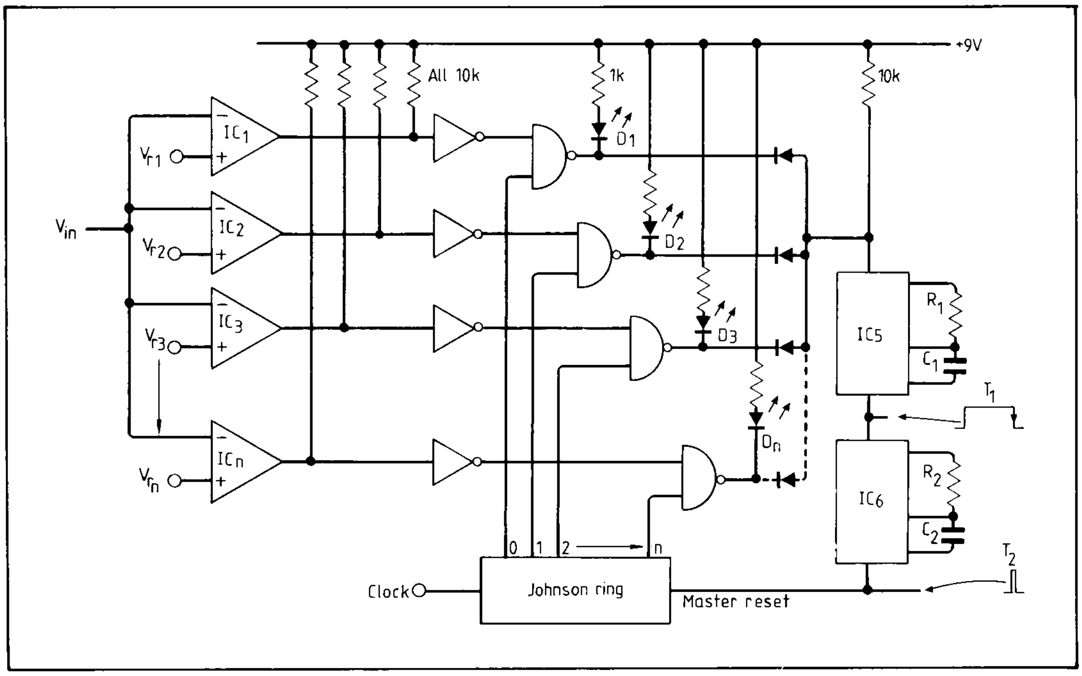
Each time a correct button is pressed, the Nand gate output goes low, discharging the reset capacitor. On button release, the gate goes high, the counter increments and the capacitor starts to charge.

This capacitor charging allows about four seconds for pressing the next key. After four seconds, if no key is pressed, the counter is reset. If a correct sequence of keys is pressed, Q_9 goes high and energizes the door lock for four seconds.

Pressing all the keys together will not operate the lock.

C. Stanforth
Oxford.





DON'T WASTE GOOD IDEAS

We prefer circuit idea contributions 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 and/or usefulness so these points should be brought to the fore, preferably in the first sentence.

Minimum payment of £35 is made for published circuits, normally early in the month following publication.

Level identification

An indication of whether a signal lies between two preset thresholds is given by this circuit in which a 4017 Johnson-ring device with master-reset facility is used to sample up to ten comparators.

Reference voltages are preset in descending order with the maximum at V_{r1} and the minimum at V_{rn}. When V_{in} is $0 < V_{in} < V_{rn}$, all comparator outputs are high. The ring sequences from zero to n but none of the leds lights, indicating that the input signal is below V_{rn}, the lowest threshold.

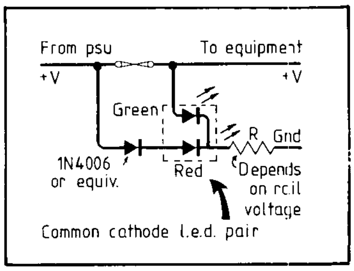
When $V_{in} \geq V_{rn}$, comparator IC_n switches to set one input of the Nand gate concerned high. On count n in the sequence, led D_n lights and triggers monostable device IC_5 for 30ms.

The second monostable device is triggered to provide the 30μs reset pulse on the falling edge of the 30ms pulse. Only led D_n flashes at each scan of the ring.

Similarly, when $V_{in} \geq V_{r3} < V_{r2}$, only D_3 flashes. The flashing led thus indicates the signal level. When $V_{in} \geq V_{r1}$, all of the comparators are switched and the leds flash sequentially — a clear overflow indication — because IC_5 receives a trigger pulse on each clock pulse.

A. de Sa
School of Physics
University of Newcastle upon Tyne.

Fuse condition indicator



A.A.J. Almond
New Territories
Hong Kong

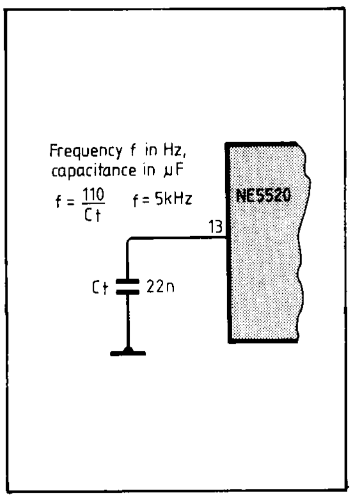
NE5520 frequency trimming

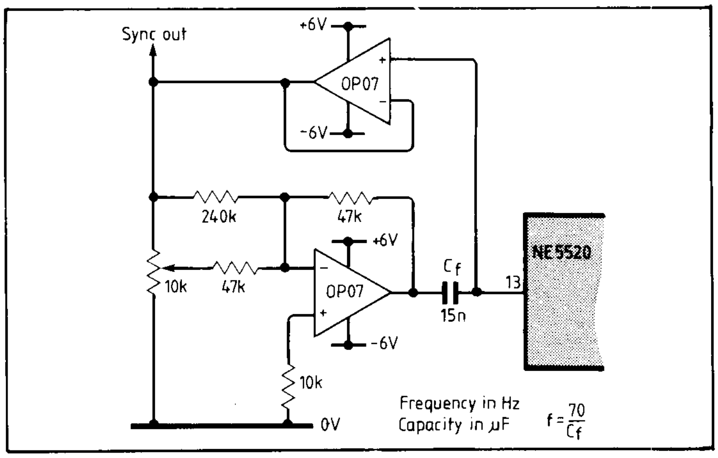
The NE5520 l.v.d.t. signal-conditioning i.c. from Signetics contains a useful combination of oscillator, synchronous demodulator and amplifier.

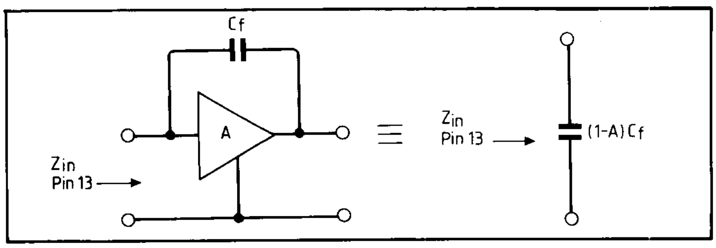
Unfortunately, oscillator frequency is set by a relatively large capacitor so trimming is difficult, top-left circuit. Since the oscillator-frequency equation is subject to 20% tolerance, trimming is necessary.

My circuit, top right, allows trimming using a potentiometer. With values shown, oscillator frequency is 4.5kHz and the trimming range is 25%.

Output of the buffer amplifier can be used to synchronize other 5520's (pin 13). The 5520 is connected for dual-supply operation.







R.C. Turner
Birmingham

Star-connected solar tracker

Usually, sun-tracking solar panels require two sets of sensors, one set following the sun from east to west and the second to provide altitude sensing. This star reverse-series configuration requires only three sensors.

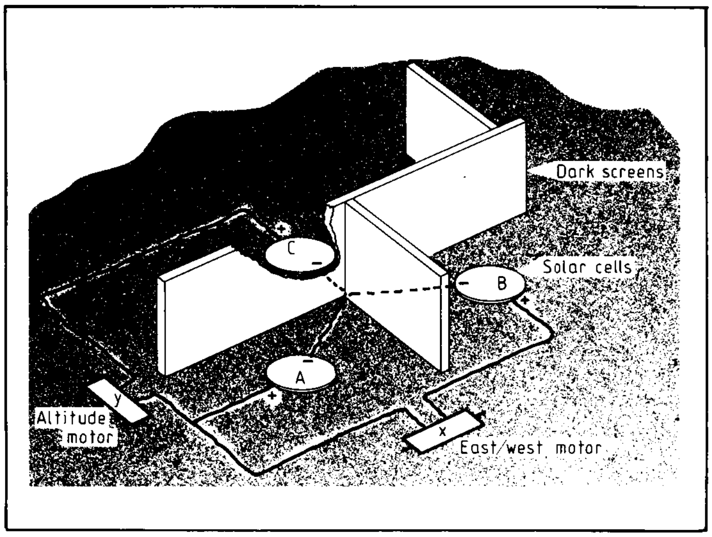
Screening panels are used. If the sun shades areas A and C together or B, motor x operates, moving the panel left or right. Sensors A and B together or C work in the same way with the up/down y motor for altitude setting.

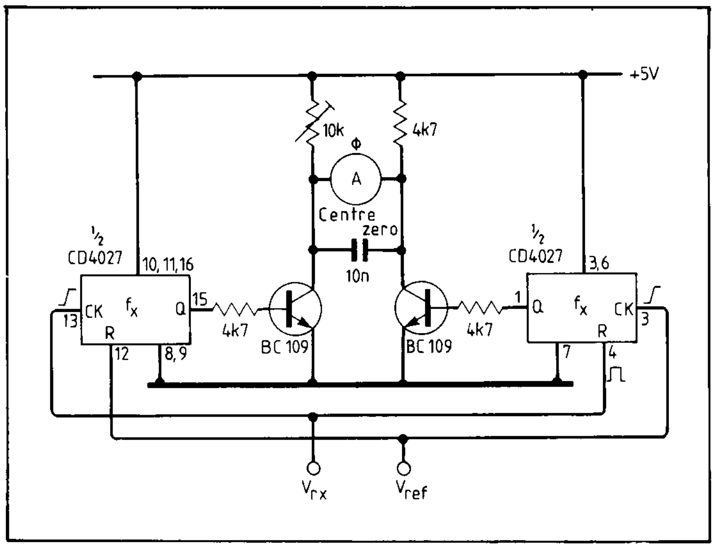
Time	Shaded sensors	General panel motion
Sunrise	A&C	right (swing)
	A&B	up
Noon	B	left
	A&B	up
Sunset	B	left
	C	down

Altitude motor y should be connected to A and C to ensure correct operation in the early morning, when the rising sun is in the east, i.e. to the right of the panel in the northern hemisphere.

Changing the shape of the screen varies the mode of control. With T-shaped screening, sensors B and C are not shaded in the early morning and while the x motor swings the panel round to the rising-sun position, the y motor also operates, moving the panel up until sensor A is not shaded.

R.C.T. Stead
Hampton
Middlesex.





One-i.c. phase meter

Simple meters using an exclusive-Or function only display phase difference. This one displays both difference and sign of two 50% duty-cycle signals on a centre-zero meter; alternatively two leds might be used for a phase relationship indication.

Differences between plus and minus 180° in signals from 20Hz to 5MHz can be measured. At low frequencies, you should use an RC network in the transistor bases.

Positive phase, $\Phi > 0°$, is represented by a positive-going V_{rx} edge occurring before a positive-going V_{ref} edge. When $\Phi > 0°$, $Q_{fr} = 0$ and

$$Q_{fx} = V\frac{\Phi}{360}.$$

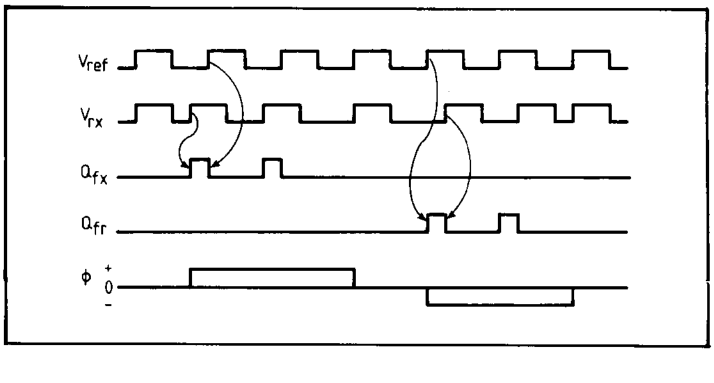
When $\Phi = 0°$, $Q_{fr} = Q_{fx}$ and when $\Phi < 0°$,

$$Q_{fr} = V\frac{\Phi}{360}$$

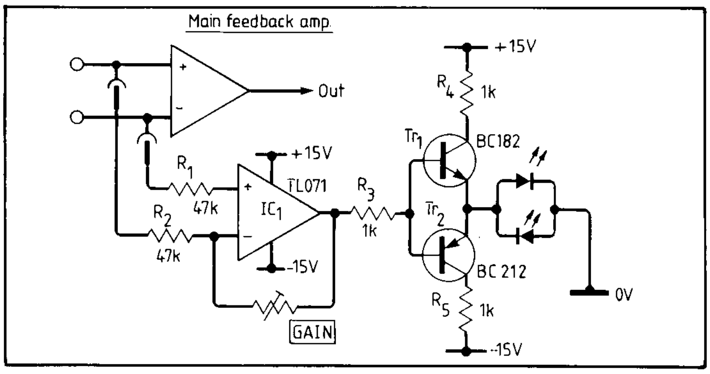
and $Q_{fx} = 0$. In this circuit, V is 5V.

Balance in the meter is adjusted with the 10kΩ potentiometer. Using a dual-trace oscilloscope and two signals whose phase relationship can be varied, set V_{ref} and V_{rx} to $\Phi > 0°$ and adjust the meter to give the desired deflection. Next interchange V_{ref} and V_{rx} and set the potentiometer so that the meter reads the same angle but with opposite sign.

Niels Witthofft
Frederikssund
Denmark.



Amplifier overload monitor



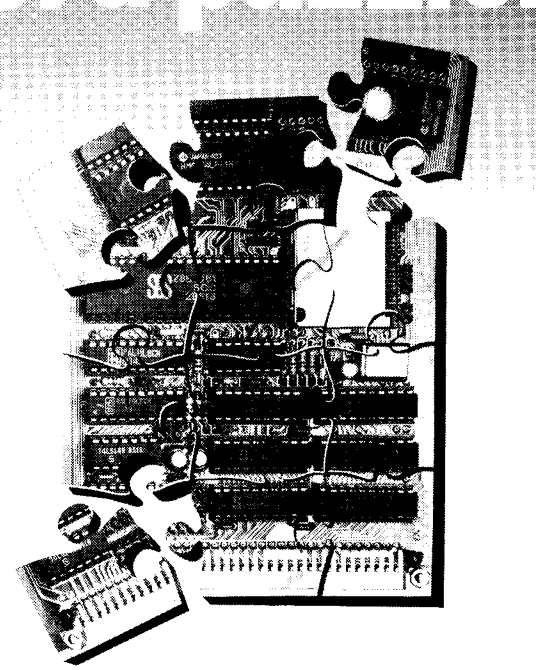
During overload in an amplifier with negative feedback, voltage between the inverting and non-inverting inputs suddenly increases.

Normally differential input voltage is small, being equal to output voltage divided by open-loop gain, but during an overload the feedback signal fails to match the input and a large input-signal differential occurs.

This circuit monitors amplifier input differential and indicates an overload in either direction. Adding a latch to prolong illumination of the overload led might help, but it would also mean that spurious noise impulses and brief clipping periods might be interpreted as serious overloads.

J.L. Linsley Hood
Taunton
Somerset.

It's a bit of a puzzle.



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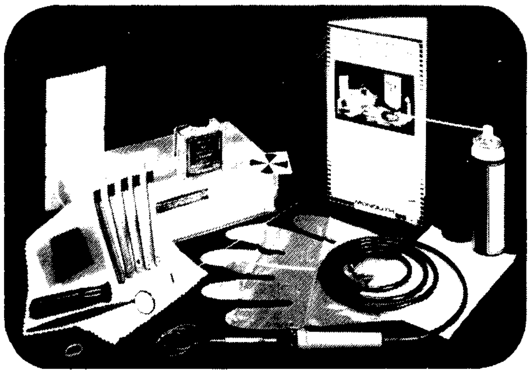

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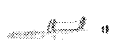

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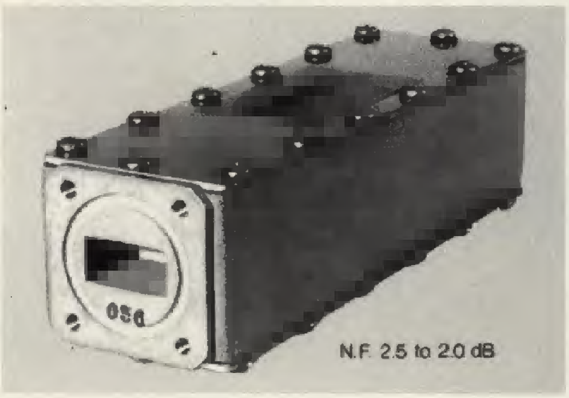

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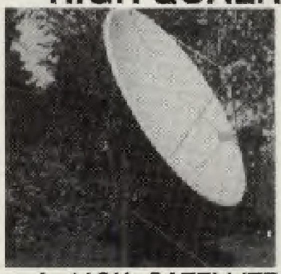

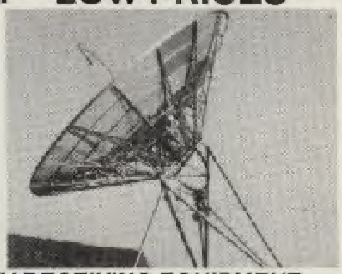

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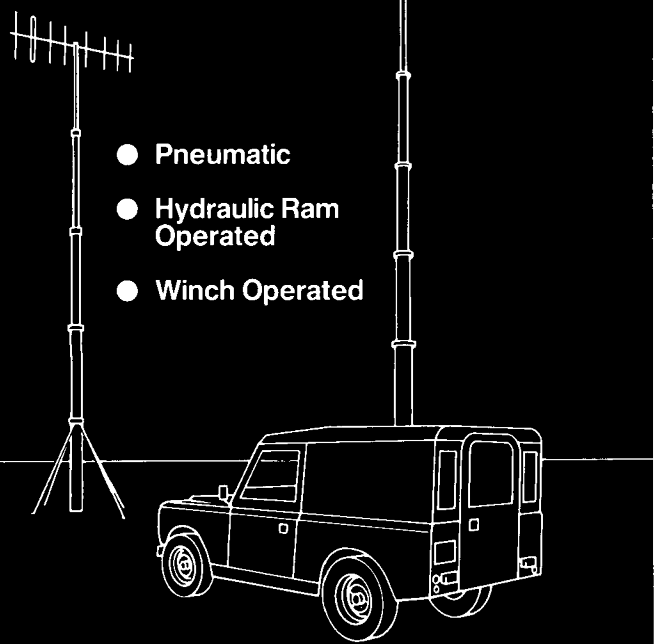

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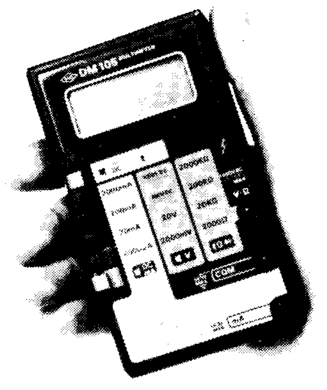

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An introduction to 3D graphics

by Hugh Gleaves

Wire-frame images are greatly enhanced by colour, but the hidden faces have to be removed first.

In my previous article I explained how three dimensional objects can be represented in a computer as models, and how to write programs for converting these models into perspective pictures in wire-frame form.

The fundamental mathematical concepts presented in the May and June issues are the starting point for any three dimensional graphics program. This article is concerned with improving the system by making the display pictures more realistic. Screen resolution and colour range limit the degree of realism that can be achieved but, by adding processing stages, the simple wire-frame images can be improved considerably.

This article explains how to implement object colouring, hidden-face removal and other subsidiary facilities to provide a useful and educational computer graphics system.

Enough information is presented to enable you to write such programs in an alternative computer language; a Pascal implementation would be a very interesting and challenging project and would result in a considerable improvement in performance.

Using the wire-frame software presented last month as a kernel, I decided to create a high-performance, yet easy to use, 3D-graphics system. The system, written entirely in SuperBasic, demonstrates those fundamental facilities that underlie all 3D graphics systems, be they for cad, defence or advertising.

Figures 1 and 2 show the general structure and data flow of the system, named the graphic-manipulation facility (g.m.f.) Figure 2 shows the system module structure and is a rough representation of the program's procedural structure. Making a module map is one of the first steps taken when designing reasonably large systems and is a hallmark of a structured approach to program design.

The control-module procedure receives control from the operating system and is the first procedure to be given control. This module's task is to initialize windows, set up modes, and generally prepare the system for the subsequent procedures. The control module can call any of the four modules immediately below it in the diagram.

The option processor is a control-module subprocedure handling low-level processing like laying out screen menus and checking user options; it passes control back to the control module whenever a satisfactory user selection has been made.

On receipt of a particular user selection, the control module passes control to the transformation processor, i/o processor or editing processor, according to the selection.

The transformation processor

To a great extent, the transformation processor is the

All the software discussed in these articles can be obtained by sending £3 and a microdrive cartridge or £5 to Hugh Gleaves at PO Box 594, London N10 3PF. Written in QL SuperBasic, this software includes the wire-frame image program (discussed in the May and June issues), the complete g.m.f. packages, a number of sample 3D objects and written instructions and documentation.

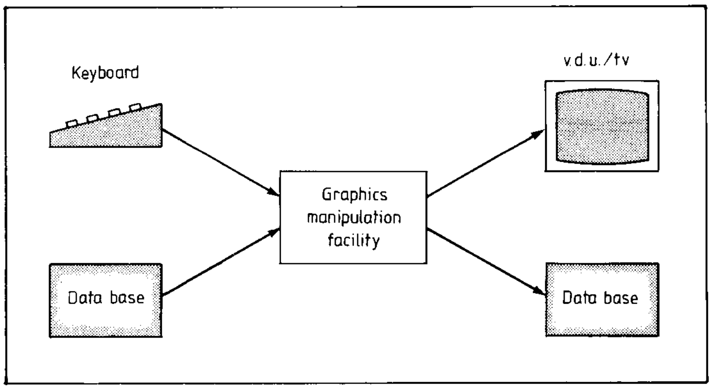


Fig. 1. General structure of the graphic manipulation facility (g.m.f.)

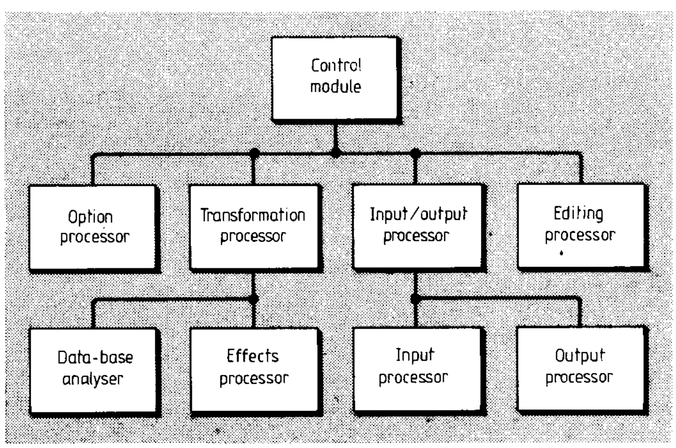


Fig. 2. Module structure of the graphics system.

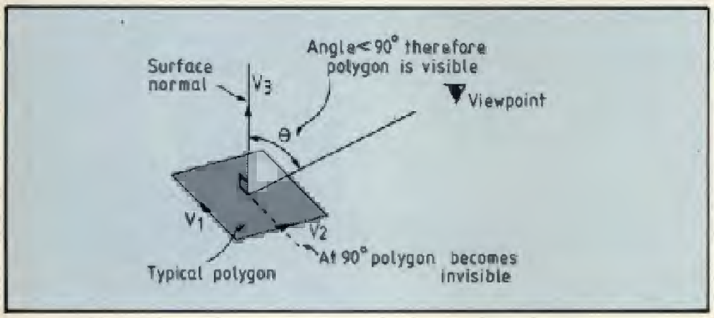


Fig. 3. Determining visibility of a polygon. The normal can be anywhere on the surface.

program given in the previous article. As you may remember, the procedure VIEW handles all the mathematics and line drawing needed for three-dimensional graphics.

However, VIEW now becomes a subprocedure of a larger program and has been given a few enhancements and generalizations to make it a high-performance, general-purpose 3D processor. Essentially though, its function is unchanged; it performs 3D coordinate and perspective transformations on the bodies and vertices in the database.

Input/output processor

A completely new set of input/output procedures is essential if the system is to be of any practical use. This group of procedures, called the i/o processor, allows you to load and save complete 3D a.e. (artificial environment) databases.

The i/o processor works by examining all the arrays used to hold geometrical data and storing the data on 'microdrive' (or any external storage medium) so that they can be reloaded at any time and restored to their original condition. All details regarding colour, size, position etc., are saved and a facility for naming environments is provided.

These features make the system much more enjoyable to use.

Editing processor

A simple database editor allows some changes to be made to parameters like colour, vertices and polygon numbers.

There are some minor restrictions in the generality of changes because of the way that the databases are stored internally, but these do not detract from the flexibility and ease of use of the g.m.f. To allow total and general alteration of any database feature would involve a complete redesign of the system.

Remaining modules of Fig. 2 are fairly self-explanatory, with the possible exception of the database analyser and effects processor. These procedures are responsible for getting certain items out of the database when requested and for implementing colour, back face removal and local coordinates.

This article is primarily concerned with exactly how the 3D effects are achieved and how programs to perform these can be written, so it is mainly concerned with the operations of the effects processor.

The effects processor is a set of procedures and functions used for colouring, surface-area calculation, back-face elimination and local coordinates.

Back-face elimination

One of the most visually effective techniques that can be incorporated into any 3D graphics system is hidden-surface elimination. This feature is essential when one is looking at even a simple scene, and is the next step up from the simple wire-frame scenes discussed in my previous article.

In one sense, computer graphics deals with the reverse of the problem of computer vision. In computer vision the problem is to extract maximum spatial and geometrical information given only a scene, whereas computer graphics tries to construct the most realistic scene from spatial and geometrical information.

The problem is to remove those parts of the scene that would not be visible in the real scene. This problem is compounded by a number of special situations that can occur.

For example when two surfaces such as two interlocked rings overlap, the algorithm has to detect this and then break the surfaces into smaller pieces until no overlap occurs. Such a generalized facility is not included in this graphics system because the extra processing requirement is noticeable; such an advanced feature would also be out of place in this introductory treatment.

We avoid the need for such complex generalized algorithms by avoiding the type of geometries for which they are needed. Because the system described here is intended only for convex polyhedra, mutual overlap of polygons or bodies is eliminated.

The first problem is to remove all invisible faces from each polyhedron. This is called 'back-face elimination' or 'hidden-face removal' to dis-

Three-dimensional vector calculus

A vector is merely a line segment of definite length and with a specific direction. It therefore has two endpoints and each endpoint has coordinates.

The differences between these coordinates are called the vector's 'components'. For example if an endpoint has coordinates x_1, y_1, z_1 and the other endpoint has coordinates x_2, y_2, z_2, then the vector components are x_2-x_1, y_2-y_1, z_2-z_1, the direction of the vector being from point one to point two. Components are conventionally written in small letters, and the above vector could be written a_x, a_y, a_z.

Thus when dealing with mathematical operations on vectors we are really dealing with mathematical operations on their components. It is possible to combine vectors in numerous ways and get other new vectors as a result, just as is done with numbers.

tinguish it from the more general algorithms called 'hidden-surface removal'.

Removal of invisible faces is as follows. A polygon is only visible if the angle formed by its normal and the viewer's line of sight is less than 90°, Fig. 3. The vector leaving the surface, the surface normal, need not be calculated for the centre of the polygon; the normal can lie anywhere on the surface since the surface will be visible if any normal forms an angle of <90°.

The software contains a function that accepts a polygon number and returns either a one or zero denoting visibility of invisibility. Firstly consider any three successive vertices on the polygon. Starting with the centre vertex, we have two vectors $\mathbf{v}_1$ and $\mathbf{v}_2$. These vectors are defined with respect to the object co-ordinate system and are completely specified by the coordinates of their endpoints.

Now calculate the new vector $\mathbf{v}_3$ which is the normal vector. This normal vector will have one of two directions, depending on whether vectors $\mathbf{v}_1$ and $\mathbf{v}_2$ are multiplied in a clockwise or anticlockwise direction. For readers unfamiliar with three-dimensional vector calculus, a brief explanation is given separately.

The two vector operations that we are concerned with are the scalar product and the vector product, sometimes called dot product and cross product. For vectors **A** and **B** with components a_x, a_y, a_z and b_x, b_y, b_z the scalar product is

$$\mathbf{A}\times\mathbf{B}=a_xb_x+a_yb_y+a_zb_z$$

and is numerically equal to the product of the vector magnitudes and the cosine of the angle between them. It is by means of the scalar product that the angle between a polygon's normal and the viewer's line of sight is determined.

The other vector operation needed for back-face elimination is the vector product. The result of calculating the vector product is a new vector that is orthogonal to the plane containing the two vectors. Considering the two previous vectors **A** and **B**, the vector product is defined as the new vector with components

$$\mathbf{A}\times\mathbf{B}=(a_yb_z-a_zb_y,\ a_zb_x-a_xb_z,\ a_xb_y-a_yb_x).$$

The important point to bear in mind about the vector product is that $\mathbf{A}\times\mathbf{B}=-\mathbf{B}\times\mathbf{A}$ and this is the reason for the earlier reference to clockwise or anticlockwise products.

This fact has great bearing upon any computer graphics software that is to include back-face elimination, because the order in which a polygon's vertices are entered determines the final direction of the normal.

In g.m.f. the convention is established that a polygon's vertices, when numbered and entered into the computer, must go in a clockwise direction, with the viewer looking at the visible side of the polygon. If this is not done, the system will treat visible polygons as invisible and *vice-versa*.

The principle is illustrated in Fig. 4. When you are looking directly at either of the labelled faces, then the numerical ordering proceeds clockwise.

Thus, when g.m.f. examines a face for visibility, it accesses vertices one, two and three, then forms the components of two vectors from vertex two to one and vertex two to three. These components are multiplied together and the resultant normal will point away from the polyhedron.

By performing a modified scalar multiplication between this normal and the line-of-sight vector, which is easily evaluated, the angle between them is calculated. This is now merely examined and visibility thus determined.

I should stress that it is not the actual vertex numbers being discussed here, but rather their order of entry at the time that the user describes the polygon to the system. This is because the system accesses the vertices for any polygon in the same order that they were initially entered.

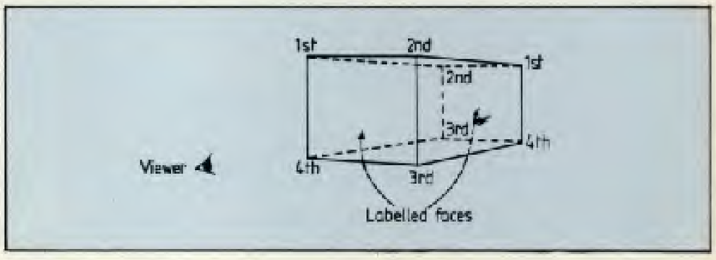
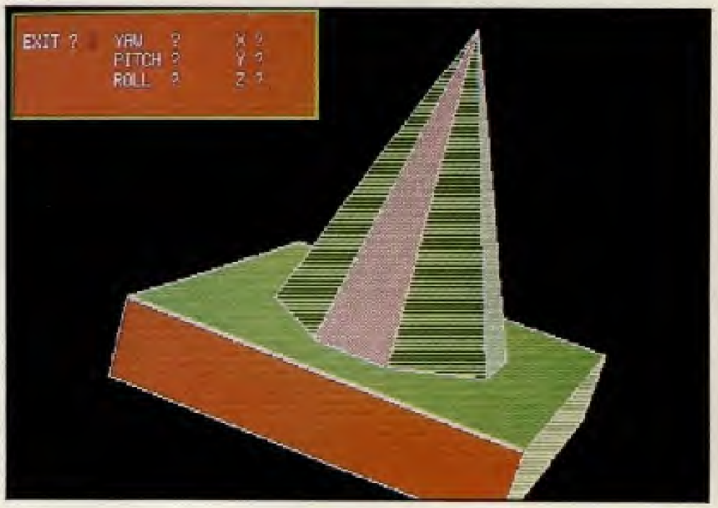


Fig. 4. Principle of clockwise ordering. When one is looking at either of the labelled faces, the numerical order is clockwise.

For example if a polygon with five sides has vertex numbers seven to eleven then they could be entered in the ascending or descending order. If ascending order were in fact a clockwise ordering, then 10, 11,7,8,9 would also be valid.

Colouring objects

By adding colour to the graphics system a high degree of realism is achieved. With a careful choice of colours, an impression of illumination can



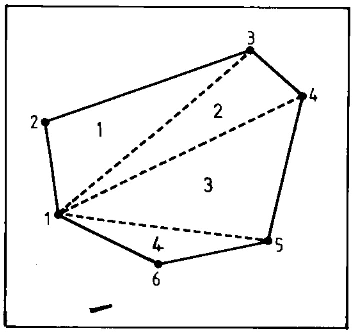


Fig. 5. Decomposition of a polygon into triangles showing how a polygon with six vertices is divided into 6-2 triangles.

be given and thus further enhance the visual impression.

G.m.f. allows you to select either colour or wire-frame viewing. Colouring the object faces of course only has any value after elimination of the back faces, so the program has to determine which polygons are visible and then colour them. It does this using the computer's FILL command.

After deciding that a particular polygon is visible the software sets the INK colour to that specified by the user for that polygon. The FILL facility is then activated and the polygon is drawn on the screen.

At this stage a coloured polygon will be on the screen and this can look rather unimpressive and sometimes jagged along its edges, especially if stippled colours are being used. Stippling is a method if increasing the colouring range by setting alternate pixels to different colours; this effect can be quite impressive.

To enhance the polygon's and hence the complete body's appearance, each polygon is outlined in white. The FILL facility is deactivated, the INK colour set to white, and the polygon redrawn. The final image has a clean, bright and solid appearance, giving a most attractive picture for some solids.

Local coordinates

One of the most awkward features of the wire-frame software discussed in the previous article is the method of specifying camera motion. Initially, after invoking VIEW, motion specification is fairly straightforward, up being up, left being left etc.

But as one's orientation moves away from the default, control becomes increasingly difficult. For example if you have performed a 180° ROLL, then the positive Y axis is now downward as far as you are concerned, and mental allowance has to be made for this when determining subsequent motion parameters.

This problem is overcome by introducing the concept of a local co-ordinate system — an approach used for most professional computer graphics systems. With this feature, orientation and motion parameters are always interpreted as being relative to the camera coordinate system, i.e. the local system.

Up is therefore always what the viewer considers to be up, and left always left, regardless of the camera's position and orientation. This achieved in software by keeping a copy of the transformed world coordinates and using these transformed values as the world coordinates when the next camera motion is entered.

In other words, the world coordinate system is always changing. The entire vertex database is continually updated, but a permanent copy is always retained of the original world coordinates so that when VIEW is reselected, the user can return to a known default condition.

Whether or not the LOCAL facility is in operation is determined by the user from the VIEW menu.

Calculating surface area

In commercial cad systems, especially those intended for mechanical engineering design, a number of physical properties relating to a component are calculable from the component's model. Among these are mass, volume, centre of gravity and moment of inertia.

These properties are often of great concern to the engineer or designer, and are referred to as mass properties. The software that incorporates these facilities is referred to as a solid modeller.

Analysing such properties takes large amounts of processing capability and cad systems with these facilities are expensive items. However, one physical property of a geometric solid is relatively easy to calculate. This property is surface area, which is important in a number of engineering situations, including surface-protection estimates, wind resistance and radiative properties.

This facility can be incorporated into the graphics system to give it an elementary design capability and also to familiarize you with the sort of problems that face cad and graphics software designers.

The problem is to write software for accepting a particular body number and returning its surface area value. Since this graphics system deals with closed convex polyhedra that are bounded completely by plane polygons, you can see immediately that total surface area is merely the sum of the polygon areas.

These polygons can, however, be totally arbitrary in shape and number of vertices, giving the impression of being far too generalized to have their area readily calculated. A way must be found of calculating the area of any convex polygon, given only the three cartesian coordinates of its vertices. Any polygon can be decomposed into a number of arbitrary triangles and it is a simple matter to calculate the area of these triangles, given the lengths of all three sides.

Fig 5 shows that a polygon of n vertices needs to be decomposed into n-2 triangles so that the length of each side of each triangle can be calculated.

To find the length of any side of a triangle, the 3D version of Pythagoras' theorem is used, which states that the distance s between points x_1, y_1, z_1 and x_2, y_2, z_2 is given by

$$s=\sqrt{(x_1-x_2)^2+(y_1-y_2)^2+(z_1-z_2)^2}$$

When the length of each triangle side has been found, say s_1, s_2 and s_3, its area can be found, by the well known formula

$$A=\sqrt{t(t-s_1)(t-s_2)(t-s_3)}$$

Where

$$t=\tfrac{1}{2}(s_1+s_2+s_3).$$

In the graphics system software there is a SuperBasic function that accepts the body number and breaks that body into its component polygons. Each polygon is broken down into triangles and the surface area is then gradually built up. Ultimately the function returns the body's total area. ■

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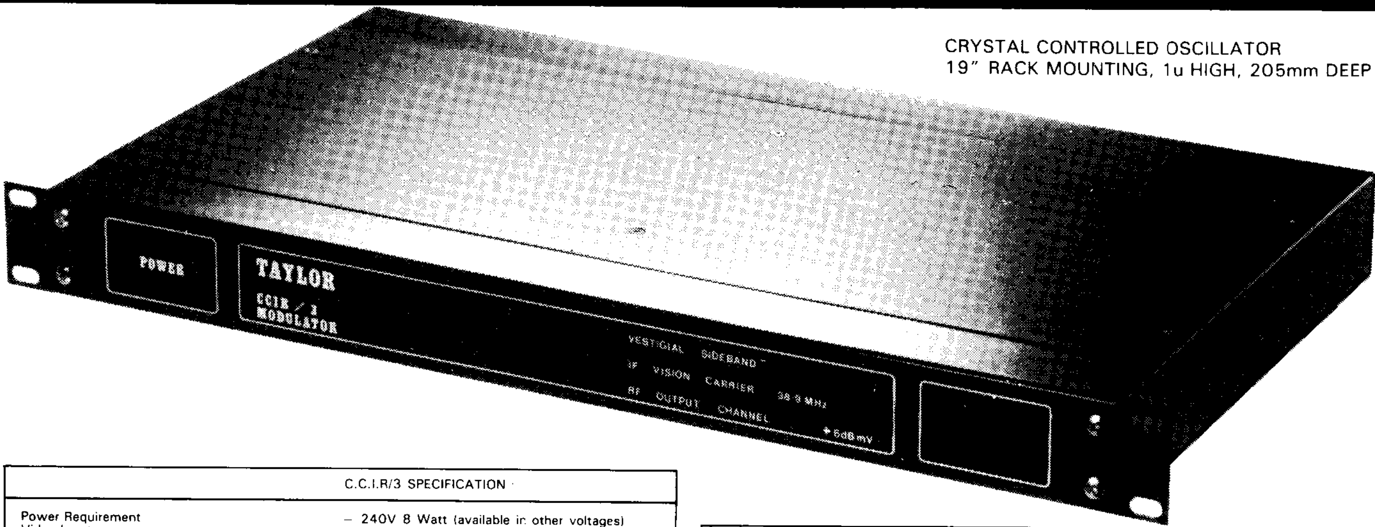

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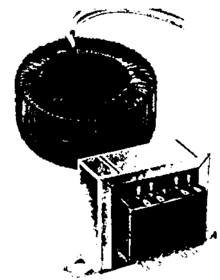

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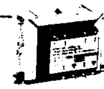

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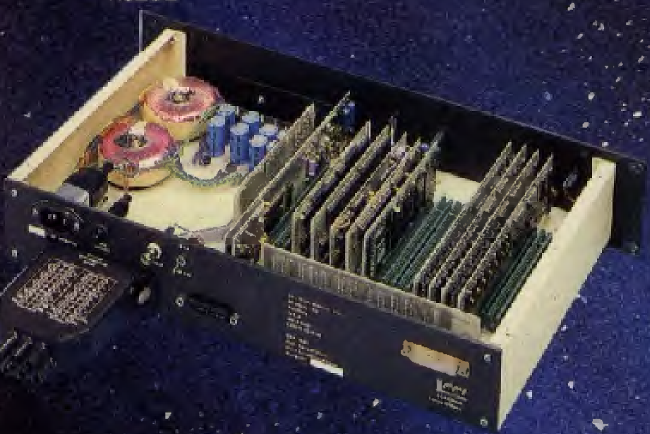

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CIRCLE 48 FOR FURTHER DETAILS

"Q"

by K.L. Smith, Ph.D.

University of Kent at Canterbury

Ken Smith looks at the origins and subsequent applications of this often misunderstood ratio.

While talking to a student using the Q-meter the other day, I was reminded of the vast field of applications in which this un-named letter now appears. I asked the student what he was measuring He replied that Q was something to do with how 'good' the coil was – but looked blankly at me when I said, "What about its application to the width of spectral lines?"

I was hardly being fair, of course. Q has to do with the characteristics of spectral lines *and* inductors, *and* tuned circuits... But Q also appears when piano strings, quartz resonators, motor cars, auditoriums, bouncing balls and, among other things, the earth itself are discussed. The student was studying electronics engineering, which these days hardly results in any breadth of education at all, so how was he to know?

The odd thing about Q is that it is just... Q. There is no named quantity which is then given the symbol. It turns out that Q measures a number of things, all of which are often only partly understood. Here again we have an example of a fuzzy area often treated badly in lecture courses and so on.

This topic has developed into a little flurry of interest again recently in *Electronics and Wireless World*, via letters from august institutions in Cambridge enquiring about it. Lady Jeffreys[1,2] and D. McMullan[3,4] made the enquiries and also wrote short papers in the Royal Astronomical Society's *Quarterly Journal*. Geophysicists appear to have discovered Q through the work of the microwave engineers during and after the second world war. Further, it seems these colleagues of ours like to use the reciprocal of Q, but as I show a little later, this is the dissipation factor, and is already available as such. I was surprised to see a reference in the cited literature that someone had called Q the dissipation factor – an error, of course.

It is undoubtedly true that Nikola Tesla was aware of circuit magnification when he exploited his enormous LC ratios to produce kilo and megavolt r.f. intensity levels on his Tesla Coil secondaries.

Origins

The question of origin of this un-named symbol is a little obscure. I have adopted the evidence that Q first appeared in the notebooks of K.S. Johnson, who was working in the Western Electric Co. engineering department, USA, at the time of the first world war. Johnson appeared to be aware of the importance of the ratio, 'coil reactance to resistance' as early as 1914, but labelled it K. By 1920 he was using Q for this ratio and said when asked why Q? "Well, it does not stand for 'quality factor' but since all the other letters are so overworked, I only had Q left." He certainly published many references to Q in his book[5] on telephone engineering published in 1924/25.

At this stage, Q was a dimensionless factor with no precise name, but it was defined as

$$Q=\frac{\omega L}{R}$$

Engineers well before this time had utilized the rate of decay of a wave train, or the *logarithmic decrement* δ, on the wireless communications side and the *power factor* cosϕ, in heavy engineering circles. *Dissipation factor* D, was also widely used and it was apparently the 'upside down' or psychologically dissatisfying nature of D that prompted Johnson to use its reciprocal and ultimately to label it Q. D becomes larger as the losses, or performance, gets worse. The dissipation factor also tends to be a small fractional number in light current work. Its reciprocal Q, is an integer or large integer and grows as the quality of performance grows. Although Johnson denied 'quality factor' was ever in his mind, nevertheless V.E. Legg popularized this possible meaning and it has stuck.

Very quickly Q was seen to relate not only to D but to δ and cosϕ also. As an interesting sideline, the log.dec. δ was very important in the days of spark transmission, with its damped wave trains. But as c.w. narrow-band techniques took over, it faded into insignificance, (back to the laboratory where a few ballistic galvanometers were still employed).

What is Q

Figure 1 shows an ordinary phasor diagram that, in this example, applies to a lossy inductor. From the phasor geometry, the power factor is

$$\cos\phi=\frac{R}{Z}$$

The dissipation factor is

$$D=\frac{R}{\omega L}=\tan\psi$$

Q is simply the reciprocal of D

$$\therefore Q=\frac{\omega L}{R}=\cot\psi$$

Of some interest is to note that D is proportional to the *dissipated power* in the circuit (i^2R), while Q is proportional to the *stored energy*, ($\frac{1}{2}Li^2$).

Another interesting point is that power engineers strive to maximize the dissipation, in other words, they try to arrive at a zero phase angle, giving

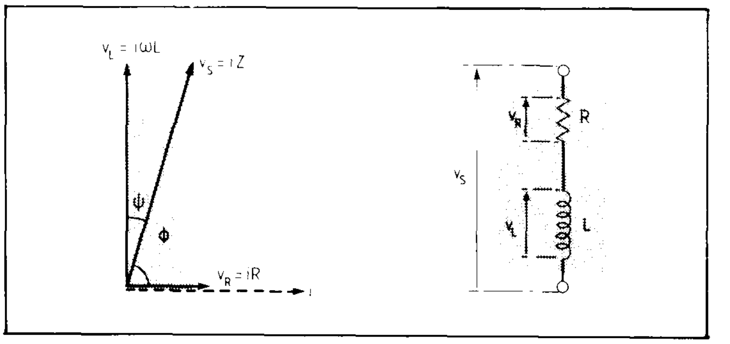

Fig. 1. The current phasor i is common to L and R in the series arrangement shown. V_R is in phase with i, while v_L leads i by 90°. The phase angle between i and v_s is used for power factor calculations. ($\psi = 90° - \phi$) is often called the loss angle.

cosϕ = 1; while communications engineers want to minimize losses, i.e. make ψ as small as possible, which is the same thing as obtaining large Q.

Q factors for inductors tend to be much lower than those attained in good-quality capacitors. Therefore, the coil losses in a resonant circuit predominate. A major step forward was realised when it was found that Q could be applied to a tuned circuit at its particular resonant frequency f_0, as

"Well, it doesn't stand for 'quality factor', but since the other letters are so overworked, I only had Q left." – K.S. Johnson.

well as meaning a figure of merit for an inductor at any frequency. A number of results followed from this. The tuned circuit in Fig. 2 stores energy in its reactances and dissipates it as heat in the resistance.

The stored energy oscillates between the magnetic field of the inductor and the electric field in the capacitor.

$\therefore$ energy stored = $\frac{1}{2}L\hat{I}_s^2$ joules

(Alternatively, energy stored could be written, $\frac{1}{2}C\hat{V}_s^2$.) The average power lost in the resistor is

$$\frac{\hat{I}_s^2 R}{2},$$

because the r.m.s. current

$$I_s = \frac{\hat{I}_s}{\sqrt{2}}.$$

Therefore the energy lost per cycle is

$$\frac{\hat{I}_s^2 R}{2f}$$

where f is the frequency in hertz.

We are now in a position to examine the relationship of the energy stored to that dissipated per cycle. The ratio is

$$\frac{\frac{1}{2}fL\hat{I}_s^2}{\frac{1}{2}R\hat{I}_s^2} = \frac{fL}{R} = \frac{2\pi fL}{2\pi R} = \frac{\omega L}{2\pi R} = \frac{Q}{2\pi} \quad (1a)$$

This is now a more fundamental definition of Q than Johnson's original, as it is based on energy relationships.

$$Q = 2\pi \frac{\text{total energy stored in periodic system}}{\text{energy dissipated in one period}} \quad (1b)$$

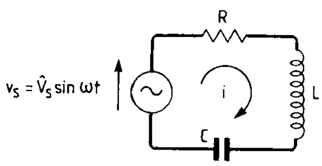

Fig. 2. As v_s drives current through the circuit, the stored energy alternates between the capacitor containing it all and the inductor storing it as magnetic energy. R dissipates some energy as heat during every cycle.

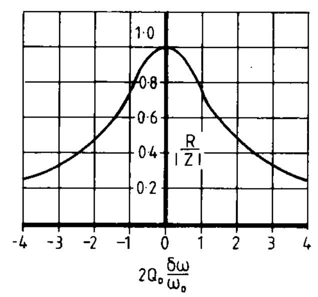

Fig. 3. The response curve of a tuned circuit is the well known bell-shaped curve. In the normalized form shown here, it applies to any series LCR circuit and the larger Q becomes, the narrower the peak between the points which are 0.707 times down.

Since in the tuned circuit at resonance

$$\omega = \omega_0 \text{ and } \omega_0 L = \frac{1}{\omega_0 C'}$$

the current is

$$I_s = \frac{V_s}{R}$$

and is a maximum. This current flows through the inductor (and the capacitor...) and the voltage drop across L is

$$V_L = I_s \omega L = \frac{V_s \omega L}{R} = QV_s$$

This shows that the voltage across L (or across C) is Q times the voltage generator value. With Q of some hundreds, V_L can be large. This explains why Tesla managed such large 'magnification factors'.

Very similar relationships can be derived for a parallel tuned circuit, which is the dual of the series one I have treated.

Detuning: selectivity and bandwidth

A look at the series tuned circuit again shows that, off-tune, it appears to offer an impedence given by

$$Z = R + j\left(\omega L - \frac{1}{\omega C}\right)$$

On tune, $\omega = \omega_0$ and

$$\omega_0 L = \frac{1}{\omega_0 C},$$

$$\therefore \frac{1}{C} = \omega_0^2 L, \text{ so that Z can be written}$$

$$Z = R + j\omega_0 L\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)$$

$$= R\left[1 + jQ_0\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)\right]$$

Q_0 is the *unloaded* Q of the circuit at frequency ω_0.

If the Q is large, then the variations of ω about ω_0 are fractionally very small to maintain significant results. (In other words, resonance is over and done with very quickly if Q is large.) This means can be written $\omega_0 \pm \delta\omega$ where $\delta\omega$ is very small. Inserting $\omega_0 + \delta\omega$ into

$$\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}$$

gives

$$\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega} \triangleq \frac{2\delta\omega}{\omega_0}$$

by neglecting $(\delta\omega)^2$ in comparison to other terms.

$$\therefore Z = R\left[1 + j2Q_0\frac{\delta\omega}{\omega_0}\right]$$

By considering the absolute value, or modulus of Z, some further interesting results follow.

$$\therefore |Z| = R\sqrt{1 + 4Q_0^2\left(\frac{\delta\omega}{\omega_0}\right)^2}$$

A plot of R/|Z| against $2Q_0\delta f/f_0$ (the 2π having cancelled) gives a normalized universal resonance curve applicable to all tuned circuits, and by implication, to all resonant systems, see Fig. 3.

When $4Q_0^2(\delta f/f_0)^2 = 1$ the magnitude of the reactance of the circuit equals the resistance, and the amplitude of the current drops to $1/\sqrt{2}$ of the value at f_0, which means that the power dissipated drops to one half the value at resonance. This yields another significant relationship for Q,

$$Q_0 = \frac{f_0}{2\delta f}$$

$2\delta f$ can be written Δf, the "half power bandwidth", and the ratio of f_0 to $2\delta f$ is a measure of *sharpness of reasonance* or selectivity.

Damping, the logarithmic decrement

A tuned circuit, or a church bell, a tuning fork, a motor car on its springs and (if they are not too good!) shock absorbers – all oscillate with an exponential decay, or ringing of the type shown in Fig. 4.

A solution of the equations for these natural oscillations is, (for the LCR circuit)[6],

$$i(t) = \hat{I}_s e^{-\left(\frac{R}{2L}\right)t} \cos\omega_0' t$$

where ω_0' is nearly equal to the ω_0 used previously.

From Figure 4 you can see that the time to go from one peak value to the next is $t_2 - t_1 = T$ and if the two peak currents corresponding to t_1 and t_2 are I_1 and I_2, then

$$\frac{\hat{I}_2}{\hat{I}_1} = e^{-\frac{R}{2L}(t_2 - t_1)} = e^{-\frac{RL}{2L}} = e^{-\delta}$$

where δ is known as the *logarithmic decrement*[7]

$$\therefore \delta = \frac{RT}{2L},$$

$$\text{or because } T = \frac{1}{f}, \delta = \frac{R}{2fL}$$

$\therefore \delta=\frac{\pi}{Q}, \text{ or } Q=\frac{\pi}{\delta}$

This shows that the oscillating current in a circuit with a Q of 100 dies away to 37% of its initial value after about 32 cycles. (It also shows that a car suspension Q of 100 would cause the car to oscillate the same number of times after a bump in the road, and so high Q is not always sought!)

Loaded, unloaded and external Q

In Figure 5, the tuned circuit is driven from a voltage generator whose internal resistance is R_s. Now, from the definition of Q as 2π times the ratio of energy stored to energy leakage, as given in equation (1), the sinks of energy loss have been simple up until now. There was only one, the coil resistance. But in Fig. 5, R_s will also dissipate energy.

$$\therefore Q_L=\frac{\omega_0 L \hat{I}_s^2}{2} \Big/ \frac{\hat{I}_s^2(R=R_s)}{2}$$

$$=\frac{\omega_0 L}{R+R_s} \qquad (2)$$

Q_L is the *loaded Q,* and is the Q of the entire system. The reciprocal of equation (2) gives,

$$\frac{1}{Q_L}=\frac{R}{\omega_0 L}+\frac{R_s}{\omega_0 L}$$

$$\therefore \frac{1}{Q_L}=\frac{1}{Q_0}+\frac{1}{\omega_{Qex}}$$

In this equation, Q_0 is the *unloaded* Q of the tuned circuit only: Q_{ex} is the *external* or *radiation* Q.

In a transmitter, for example, Q_0 should be large and therefore $1/Q_0$ very small, so that although the loaded Q may be low, nearly all of it is radiation Q, (and the r.f. energy is not warming up the inductor very much).

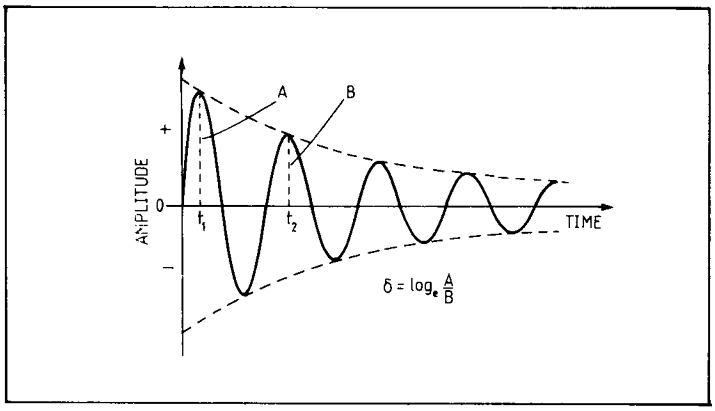

Fig. 4. If the drive v_s is suddenly turned off in Fig. 2, then the energy is gradually dissipated and the damped oscillation, or "ringing" shown is the result. The logarithmic decrement is defined from the rate of decay.

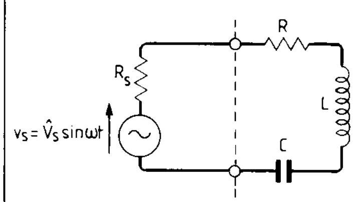

Fig. 5. Some energy per cycle is dissipated internally in R. Further energy appears as heat in R_s. The loaded and unloaded Q definitions arise from this division of labour.

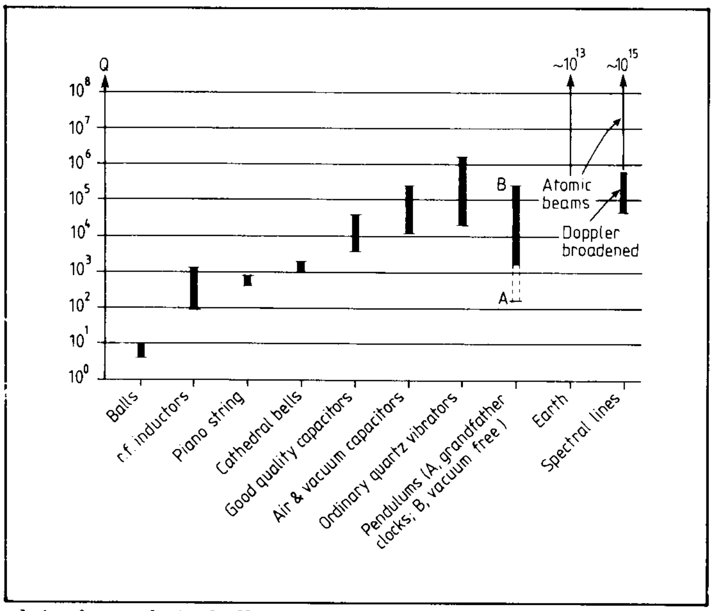

Fig. 6. Shown here is a schematic representation of the Q of some periodic systems and devices met in technology and everyday life.

Q is everywhere

The use of Q rapidly proliferated. *Any* periodic system was said to have a Q if it stored energy and dissipated it over time. From equation (1) a tennis ball can be tested for its Q, and there would be a relationship with its coefficient of restitution. Are we one day going to see advertisements from the makers extolling their "High-Q tournament balls..."? If wild claims were made, such as balls with Q of 1000, they would have to explain how their ball should still be rising to 37% of its initial height after bouncing 320 times. Actual balls possess Q of ~ 6 or 7. Table 1 gives a diagrammatic list of some typical values.

Even the earth, as a periodic system, has a Q. It was this very high Q that timed the world's clocks until recently – when higher precision atomic clocks took over, (the caesium clock). The earth has an irregular rotation period, mainly due to the seasonal sap rising and falling in the vegetation, but it has a monotonic decline in its period of around 1.64×10^{-3} per century. The energy stored in the earth's rotation is $\frac{1}{2}I\omega^2$ joules: I is its moment of inertia, ω the angular velocity. Therefore, from the energy lost in one period compared to 2 times the energy stored, the earth's Q is $\sim10^{13}$.

The ubiquitous Q is a remarkable idea that, although represented by just a single letter from the alphabet, has grown from Johnson's original ratio of reactance of a coil to its resistance, to encompass the vibrations of atoms on the one hand, to the rotation of the earth itself on the other. One day perhaps we shall hear about the Q of the Galaxy. . . .

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by P.B. Unstead
and A. Blunden

Data logger for Apple II

This eight-channel analogue interface can be driven by the real-time clock described in April, or may be adapted for other 6502 systems.

Range of sampling intervals available with the data logger. Timing interrupts can be obtained either from the versatile interface adapter i.c. or from the real-time clock.

Timing device	Unit chosen	Minimum period	Maximum period
v.i.a.	ms	0.001s	0.256s
v.i.a.	1/16s	0.0625s	16s
r.t.c.	s	1s	4min 16s
r.t.c.	min	60s	4h 16min
r.t.c.	h	1h	10 days, 16h
r.t.c.	day	1 day	256 days

The interface is based on the RS7581LN c-mos chip, an eight bit, eight channel monolithic memory-buffered data acquisition system which uses successive approximation conversion.

The converter free-runs and stores its results in an on-board 8 × 8 bit ram which is accessed through the address bus of the microprocessor. On-board address bus latches can be made transparent by tying address latch enable, ALE, pin 16, high.

Data is made available to the processor via a tristate buffered data bus. Chip select, $\overline{CS}$, pin 13, activates the buffers to place the addressed data on the bus during a read cycle. The ram is updated only when the microprocessor is not addressing the converter memory.

Conversion of a single channel takes 80 clock pulses; the complete scan through all eight channels, controlled by an internal multiplexer, therefore takes 640 cycles.

With a 1MHz clock applied to pin 15, the input signal frequency for a sinusoidal input on any one channel should not exceed about 800Hz. However 400Hz would be a more suitable limit for reasonable reproduction, without aliases, of the input signal waveform.

A status signal, pin 12, indicates when a conversion is complete but it is not used in this design. Another detail of interest is pin 1, an offset voltage adjustment to allow the converter to be set up correctly in conjunction with the reference voltage on pin 10.

The 7581 appears to the processor as eight read-only memory locations which, for the Apple II interface, are located at $C0B0 to $C0B7 using the signal $\overline{\text{DEVICE SELECT}}$ available from pin 41 of the edge connector.

For other machines, the address bus may have to be decoded to produce an equivalent signal. The simplest way of achieving this would be to use a multi-bit comparator, such as the ten-bit device DM8130, with a bank of dil switches and resistors (Fig. 2a). The switch positions could then be used to locate the device in the system memory map as required since the output would be high only when the two input binary words were the same.

If this is wasteful of address space, through insufficient bit comparison, a three line to eight line decoder, 74138, could be added to produce complete decoding; or alternatively more than one comparator could be used. A possible solution using a 74138 is shown in diagram 2b.

For this method the active-high output from the comparator would need to be inverted to drive the enable inputs G_{2a}, G_{2b} of the decoder. The $R/\overline{W}$ line of the processor can then be used to control the G_1 input to produce a fully decoded signal, from the appropriate Y_n output, to operate $\overline{CS}$ on the 7581. For the Apple II $\overline{\text{DEV SEL}}$ is inverted before being gated with $R/\overline{W}$ to provide the read-dependent chip-select.

To achieve the specified performance V_{ref} should be set to −10V. With the Apple this is achieved by a zener diode and a series resistor across the −12V

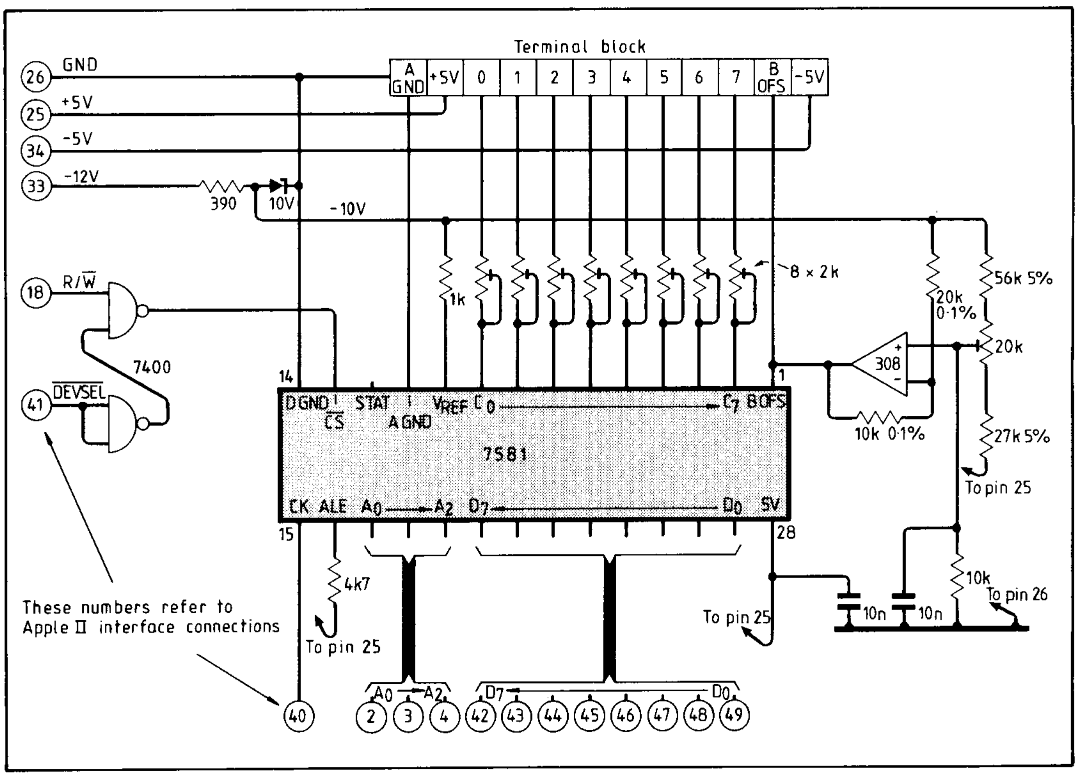


Fig. 1 Apple II interface for 7581. This converter offers an input voltage range of ±5V with a single offset adjustment for all channels.

output at the edge connector.

Each input channel has its own gain-trimming potentiometer. Without this, its analogue input resistance is typically 20kΩ. The circuit configuration in Fig. 1 is for bipolar operation and requires an offset facility with gain. That for unipolar operations requires only a unity gain buffer.

Replacing the feedback resistor around the 308 amplifier with a short-circuit and removing the 10kΩ resistor on its inverting input will convert the circuit to unipolar operation with an input range of 0 to 10V. Further range changing can be achieved using series resistors.

For bipolar operation the output code is offset binary whilst for unipolar operation the output is pure binary. The accompanying software is for bipolar operation.

Calibration

The system may be calibrated for a weighting of 40mV per l.s.b. as follows. Set up an input voltage of −5.06V between channel 0 input and ground. CALL (51968) and select all eight input channels, one second intervals and, say, $4000 bytes. Adjust the offset potentiometer until the display flickers between −126 and −127. Reverse the polarity of the input supply and trim the input potentiometer until the display flickers between +126 and +127.

Repeat the last step with the input connected to each of the other seven channels. If after this procedure the channels do not all read zero with no applied voltage repeat all the calibration steps.

Real-time clock

Interrupts generated by the real-time clock (which occur every half-second) may be used to drive the converter. But if this sampling rate provides insufficient bandwidth, the a-to-d may be operated in conjunction with a 6522 versatile interface adapter (Fig. 3).

The v.i.a. occupies the same address space as the p.i.a. of the eprom programmer (May issue). That is, it is located at a base address of $C0C0 and occupies slot 4 in the Apple II, but it uses 16 register locations. For the present purpose we are concerned only with one of its two counter timers, T_1 the interrupt flags register, i.f.r., at base+D, and the interrupt enable register, i.e.r. at base+E.

For data logger operation, T_1 must operate in the free-running mode to generate a series of timed interrupts. With bits 7 and 6 of the a.c.r. set to 0 and 1 respectively, every time the count decrements through 0, the appropriate flag bit (bit 6 of the i.f.r.) will be set to 1. If the corresponding bit in the i.e.r. enables the interrupt, bit 7 of the i.f.r. will be set to 1 and the IRQ line from the v.i.a. to the processor will be taken low. At this time the counter will be reloaded from data stored in its latches to start the next timing sequence. This sequence is used in the subroutine 'viarun' included in the program listing.

In the interrupt service routine the interrupt flag is cleared by reading the content of the low order counter. All interrupts are disabled other than those from T_1, so that bit 7 of the i.f.r. is set when the timer times out.

When the v.i.a. timer is used to generate interrupts, those from real-time clock must be disabled using the 'disabl' subroutine given in the April article.

At the end of data acquisition, all interrupts are disabled by writing $7F_{16}$ to the i.e.r.

Software

The firmware is activated by CALL (51968); this allows an initialization procedure to be carried out as follows. Each of the eight analogue inputs is selected (or not selected) by entering 1 or 0 at the keyboard pressing RETURN on each occasion. The combination chosen is stored in zero page at $F9.

The interval between readings is selected by first choosing the unit (days, hours, minutes, seconds, sixteenth seconds, or milliseconds) and then the multiple of the unit. The 'disabl' subroutine from the clock firmware displays a clock face and the flashing cursor appears over DAYS. Each time 0 is entered the cursor shifts to the next digit until a 1 is entered; after 0 is entered for "seconds" the v.d.u. displays 16THSEC then MILLISEC.

The input from the process is used to vector interrupts through two different entry points to the interrupt service routine (i.s.r.) according to whether the clock or the v.i.a. is used. If the clock, the position of the active digit is stored in zero page; if the v.i.a., timer

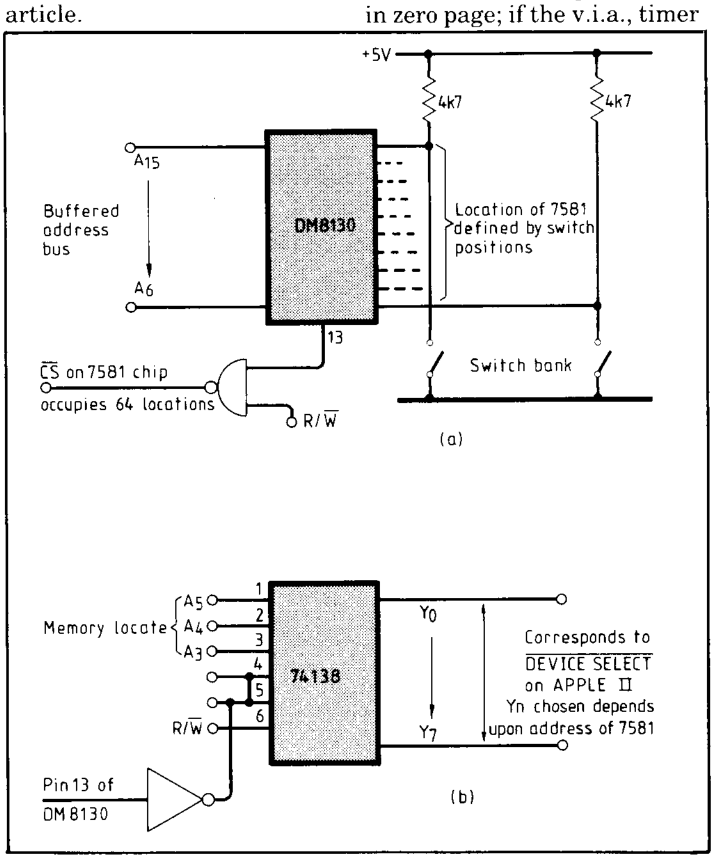


Fig. 2a. Using the a-to-d with other 6502 machines: a DM8130 and a bank of switches provide the necessary address decoding.

Fig. 2b. A three-to-eight line decoder completes the address decoding for the 7581.

Below: hex memory dump of the software. An assembly language listing is also available: details on the next page.

```
C848                      93 5E A0 40
C850  62 7A 40 86 90 82 9C 9C
C858  8A 98 40 AA A6 8A 88 93
C860  9C A8 8A A4 AC 82 98 63
C868  6C A8 90 5E A6 8A 86 9B
C870  92 98 98 92 A6 8A 86 75
C878  48 60 60 40 90 9E 5E 84
C880  B2 A8 8A A6 74 48 60 60
C888  60 60 4C AE CB 00 00 00
C890  B2 CF 4C BD CB 80 24 F4
C898  B2 CF 4C BD CB 80 E8 03
C8A0  B2 CF

CB00  A9 17 85 23 A0 A7 A2 5F
CB08  20 4B CD A9 80 85 E3 A0
CB10  00 20 95 CD E6 E3 C0 28
CB18  90 F7 A0 03 20 9D CF 4A
CB20  66 F9 C8 C8 C8 C8 C8 C0
CB28  27 90 F1 A2 67 A0 A2 20
CB30  4B CD 20 4F CF A2 0A CA
CB38  CA F0 0F BC D3 CF 20 9D
CB40  CF 4A 90 F3 84 FF A2 92
CB48  D0 20 A2 6F A0 90 20 4B
CB50  CD 20 9D CF 4A 90 04 A2
CB58  9A D0 0F A2 77 A0 90 20
CB60  4B CD 20 9D CF 4A 90 C3
CB68  A2 A2 A0 08 BD FF C7 99
CB70  F7 03 CA 88 D0 F6 A2 7C
CB78  A0 A7 20 4B CD A0 A4 A2
CB80  05 20 0B CD 85 E3 20 E0
CB88  CD AD FB 03 D0 03 4C F5
CB90  CE A9 40 8D CB C0 A9 3F
CB98  8D CE C0 A9 C0 8D CE C0
CBA0  AD FC 03 8D C4 C0 AD FD
CBA8  03 8D C5 C0 58 60 20 5A
CBB0  CF A4 FF BE 50 07 E4 1F
CBB8  86 1F D0 04 60 AD C4 C0
CBC0  C6 E3 D0 35 A2 00 A5 F9
CBC8  85 1E A0 00 46 1E 90 1C
CBD0  BD B0 C0 85 E3 8A 48 20
CBD8  92 CD 68 AA 20 8B CD 20
CBE0  7E CD D0 0D A9 7F 8D CE
CBE8  C0 4C 4F CF 98 69 05 A8
CBF0  E8 E0 08 D0 D7 A5 FE 85
CBF8  E3 A0 94 A5 E3 4C AC CD

CD90        20 D8 CD A2 A0 20
CD98  D0 CD A5 E3 08 29 7F 28
CDA0  30 07 A2 AD 18 49 7F 69
CDA8  01 20 D0 CD A2 A0 C9 64
CDB0  90 09 A2 B0 E9 64 E8 C9
CDB8  64 B0 F9 20 D0 CD A2 B0
CDC0  C9 0A 90 05 E9 0A E8 D0
CDC8  F7 20 D0 CD 09 B0 AA EA
CDD0  48 8A 99 50 07 68 C8 60
CDD8  A5 E3 A2 00 81 FA 60 60
CDE0  A0 A6 A2 8A 20 4B CD A2
CDE8  04 A0 A2 20 08 CD 38 A5
CDF0  73 E5 FC 85 73 85 FA A5
CDF8  74 E5 FD 85 74 85 FB 60

CEF0                   20 4A CF
CEF8  A4 FF BE 50 07 86 1F 60
```

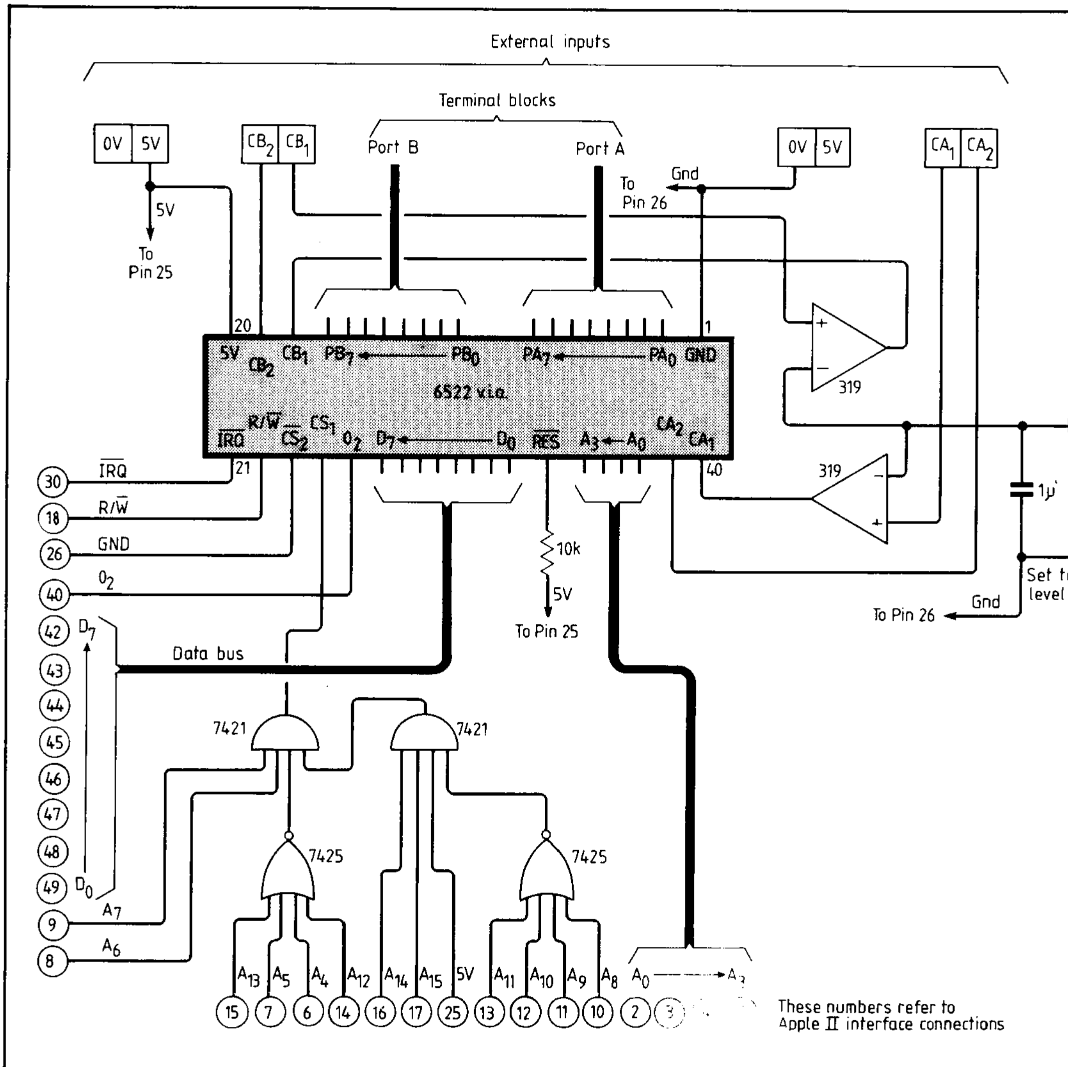
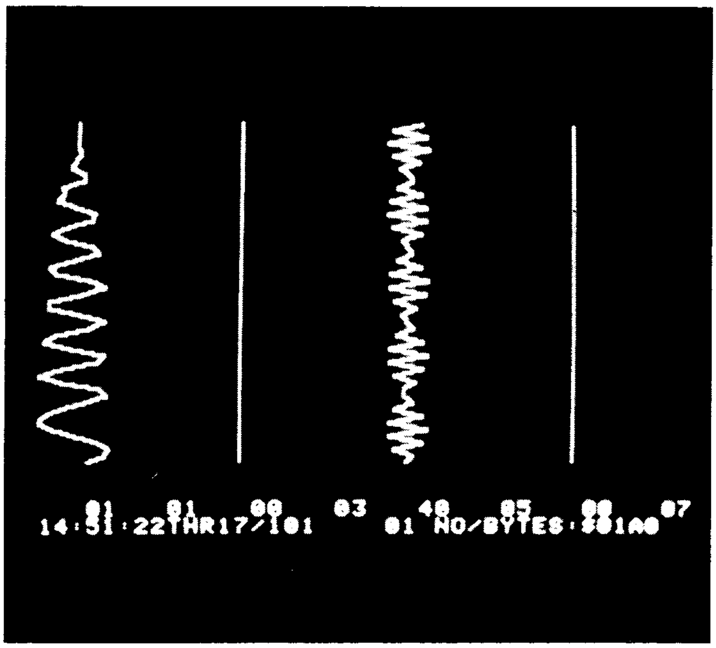


Fig. 3. For faster sampling rates, timing signals may be derived from a 6522 versatile interface adapter, which occupies the same address space as the p.i.a. described in May's eprom programmer article.

Screen display shows the converter in use as a simulated pen-recorder.



T_1 has its latches set.

The number of bytes, the products of the number of channels and the number of readings to be taken is then entered as a four digit hexadecimal number.

Acquisition begins when the return key is pressed for the last digit. One of the two routines "viarun" or "clkrun" is then implemented to enable interrupts from the v.i.a. or the real-time clock and control returns to the Basic operating system.

Interrupts from either the r.t.c. or the v.i.a. are serviced without affecting any registers of the 6502 processor, and so the data logger may be operated in parallel with a Basic program.

With the r.t.c. in use the i.s.r. updates the displayed time and checks the current value of the active digit. Acquisition begins on the first change. The i.s.r. clears the interrupt on the device and then displays a countdown on the v.d.u.

When the countdown times out, the i.s.r. rotates the zero-page location $F9, reads the a-to-d's data registers and stores each byte. As calibrated, $80 corresponds to 0V, ± 1 unit to ± 40mV. Readings are also shown in decimal, −128 to +127, on the screen.

When the specified number of bytes has been read, further interrupts from the r.t.c. and the v.i.a. are disabled, leaving on the screen the time at which data acquisition was completed.

The available intervals form a series of overlapping ranges as shown in the table. Note that the half-second interrupt generated by the clock is not precise and that intervals of less than 16 seconds should be defined in sixteenths of a second. Intervals defined in "16THSEC" and "MILLISEC" are measured by the v.i.a. and are precise, if the clock period of the processor is known.

To re-enter the code without re-selecting the channels used and the interval unit, CALL(52086).

The authors would like to record their appreciation of the help of George Rigelsford in developing these interfaces.

An assembly-language listing of the code given on the previous page is available from the editorial office. Please enclose a stamped, self-addressed envelope and mark your covering envelope 'Apple logger'. Readers overseas should include two international reply coupons for return postage.

In the next article, the authors describe a waveform recorder interface which enables measurements to be made on rapidly varying input signals. Conversion time is approximately 15us.

Faster Fourier transforms

by Weysel Omer

This last part completes discussion on input and output representations, illustrating the transformation process with Basic programs.

The four permutations of data presentation are shown in the diagrams. An extension to the program to print a table of the results in magnitude reponse form is suggested:

```
80 FOR I = &2C00 TO &2DFF
STEP 4
90 A% = !I
100 B% = !(I+&200)
110 PRINT SQR
(A%*A%+B%*B%)
120 NEXT 1
```

The real part of X(m) is referred to above by A% and the imaginary part by B%; the real data table starts 512 (&200) bytes before the imaginary data table.

Listing 5* performs the transformation of a square pulse with its output shown below, using the magnitude representation. An array is used to store the values of 1×(m) which are then plotted on a frequency axis such that 0Hz lies at the centre with negative frequencies to the left and postitive frequencies to the right. The axis extends over the range of frequency equal to twice the Nyquist frequency. The phase response for values of the harmonic number m is given by

$$\Phi = \tan^{-1}\left(\frac{\mathrm{ImX(m)}}{\mathrm{ReX(m)}}\right).$$

Since the phase response is derived from a ratio, an important point arises as to its validity under noisy conditions because two noise components can combine to yield phase errors. The effect can be reduced by establishing a threshold value of the computed Fourier coefficients; any value of Re X(m) or Im X(m) below this threshold is reduced to a miniscule value (not zero). No phase response routine is implemented here, but you should incorporate these thoughts when writing suitable software.

Listing 6 produces the spectrum of an 8Hz sinusoid, which confirms the result of a classical Fourier transform. The function defined in line 20 reads:

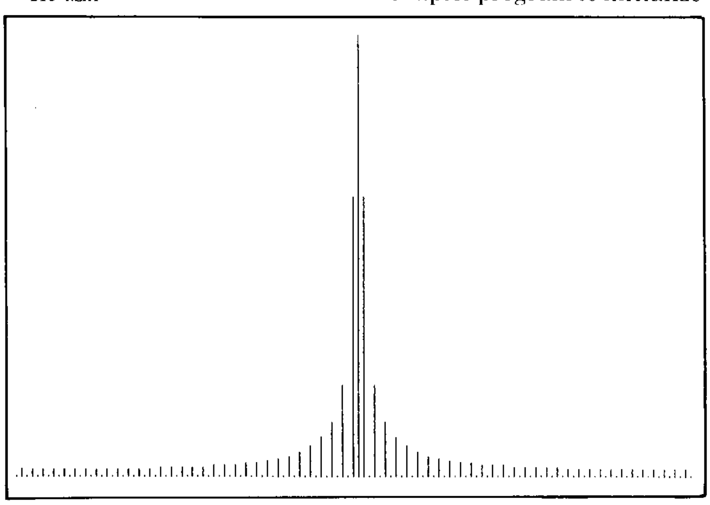
SIN(16*PI*I)

which is of form:

SIN(2*F*PI*t).

The number of cycles contained within the window is variable from 1 to the Nyquist limit of 64 (for N=128) i.e. if the window length is taken to be 1 second then the maximum frequency waveform that can be sampled is 64Hz. If a higher frequency waveform is to be sampled then the window has to be reduced accordingly. It is interesting to confirm the sampling concepts described earlier by including a non-integral number of cycles within the the sampling window; the effect of this is to produce a leakage effect. If the frequency of the sinewave is increased to beyond the Nyquist limits, the spectrum is subject to aliasing effects rendering the results meaningless.

```
10 MODE7
20 REM SQUARE WAVE
30 DIM X(128)
40 FORI=&25C5TO&2605:?I=1:NEXT
50 FORI=&2606TO&2645:?I=0:NEXT
60 CALL &2646
70 J=0
80 FORI=&2C00TO&2DFF STEP4
90 A=!I:B=I+&200
100 X(J)=SQR(!A*!A+!B*!B)
110 J=J+1
120 NEXT
130 MODE0
140 FORJ=64TO127
150 MOVE (J-64)*8,1
160 DRAW (J-64)*8,X(J)/10
170 NEXT
180 FORJ=0TO63
190 MOVE (J+64)*8,1
200 DRAW (J+64)*8,X(J)/10
210 NEXT
```

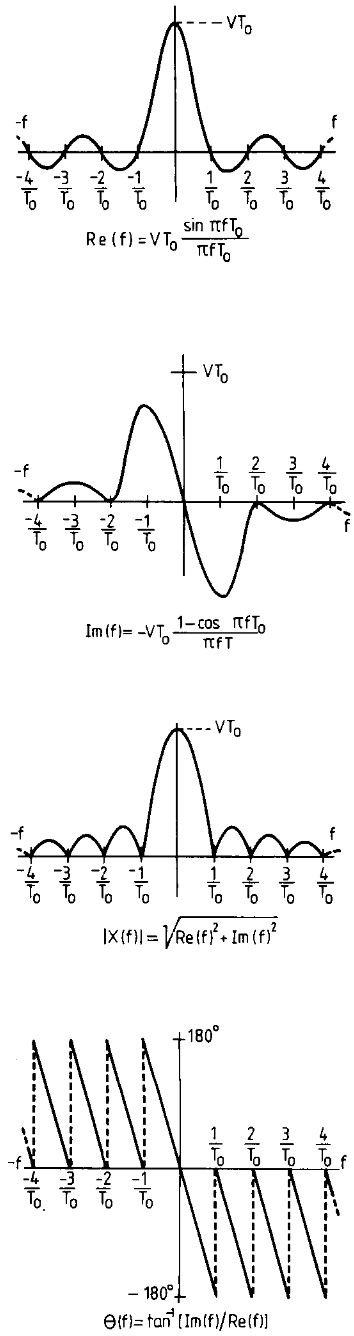


A second bit-reversal routine included in the FFT is conveniently used for pulse train transformations where each sample point can take only one of two discrete levels and it can thus be described by a single byte. For 128 sample points, only 128 bytes are required for an input buffer rather than the 512 bytes necessary in the arrangement discussed previously. This buffer is located in the area of memory, &25C6 to &2645, each location begins defined in the following manner:

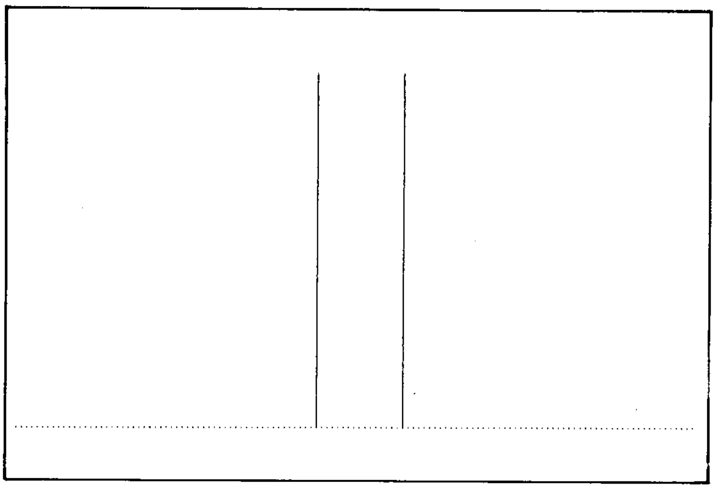
&XXXX = 0 lower discrete level
&XXXX ≠ 0 higher discrete level

The FFT assigns the positive level to an amplitude of 128 regardless of the non-zero value in a particular location. A simpler program to initialize

Four permutations of data presentation.



* Listings 1 to 4 appear on disc.



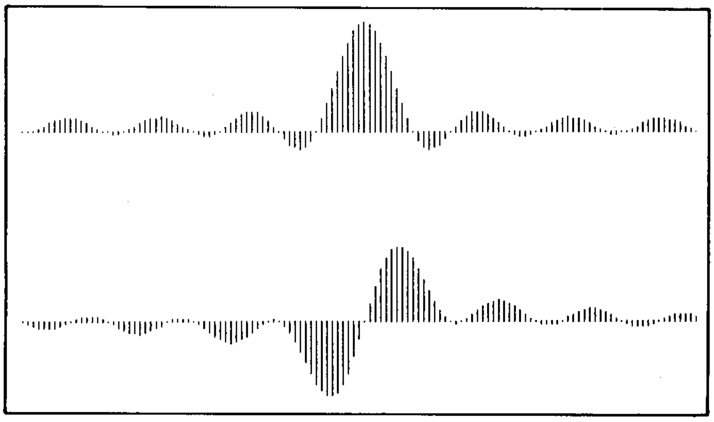
```
10 REM SINEWAVE
20 MODE 7
30 DIM X(128)
40 FORI=0TO128:X%=SIN(16*PI*I/128)*1024
50 !(I*4+&2200)=X%
60 NEXT
70 FORI=&2400TO&2600 STEP4
80 !I=0:NEXT
90 CALL &2175
100 J=0
110 FORI=&2C00TO&2DFF STEP4
120 A=I:B=I+&200
130 X(J)=SQR(!A*!A+!B*!B)
140 J=J+1
150 NEXT
160 MODE0
170 FORJ=64TO127
180 MOVE (J-64)*8,1
190 DRAW (J-64)*8,X(J)/100
200 NEXT
210 FORJ=0TO63
220 MOVE (J+64)*8,1
230 DRAW (J+64)*8,X(J)/100
240 NEXT
```

buffer with a square pulse is

```
10 FOR I = &25C6 TO &2605
20 ?I = 1
30 NEXT I
40 FOR I = &2606 TO &2645
50 ?I = 0
60 NEXT I
```

Note that an imaginary part is not required for the forward transform (for the reasons explained earlier). The FFT is called by the line:

```
70 CALL &2646
```



```
10 REM REAL AND IMAG PARTS OF A PULSE
15 MODE 7
20 DIM X(128)
30 DIM Y(128)
40 FORI=&25C6TO&2645:?I=0:NEXT
50 FORI=&25C6TO&25CD:?I=1:NEXT
60 PRINT"FFT START"
70 CALL &2646
80 PRINT"FFT FINISH"
90 J=0
100 FORI=&2C00TO&2DFF STEP4
110 A=I:B=I+&200
120 Y(J)=!B
130 X(J)=!A
140 J=J+1
150 NEXT
160 MODE0
170 FORJ=64TO127
180 MOVE (J-64)*8,600
190 DRAW (J-64)*8,X(J)/5+600
200 MOVE (J-64)*8,250
210 DRAW (J-64)*8,Y(J)/5+250
220 NEXT
230 FORJ=0TO63
240 MOVE (J+64)*8,600
250 DRAW (J+64)*8,X(J)/5+600
260 MOVE (J+64)*8,250
270 DRAW (J+64)*8,Y(J)/5+250
280 NEXT
```

References

1. The Fast Fourier Transform by E.O. Brigham, Prentice Hall.
2. Theory and Application of Digital Signal Processing by L.R. Rabiner and B. Gold. Prentice Hall.
3. Introduction to Communications Systems F.G. Stremler, Addison Wesley.
4. FFT Fundamentals and Concepts by R.W. Ramirez, Prentice Hall.

The entry point to the FFT routine is different to that of the previous input definition, because of the two-state bit-reversal routine, but the results of the transformation are stored in the same to input/output buffer. Adding the following lines causes the magnitude data of the pulse transform to be printed out:

```
80 FOR I = &2C00 TO &2DFF
STEP 4
90 A% = !I
100 B% = !(I+&200)
110 PRINT SQR
(A%*A%+B%*B%)
120 NEXT I
```

This program gives the same results as for those obtained from the previous (square pulse) program which used the four byte representation of the data elements. This merely alllows a simpler form of the input data for the special case of pulse trains. Listing 7 form the real and imaginary graphs for the transform of a pulse using this method. It is an interesting exercise to 'balance' a single pulse such that imaginary parts reduce to zero to produce an even function.

Application

From an engineering point of view, the FFT is best treated as a 'black box' the use of which merely requires of knowledge of the form of input and output data. Correct interpretation of results relies on an appreciation of time and frequency domains and their relationship via Fourier transform theory (ref. 4). The algorithm can be applied to such areas as systems analysis using convolution (multiplication in the frequency domain), communications and device testing (utilizing cross and auto-correlation).

The original work was completed using a BBC model B microcomputer and the article has assumed its use throughout; the FFT itself and bit-reversal routines are written in 6502 machine language and are transportable to any machine using this microprocessor with the area of memory defined in Fig. 8 free. Listing 3, which generates the rotation factors, is written in BBC Basic and must be converted into the resident Basic of a particular machine. Relocation of the routines is not easily carried out if the memory specified is not available but guidelines on the process of transfer can be made available if required. The Basic listings serve to illustrate various aspects of the use of the FFT algorithm and do not form part of the transform function.

The work presented formed the first stage of a final year project which has been extended to operate in two dimensions and applied to image processing. The one-dimensional transform discussed here can also be used in the area applied to image processing, called 'Fourier description'. In this application (sample number N) points are defined on the outline of an image and their co-ordinates are treated as on an Argand diagram (a+jb) and fed into the FFT input. The transformation of these co-ordinates into the frequency domain followed by a normalization process allows the recognition of similar shapes regardless of rotation or size. Furthermore, truncation of the frequency domain data down to the first eight harmonics still allows a reasonable approximation to the original image when inverse transformed. Thus an effective means of data compression is produced.

● In the last column of part one, page 25, the lowest frequency in the two buffer locations should read "d.c." of course, or zero frequency, and not "x" as printed. In Fig. 8 which unfortunately went uncorrected, please chance the second, seventh and ninth memory locations to 2200, 2B80 and 2E00. In the panel, letters a to e should accompany the illustrations, Fig. 2 referring to the table, whilst in column 4 the reference to equation x should be to (i). Mr Omer apologizes for the slip in column 3 where "m" should be k on the first three occasions.

The author's software can be supplied on disc from the editorial office. Send a formatted disc (Acorn DFS or Kenda DMFS, 40 or 80 track – please indicate which) and a stamped, addressed envelope for its return. Mark your covering envelope "FFT/Omer".

Adjustable accuracy

The sole source of inaccuracy in FFT calculation is in the multiplication of rotation coefficients and data words, and is due to the limitation in the number of decimal places of the sine coefficient table elements. Line 40 of SINGEN, defines a constant, 1024, to scale the sine coefficients into the integer format giving three decimal places of accuracy. This scalar may be varied to provide increased resolution for a particular application – bearing in mind the constraints identified in the earlier part of the article concerning overflow. At each combining stage the scalar must be divided to preserve linearity in the algorithm. Locations &2833 and &2974 contain this value as the number of bicimal places, initially set to 10 corresponding to 1024. If accuracy is to be increased, say to 11 bicimal places, then the rotation factor scalar (line 40 of SINGEN) would be 2048 and the appropriate locations would have their constants altered to 11.

CROWDED SPACE

It is often difficult to explain to non-engineers that a significant limitation exists for satellite communications systems and direct broadcasting from satellites because of the risk of "overcrowding" the geostationary orbit. "Over-crowding an orbit with a circumference of what must be over 150,000 miles? Impossible! is not an unusual reply.

It is of course not the limitations of physical space but of the available frequency spectrum and of the directivity of the antennas on the satellites. The smaller the antennas the more chance of co-channel or adjacent-channel interference as orbital positions are brought closer together or, as for direct broadcasting, dishes are smaller. Some advantage can be taken of polarization discrimination (circular right-hand and circular left-hand) but the major problem remains that even weak interfering signals can severely degrade the quality of television pictures in the form of "ghosts" or by providing annoying "echoes" on speech.

Work at Ohio State University, supported by NASA, on adaptive antenna arrays designed to reject even very weak interfering signals (Inder Gupta and Aharon Ksienski, *IEEE Trans. Vol AP-34*, No 3, March 1986) suggests that since the spectral characteristics and modulation techniques of desired and undesired signals are normally the same, even co-channel signals several decibels below the noise level can cause objectionable interference. Ghosts and echoes are more annoying than 'snow' or static: "Very faint wavy lines across a television picture are more easily detectable by the human eye than by an instrument and this makes their suppression difficult though necessary."

Whereas the carrier-to-noise ratio of the f.m. signals on a satellite link might be 15dB, undesired signals at levels 10 to 30dB below this can result in objectionable interference.

The authors claim that although adaptive satellite antennas have been developed to reduce interference they cannot conventionally suppress very weak interfering signals, since thermal noise is the major source of degradation and dictates the array weights Their work has involved the modification of feedback loops, reducing the noise level in them by reducing the correlation between the noise components of the two inputs to the loop correlator.

Adaptive arrays specially for the rejection of television co-channel interference on u.h.f. vestigial-sideband broadcasts signals were developed in the late 1970s by an IBA team, and two such arrays are currently used to provide programme links to the Channel Islands; originally from Plymouth (Stockland Hill, Devon) and more recently from Southampton (Rowridge, Isle of Wight). However, since these are not f.m. systems, there is no requirement for them to adapt to reject very weak signals below the noise level, but rather to insert deep, highly-directive nulls on unwanted signals.

The thinking behind the work at Ohio University is that such adaptive arrays would allow satellites to be spaced closer together, so increasing the maximum number of systems.

TUTORIALS

Most of the regular international conferences organized by the professional institutions have settled into fairly established patterns. It is therefore interesting to note that the IERE for their fourth "Radio receivers and associated systems" conference (University College of North Wales, Bangor, July 1 to 4) have designated the first day as a "tutorial day" covering topics related to the main theme of the conference but offered to both delegates and non-delegates.

Tutorials will be given on frequency synthesis and phase-locked loops; cryptography; digital signal processing; modulation and coding; spread-spectrum techniques; and gallium arsenide applications.

The IERE are also responsible for the organization of the fifth international conference on electromagnetic compatibility (September 30 to October 3, University of York). This will include sessions on improving immunity to interference arising within printed circuit boards, e.m.c. education, measurement of emissions from antenna systems, test methods and specifications. Again, the first day of the conference is being given over to tutorial papers on spectrum analysis, screening, suppression components and filters, electromagnetic pulses, measuring techniques and instrumentation, designed for those with limited previous knowledge of the many and increasing problems of e.m.c. A 30-stand trade exhibition is also being organised.

It would seem that a "tutorial day" may become a permanent feature of such international conferences.

BOOM OR BUST?

In the 1986 *National Electronics Review*, Dr William Gosling notes that "the history of technology is written as a history of firsts", although this is not the case in other fields of human genius. Whereas we value great paintings as monumental achievements in their own right "the whole pattern of Western technical and scientific thought is based on an assumption of ceaseless progress and development". He quotes Dr Ian Ross of Bell Laboratories that "technologies come in two kinds: those which are exponentially developing and those which are unimportant." Dr Gosling writes: "We take it for granted that the science and techology of today will necessarily differ in essence from that of yesterday, and will be better. It is just because of this, because we know how very high we shall subsequently build, that we particularly honour those who lay the first foundations."

Dr Gosling undoubtedly reflects widely-held attitudes towards the history of technology. But the assumption that progress is science is pervasive and irresistible and that a particular technology either grows or dies, still widely held among technologists, is surely a view that today finds less support not only among the public but also among those who fear that it leads to a distorted view of the history of technology and may indeed be one reason why so many British scientists and engineers spend their working lives straining after the new rather than taking discoveries out of the laboratory and into the market place, by means of product development and good production engineering. It leads inevitably to the pervasive "not invented here" syndrome.

Dr Gosling credits Heinrich Hertz with first demonstrating the existence of electromagnetic waves, yet it was the commercially-minded Marconi who is regarded, with some justification, as the "inventor" of radio, just as, with far less justification, the British public have pinned the label "inventor of television" on Baird and with some, but only partial justification, "inventor of radar" on to Watson-Watt. Perhaps if we took more care to get our history right, we might get our electronics industry in better shape. In turn, this might reduce the tendency to jump on fashionable research bandwagons and to realize that there is often exciting new ideas to be found in old technology.

HI-TECH PAPER

The continuing popularity of thermionic valves for amateur radio transmitters has endorsed the saying that "had the transistor been invented first, the valve would have been hailed as the answer to all our problems". Professor Igor Aleksander of the Kobler Unit for the Management of Information Technology at Imperial College, in advising businesses to show a healthy degree of scepticism towards the "paperless office", puts it similarly that had computers been invented before paper, the latter would be hailed as "as a remarkable achievement of high technology, permitting much information to be stored at a fraction of the cost of the magnetic medium". He postulates whether computer storage of, for example, diary events may be superseded by "those natty little bits of yellow paper which may be stuck (temporarily) on the nearest wall or even on the face of the nearest video screen." Such paper labels are designed to be peeled off easily when they have served their purpose.

STEREO DRAMA

With the growing expectation of stereo sound becoming available in the UK on both satellite and terrestrial television broadcasting, it is interesting to consider how producers will cope with the added problems of stereo on a relatively small screen. There is the continuing problem of the studio environment where many people are likely to be working and contributing to the ambient noise. More importantly, with the exception of, for example, stage opera, where the cameras will normally all shoot from the front of the stage, drama production involves frequent variation of shot, involving changing camera angles. Studio practices will thus need to be adjusted to make sure that effective use is made of stereo.

If cinema film practice is adopted, most dialogue is likely to be recorded in mono, leaving it to appear as coming from the centre of the screen, with only the sound effects dubbed on in stereo. Film technicians argue that "dialogue popping around even a wide screen is jarring and difficult to understand." Even in some Hollywood major productions such as "Star Wars" which featured elaborate stereo dubs, very little of the dialogue was actually planned to match characters away from the centre of the screen.

MORE PACKETS

The RSGB is pressing the DTI for licence changes that will open the way to the establishment of an extensive network of packet radio repeaters ("digipeaters") linking around 40 major UK cities and towns with a large number of smaller towns and villages. This would in effect provide an 'electronic mail' system for use by licensed radio amateurs. At present there are doubts whether digipeaters represent a form of third-party message handling, although some European countries, including West Germany, do not regard messages from and to licensed amateurs, when passed through intermediate stations, as being third-party traffic.

There is, undoubtedly an increasing interest among UK amateurs in packet systems based on the X.25 protocol, permitting the sharing of channels by a considerable number of stations, though some are doubtful whether what is essentially a depersonalized form of communication is likely to have the same long-lasting appeal as a hobby activity once the technical and software challenges have been overcome, as speech and manual morse.

The RSGB, however, foresees the future development of a world-wide packet network as appealing not only to existing amateurs but as attracting into the hobby many new people, including computer hobbyists.

CLASS B MORSE

The DTI have confirmed that as from May 2, 1986 all holders of Class B licences may use morse code on a permanent basis, provided that operation is restricted to the frequencies covered by the Class B licence. This follows the experimental year during which holders of Class B were able to apply to the RSGB for a "letter of variation" permitting the use of morse for a twelve-month period.

There is evidence that a significant number of Class B licensees took advantage of this facility and as a result have been able to bring their operating speed up to the 12 words per minute needed to obtain a Class A licence with its use of h.f. bands.

There remains, however, a number of Class B amateurs who are antipathetic to the morse code and continue to press for the right to operate on the 28 MHz band, although it seems unlikely that the DTI would breach the ITU Radio Regulations that require morse test below 30 MHz, though this does not rule out, for example, a code test at say five words per minute for a novice licence.

The RSGB is still engaged in setting up its promised country-wide morse-test centres, but in the interim period tests are being held at a number of the mobile rallies.

G2DX FAREWELL

Ken Alford, G2DX who held an amateur experimental licence for almost three-quarters of a century, died in March, aged 92 years. He was one of the last survivors among those who had held the three-letter "experimental" callsigns issued by the GPO before the Great War, 1914-18.

His spark transmitting station (TXK) was one of the first to be described in *Wireless World* and on August 2, 1914 he received the German message from POZ (Nauen) announcing the outbreak of war with France and Russia. He was also one of the first people to transmit from an aircraft in flight, using his own spark transmitter.

For many years he was professionally concerned with the development of military radio equipment at Woolwich. He played an active role in the original 'Transatlantic Tests' of the 1920s. In retirement he remained an active amateur transmitter until quite recently. The callsign G2DX, dating from 1920-21, was in use for some 65 years.

Another early user of aircraft radio, Jim Tovell, G5LQ has also died, aged 88 years. As a radio-operator with the RN and RFC during the 1914-18 war, he made a "first" air-to-ground radio contact while flying over Istanbul (then Constantinople).

RADIO

The International "language" of radio operators stretches back far further than many people realize. The international Q code was formulated about 1912, but far older is the abbreviation "73" meaning "best regards". This dates back to 1859 when an American telegraph committee was formed to devise a code to reduce standard expressions to symbols or figures to save transmission time.

1 stood for "Wait a minute", 5 for "have you anything for me". 13 for "I do not understand"; 22 for "love and kisses" (curiously the symbol 88 has replaced 22); 73 for "my compliments" or "best regards".

Only "73" of the original list has survived unchanged. An altogether more debatable symbol is 55 ("much pleasure") that appears to have originated in Germany about 1947. There is a strong suspicion that this was derived, as a form of black joke, from the almost mandatory pre-war German abbreviation HH ("Heil Hitler") simply by adding a dot to each H to make the five dots of 5. Today, entirely unwittingly, it is used by many amateurs.

SATELLITES

A colloquium on the amateur radio satellite service is being organized by AMSAT-UK in conjunction with the University of Surrey, Guildford. It will be held at the university on the weekend of July 5 and 6, with some overnight accommodation available. Topics to be covered will include the latest information on the Russian satellites, RS9 and RS10. Karl Meinzer, DJ4ZC is expected to describe progress on the high altitude Phase 3C satellite project.

The first Japanese amateur satellite, JAS-1, could be launched this autumn as part of the load on a test flight of the Japanese H1 launch vehicle. This medium-altitude satellite will carry two mode-J transponders (145 MHz up, 435 down). One of the transponders is for digital store-and-forward applications. Satellite users are finding increasing difficulty with 145 MHz downlinks due to the very crowded state of the band in the UK and some other parts of the world.

PAT HAWKER G3VA

Leetronex

1–3 JULY 1986

Leeds Electronics Exhibition

The 1986 Leeds Electronics Exhibition will be held in the Department of Electrical and Electronic Engineering at the University of Leeds.

Among the exhibitors will be:

Ampicon Electronics Ltd, Stand 200. On the Amplicon stand will be a number of products from National Instruments who specialize in IEEE-488 interfaces. They not only include GPIB interfaces for a number of computers but also instruments which will convert the computers into, for example, GPIB analysers for testing and debugging networks of test instruments. **EWW 250**

Electronic Components Ltd, Stand 61 are showing a new two-wire data transmission system for monitoring and control. The Dupline system can transmit 128 mutually independent signals in any direction over distances up to 20km through two-wire cable. It is possible to interconnect and control a network of remote transmitter modules with one multi-channel generatcr. **EWW 251**

Lucas Semicomps Ltd, Stand 29 are offering components from a number of manufacturers but have taken, as a theme, display devices. Featured are display modules by Racal. **EWW 252**

Chase Electronics Ltd, Stand 53 is the UK representative for Advantest who offer an extensive range of instrumentation from d.c. to microwave frequencies. Of note: 60GHz spectrum analyser; 3.5GHz portable spectrum analyser; and a dual channel f.f.t. digital spectrum analyser. Chase's own products include measuring and monitoring instruments for mobile radio. **EWW 253**

Rittal Ltd, Stands 34, 35 & 36 are exhibiting a selection from their range of 19in racks, enclosures, instrument cases and consoles. Various standards are met for e.m.i. and r.f.i. protection for sensitive equipment. **EWW 254**

Thorn EMI, on **Stands 64 & 65** are showing instruments from the Systron Donner division, including the model 1502 signal generator covering 100kHz to 2.5GHz with 1Hz resolution. Frequency or level sweeps are provided, as is a.m. or f.m. applied internally or externally. **EWW 255**

On **Stand 111,** Thorn EMI Datatech offer a range of portable and laboratory instrumentation tape recorders, and high-density recording systems. **EWW 256**

Tinsley Strain Measurement, Stand 57 have a new Multi-Monitor developed for measuring strain, volts, microvolts and temperature with seven different thermocouple types. TA880 also offers thermocouple simulation, linearity checking and communication to a computer or direct to a printer through GPIB or RS323. Seven outputs are included. **EWW 257**

Farnell Instruments Ltd, Stand 25 & 26 will be showing a number of new products; a portable communications test set which combines all the necessary facilities in one unit to test transmitters and receivers up to 520MHz. Their 352C is a portable spectrum analyser intended for monitoring spurious radiations in the range 300kHz to 1GHz. The LB series of bench power supplies with outputs up to 30V at 2 or 4A can be controlled locally or through a GPIB. DTS12T is a 12MHz dual-trace d.s.o. that has GPIB and BBC model B interfaces. **EWW 258**

Computer Solutions Ltd (Comsol) are returning to Leetronix with Interactive Cross Target Compilation (IXTC) which produces compact and efficient code for single-chip microcomputers. The development software runs on a standard PC running the multi-tasking PolyForth. Real-time signal processing will be demonstrated on the Novix NC4000 Forth processor. **EWW 259**

Kontron Electronics Ltd, Stands 31 & 32 have a logic analyser with up to 64 channels, each with 2K of memory and a sample rate of 500MHz. Their development systems division has come up with KPDS, the means of converting an IBM PC into a microprocessor development system with the ability to accommodate all the popular 8 and 16-bit processor families. Coupled with a slave logic analyser it enables simultaneous analysis and emulation. **EWW 260**

Elex Systems Ltd, Stand 120 are showing their p.c.b. layout and schematic capture software for the personal computer. The Analog Workbench is a design and development tool for linear circuits. **EWW 261**

Gould Electronics, Stands 43, 44 & 45 The highlight on Gould's stand will be on three real-time (i.e. analogue) oscilloscopes with bandwidths of 60, 100 and 150MHz. Each features on-screen cursor measurement. They are also showing d.s.os, logic analysers and strip/chart recorders. **EWW 262**

Lawrie T & M Ltd, Stands 14 & 15 are launching the LAT3 logic system which integrates the Zicon logic analyser with the BBC Master computer. The 20MHz analyser has 1K of memory for each of its 40 channels. They have also produced a portable version of the BBC Master which can be battery-powered and can have a built in Eurocard rack. A kit is available to convert a Master to the portable version. **EWW 263**

Cropico Ltd, Stand 113 have a range of test and measurement instruments that includes counters, insulation testers, resistance and voltage counters. New is a hand-held digital wattmeter and the mode D1218 multimeter intended specifically for the commissioning electrician with a 30A a.c. range, phase sequence indication, temperature measurement with a type-K thermocouple and storage of maximum and minimum recorded values. These facilities are in addition to the usual multimeter functions. **EWW264**

Tektronix UK Ltd, Stands 9, 10, 11 & 12 are introducing several new products, but perhaps the star of their stand and maybe the star of the show is the DAS 9200 modular digital signal analysis system. Fully expanded, the instrument can acquire 540 channels at 20MHz with 32K deep memory for each channel; or 432 channels at 200MHz with 4K memory; or even 160 channels at 2GHz with 8K memory/channel. It can also provide up to 180 output stimulus channels at 50MHz with 8K memory depth. The interactive triggering and pattern generation facilities allow an intriguing possibility of testing a part-finished circuit with the unfinished parts being simulated by the system. Can be used for hardware development systems at the board or integrated circuits level; including verification of asics. And for software analysis. **EWW 265**

Electronic Brokers Ltd, will be displaying test instruments from Marconi, Philips and Grundig. **EWW 200**

And Electronics & Wireless World on Stand 62

NEW PRODUCTS

Data acquisition

A range of data aquisition modules are available from Adac for use with DEC LSI 11 series Q-bus computers. Basys is a family of plug-in modules used in conjunction with Fastrak, a high-speed system acquisition system. They can be configured to meet the user's requirements with modules and termination panels specific to the type of transducer used and the number and speed of the input channels. Suitable si..gle or multi-user software operating under I/O Basic is also available. Adac Corporation (Europe) Ltd, PO Box 42, Epsom, Surrey KT18 7SP.
EWW 211 on the reply card.

An 'intelligent' data logger, the Quartel from Gulton, automatically identifies and selects the most important data, and measurement fluctuations, by constant comparison of new data with that already recorded. It incorporates an adaptive memory system that adjust to the data it is storing to provide optimum resolution and accuracy for periods up to 100 days. Quartel has four input channels which accept analogue signals, three of them also accepting digital information. Review and analysis of data is provided by a versatile software package designed to operate on IBM PC, compatible PCs, and on the BBC micro. The graphics program enables detailed expansion of significant data to be displayed. The same program also enables vertical or horizontal screen splitting to allow comparison, investigation and analysis. Programming of the type of sensor, recording time, real time (including date), recording start, playback and channel display can all be controlled by the user. Gulton Ltd, Graphics Instrumentation division, Maple Works, Old Shoreham Road, Hove, Sussex BN3 7EY.
EWW 212 on the reply card.

Many switching and interfacing problems can be solved by the PPM 8200 switching system. It can switch signals from 1μV to 240V r.m.s, up to 5A, with frequencies from zero to 18GHz. It can also measure 10μV to 750V at sampling rates of up to 18000/s:digital input/output is also provided. The instrument can read and control synchronizers and resolvers. It communicates with a computer through GPIB.

PPM also make a multi-tasking, multi-user, distributed data logger with high-resolution colour graphics. Based around a 6809 processor running OS/9, Magus supports up to four concurrent graphics controllers to provide different status information in parallel. Up to 20 tasks can be run concurrently, allowing more than one data collection or control loop to be processed at a time by independent users. Extensive I/O capabilities include a 16/12bit a-to-d converter with 0.75μV sensitivity; signal conditioning unit for d.c. inputs as provided by thermocouples, strain gauges, p.r.ts and signal transmitters; and direct voltages from 0 to 10V. Reading rates are 16 channels/s in 16-bit and 1000 channels/s in 12-bit modes. Memory can be expanded up to 1Mbyte for large programs, with mass storage up to 50Mbyte. The data collection front end can be up to 1km from the master unit. Individual signal conditioning cards can be up to 200m from the Magus logger, thus reducing transducer wiring to a minimum. PPM Instrumentation, Hermitage Road, St. Johns, Woking, Surrey GU21 1TZ.
EWW 213 on the reply card.

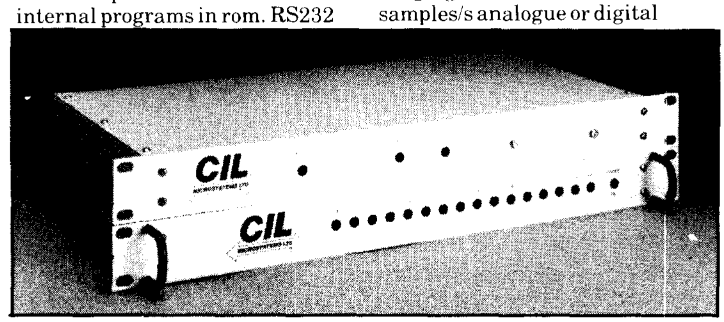
CIL Microsystems have produced a data logging system, the DTR 1680, for use with RS232 or GPIB, especially designed for strain gauges, thermocouples and millivolt signals. The system is designed around the PCI 16-bit a-to-d converter with the addition of 24 channel input conditioning and multiplexer units to provide direct measurement at low signal levels. Each a-to-d converter thus has the capacity of 192 channels with possible expansion to over 2000 channels. The hardware is complemented by a selection of software packages for a variety of popular microcomputers, including the IBM PC, Apricot, Commodore, and Apple IIe. Example programs are provided to demonstrate the techniques used to acquire data and control the system.

A more modest box from CIL, the Jay, takes one module at a time from a range that includes temperature, d.m.m, strain, calibration and simulation. It incorporates a Z80-based microcomputer which has its internal programs in rom. RS232 communication is an optional extra. CIL Microsystems Ltd, Decoy Road, Worthing, Sussex BN14 8ND.
EWW 214 on the reply card.

A stand-alone data gathering system that can also interface with a computer is provided by the Translog 500. This consists of plug-in transducer-scanning modules and microprocessor control to offer retrieval, recording, alarm monitoring and processing of data from transducers. The controller is fully programmed with a large range of data logging functions so that the host computer can easily control the operation of the data collection by calling up these standard routines. In addition to the internal operating system within the controller, there is an interactive applications systems programme for an Apple IIe computer which is supplied as part of the basic package. Additional software can be supplied to suit specific applications or for other computers. The E500 can also communicate with other computers through an RS232c interface.

The various data scanning modules include the l.v.d.t. module for up to eight inductive transducers; an eight-channel strain-gauge module and a large-signal (up to 50V) scanner module. The system is under the control of a multi-purpose instrument controller which supervises the operation of the other modules, addresses the required channels, supplies the zero and scale constants and carries out the a-to-d functions. It is a single-board computer with a 15-bit resolution a-to-d converter. Up to 32 modules can be addressed by the controller to provide a total capacity of 256 channels. R.D.P. Electronics Ltd, Grove Street, Heath Town, Wolverhampton, W. Midlands WV10 0PY.
EWW 215 on the reply card.

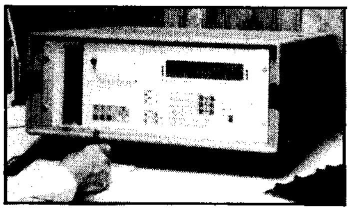
A wide range of interface boards will turn an IBM PC (and compatibles) into a data aquisition system. The series includes analogue input/output boards. ranging from the Dascon-1 with 30 samples/s analogue or digital



interface to the Dash-16 which has the capacity for 50k samples/s and includes direct memory access. There is a 24-bit parallel digital i/o board and communications interfaces for GPIB and RS 232. An additional analogue output board is available for the Apple PC. An additional range of boards use the proprietary Metrabus system to connect several interface cards to a parallel communications bus. A driver board plugs into the IBM PC (etc.) and it can cope with 512 digital or 256 analogue inputs. Additional driver cards boost the capacity of the PC into thousands of channels. The card is connected to the interface boards through the Metrabus cable which carries all data and control signals and the power required. The system as a whole can be used for energy management, factory automation, product testing, process control and other areas requiring large numbers of analogue/digital I/O points.

Metrabyte products are available in the UK through Keithley Instruments Ltd, 1 Boulton Road, Reading, Berks RG2 0NL.
EWW 216 on the reply card.

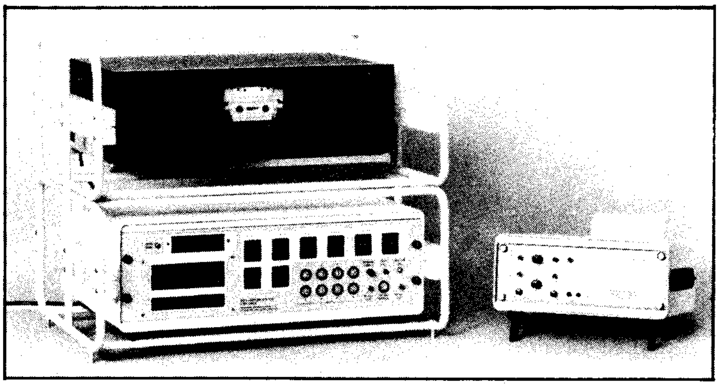
Each input on the analogue or digital scanner cards of the M 1800 from Microdata can be configured by the software to the sensor in use, which can be of virtually any type; analogue inputs, alternating or direct voltages or currents, resistances, p.r.ts, thermocouples or strain gauges. Digital functions include pulse and frequency counting, events, status and parallel data entry. Up to six



scanners, with internal or external start/stop and triggering, plus various delay options, make easy the programming of complex logging routines, at rates up to 100 channel/s. The M 1800 accept 100 inputs and expansion is possible up to 500. The instrument uses a logical menu for input configuration, scanner programming and other instructions. It has its own 160-character display and an alpha-numeric keypad for input. The internal software reduces and converts the raw data into engineering units before it is logged. It also supervises the logger's control/alarm output lines. An integral tape cartridge unit can store programs or data (up to 200 000 readings) and a built-in printer offers a hard-copy record of the readings. RS232c serial ports enable control and output of data on or off-line. Microdata Ltd, Monitor House, Station Road, Radlett, Herts WD7 8JX.
EWW 217 on the reply card.

An eight-channel waveform capture system works in conjunction with the HP98165 16-bit microcomputer. The system 1298 is thought to be of special interest to those who wish to replace pen plotters or tape recorders with a computerized system, offering an integrated package to take over from test rigs built from many separate units. Another product from Datalab is Multitrap, a very flexible data acquisition system that offers up to 200 channels and a choice of a-to-d converters to match the application. It has GPIB and/or RS232 interfaces and direct memory access as standard with memory from 16K to 128K per channel. These segmented to make optimum use of all available memory. Data Laboratories Ltd, 28 Wates Way, Mitcham, Surrey CR4 4HR.
EWW 219 on the reply card

An interesting applications story comes with the literature describing the Hereford Microsystems' D800. It uses a stereo cassette recorder to log the data. When investigating noise at power stations and other installations, it was possible to record the noise on one channel while recording the weather data (wind speed and direction, and temperature, humidity) that can affect the perceived noise, on the other channel. The system could of course be used to record any simultaneous analogue and digital events and to establish a causal relationship between them. The instrument offers eight transducer channels, which may be expanded, and is particularly suited to long-duration studies with from 1 to 99 minutes between samples and a sample duration of between 1 and 99 seconds. The main processor accepts plug-in cards for conditioning the input signals. A range of cards is available, as are blanks with which the user can build specialized circuits. A supervisory module can be included which, amongst its other functions, will allow the eight channels to be multiplexed and expanded to 14. The tape recorder is Nakamichi which has been modified to be controlled by the logger, to accept alternative power supplies and to automatically switch to the second side if the first has reached the end. A C60



cassette can typically acommodate 150 hours of sample recording. A decoder incorporating a 40-column printer constitutes the third part of the system. It can read back the digital information on the recorded tape. It is also provided with an RS232 interface to output the data to an external computer or other device. Hereford Microsystems Ltd, PO Box 60, Hereford.
EWW 218 on the reply card.

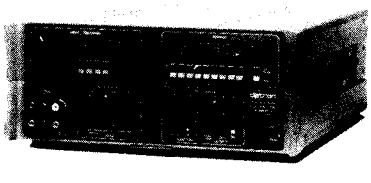
Claimed to be low cost is the Multi-Monitor Logger from H. Tinsley. It has direct output to a printer for 14 channels and can measure strain, temperature or voltage. Additional features include signal simulating and analysis of signals. Communicates through GPIB or RS232. The company also makes a multi-range thermometer bridge, and a strain gauge data logging system both with communication capabilities. H. Tinsley & Co. Ltd, Standards House, Imperial Way, Croydon, Surrey CR0 4TT.
EWW 220 on the reply card.

Communicating instruments

Apart from the data loggers described above, there are wide number of instruments which are usually self-contained but also offer communication to a host computer through a serial or parallel port. Of course, many of them are logic analysers or digital storage oscilloscopes and these are covered in other, similar articles in the magazine from time to time. We concentrate here on some of the other instruments which may be of use in the laboratory (though the odd d.s.o. or logic analyser might also creep in if it is particularly new or different!). Many of the major manufacturers produce enormous catalogues of such instruments. After all, Hewlett-Packard, for example, invented the system now known as the GPIB or IEEE488 interface, so that its instruments could be used interactively with a computer. Here are a few examples:

Calibrator for d.m.ms

Calibration requires accurate standards and the Autocal Multifunction Calibrator from Datron offers 90-day absolute accuracies to ±10p.p.m. with a linearity specification of ±0.5p.p.m. for its entire life. It is used to calibrate and check the linearity of five and six digit multimeters. It has current, voltage and resistance ranges and frequencies up to 1MHz. There are a number of options to meet



specific applications, including a 1kV standard which fits inside the instrument and eliminates the need for an external amplifier when checking the high-voltage, high-frequency facilities on some of the latest d.m.ms. It performs its automatic calibration tasks through an IEEE488 interface bus and can itself be automatically calibrated through the bus in a suitable standards calibration system. Datron Instruments Ltd, Hurricane Way, Norwich Airport, Norwich NR6 6JB.
EWW 221 on the reply card.

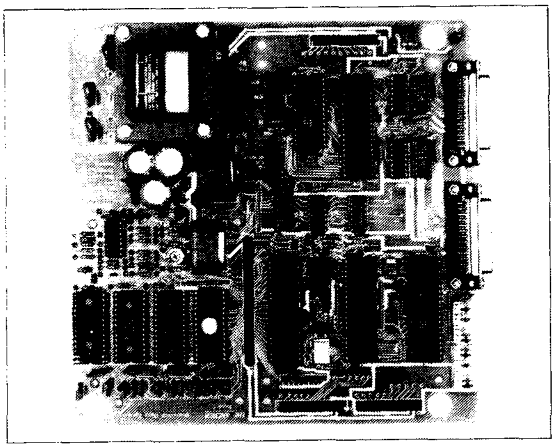
Fibre-optics testing

Anritsu makes a very wide range of test instruments, all capable of communicating with a network. As well as all the regular instruments seen in the catalogues the company has a specialist corner in optical-fibre test equipment. Anritsu Europe Ltd, Thistle Road, Windmill Trading Estate, Luton, Beds LU1 3XJ.
EWW 223 on the reply card.

Continued on p.66

The Archer Z80 SBC

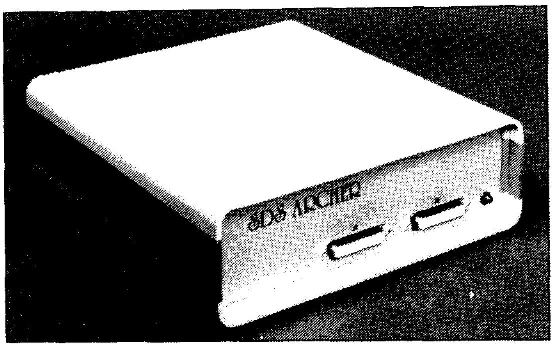
The **SDS ARCHER** — The Z80 based single board computer chosen by professionals and OEM users.



- ★ High quality double sided plated through PCB
- ★ 4 Bytewide memory sockets — upto 64k
- ★ Power-fail and watchdog timer circuits
- ★ 2 Serial ports with full flow control
- ★ 4 Parallel ports with handshaking
- ★ Bus expansion connector
- ★ CMOS battery back-up
- ★ Counter-timer chip
- ★ 4 MHz. Z80A

OPTIONS:

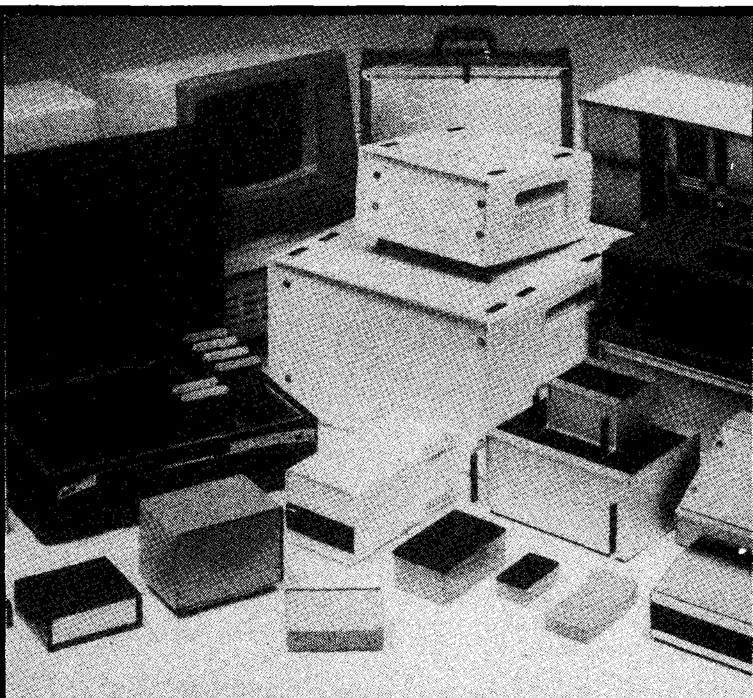
- ★ SDS BASIC with ROMable autostarting user code
- ★ The powerful 8k byte SDS DEBUG MONITOR
- ★ On board 120 / 240 volt MAINS POWER SUPPLY
- ★ Attractive INSTRUMENT CASE — see photo.
- ★ 64k / 128k byte DYNAMIC RAM card
- ★ 4 socket RAM — ROM EXPANSION card
- ★ DISC INTERFACE card



Sherwood Data Systems Ltd

Sherwood House, The Avenue, Farnham Common, Slough SL2 3JX.Tel. 02814-5067

CIRCLE 6 FOR FURTHER DETAILS



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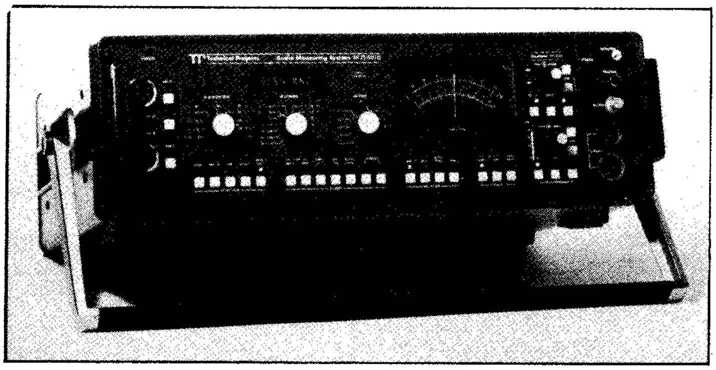
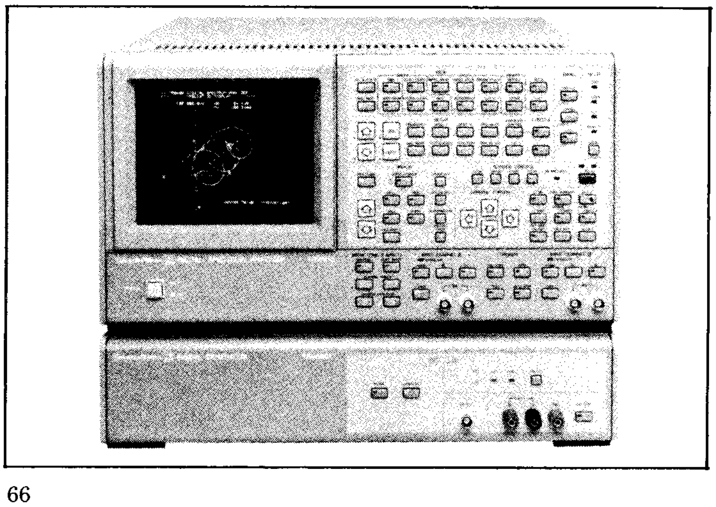


Measuring audio systems

An already successful audio measurement system has had an IEEE488 interface bus added to allow it to be automatically controlled. In addition to its frequency, distortion and impedance test it has been provided with wow and flutter, drift and rumble to be measured on reel-to-reel recorders, both audio and video. Software is being developed for the BBC micro and the IBM PC to allow complete test procedures to be developed without resort to programming languages. The computer provides a representation of the instrument's front panel on screen. The parameters selected can be run directly or saved and linked to provide a test sequence. Another addition is intermodulation distortion measurement, providing two-tone measurements to SMPTE, DIN or CCIR standards. The MJS401D comes from Technical Projects Ltd, Unit 2, Samuel White's Industrial Estate, Medina Road, Cowes, Isle of Wight PO31 7LP.
EWW 222 on the reply card.

Radio spectrum analysers

Chase Electronics manufactures and supplies measuring receivers for interference and field strength measurements in the frequency range 10kHz to 1GHz. The company distributes the Takeda Riken range of r.f. and microwave instruments among which is a range of spectrum analysers. There is also a range of f.f.t. analysers and a signal source with multi-modulation capability including wide-band f.m. All are provided with GPIB interfaces. Chase Electronics Ltd, St. Leonards House, St Leonards Road, London SW14 7LY.
EWW 225 on the reply card.



Low-cost logic analyser

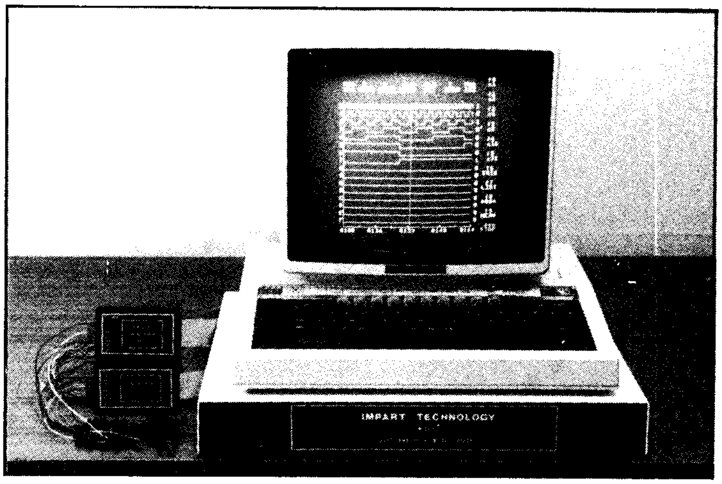
A menu-driven, easy to use logic analyser provides the user with a means of investigating hardware and software problems on a digital system under test. The A1024 analyser is used with a BBC micro through the 1MHz bus and displays the menus and traces on the computer's monitor. Traces and test set-ups can be stored on disc and recalled later which is useful in comparisons against known valid data.

The main menu permits the selection of clock source and rate, the position of the 1024 samples relative to the trigger, and identification of each of the 24 data channels and their respective bases. The trigger menu provides two 24-bit trigger words and offers both delayed and sequential triggering, a persistency filter on one of the triggers and selective data capture on the trigger recogniser. The display can be programmed to show events after, before or during the trigger event. It also includes two cursors which can be positioned over an area of interest, which can then be expanded to be examined in greater detail. When comparing traces with pre-recorded patterns, the computer will automatically highlight any differences that occur.

There is a timing function which can measure the time elapsed between wo trigger functions and thus determine the execution time of a function or program.

The analyser can sample data relative to its internal clock, which has a frequency range of 20Hz to 10MHz. An external clock up to 20MHz can also be used.

The analyser is to be enhanced by the addition of c-mos signals (t.t.l. is used at present); it is to be expanded to 32 channels and software for other computers is under preparation. Impart Technology Ltd, PO Box 2, Hitchin, Herts SG4 0EY.
EWW 226 on the reply card.



PC developement system

An add-on to a IBM PC provides an instrument package for the development of microprocessor systems. The Universal Development Laboratory from Thorn-EMI combines a 48-channel bus-state analyser with an 8/16-bit universal emulator, an eprom programmer and a test pattern generator to provide a complete development system. Thorn EMI Instrument Ltd, Archcliffe Road, Dover, Kent CT17 9EN.
EWW 230 on the reply card.

Test consultancy

If you are lost amongst all this test equipment it might be worth consulting Testech, a company that provides software and hardware solutions to test problems. It are not connected to any test equipment manufacturers and can offer an unbiased opinion. Testech Ltd, 129 Commercial Road, Parkstone, Poole, Dorset BH19 0JD.
EWW 229 on the reply card.

Computer trouble-shooter

An instrument that works in reverse to the others so far mentioned is the Ferret from Bell Technical. It can communicate with computers through the RS232, 20mA, or parallel interfaces but it does this in order to test the computers. It can also be used as an exerciser and trouble shooter on peripheral equipment such as printers, plotters, display terminals, modems and the like. Available through Omnitest Ltd, Highcliffe House, Lymington Road, Highcliffe, Christchurch BH23 5EN.
EWW 224 on the reply card.

Dutch bus

Philips Test and Measurement has recently launched a number of new GPIB instruments. These include the PM 3295 350MHz oscilloscope that boasts a writing speed of 4div/ns and a "wealth of advanced and innovative design features."

The PM 2534 system multimeter offers 3.5 to 6.5-digit sensitivity and can transmit up to 100 measurements/s through its interface, for a.c, d.c, resistance and temperature measurements.

A frequency synthesizer and function generator with a range of 0.1 to 50MHz. Pushbutton operation and a digital display make it particularly easy to use; says Philips.

Their high-speed, high-accuracy plotter has a maximum writing speed of 100cm/s with a minimum addesable step of 0.025mm with a repeatability of 0.1mm with a given pen. Thought to be of particular interest in cad/cam and business graphics.

These are recent additions to a very wide range of IEEE488 bus instruments. Pye Unicam Ltd, York Street, Cambridge CB1 2PX.
EWW 228 on the reply card.

High-speed counters

Racal-Dana has added to its range of systems counters. The new instruments feature 1.3GHz frequency range, GPIB transfer of data, nine-digit resolution in one second, 1ns single time interval measurement and many other features. Models 1995 and 1996 incorporate 16-bit microprocessors to give a high output rate of data over the GPIB – 150 fully formatted readings/s. The counters also include mathematical and statistical analysis of the collected measurements. All measurement functions can be controlled through the GPIB; rise and fall time, slew rates, pulse width, selective arming, automatic burst measurement and hysteresis compensation. A third model (1994) retains many of the features but is designed for rack systems and costs less. Optional extras include ultra-high stability reference crystal oscillators and atomic frequency standards. Racal-Dana Ltd, Duke Street, Windsor, Berks.
EWW 227 on the reply card.

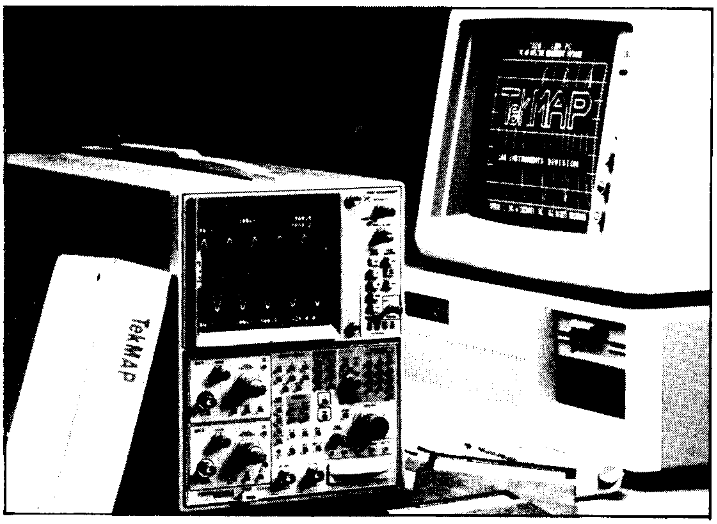
SOFTWARE

Spurious signals analysed

A package to run on the Amstrad CPC6128 computer offers a prediction of the frequencies and powers of significant spurious signals generated by r.f. and microwave equipment. The software is divided into two sections; one to enter the data and another to perform the analysis. The equipment being modelled is assumed to be a chain of ideal blocks that are analysed sequentially, following the signal path through the system.

The user is guided through the data entry and analysis by a series of menus and the choice of files for analysis is a straightforward matter of answering an on-screen questionnaire.

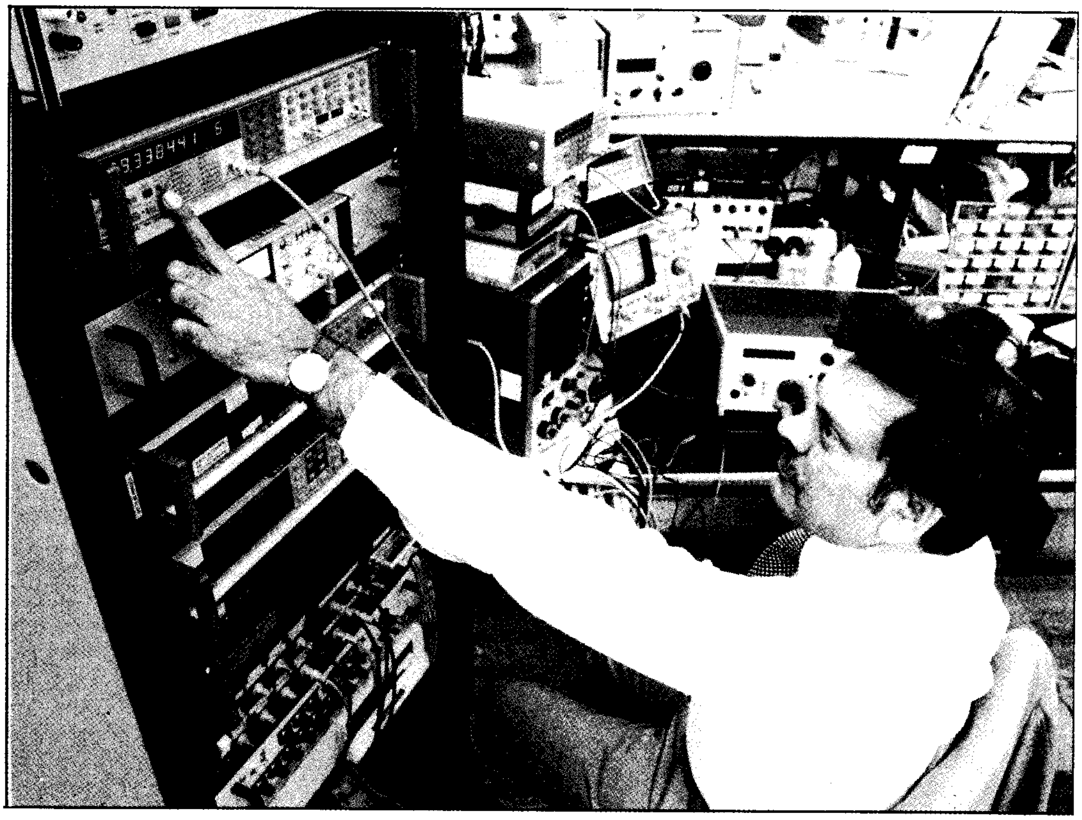
The analysis suite is divided into six programs to perform the calculations on splitters, combiners, filters, linear and non-linear amplifiers and mixers. The system can also model all the other elements in a transmitter chain, to produce a harmonic spectrum analysis of the output and identify the sources of spuriae. More details from Microcom Systems Ltd, 21 Holt Drive, Wickham Bishops, Essex CM8 3JR.
EWW 231 on the reply card.



Link oscilloscopes to computers

Software packages are available from Tektronix to link their 7854 oscilloscope and the 7D20 programmable digitizer to H-P 200 and IBM PCs. They enable laboratories using these instruments to automate test and measurement functions.

The computer can record the front panel set-up from the instrument and automatically reset the parameters for a particular test sequence. Waveforms are stored and recalled from the computer's memory or from disc. The computer monitors can display up to six waveforms simultaneously when running the software. The programs enable the user to reposition and zoom in on waveform portions that are of particular interest. Though they are largely similar, the packages have differing features stemming from the special performance characteristics of the instruments and computers that they link. Tektronix UK Ltd, Fourth Avenue, Globe Park, Marlow, Bucks SL7 1YD.
EWW 232 on the reply card.



Logic analyser program

A new development from Dolch is an IBM PC software package that give the computer full control over their Palas logic analyser. It allows the use of menu selection for the controls, and for the downloading of test set-ups from disc. The PC can perform further analysis of the collected data to simplify results and speed up procedures. Dolch Logic Instruments Ltd, 4 London Street, Andover, Hants SP10 2PA.
EWW 233 on the reply card

Smartpak from Gould Electronics

...is a software package linking the Gould K105D logic analyser with a computer to offer an engineering tool for research and development as well as in automatic test equipment. Gould Instruments Ltd, Roebuck Road, Hainault Road, Ilford, Essex IG6 3UE.
EWW 235 on the reply card.

74 SERIES

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7426 0.40
7427 0.32
7428 0.43
7430 0.30
7432 0.36
7433 0.30
7437 0.30
7438 0.40
7439 0.40
7440 0.40
7441 0.90
7442A 0.70
7443A 1.00
7444 1.10
7445 1.00
7446A 1.00
7447A 1.00
7448 1.00
7450 0.36
7451 0.35
7453 0.38
7454 0.38
7460 0.55
7470 0.50
7472 0.45
7473 0.45
7474 0.50
7475 0.60
7476 0.45
7480 0.65
7481 1.80
7483A 1.05
7484A 1.25
7485 1.10
7486 0.42
7489 2.10
7490A 0.55
7491 0.70
7492A 0.70
7493A 0.55
7494 1.10
7495A 0.60
7496 0.80
7497 2.10
74100 1.90
74107 0.50
74109 0.75
74110 0.75
74111 0.55
74116 1.70
74118 1.10
74119 1.70
74120 1.00
74121 0.55
74122 0.70
74123 0.80
74125 0.65
74126 0.55
74128 0.55
74132 0.75
74136 0.70
74141 0.90
74142 2.50
74143 1.30
74144 2.70
74145 1.10
74147 1.70
74148 1.40
74150 1.75
74151A 0.70
74153 0.80
74154 1.40
74155 0.80
74156 0.90
74157 0.80
74159 1.75
74160 1.10
74161 0.80
74162 1.10
74163 1.10
74164 1.20
74165 1.10
74166 1.40
74167 4.00
74170 2.00
74172 4.20
74173 1.40
74174 1.10
74175 1.05
74176 1.00
74178 1.50
74179 1.50
74180 1.00
74181 3.40
74182 1.40
74184 1.80
74185A 1.80
74190 1.30
74191 1.30
74192 1.10
74193 1.15
74194 1.10
74195 0.80
74196 1.30
74197 1.10
74198 2.20
74199 2.20
74221 1.10
74251 1.00
74259 1.50
74265 0.80
74273 2.00
74276 1.40
74278 1.70
74279 0.90
74283 1.05
74742 3.20
74290 0.90
74293 0.90
74298 1.80
74351 2.00
74365A 0.80
74366A 0.80
74367A 0.80
74376 1.60
74390 1.10
74393 1.20
74490 1.40

74LS SERIES

74LS00 0.24
74LS01 0.24
74LS02 0.24
74LS03 0.24
74LS04 0.24
74LS05 0.24
74LS08 0.24
74LS09 0.24
74LS10 0.24
74LS11 0.24
74LS13 0.34
74LS14 0.50
74LS15 0.24
74LS20 0.24
74LS21 0.24
74LS22 0.24
74LS24 0.50
74LS26 0.26
74LS27 0.24
74LS28 0.24
74LS30 0.24
74LS32 0.24
74LS32 0.24
74LS33 0.24
74LS37 0.24
74LS38 0.24
74LS40 0.24
74LS42 0.50
74LS43 1.50
74LS48 0.90
74LS49 1.00
74LS51 0.24
74LS54 0.24
74LS55 0.24
74LS73A 0.30
74LS74A 0.35
74LS75 0.45
74LS76A 0.36
74LS78 0.42
74LS83A 0.70
74LS85 0.75
74LS86 0.35
74LS90 0.48
74LS91 0.90
74LS92 0.35
74LS93 0.54
74LS95B 0.75
74LS96 0.90
74LS107 0.40
74LS109 0.40
74LS112 0.45
74LS113 0.45
74LS114 0.45
74LS122 0.70
74LS123 0.80
74LS125 0.50
74LS126 0.50
74LS132 0.65
74LS133 0.55
74LS136 0.45
74LS138 0.55
74LS139 0.55
74LS145 0.95
74LS147 1.75
74LS148 1.40
74LS151 0.65
74LS152 2.00
74LS153 0.65
74LS154 1.60
74LS155 0.65
74LS156 0.65
74LS157 0.50
74LS158 0.65
74LS160A 0.65
74LS161A 0.75
74LS162A 0.75
74LS163A 0.75
74LS164 0.75
74LS165A 1.10
74LS166A 1.50
74LS168 1.30
74LS169 1.00
74LS170 1.40
74LS173A 1.00
74LS174 0.75
74LS175 0.75
74LS181 2.00
74LS183 1.90
74LS190 0.75
74LS191 0.75
74LS192 0.80
74LS194A 0.75
74LS195A 0.75
74LS196 0.80
74LS197 0.80
74LS221 0.90
74LS240 0.80
74LS241 0.80
74LS242 0.90
74LS243 0.90
74LS244 0.80
74LS245 1.10
74LS247 1.10
74LS248 1.10
74LS249 1.10
74LS251 0.75
74LS253 0.75
74LS256 0.90
74LS2457A 0.70
74LS258A 0.70
74LS259 1.20
74LS260 0.75
74LS266 0.60
74LS273 1.25
74LS279 0.70
74LS280 1.90
74LS283 0.80
74LS290 0.80
74LS292 9.00
74LS293 0.80
74LS295 1.40
74LS297 9.00
74LS298 1.00
74LS299 2.20
74LS321 3.70
74LS322A 3.90
74LS323 3.00
74LS324 3.20
74LS348 2.00
74LS352 1.20
74LS353 1.20
74LS356 2.10
74LS363 1.80
74LS364 1.80
74LS365 0.50
74LS366 0.50
74LS367 0.52
74LS368 0.50
74LS373 0.90
74LS374 0.90
74LS375 0.75
74LS377 1.30
74LS378 0.95
74LS379 1.30
74LS381 4.50
74LS385 3.25
74LS390 0.60
74LS393 1.00
74LS395A 1.00
74LS399 1.40
74LS445 1.80
74LS465 1.20
74LS467 1.20
74LS490 1.50
74LS540 1.00
74LS541 1.00
74LS608 7.00
74LS610 19.00
74LS612 19.00
74LS624 3.50
74LS626 2.25
74LS628 2.25
74LS629 1.25
74LS640 2.00
74LS640-1 3.00
74LS641 1.50
74LS642 2.50
74LS642-1 3.00
74LS643 2.50
74LS643-1 3.00
74LS644 3.50
74LS645 2.00
74LS645-1 4.00
74LS668 0.90
74LS669 0.90
74LS670 1.70
74LS682 2.50
74LS683 3.00
74LS684 3.50
74LS687 3.50
74LS688 3.50
74LS783 21.00

74S SERIES

74S00 0.50
74S02 0.50
74S04 0.50
74S05 0.50
74S08 0.50
74S10 0.50
74S11 0.75
74S20 0.50
74S22 0.50
74S30 0.50
74S32 0.60
74S37 0.60
74S38 0.60
74S40 0.50
74S51 0.60
74S64 0.45
74S74 0.70
74S85 3.00
74S86 1.00
74S112 1.50
74S113 1.20
74S114 1.20
74S124 3.00
74S132 1.00
74S133 0.60
74S138 1.80
74S139 1.80
74S140 1.00
74S151 1.50
74S153 1.50
74S157 2.00
74S158 2.00
74S163 3.00
74S169 5.50
74S174 3.00
74S175 3.20
74S188 1.80
74S189 1.80
74S194 3.00
74S195 3.00
74S196 3.50
74S200 4.50
74S201 3.20
74S225 5.20
74S240 4.00
74S241 4.00
74S244 4.50
74S251 2.50
74S257 2.50
74S258 2.50
74S260 1.00
74S261 3.00
74S283 2.70
74S287 2.25
74S288 2.00
74S289 2.25
74S299 4.50
74S373 4.00
74S374 4.00
74S387 2.25

74C SERIES

74C00 0.70
74C04 0.50
74C08 0.70
74C10 0.70
74C14 0.50
74C20 0.70
74C32 1.00
74C42 1.50
74C48 1.50
74C73 1.00
74C74 1.20
74C76 1.00
74C83 2.00
74C85 2.25
74C86 0.50
74C90 1.90
74C93 1.50
74C95 1.60
74C107 1.00
74C150 5.00
74C151 2.00
74C157 2.50
74C160 1.80
74C161 1.80
74C162 1.80
74C163 1.80
74C173 1.00
74C174 1.50
74C175 1.50
74C193 1.50
74C194 1.50
74C195 1.50
74C221 2.50
74C244 2.00
74C245 2.25
74C373 2.25
74C374 2.25
74C902 1.20
74C911 9.00
74C912 4.50
74C922 6.00
74C923 6.50
74C925 6.50
74C926 7.50

74ALS SERIES

74ALS00 0.45
74ALS02 0.45
74ALS04 0.50
74ALS08 0.50
74ALS10 0.45
74ALS20 0.45
74ALS32 0.45
74ALS74 0.70
74ALS138 1.50
74ALS139 1.50
74ALS244 4.00
74ALS245 4.75
74ALS573 2.60
74ALS574 4.50
74ALS580 2.60

4000 SERIES

4000 0.20
4001 0.24
4002 0.25
4006 0.70
4007 0.25
4008 0.60
4009 0.45
4010 0.60
4011 0.24
4012 0.25
4013 0.36
4014 0.60
4015 0.70
4016 0.36
4017 0.55
4018 0.60
4019 0.60
4020 0.80
4021 0.60
4022 0.70
4023 0.30
4024 0.48
4025 0.24
4026 0.90
4027 0.40
4028 0.60
4029 0.75
4030 0.35
4031 1.25
4032 1.00
4033 1.25
4034 2.50
4035 0.70
4036 2.50
4037 1.10
4038 1.00
4040 0.60
4041 0.55
4042 0.50
4043 0.60
4044 0.60
4045 1.00
4046 0.60
4047 0.60
4048 0.55
4049 0.36
4050 0.35
4051 0.65
4052 0.60
4053 0.60
4054 0.80
4055 0.80
4056 0.85
4060 0.70
4063 0.85
4066 0.40
4067 2.30
4068 0.25
4069 0.24
4070 0.24
4071 [illegible]
4072 [illegible]
4073 0.24
4075 0.24
4076 0.65
4077 0.25
4078 0.25
4081 0.24
4082 0.25
4085 0.60
4086 0.75
4089 1.20
4093 0.35
4094 0.90
4095 0.95
4096 0.90
4097 2.70
4098 0.75
4099 0.99
4501 0.36
4502 0.55
4503 0.36
4504 0.95
4505 3.60
4506 0.90
4507 0.35
4508 1.20
4510 0.55
4511 0.55
4512 0.55
4513 1.50
4514 1.10
4515 1.10
4516 0.55
4517 2.20
4518 0.48
4519 0.32
4520 0.60
4521 1.15
4522 0.80
4526 0.70
4527 0.80
4528 0.65
4529 1.00
4531 0.75
4532 0.65
4534 3.80
4536 2.50
4538 0.75
4539 0.75
4541 0.90
4543 0.70
4551 1.00
4553 2.40
4555 0.36
4556 0.50
4557 2.40
4560 1.40
4566 1.40
4568 2.40
4569 1.70
4572 0.45
4583 0.90
4584 0.48
4585 0.60
4724 1.50
14411 7.50
14412 7.50
14416 3.00
14419 2.60
14490 4.20
14495 4.50
145000 6.50
14599 2.00
22100 3.50
22101 7.00
22102 7.00
40014 0.48
40085 1.20
40097 0.36
40098 0.40
40100 1.50
40101 1.25
40102 1.30
40103 2.00
40104 1.20
40105 1.50
40106 0.48
40107 0.55
40108 3.20
40109 0.80
40110 2.25
40114 2.25
40147 2.80
40163 1.00
40173 1.20
40174 1.00
40175 1.00
40192 1.00
40193 1.00
40194 1.00
40244 1.50
40245 1.50
40257 1.80
40373 1.80
40374 1.80
80C95 0.75
80C97 0.75
80C98 0.75

LINEAR ICs

AD7581 12.00
ADC0808 11.90
AM7910DC 25.00
AN-1-5050 1.00
AY-3-1350 3.50
AY-3-8910 4.90
AY-3-8912 5.00
CA3019A 1.00
CA3020 3.50
CA3028A 1.10
CA3046 0.70
CA3059 3.25
CA3060 3.50
CA3080E 0.70
CA3085 1.50
CA3086 0.60
CA3089E 2.50
CA3090AQ 3.75
CA3130E 0.90
CA3130T 1.30
CA3140E 0.45
CA3140T 1.00
CA3146 2.25
CA3160E 1.50
CA3161E 2.00
CA3162E 6.00
CA3189E 2.70
CA3240E 1.50
CA3280G 3.00
D7002 6.00
DAC1408-8 3.00
DAC0800 3.00
DAC0808 3.00
DG308 3.00
HA1366 1.90
ICL7106 6.75
ICL7611 0.95
ICL7650 4.00
ICL7660 2.50
ICL8038 4.00
ICM7216B 22.00
ICM7217 7.50
ICM7555 0.90
ICM7556 1.40
LC7120 3.00
LC7130 3.00
LC7131 3.50
LC7137 3.50
LF347 1.20
LF351 0.60
LF353 0.90
LF355 0.90
LF356N 1.10
LF357 1.00
LF398 4.00
LM10CLH 4.50
LM301A 0.30
LM307 0.45
LM308CN 0.75
LM310 2.25
LM311 0.60
LM318 1.50
LM319 1.80
LM324 0.45
LM334Z 1.15
LM335Z 1.30
LM336 1.60
LM339 0.40
LM348 0.60
LM358P 0.50
LM377 3.00
LM380N-8 1.50
LM380N 1.50
LM381AN 1.70
LM383 3.25
LM384 2.20
LM386N-1 1.00
LM387 2.70
LM389 1.89
LM391 1.80
LM392N 1.10
LM393 0.85
LM394CH 4.00
LM709 0.35
LM710 0.48
LM711 1.00
LM723 0.60
LM725CN 3.00
LM733 0.65
LM741 0.22
LM7747 0.70
LM748 0.30
LM1011 4.80
LM1014 1.50
LM1801 3.00
LM1830 2.50
LM1871 3.00
LM1872 3.00
LM1886 6.00
LM1889 4.50
LM2917 3.00
LM3302 0.90
LM3900 0.80
LM3909 1.00
LM3911 1.80
LM3914 3.50
LM3915 3.40
LM3916 3.40
LM13600 1.50
M51513L 2.30
M51516L 4.50
MB3712 2.00
MC1310P 1.50
1413 0.75
MC1458 0.45
MC1495 3.00
MC1496 0.70
MC3340P 2.00
MC3401 0.70
MC3403 0.65
MF10CN 4.10
MK50240 9.00
MK50398 11.00
ML902 5.00
ML922 4.00
MM6221A 3.00
NE529 2.20
NE531 1.20
NE544 1.90
NE555 0.22
NE556 0.60
NE564 4.00
NE565 1.20
NE566 1.50
NE567 1.25
NE570 4.00
NE571 3.00
NE592 0.90
NE5532P 1.50
NE5533P 1.60
NE5534P 1.20
NE5534AP 1.50
OP-07EP 3.50
PLL02A 5.00
RC4136 0.55
RC4151 2.00
RC4195 1.50
RC4558 0.55
S566B 2.20
S50240 9.00
SAA1900 16.00
SFF96364 8.00
SL490 3.00
SN76013N 3.00
SN76023N 3.00
SN76033N 3.00
SN76115N 2.15
SN76489 4.00
SN76495 4.00
SN76660 1.20
SP0256AL2 7.00
SP8515 7.50
TA7120 1.20
TA7130 1.40
TA7204 1.50
TA7205 0.90
TA7222 1.50
TA7310 1.50
TBA641BX1 4.00
TBA231 1.20
TBA800 0.80
TBA810 0.90
TBA20 0.80
TBA820M 0.75
TBA920 2.00
TBA950 2.25
TC9109 5.00
TCA210 3.50
TCA220 3.50
TCA270 3.50
TCA940 1.75
TDA1004A 5.00
TDA1010 2.25
TDA1022 4.50
TDA1024 1.10
TDA1170S 3.00
TDA2002 3.25
TDA2003 1.90
TDA2004 2.40
TDA2006 3.20
TDA2020 3.20
TDA2030 2.50
TDA2593 5.00
TDA2653 7.00
TDA3560 7.50
TDA3810 7.50
TDA7000 3.50
TEA1002 7.00
TL061CP 0.40
TL062 0.60
TL064 0.90
TL071 0.40
TL072 0.70
TL074 1.10
TL081 0.35
TL082 0.55
TL083 0.75
TL084 1.00
TL094 2.00
TL170 0.50
TL430C 1.20
UAA1003-3 9.35
UA759 3.20
UA2240 1.20
UAA170 1.70
UCN4801A 4.00
ULN2001A 0.75
ULN2002A 0.75
ULN2003A 0.75
ULN2004A 0.75
ULN2068 2.90
ULN2802 1.90
ULN2803 1.80
ULN2804 1.90
UPC575 2.75
UPC592H 2.00
UPC1156H 3.00
UPC1185H 5.00
XR210 4.00
XR2206 4.50
XR2207 3.75
XR2211 5.75
XR2216 6.75
XR2240 1.20
ZN404 1.00
ZN414 0.80
ZN419P 1.75
ZN423E 1.30
ZN424E 1.30
ZN425E8 3.50
ZN426E8 3.00
ZN427E8 6.00
ZN428E8 4.50
ZN429E8 2.25
ZN447E 9.00
ZN449E 3.00
ZN450E 7.50
ZN459CP 3.00
ZN1034E 2.00
ZNA1040 6.60
ZNA134J 23.00
ZNA234E 9.50

VOLTAGE REGULATORS

1A FIXED VOLTAGE PLASTIC TO220

+VE		−VE	
5V 7805	0.45	7905	0.50
6V 7806	0.50	7906	0.50
6V 7808	0.50	7908	0.50
12V 7812	0.45	7912	0.50
15V 7815	0.50	7915	0.15
18V 7818	0.50	7918	0.50
24V 7824	0.50	7924	0.50

1A FIXED VOLTAGE PLASTIC TO92

5V 78L05	0.30	5V 79L05	0.45
6V 78L06	0.30	12V 79L12	0.50
8V 78L08	0.30	15V 79L15	0.50
12V 78L12	0.30		
15V 78L15	0.30		

OTHER REGULATORS

FIXED REGULATORS
LM309K 1A 5V 1.40
LM323K 3A 5V 3.50
78H05KC 5A 5V 5.40
78H12 5A 12V 6.40
78P05 10A 5V 9.00

VARIABLE REGULATORS
LM305AH 2.50
LM317T TO-220 .... 1.50
LM317K TO3 .... 2.40
LM337T 2.25
LM350T 10A+VAR 4.00
LM396K 10A+VAR 15.00
LM723N 0.50
78HHO5KC 5A 5V 5.75
78HGKC 5A+VAR 6.50
78GUIC 1A+VAR 2.25
79HGKC 5A−VAR 6.75
79GUIC 1A−VAR 2.50

SWITCHING REGULATIONS
ICL7660 .... 2.50
SG3524 .... 3.00
TL494 .... 3.00
TL497 .... 3.00
78S40 .... 2.50
RC4195 .... 1.50

COMPUTER COMPONENTS

CPU

1802CE 6.50
2650A 10.50
6502 4.50
65C02-2MHz 12.00
6502A 6.50
6502B 8.00
6800 2.50
6802 3.00
6803-2 12.00
6809 6.50
6809E 10.00
68B09 10.00
68B09E 12.00
68000-LB 36.00
8035 3.50
80C35 6.00
8039 4.20
80C39 7.00
8080A 4.20
8085A 3.00
80C85A 7.50
8086 22.00
8088 17.50
8741 15.00
8748 16.00
TMS1601 12.00
TMS9980 14.50
TMS9995 12.00
Z80 2.50
Z80A 2.90
Z80B 5.50
Z80H 7.50
TMS4500 14.00
TMS9901 5.00
TMS9902 5.00
TMS9911 18.00
TMS9914 14.00
Z80PIO 2.50
Z80APIO 2.75
Z80CTC 2.50
Z80ACTC 2.75
Z80DART 6.50
Z80ADART 7.00
Z80DMA 7.00
Z80ADMA 7.50
Z80ASIO/0/2/9 7.00
Z80BPIO 5.00
Z80BCTC 5.00
Z80BDART 9.00

SUPPORT DEVICES

2651 12.00
3242 8.00
3245 4.50
6520 3.00
6522 3.50
6522A 5.50
6532 4.80
6551A 6.00
6821 1.50
68B21 2.50
6829 12.50
6840 3.75
68B40 6.00
6850 1.60
68B50 2.50
6852 2.50
6854 6.50
68B54 8.00
6875 5.00
8154 8.50
8155 3.80
8156 3.80
8205 2.25
8212 2.00
8216 1.60
8224 P.O.A
8226 4.25
8228 5.50
8243 2.60
8250 9.50
8251A 3.25
8253C-5 3.50
8255AC-5 3.20
8256 18.00
8257C-5 54.00
8259C-5 4.00
8271 P.O.A
8275 29.00
8279C-5 4.80
8282 4.00
8284 4.60
8287 3.80
8288D 9.50
8755A 16.00

MEMORIES

216-150 4.00
2101 4.00
2102 2.50
2107B 5.00
2111A-35 4.00
2114 2.50
2114-2 3.50
2147 4.00
4116 2.00
4116-20 1.50
41256-207 0.50
41256-157 0.50
4164-15TI 3.00
4164 2.00
4164-20 2.00
4416-15 3.50
4532-20 2.50
4816AP/3 2.00
5101/5501 4.00
5514/5114 4.00
5516 6.00
5517AP 6.00
6116P-3 3.50
6116LP-3 3.50
6264-12 12.00
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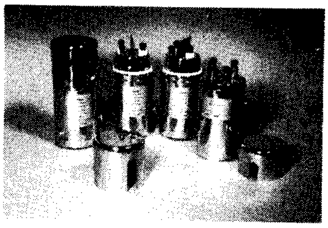

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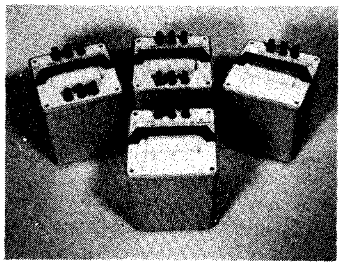

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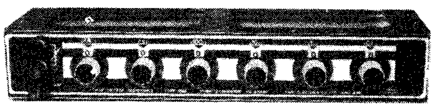

* In-line readout
* Precise
* Mechanically and electrically robust
* High dissipation
* Fully screened
* Range 0.1 ohm to 120K ohm

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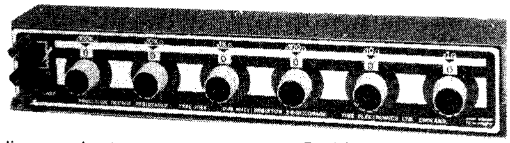

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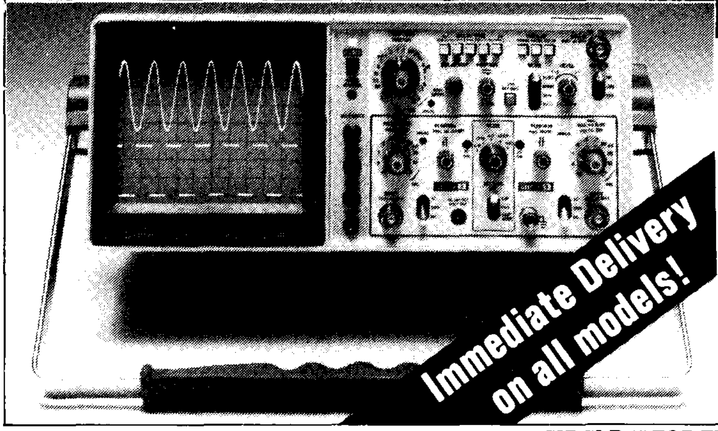

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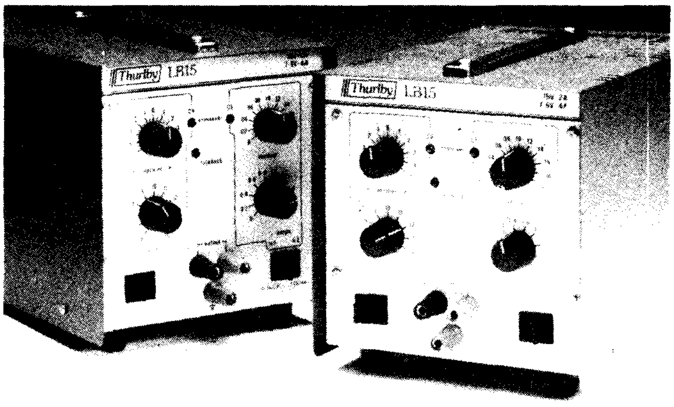

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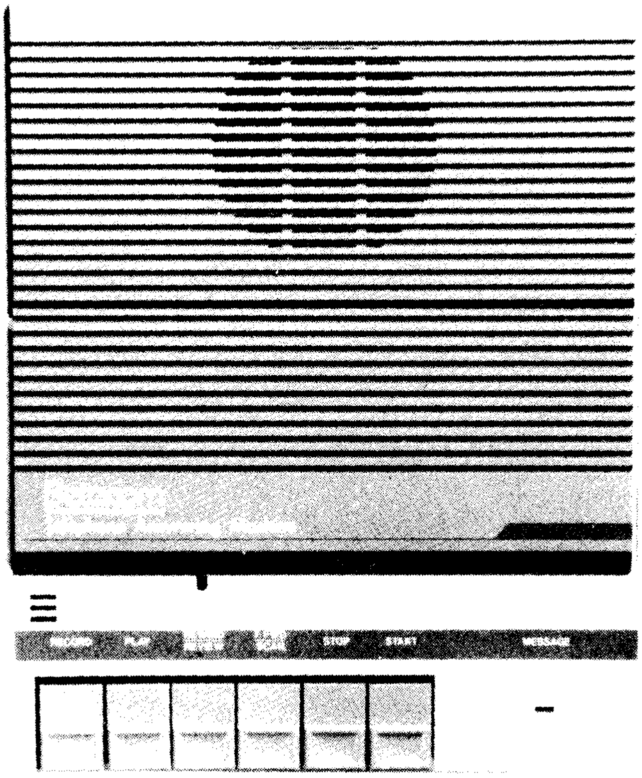

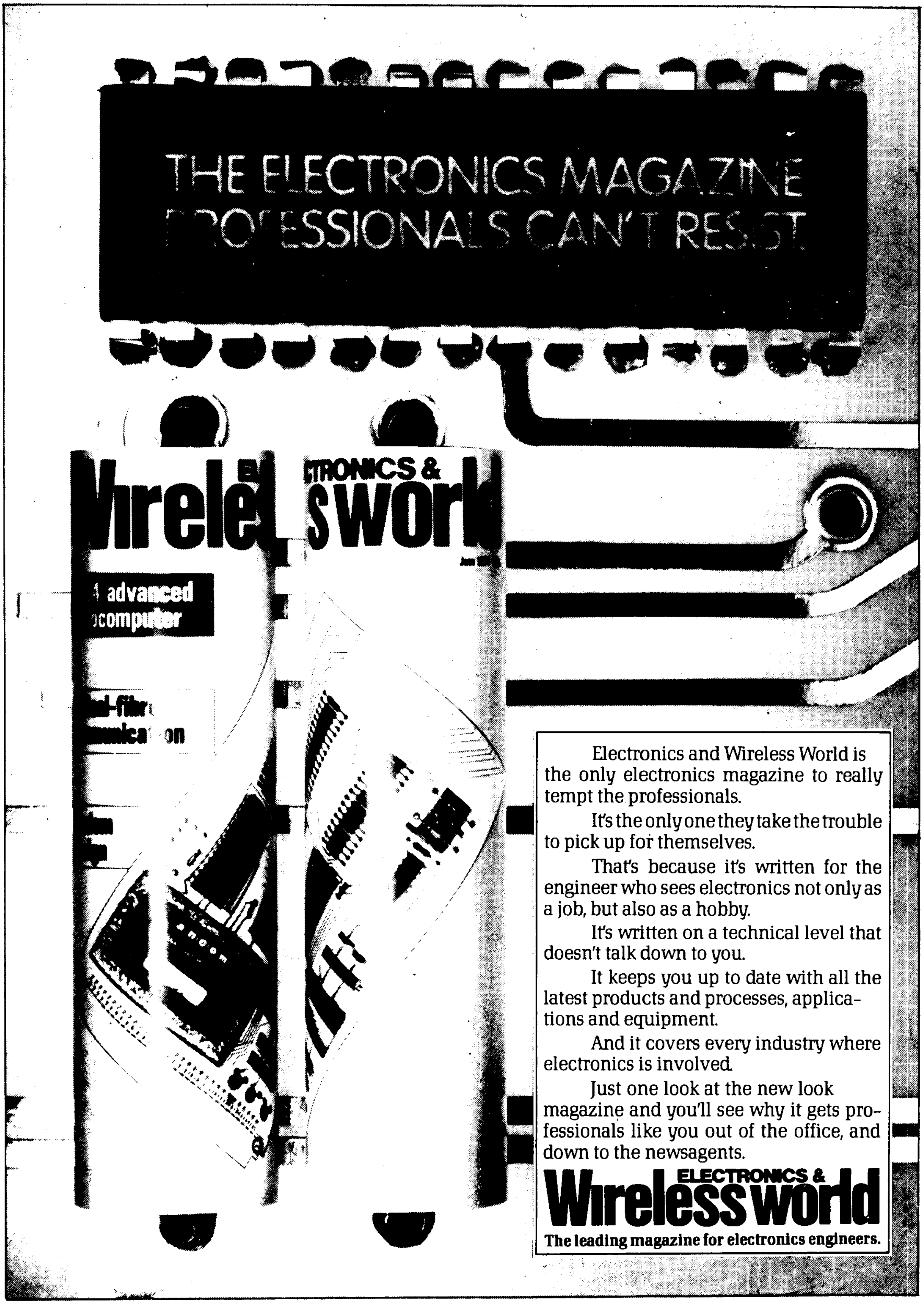
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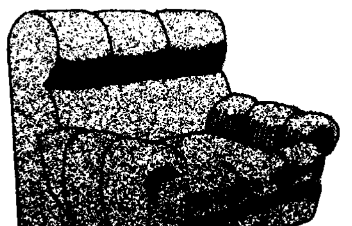

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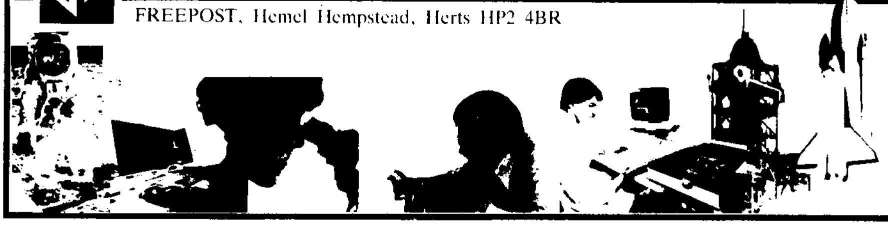

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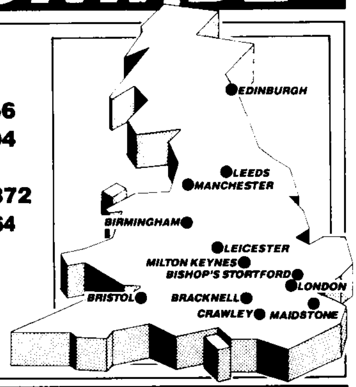

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