Electronics World's renowned news section starts on page 5

ELECTRONICS WORLD

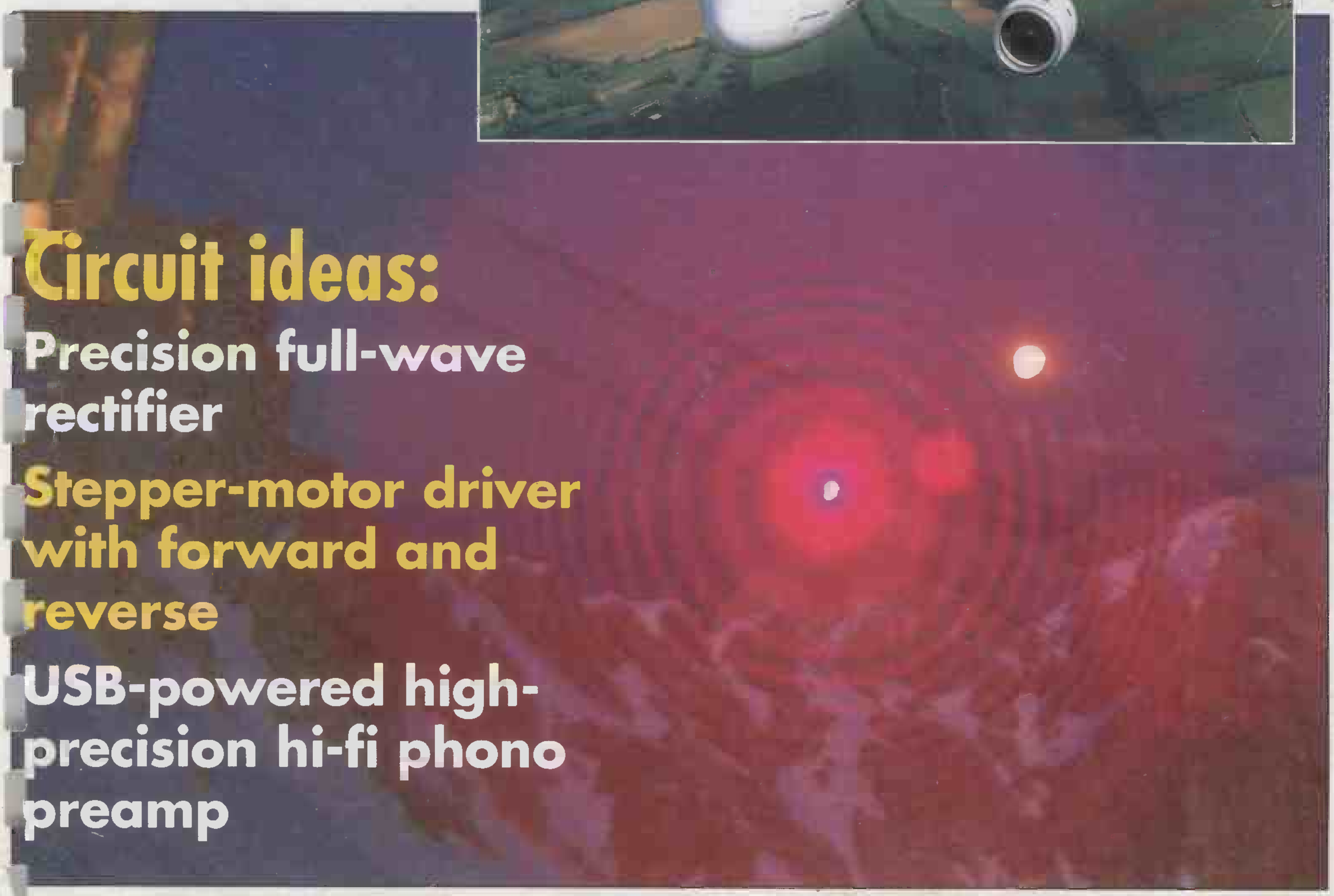
9 770959 833097 01

JANUARY 2003 £3.25

An alternative air traffic control system

Impedance measurement part 2

Capacitor sound part 6



Circuit ideas:

Precision full-wave rectifier

Stepper-motor driver with forward and reverse

USB-powered high-precision hi-fi phono preamp

Telnet

Quality second-user test & measurement equipment

Hewlett Packard 3314A Function Generator 20MHz	**£1250**
Hewlett Packard 3324A synth. function/sweep gen. (21MHz)	**£2250**
Hewlett Packard 3325B Synthesised Function Generator	**£3250**
Hewlett Packard 3326A Two-Channel Synthesiser	**£3000**
H.P. 4191A R/F Imp. Analyser (1GHz)	**£4995**
H.P. 4192A L.F. Imp. Analyser (13MHz)	**£4000**
Hewlett Packard 4193A Vector Impedance Meter (4-110MHz)	**£3000**
Hewlett Packard 4278A 1kHz/1MHz Capacitance Meter	**£3750**
H.P. 53310A Mod. Domain Analyser (opt 1/31)	**£6750**
Hewlett Packard 8349B (2 - 20 GHz) Microwave Amplifier	**£2500**
Hewlett Packard 8904A Multifunction Synthesiser (opt 2+4)	**£1950**
H.P. ESG-D3000A 3GHz Signal Gen	**£6995**
Marconi 6310 – Prog'ble Sweep gen. (2 to 20GHz) – new	**£2500**
Marconi 2032 10Khz-5.4GHz Sig. Gen.	**£6995**
Marconi 6311 Prog'ble sig. gen. (10MHz to 20GHz)	**£2995**
Marconi 6313 Prog'ble sig. gen. (10MHz to 26.5GHz)	**£3750**
R&S SMG (0.1-1GHz) Sig. Generator (opts B1+2)	**£2750**
Fluke 5700A Multifunction Calibrator	**£12500**
Fluke 5800A Oscilloscope Calibrator	**£9995**
H.P 3458A DMM (8.5 digits)	**£3750**
Tek 371A Programmable Curve Tracer	**£15000**

OSCILLOSCOPES

Gould 400 20MHz - DSO - 2 channel	£695
Gould 1421 20MHz - DSO - 2 channel	£425
Gould 4068 150MHz 4 channel DSO	£1250
Gould 4074 100MHz - 400 Ms/s - 4 channel	£1100
Hewlett Packard 54201A - 300MHz Digitizing	£750
Hewlett Packard 54502A - 400MHz – 400 MS/s 2 channel	£1600
Hewlett Packard 54520A 500MHz 2ch	£2750
Hewlett Packard 54600A - 100MHz – 2 channel	£675
Hewlett Packard 54810A 'Infinium' 500MHz 2ch	£2995
Hitachi V152/V212/V222/V302B/V302F/V353F/V550BV650F	from £100
Hitachi V1 100A - 100MHz - 4 channel	£750
Intron 2020 - 20MHz. Dual channel D.S.O (new)	£450
Iwatstu SS 5710/SS 5702 -	from £125
Kikusui COS 5100 - 100MHz - Dual channel	£350
Lecroy 9314L 300MHz - 4 channels	£2750
Meguro MSO 1270A - 20MHz - D.S.O. (new)	£450
Philips 3295A - 400MHz - Dual channel	£1400
Philips PM3070 - 100MHz - 2 channel - cursor readout	£650
Philips PM3392 - 200MHz - 200Ms/s - 4 channel	£1750
Philips PM3094 - 200MHz - 4 channel	£1500
Tektronix 468 - 100MHz D.S.O.	£500
Tektronix 2213/2215 - 60MHz - Dual channel	£300
Tektronix 2220 - 60MHz - Dual channel D.S.O	£850
Tektronix 2221 - 60MHz - Dual channel D.S.O	£850
Tektronix 2235 - 100MHz - Dual channel	£500
Tektronix 2245A - 100MHz - 4 channel	£700
Tektronix 2430/2430A - Digital storage - 150MHz	from £1250
Tektronix 2445 - 150MHZ - 4 channel +DMM	£850
Tektronix 2445/2445B - 150MHz - 4 channel	£800
Tektronix 2465/2465A /2465B - 300MHz/350MHz 4 channel	from £1250
Tektronix 7104 - 1GHz Real Time – with 7A29 x2, 7B10 and 7B15	from £1950
Tektronix TAS 475 - 100MHz - 4 channel	£850
Tektronix TDS 310 50MHz DSO - 2 channel	£750
Tektronix TDS 520 - 500MHz Digital Oscilloscope	£2500

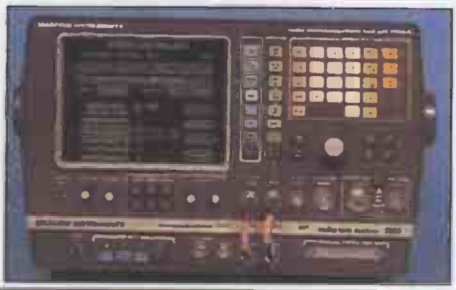
SPECTRUM ANALYSERS

Advantest 4131 (10kHz – 3.5GHz)	£3750
Advantest/TAKEDA RIKEN - 4132 - 100KHz - 1000MHz	£1350
Anritsu MS2613A 9kHz - 6.5GHz Spectum Analyser	£4950
Ando AC 8211 - 1.7GHz	£1500
Avcom PSA-65A - 2 to 1000MHz	£750
Farnell SSA-1000A 9KHz-1GHz Spec. An.	£1250
Hewlett Packard 182T Mainframe + 8559A Spec.An. (0.01 to 21GHz)	£2000
Hewlett Packard 853A Mainframe + 8559A Spec.An. (0.01 to 21GHz)	£2500
Hewlett Packard 3582A (0.02Hz - 25.5kHz) dual channel	£1500
Hewlett Packard 3585A 40 MHz Spec Analyser	£3000
Hewlett Packard 3561A Dynamic Signal Analyser	£3500
Hewlett Packard 8560A (50MHz–2.9GHz) High performance with Tracking Generator option (02)	£5500
Hewlett Packard 8567A -100Hz - 1500MHz	£3400
Hewlett Packard 8568A -100kHz - 1.5GHz Spectrum Analyser	£3500
Hewlett Packard 8590A (opt 01, 021, 040) 1MHz–1.5MHz	£2500
Hewlett Packard 8596E (opt 41, 101, 105,130) 9KHz - 12.8GHz	£9950
Hewlett Packard 8713C (opt 1 E1) Network An. 3 GHz	£6000
Hewlett Packard 8713B 300kHz - 3GHz Network Analyser	£5000
Hewlett Packard 8752A - Network Analyser (1.3GHz)	£4995
Hewlett Packard 8753A (3000KHz - 3GHz) Network An.	£3250
Hewlett Packard 8753B+85046A Network An + S Param (3GHz)	£6500
Hewlett Packard 8754A - Network Analyser 4MHz -1300MHz)	£1500
Hewlett Packard 8756A/8757A Scaler Network Analyser	from £900
Hewlett Packard 70001A/70900A/70906A/70902A/70205A - 26.5 GHz Spectrum Analyser	£7000
IFR A7550 - 10KHz-GHz - Portable	£1750
Meguro - MSA 4901 - 30MHz - Spec Anaylser	£600
Tektronix 492P (opt1,2,3) 50KHz - 21GHz	£3500
Wiltron 6409 - 10-2000MHz R/F Analyser	£1250
Tektronic 2782 (100Hz-33GHz) Spec. An.	£9995

C2

Radio Communications Test Sets

Anritsu MT 8801C Radio Comms Analyser 300kHz - 3GHz (opt 1,4,7)	£6500
Hewlett Packard 8920B (opts 1,4,7,11,12)	£6750
Marconi 2955	£1250
Marconi 2955A	£1750
Marconi 2955B/60B	£3500
Marconi 2955R	£1995
Racal 6111 (GSM)	£1250
Racal 6115 (GSM)	£1750
Rohde & Schwarz CMD 57 GSM test set (opts B1/34/6/7/19/42/43/61	£7995
Rohde & Schwarz CMT 90 (2GHz) DECT	£3995
Rohde & Schwarz CMTA 94 (GSM)	£4500
Schlumberger Stabilock 4031	£2750
Schlumberger Stabilock 4040	£1300
Wavetek 4103 (GSM 900) Mobile phone tester	£1500
Wavetek 4106 (GSM 900, 1800, 1900) Mobile phone tester	£2000



TELNET

MISCELLANEOUS

Ballantine 1620A 100Amp Transconductance Amplifier	£1750
EIP 545 Microwave Frequency Counter (18GHz)	£1000
EIP 548A and B 26.5GHz Frequency Counter	from £1500
EIP 575 Source Locking Freq.Counter (18GHz)	£1200
EIP 585 Pulse Freq.Counter (18GHz)	£1200
Fluke 6060A and B Signal Gen. 10kHz - 1050MHz	£1250
Genrad 1657/1658/1693 LCR meters	from £500
Gigatronics 8541C Power Meter + 80350A Peak Power Sensor	£1495
Gigatronics 8542C Dual Power Meter + 2 sensors 80401A	£1995
Hewlett Packard 339A Distortion measuring set	£750
Hewlett Packard 436A power meter and sensor (various)	from £750
Hewlett Packard 438A power meter - dual channel	£2000
Hewlett Packard 3335A – synthesiser (200Hz-81MHz)	£1995
Hewlett Packard 3457A muli meter 6 1/2 digit	£850
Hewlett Packard 3784A - Digital Transmission Analyser	£3750
Hewlett Packard 37900D - Signalling test set	£2950
Hewlett Packard 34401A Multimeter	£450
Hewlett Packard 4274A LCR Meter	£2000
Hewlett Packard 4276A LCZ Meter (100MHz-20KHz)	£1400
Hewlett Packard 5342A Microwave Freq.Counter (18GHz)	£850
Hewlett Packard 5350B 20KHz Microwave Freq.Counter	£2000
Hewlett Packard 5385A - 1 GHz Frequency counter	£495
Hewlett Packard 6033A - Autoranging System PSU (20v-30a)	£750
Hewlett Packard 6060A and B Electronic Load 300W	from £750
Hewlett Packard 6622A - Dual O/P system p.s.u	£1250
Hewlett Packard 6624A - Quad Output Power Supply	£2000
Hewlett Packard 6632A - System Power Supply (20v-5A)	£695
Hewlett Packard 8350B - Sweep Generator Mainframe	£1500
Hewlett Packard 8642A – high performance R/F synthesiser (0.1-1050MHz)	£2500
Hewlett Packard 8656A - Synthesised signal generator	£750
Hewlett Packard 8656B - Synthesised signal generator	£995
Hewlett Packard 8657A - Synth. signal gen. (0.1-1040MHz)	£1500
Hewlett Packard 8657B - 100MHz Sig Gen - 2060 MHz	£3950
Hewlett Packard 8657D - XX DQPSK Sig Gen	£3950
Hewlett Packard 8901B - Modulation Analyser	£2250
Hewlett Packard 8903A, B and E - Distortion Analyser	from £1000
Hewlett Packard 11729B/C Carrier Noise Test Set	from £2500
Hewlett Packard 53131A Universal Frequency counter (3GHz)	£850
Hewlett Packard 85024A High Frequency Probe	£1000
Keithley 228A Prog'ble Voltage/Current Source IEEE.	£2000
Keithley 237 High Voltage - Source Measure Unit	£4500
Keithley 238 High Current - Source Measure Unit	£4500
Keithley 486/487 Picoammeter (+volt.source)	£1350/£1850
Keithley 8006 Component Test Fixture	£1750
Marconi 2840A 2 Mbit/s Transmission Analyser	£1100
Marconi 6950/6960/6960A/6970A Power Meters & Sensors	from £400
Philips 5515 - TN - Colour TV pattern generator	£1400
Philips PM 5193 - 50 MHz Function generator	£1350
Philips PM 6654C System Timer Counter	£750
Sig. Gen. (100KHz-140MHz) AM/FM/CW	as new £650
Rohde & Schwarz FAM (opts 2,6 and 8) Modulation Analyser	£3750
Rohde & Schwarz NRV/NRVD Power meters with sensors	from £1000
Schlumberger 1250 Frequency Response Analyser	£2250
Tektronix 1720 Vectorscope	£1150
Tektronix 1735 Waveform Monitor	£1150
Tektronix AM503 - AM503A - AM503B Current Amp's with M/F and probe	from £800
Wavetek 178 Function generator (50MHz)	£750
Wayne Kerr 3245 - Precision Inductance Analyser	£1850
Bias unit 3220 and 3225L Cal.Coil available if required.	(P.O.A)
Wayne Kerr 3260A + 3265A Precision Magnetics Analyser with Bias Unit	£5500
Wayne Kerr 6245 - Precision Component Analyser	£2250
W&G PCM-4 PCM Channel measuring set	£3750

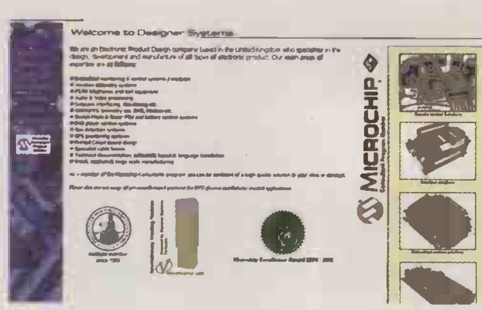
All equipment is used - with 30 days guarantee and 90 days in some cases
Add carriage and VAT to all goods.

Telnet, 8 Cavans Way, Binley Industrial Estate, Coventry CV3 2SF.

Tel: 02476 650 702
Fax: 02476 650 773
Web: www.telnet.uk.com
Email: sales@telnet.uk.com

CONTENTS

JANUARY 2003 VOLUME 109 NUMBER 1801



EDITOR
Phil Reed
p.reed@highburybiz.com

CONSULTANT
Ian Hickman

CONTRIBUTING EDITOR
Martin Eccles

EDITORIAL ADMINISTRATION
Jackie Lowe
020 8722 6054

EDITORIAL E-MAILS
j.lowe@highburybiz.com

GROUP SALES
Reuben Gurunlian
020 8722 6028

ADVERTISEMENT
E-MAILS
r.gurunlian@highburybiz.com

EDITORIAL FAX
020 8722 6098

CLASSIFIED FAX
020 8722 6096

PUBLISHING DIRECTOR
Tony Greville

MANAGING DIRECTOR
Roy Greenslade

ISSN 0959-8332
SUBSCRIPTION QUERIES
Tel (0) 1353 654431
Fax (0) 1353 654400

Specialisation and availability

When I was an undergraduate, in the late 50s and early 60s, all engineering students (with the exception, if I remember rightly, of the aeronauticals and the chemicals) took the same course in the first year. So we all studied thermodynamics, strength of materials, dynamics of fluids, theory of structures and metallurgy, as well as electrical engineering. This broad syllabus was both interesting and stimulating, and some has stuck permanently. If ever I had to calculate the flow versus height over a given Vee-notch weir (can't remember off hand whether I need Francis' formula or d'Arcy's formula), I could still do so as the appropriate textbook is residing awaiting (improbable) use, in the technical section of my library. In the later years of the course, the content of the maths curriculum was identical to that of the Honours Maths syllabus, except that we made do with "... it can be shown that..." rather than proving all those results in full mathematical rigour.

The situation is very different nowadays, since the frontiers of knowledge have expanded so enormously. Such a broadly based foundation is considered an unaffordable luxury. It is now thought that, to be useful to an employer and hence secure a job, a new graduate must specialise - not in electrical, or some other branch, of engineering. Not even in light versus heavy electrical engineering, but in a smaller field still - telecommunications for example. Presumably the heavy electricals have also partitioned themselves into ever smaller specialisms, while various universities, some redbrick, some even newer, offer specialised degrees in a variety of arcane subjects, from the infamous 'media studies' to others as bizarre as African tribal art.

So does the newly qualified telecomms (or whatever) engineer emerge with exactly the right toolkit of knowledge to fit into a research or development job like a round peg in a round hole? The answer of course is no. The syllabus is never really up to date: when I graduated in 1961, there were plenty of valves in the syllabus, but no semiconductors. I gather that syllabuses are nowadays not quite as far behind the times as that nowadays, but the technology moves on remorselessly and the new graduate, assuming he is lucky enough to find an employer, is likely to find himself faced with a fairly steep learning curve, despite the best efforts of universities. The inadequacies of the syllabuses are generally recognised, even by politicians, so they must be glaring indeed! For example, the UK government (or, to be more specific, the Department of Trade and Industry) sponsored over the last few years, the Radio Frequency Engineering Education Initiative, in an attempt to alleviate the dearth of competent RF engineers face by an industry busy with Bluetooth, IEEE 802.11a, b, c, and g, HomeRF, WLANs of all sorts, etc. Having been involved with the Initiative, I know from first hand that current electronics courses are completely deficient in practical hands on work with real live components and circuitry - it is so much easier to sit a student down in front of a PC and tell him to work through the exercises with SPICE.

Not surprising, then, that employers are always looking for engineers already experienced in whatever happens to be their particular line of product development. Some firms, only the largest and then not always, are willing to take on the raw new graduate, and let him build up his experience base to the point where he is positively contributing to the firm's advancement. But a glance at the recruitment ads in the 'freebies' (controlled circulation magazines) shows that most firms seek to obtain their experience staff by recruiting from other firms, who then, naturally, feel forced to poach engineers in their turn.

The problem is, of course, the low esteem in which engineers are held; not by the general public - who cares about that - but by employers. And let's be honest, esteem is a quality that can be accurately measured - in pounds sterling.

Ian Hickman

Erratum

Keen readers have noticed that in Colin Attenborough's article 'Wide digital i/o from the USB port' in November we refer to a disk – insinuating that a CD should have been stuck to the front cover. Whilst we do intend to put a CD on the front that will include this and other software, the incorrect version of the article was published. If any reader would like the software, please email or write to Jackie Lowe at the addresses on this page with 'USB' as the subject and let her know what your preferred method of delivery is i.e. the whole thing in one email (6.5MB) or split into 2 meg chunks – or indeed a CD. Apologies to Colin and interested readers. – Ed.

Electronics World is published monthly. Orders, payments and general correspondence to **Jackie Lowe, Highbury Business Communications, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey, SM3 8BZ.**

Newstrade: Distributed by COMAG, Tavistock Road, West Drayton, Middlesex, UB7 7QE Tel 01895 444055.
Subscriptions: Wyvern Subscription Services, Link House, 8 Bartholomew's Walk, Ely Cambridge, CB7 4ZD. Telephone 01353 654431. Please notify change of address.
Subscription rates
1 year UK £38.95 O/S £64.50
US$100.62 Euro 102.55

Overseas advertising agents: France and Belgium: Pierre Mussard, 18-20 Place de la Madeleine, Paris 75008. United States of America: Ray Barnes, Reed Business Publishing Ltd, 475 Park Avenue South, 2nd Fl New York, NY 10016 Tel; (212) 679 8888 Fax; (212) 679 9455
USA mailing agents: Mercury Airfreight International Ltd Inc, 10(b) Englehard Ave, Avenel NJ 07001. Periodicals Postage Paid at Rahway NJ Postmaster. Send address changes to above.
Printed by Polestar (Colchester) Ltd,
Filmsetting by G&E 2000
A1 Parkway, Southgate Way, Orton Southgate, Peterborough, PE2 6YN

HIGHBURY
Business Communications
A SUBSIDIARY OF HIGHBURY HOUSE COMMUNICATIONS PLC

Quasar Electronics Limited
PO Box 6935
Bishops' Stortford, CM23 4WP
Tel: 0871 717 7168
Fax: 0871 277 2728
E-mail: sales@quasarelectronics.com

Add £2.00 P&P to all UK orders. 1st class recorded - £4. Next day (Insured £250) - £7. Europe - £5. Rest of World - £10. We accept all major credit/debit cards. Make cheques/PO's payable to Quasar Electronics. Prices include 17.5% VAT. MAIL ORDER ONLY. Free catalogue with order or send 2 x 1st class stamps (refundable) for details of over 200 kits and publications.

QUASAR electronics

0871 CREDIT CARD SALES 717 7168

Controllers & Loggers

The I/O Module and the Call Logger include plastic cases and don 't need to be attached to a computer during operation. Complete documentation available from our web site.

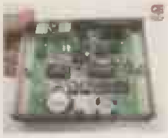
Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12VDC/6mA (standby)
Kit Order Code: 3180KT - £41.95
Assembled Order Code: AS3180 - £49.95

Computer Temperature Data Logger

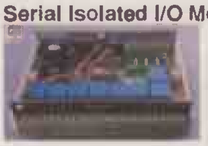
4-channel temperature logger for PC serial port. Deg. C or F. Allows continuous logging of 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 38x38mm. Powered by PC. Includes one DS1820 sensor and four detachable header cables.
Kit Order Code: 3145KT - £23.95
Assembled Order Code: AS3164 - £29.95
Additional DS1820 Sensors - £3.95 each

Telephone Call Logger



Stores over 2,800 x 10 digit DTMF numbers. Records all buttons pressed during a call. The time and date also recorded. No need for any connection to a PC during operation but logged data can be downloaded into a PC via a serial port and saved to disk. Includes a plastic case 130x100x30mm. 9-12VDC.
Kit Order Code: 3164KT - £54.95
Assembled Order Code: AS3164 - £59.95

Serial Isolated I/O Module



PC controlled 8-Relay Board. 115/250V relay outputs and 4 isolated digital inputs. Useful in a variety of control and sensing applications. Uses PC serial port for programming (using simple text batch files). Once programmed unit can operate without PC. Includes plastic case 130x100x30mm. Power: 12VDC/500mA.
Kit Order Code: 3108KT - £54.95
Assembled Order Code: AS3108 - £64.95

Infrared RC Relay Board

12-channel relay board. Each relay individually controlled with included infrared remote control unit. Toggle or momentary. Over 15m range. PCB: 112 x 122mm. Power: 12VDC/500mA
Kit Order Code: 3142KT - £44.95
Assembled Order Code: AS3142 - £64.95

PIC & ATMEL Programmers

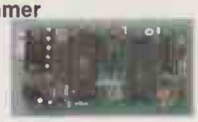
We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

Programmer Accessories:
40-pin Wide ZIF socket (ZIF40W) £15.00
Power supply (PSU201) £5.95
Parallel Cable (CSLEAD108) £4.95

Enhanced "PICALL" ISP PIC Programmer

Will program virtually ALL 8 to 40 pin PICs plus certain ATMEL AVR, SCENIX SX and EEPROM 24C devices. Also supports In System Programming (ISP) for PIC and ATMEL AVRs. Free software. Blank chip auto detect for super fast bulk programming. Requires a 40-pin wide ZIF socket (not inc.)
Kit Order Code: 3144KT - £59.95
Assembled Order Code: AS3144 - £64.95

ATMEL 89xxxx Programmer



Uses PC serial port. No special programming software required. 4 LED's display the status. ZIF sockets not included. 16VDC.
Kit Order Code: 3123KT - £29.95
Assembled Order Code: AS3123 - £39.95

P16Pro PIC Programmer

Super low cost programmer for 8/18/28/40 pin DIP serial PICs including 16F84 & 12C508. Software needs to be registered @ £20.95. 17-30VDC or 13-20VAC
Kit Order Code: 3096KT - £10.95
Assembled Order Code: AS3096 - £15.95

ATMEL AVR Programmer

Programmer for 20 and 40 pin DIP (AT90Sxxxx) "AVR" micro controllers. Uses PC serial port. No special software required. ZIF sockets not incl. 16VDC.
Kit Order Code: 3122KT - £24.95
Assembled Order Code: AS3122 - £29.95

Timers & Counters

These modules use a microcontroller and crystal for accurate and low-cost. 4 digit 14mm LED display used on all but 3141.

Presettable Down Counter

Starting count can be set. The 4-digit counter has four modes to control how the output behaves when it reaches zero. Max count rate of 30/sec or 30,000/sec. PCB: 51x64mm. 9-12VDC.
Kit Order Code: 3154KT - £13.95
Assembled Order Code: AS3154 - £22.95

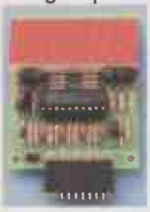
4-Digit Timing Module

The firmware included with this motherboard kit is a programmable down timer of 10,000 sec. Timing accuracy: 0.04%. PCB: 51x64mm. 9-12VDC Current: 50mA. 5 other firmware chips can be used with this motherboard. Each has a different timing mode and can be purchased as a pack.
Kit Order Code: 3148KT - £9.95
Assembled Order Code: AS3148 - £18.95
5 Piece Firmware Pack: F3148 - £14.95

Multi Mode Universal Timer

Seven different timing modes in one! Modes and delay ranges are set by DIP switches. Timing delays range between 255sec (1sec steps) and 42.5h(10min steps) Mains rated relay output. PCB: 48x96mm. 12VDC
Kit Order Code: 3141KT - £14.95
Assembled Order Code: AS3141 - £21.95

4-Digit Up/Down Counter



Count range is from 0000,1,2.. to 9999.It can also count down. Maximum count rate of about 30 counts per second. Two counters can be connected together to make an 8-digit counter. PCB: 51x64mm. 9-15VDC.
Kit Order Code: 3129KT - £13.95
Assembled Order Code: AS3141 - £22.95

Most items are available in kit form (KT suffix) or assembled and ready for use (AS prefix).

No.1 for KITS

www.quasarelectronics.com

Secure Online Ordering Facilities • Full Product Listing, Descriptions & Photos • Kit Documentation & Software Downloads

Researchers weld nanotube for first time

Researchers at the Rensselaer Polytechnic Institute in New York State have discovered how to weld together single-walled carbon nanotubes.

Professor Pulickel Ajayan with colleagues in Germany, Mexico, Belgium and the UK used irradiation and heat to form the welded junctions.

This is the first time single-walled nanotubes have been welded together, although multi-walled nanotubes with junctions previously have been created using growth techniques, said the Institute.

"No one knew if junctions could be created," said Ajayan. "Single-walled carbon nanotubes are perfect cylinders without any defects, but to create junctions between them, inter-tube carbon-carbon bonds need to form. The irradiation and heating process we use creates just enough defects for these bonds to form without damaging their electrical properties."

The process still relies on locating nanotubes which cross with the right orientation from a tangled nest as nanotubes can still not be made to order.

The researchers used a special electron microscope in Stuttgart that has the capability to irradiate and produce the heat necessary for the experiment, one of only a few worldwide that can do this.

Ajayan, with Ganapathiraman Ramanath, also recently made some unusually large super-hard crystals of boron carbide. The crystals have five-fold crystallographic symmetry - also called icosahedral.

This shape is common in nanocrystals, but micrometre-sized icosahedral crystals are rare in nature because their smaller units cannot repeat their pattern infinitely to form space-filling structures, said Ajayan. As the nuclei of these crystals grow, the strain on the crystals increases. This usually causes them to revert to their common bulk crystal structures.

Ajayan believes that the inherent structure of boron carbide, which has icosahedral units in the unit cell, allows the crystals to grow to micron size without the strain.

Nanocrystals

Micromachines go nuclear

Cornell University has built a novel nuclear power source that could supply power for decades.

The device uses a thin-film of beta-emitting isotope held parallel to a flexible springboard-like cantilever, all in a vacuum.

Beta particles are electrons and these electrons charge the springboard until it bends by electrostatic attraction to touch the emitting layer. The system then discharges and the board springs back.

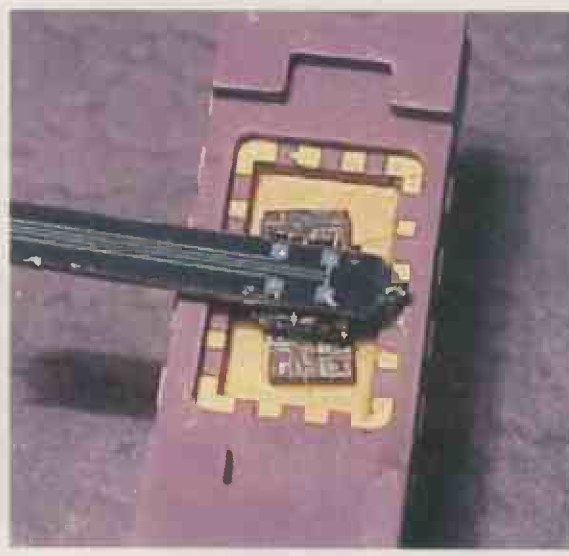
Researchers propose extracting energy as electrical pulse, mechanical movement through a micromachine or by induction with a magnet attached to the spring.

Several prototypes have been made including one with a piezoelectric springboard to generate power.

The prototype shown is made up of a copper springboard 1mm by 2cm and 60μm thick cantilevered over a thin film of nickel-63 with a half-life over 100 years.

The entire device could eventually be fitted into one cubic millimetre said Cornell.

What Cornell fails to say in its announcement is why it doesn't just collect the electrons in a capacitor and use this energy. As there are no physicists at Electronics World, we are relying on our readers to explain the merits or otherwise of this approach.



Samsung has made a prototype 46-inch active matrix colour LCD. The panel is suitable for high-definition TV, with 1,280x720 pixels, a 12ms response time, 16:9 aspect ratio and 170° viewing angle in all directions. Colour saturation is 72 per cent (against the NTSC standard) and contrast ratio is claimed to be 800:1. Samsung made the display at its fifth-generation line in Chonan, Korea which runs 1.1x1.25m substrates - big enough for two 46in panels. Mass production of 46-inch panels is expected in the first half of 2003.

PC is hi-fi

Taiwanese PC motherboard maker VIA Technologies has produced a home PC prototype that doubles as a domestic hi-fi and entertainment centre.

VIA calls the concept 'Hi-Fi PC'.

"While there are devices on the market that fulfil some of these requirements, the Hi-Fi PC is the first system to offer the best of both worlds, and completely embodies all the expectations of consumers for a living-room based device," said Wenchi Chen, president and CEO of VIA.

Operating as a hi-fi, the 19x19x34cm device powers-up in a few seconds because its operating system is stored in the motherboard flash memory alongside the bios.

In this mode it plays all of the latest digital video and audio formats under the command of its remote control, said VIA, including CD, DVD and VCD.

The remote control also switches mode between hi-fi and PC.

As a PC it boots running Windows XP and along with its audio and video interfaces, come fast Ethernet, USB 2.0 and IEEE 1394 (Firewire). There is also a TV-out.

Behind the concept is a motherboard VIA is introducing to the UK in the near future.

Measuring just 17cm x 17cm, the VIA EPIA M is based around the company's Apollo CLE266 chipset with an integrated MPEG-2 decoder and 2D/3D graphics.

For licensing reasons the bare motherboard is unlikely to be available with hi-fi capability.

VIA will be working with industry partners to introduce Hi-Fi PC systems to the market in the first quarter of 2003.

$2m for roll-up displays

Universal Display Corporation has got a two-year $2m research contract from the US Army Research Laboratories to co-develop technology to produce flexible OLED displays and communication components. The program will focus on components for what the company calls a universal communication device (see photo). The device has an extendable or roll-out flexible OLED display and the capability of a mobile phone.

Universities gang up for £4m

Five UK universities are to benefit from a technology fund established by consulting firm Generics.

Surrey, Sussex, Reading, Brunel and Royal Holloway universities will be able to access the £4m fund in order to exploit their innovations and developments.

Two tiers of investment are available from the fund. The stimulus tier is aimed at very early, high risk ideas. Up to £30,000 is available.

A growth tier is intended for less speculative developments, and up to £250,000 can be offered.

UK firms lagging in R&D

UK firms continue to lag behind US firms in the amount of revenue they plough back into research and development, according to the Government's R&D Scoreboard. The report found that the UK invests in R&D above international levels in the sectors of pharmaceuticals, biotechnology, aerospace, defence and health, but below international levels in other sectors, including electronics.

Even so, average UK R&D investment is rising, said the report, from 1.8 per cent in 1998 to 2.2 per cent in 2002. US spending on R&D has remained constant at 4.3 per cent. "This Scoreboard once again highlights the importance of R&D to a company's long term growth strategy. Taking full advantage of science and innovation is crucial to driving up productivity and generating wealth," said Trade and Industry Secretary, Patricia Hewitt.

The report's author, Dr Mike Tubbs, concluded that firms concentrating on sustained growth and R&D investment were more likely to see a return for their shareholders.

Single-photon secret keys sent over 20Km

Researchers from UK research lab QinetiQ and Ludwig Maximillians University in Munich have sent single-photon cryptographic keys over a world record 23.4km in the German Alps.

The system, set up between the mountains of Zugspitze and Karwendelspitze, was based on equipment demonstrated over 1.9km last year at QinetiQ in Malvern.

Two telescopes provided the transmit and receive optics, and these were coupled to Munich-developed miniature versions of the original Malvern transmitter and receiver.

The scheme works by setting the polarisation of a burst of laser light to one of four polarisations, then sending it to the receiver. Encoding and decoding is through fairly standard electro-optical techniques.

This transfer method would not be secure if the whole burst of light was sent as it could be eaves dropped by a third party without anyone else noticing.

To prevent this, the burst is passed through multiple attenuating filters in the transmitter to remove most of the photons.

In fact, so much attenuation is applied that, on average, only one photon leaves for every ten bursts.

Through its quantum behaviour a single photon cannot be detected without changing it, so undetected eaves dropping is impossible.

As all the attenuation means nine out of ten bits of data never actually leave the transmitter, it is essential for the receiver to tell the transmitter when a bit is detected so both ends of the chain can build up a binary word. This can be done on a non-secure link.

Because 90 per cent of information is lost in transmission, the scheme is virtually useless for data transmission, but well suited to mutual generation of cryptography keys.

QinetiQ researchers envisage a quantum key transmission link running in parallel with a more conventional laser data link.

The scheme will eventually be used for secure international data transfer where information will be passed up to a satellite, then carried over to another country and sent back down.

Technical specification.

The transmitter was mounted on a 30x60cm breadboard and its beam collimated to around 50mm. At 20km the received beam is 1-2m in diameter.

Pulses were transmitted at 10MHz randomly polarised at 0, 90, 45 or 135°.

The receiver worked through a 30cm diameter commercial telescope and polarising beam splitters divided incoming photons to one of four detectors.

With lumped optical loss around 20dB and a receiver efficiency of around ten per cent, the decoded information rate was about 1kbit/s.

US firm makes GaN breakthrough

A US firm has produced p-type gallium nitride wafers, a significant step on the road to more commercial GaN products.

Technologies and Devices International (TDI) says the 50mm wafers will result in better LEDs, laser diodes and faster high power bipolar transistors.

TDI starts with a standard 50mm sapphire wafer and then deposits a layer of GaN using hydride vapour phase epitaxy (HVPE).

"The main advantage of GaN HVPE is a combination of high growth rate, up to hundreds of microns per hour, and high material quality," said Katie Tsvetkov, product manager at TDI. "The highest electron mobility for GaN has been reported for material grown by HVPE."

Layers can be grown between 1 and 300μm thick.

To produce a p-type material, the firm dopes the GaN with magnesium, a type II element. Hole mobility varies between 1 and $10cm^2/Vs$. The bandgap remains constant at 3.39eV, Tsvetkov said. LEDs made using the material produce UV light at around 360nm.

Les Paul goes digital

Electric guitar manufacturer Gibson has decided to add a digital output to all its future instruments. The firm has used a programmable logic device from Xilinx to run its own digital transfer protocol, called MaGIC. The MaGIC protocol allows 32 channels of 32-bit data at 192kHz to be transmitted. The system will appear in all the firm's guitars in the next 12 to 18 months. Gibson will license MaGIC free of charge to makers of other audio equipment.

Fluids replace electricity

Scientists at the California Institute of Technology have made circuits that use fluids and tiny valves.

The circuits include comparators, random access memories and even a crude type of display. As the circuits use fluids, the display and circuits are non-volatile.

Dr Stephen Quake from the Department of Applied Physics at Caltech led the team which plumbed together hundreds, even thousands of valves and chambers using large scale integration techniques.

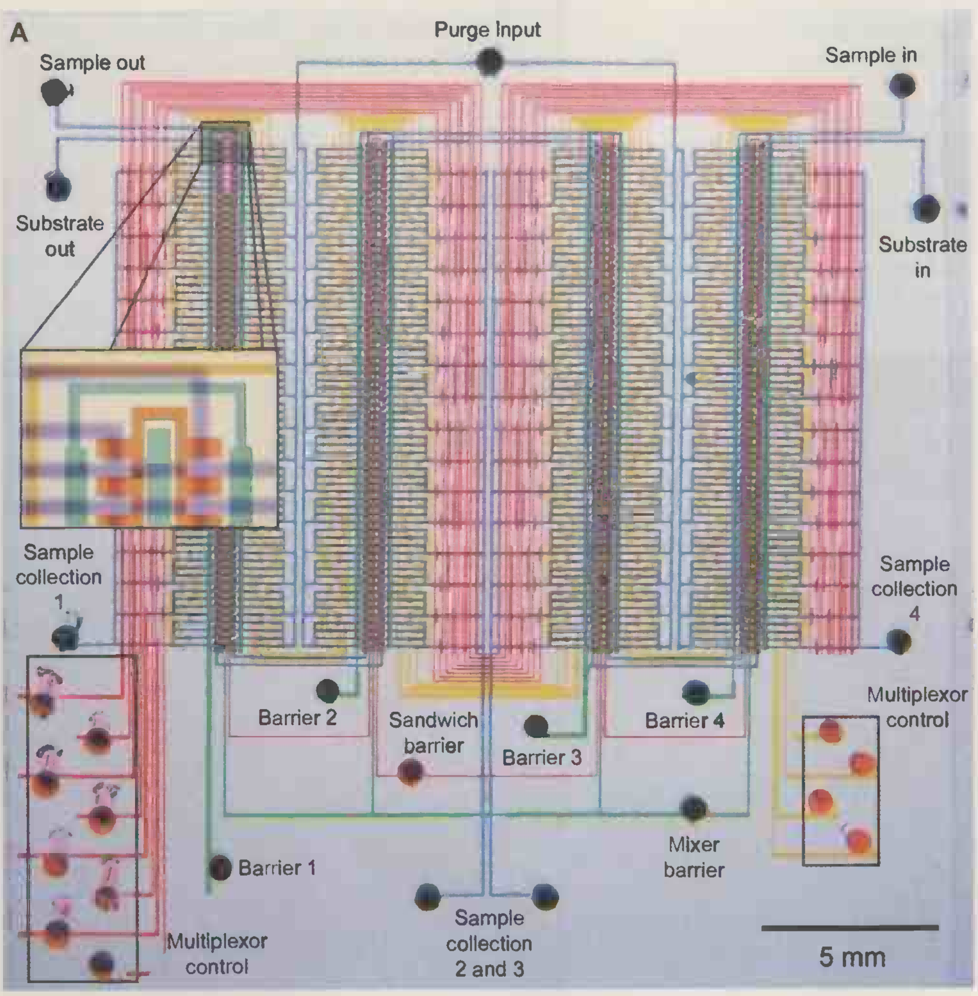
At the core of the system is what Quake calls a fluidic multiplexor, a combinatorial array of binary valves. Just like an electronic multiplexor, 2n inputs can control 2^n elements, in this case 20 inputs control 1,024 valves.

Valves are created by crossing 'control' channels over a 'flow' channel. A thin membrane is formed between the channels, each around 100μm wide, and this membrane can be deflected by hydraulic pressure. Where two controls cross a flow, the pressure is high enough to close the valve.

Chambers can also be formed with volumes of between 250 and 750picolitres.

In order to pass fluid to the chips steel pins are inserted through a layer of silicon.

Quake reckons the chips can perform biomolecular operations such as separations, enzymatic assays and polymerase chain reactions.



Coloured food dies show the multiple channels in this comparator chip. The device contains 2,056 valves and 256 reaction chambers.

Cars to get fast comms

Automotive communications running at 25Mbit/s over unshielded twisted pair wiring have been demonstrated by a Guildford-based firm.

Communication & Control Electronics (C&CE) hopes its SmartwireX protocol will be used by car manufacturers to add video and audio networking, at lower cost than fibre optic systems.

"A lot of multimedia networking has been led by the luxury market," said Steve Holland, director of professional services at C&CE.

The firm, originally set up by Philips and Matsushita as a joint venture, has sold fibre optic systems to firms such as Daimler Chrysler and Jaguar. But these systems using protocols such as D2B and MOST will prove too expensive for volume car makers, said Holland.

"We realised that optical networks didn't suit the environment of a mass production car plant," he said.

However, electrical cabling cannot easily meet the electromagnetic compatibility specifications demanded by an automotive system. Holland claimed that C&CE has solved these issues, even using UTP cabling.

The 25Mbit/s network is able to carry time critical including audio and video to various points around the car

"It's going to open up cool distributed systems to volume cars," said Holland. Systems include DVD and CD players sending different data to different passengers in the car.

Discussions with a number of manufacturers are ongoing, the firm said.

C&CE became an independent company in 1994 after a management buyout. It now has around 35 employees in Guildford, the majority of which are in R&D.

Zarlink sticks with Swindon

Canadian chip firm Zarlink Semiconductor is to site its high performance analogue design and manufacturing group in Swindon.

The firm said the considerable experience of the team, and Swindon's high quality fab process led to the decision. Engineers in the firm's Plymouth site will also contribute to design.

The current size of the team is not being revealed, although the firm said more jobs would be created as the group expanded.

"We will need additional people, because we have aggressive growth plans," said Peter Minett, marketing manager for analogue products at Zarlink.

Swindon will house design and manufacturing of wireline and wireless chips, such as frequency synthesis and timing, broadband amplifiers and broadband line drivers.

Zarlink recently sold its Plymouth fab to German firm X-Fab.

Swiss chips run at 0.5V

A subsidiary of Swiss watch firm Swatch has developed a very low voltage semiconductor process that runs down to 0.5V and at temperatures of up to 225°C.

EM Microelectronics has developed its fully depleted silicon-on-insulator (SOI) process mainly for its parent company, but will offer the process on a foundry basis.

The first product to come off the line is a mixed signal IC for Swatch. "The analogue portion of the circuit is operating at 0.5V, while the digital part works even down to 0.35V," said Mougahed Darwish, EM Microelectronics president.

EM said the 0.5μm process is suited to a variety of products such as RF tags, automotive, smartcards, and analogue front ends for sensors.

SOI is made by growing a thin layer of silicon on an insulating layer, itself on top of the bulk substrate.

Individual transistors can be separated by implanting vertical oxide blocks through the thin silicon, so leakage current is much reduced.

Partially depleted SOI has been used by microprocessor makers, and due to the thickness of the top silicon there is a layer of neutral charge between the transistor and buried oxide. This suits high frequency operation.

In fully depleted SOI, on the other hand, the silicon layer on top of the insulator is very thin - it needs to be less than 50nm - so the depletion region underneath a transistor's channel extends right down to the insulating oxide layer.

Thus fully depleted has lower leakage currents at reduced threshold voltages, so is better for low voltage and low power (but not speed).

A firm from Cambridge is proposing wireless charging of devices such as mobile phones, handheld PCs and electronic games. Splashpower's inductive technology embeds a flat coil in the product and uses a 6mm thick plate to contain the charging electronics. Multiple devices can be charged simultaneously, and the pad can be embedded under glass. The firm claims charging rates are the same as that from standard AC/DC wall plugs. In volume each pad will cost a few pounds, the embedded coils just pence, it said.

Smallest computer uses molecules

Scientists at IBM have built logic gates in which individual molecules move across an atomic surface in a domino-like structure.

This 'molecular cascade' is made from carbon monoxide molecules on a copper surface. Moving a single CO^2 molecule initiates a cascade of motion.

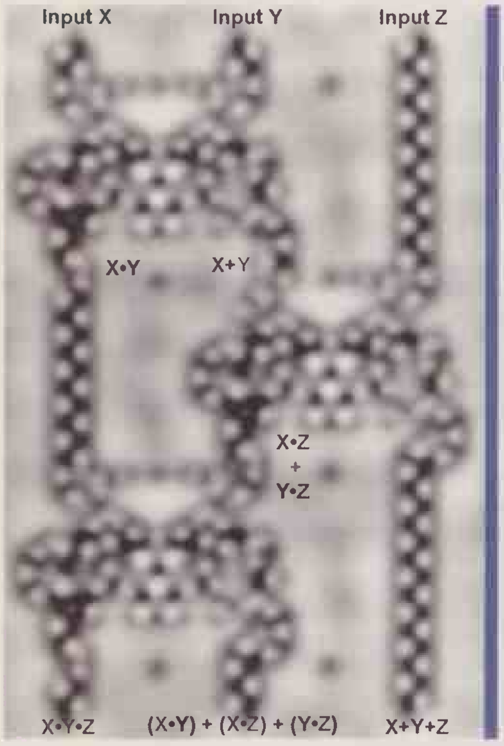
A weak repulsive force between the molecules creates a metastability, so a small movement in one affects its neighbours.

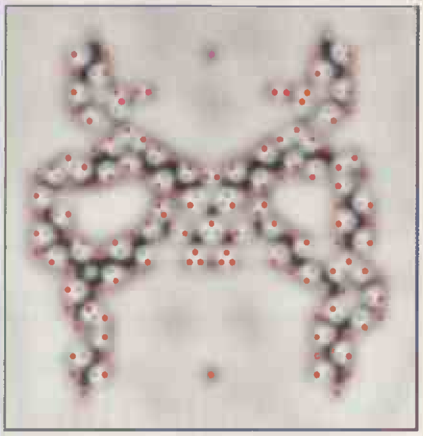
The team at IBM were able to construct OR and AND functions using the technique.

Whether a set of molecules has cascaded or not is used to represent ones and zeros.

"The molecule cascade is not only a novel way to do computation, but it is also the first time all of the components necessary for nanoscale computation have been constructed, connected and then made to compute," said Andreas Heinrich, a physicist at IBM's Almaden Research Center.

However, it's not going to result in practical circuits any time soon. Each circuit has to be formed individually by a scanning tunnelling microscope, and can only be used once.





Novel UK display looking good

Oxfordshire-based Printable Field Emitters (PFE) has released pictures of its latest field-emission display (FED) prototype. The company claims to have jumped many of the hurdles which caused earlier FED companies to falter, saying that only well understood steps are needed to get the display to a state where other companies can mass produce it. FEDs are capable of full colour operation that matches CRT performance in a package only a few centimetres thick. PFE's technology is unusual in the FED world as it allows large displays to be made. Big-screen TV is the target market.

Verification for IBIS models

PCB design tool firm Zuken has set up a verification service for the IBIS models that are often used in the simulation of board designs.

The Tewkesbury-based firm said a lack of software in the market to create and verify these models results in very low quality models.

SiQual, the engineering consultancy, recently published a report and stated that 70 per cent of all IBIS models available over the Internet were flawed.

IBIS models are created by translating Spice models provided by a chip's manufacturer.

By ensuring the accuracy of IBIS models, Zuken's service aims to improve the speed and accuracy of PCB simulation.

Zuken will take a manufacturer's model data and test its precision, either against the Spice model or even against the part itself.

"Although a few US companies offer an IBIS modelling service, it is not widely available in Europe, and certainly not with the accuracy of the models that we can produce with our experience in this area," said Werner Rissiek, the firm's manager for high-speed routeing products.

"Accurate models make a critical difference to the speed at which designs can be verified and have serious implications for product time-to-market so we expect to see significant demand for this new service," said Rissiek.

AIR TRAFFIC CONTROL: How many more air disasters?

In July last year, problems with the existing system were highlighted by the tragic death of 71 people, including 50 school children, due to the confusion when Swiss air traffic control noticed too late that a Russian passenger jet and a Boeing 757 were on a collision path. The processing of extensive radar and other aircraft input information for European air space is a very big challenge, requiring a reliable system to warn air traffic controllers of impending disaster. So why has Ivor Catt's computer solution for Air Traffic Control been ignored by the authorities for 13 years? Nigel Cook reports.

In Electronics World, March 1989, a contributor explained the long-term future of digital electronics. This is a system in which computers are networked adjacently, like places in the real world, but unlike the internet. An adjacent processor network is the ingenious solution proposed for the problem of Air Traffic Control: a grid network of computer processors, each automatically backed-up, and each only responsible for the air space of a fixed area. **Figure 1** shows the new processing system, the Kernel computer, as proposed for safe, automated air traffic control.

This system is capable of reliably tracking a vast air space and could automatically alert human operators whenever the slant distance between any two adjacent aircraft decreased past the safety factor. Alternatively, if the air traffic controllers were busy or asleep, it could also send an automatic warning message directly to the pilot of the aircraft that needs to change course.

The existing suggestions are currently based on software solutions, which are unsatisfactory. For such a life-and-death application, there is a need for reliability through redundancy, and a single processor system does not fit the bill. System freezes must be eliminated in principle. Tracking aircraft individually by reliably using radar and other inputs requires massive processing, and a safe international system must withstand the rigours of continuous use for long periods, without any software crashes or system overheat failure.

The only practicable way to do this is through using Ivor Catt's adjacent-processor network.

Originally suggested for a range of problems, including accurate prediction of global warming and long-range weather, the scheme proposed by Ivor was patented as the Kernel Machine, an array of 1,000 x 1,000 = 1,000,000 processors, each with its own memory and program, made using wafer-scale integration with 1000 silicon wafers in a 32 by 32 wafer array. The data transfer rate between adjacent processors is 100 Mb/s.

Ivor Catt's original computer development is the Catt Spiral (Wireless World, July 1981), in which Sir Clive Sinclair's offshoot computer company, Anamartic, invested £16 million. Although revolutionary, it came to market and was highly praised by electronics journals. The technology is proven by the successful introduction in 1989 of a solid-state memory called the Wafer Stack, based on a Catt patent. This received the 'Product of the Year Award' from the U.S. journal Electronic Products, in January 1990.

It is a wafer scale integration technology, which self-creates a workable computer from a single silicon wafer by automatically testing each chip on the wafer, and linking up a spiral of working chips while by-passing defective ones. This system is as big an advance as the leap from transistor to compact IC (which was invented in 1959), because the whole wafer is used without having to be divided up into individual chips for separate testing and packaging.

By having the whole thing on a single silicon wafer, the time and energy in separating, testing, and packaging the chips was saved, as well as the need to mount them separately on circuit boards. By the time Catt had completed his invention for wafer scale integration, he was already working on the more advanced project, the Kernel Machine.

In the Sunday Times (12 March 1989, p. D14), journalist Jane Bird interviewed Ivor Catt and described the exciting possibilities: "in air traffic control, each processor in the array could correspond to a square mile of airspace… weather-forecasters could see at the press of a button whether rain from the west would hit Lord's before the end of cricket play."

The Kernel machine versus P.C. thinking

The primary problem facing the Kernel Machine is the predominance of single-processor computer solutions and the natural inclination of programmers to force software fixes on to inappropriate hardware.

Ivor Catt has no sympathy with ideas to use his Kernel Machine for chemistry or biology research. However, this sort of technology is vital for simulation of all real-life systems, since they are all distributed in space and time. Chemical molecule simulation for medical research would become a practical alternative to brewing up compounds in the lab, if such computers became available. It would help to find better treatments for cancer.

Modern research on the brain shows that the neurons are interconnected locally. Quite often the false notion is spread that the neocortex of the brain is a type of 'internet'. In reality, the billions of neutrons are each only connected to about 11,000 others, locally. The network does not connect each cell to every other cell. This allows it to represent the real world by a digital analogue of reality, permitting interpretation of visual and other sensory information. Each processor of the Kernel Machine is responsible for digitally representing or simulating the events in a designated area of real space. Certainly, the Kernel machine would be ideally suited to properly interpret streamed video from a camera, permitting computers to 'see' properly. This would have obvious benefits for security cameras, satellite spy and weather video, etc.

Catt filed patents for the Kernel Machine in Europe (0 366 702 B1, granted 19 Jan 1994) and the U.S. (5 055 774, granted 8 Oct 1991), a total patenting cost around the world of about £10,000. His earlier invention, the Catt Spiral, was patented in 1972 but only came to market 17 years later after £16 million of investment by Anamartic Plc.

Patented design for the new kernel computer

Figure 2 shows how the Kernel patent differs from the Spiral in two important ways. The Spiral design as utilised in the Anamartic memory wafer, once it has been manufactured like an ordinary silicon wafer, is set up as a whole wafer computer by sending test data into a chip on the edge of the wafer.

If that chip works, it sends test data into another adjacent chip, which in turn repeats the process: side-stepping faulty chips and automatically linking up the good chips into a series network. Each chip that works is therefore incorporated into a 'Spiral' of working chips, while each defective chip is bypassed. The result saves the labour of dividing up the wafer, packaging the individual chips separately, and soldering them separately on to circuit boards. It

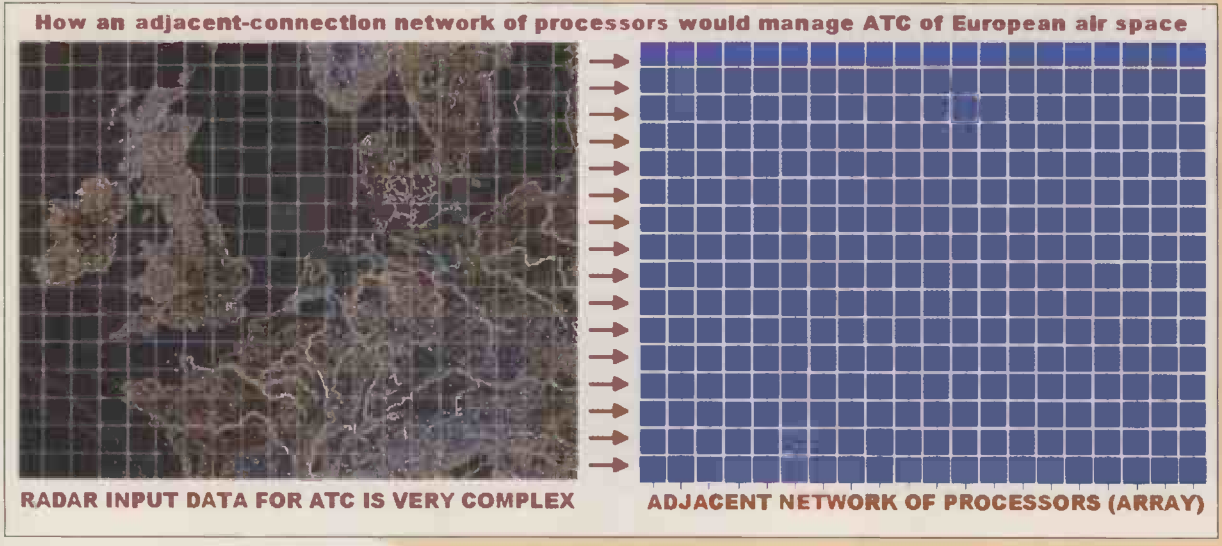
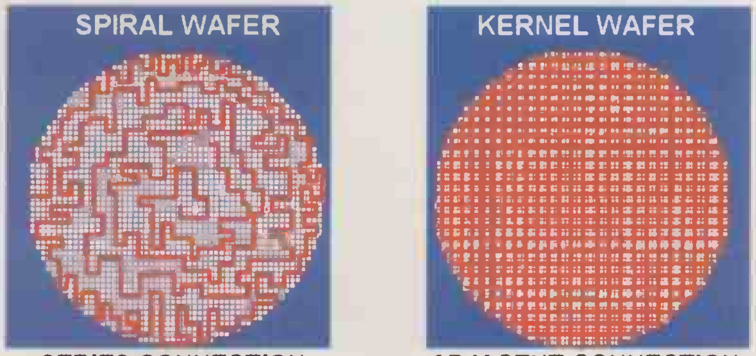


Figure: 1.

Figure: 2.

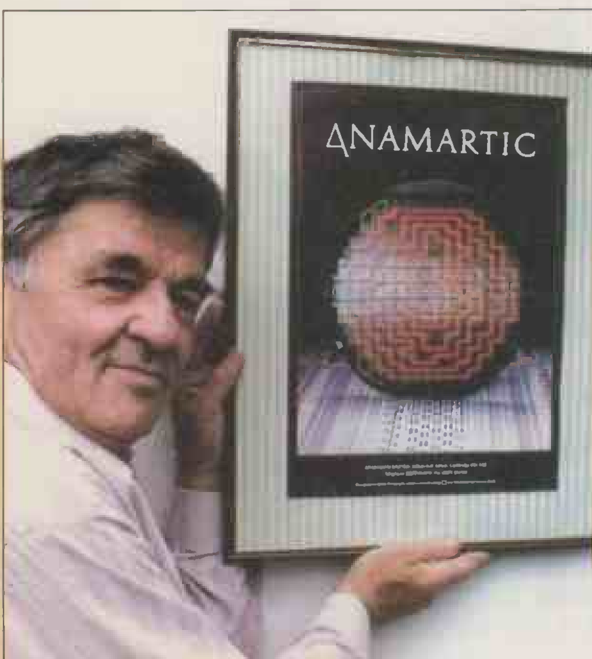


SERIES CONNECTION (Chips are tested, then defects are side-stepped to give a good chip "spiral")

ADJACENT CONNECTION (Every chip has small "Kernels" for networking links through the bad chips)

saves space, time, and money.

The problem with the Catt Spiral is that by creating a spiral or series connected memory, it causes time delays in sending and receiving data from chips near the end of the spiral. Data can also be bottlenecked in the spiral. The invention was innovative, and won awards; yet by the time Sir Clive Sinclair was ready to begin production for a massive wafer scale plug-in memory for computers, Ivor Catt was already arguing that it was superseded by his later invention, the Kernel machine. Born in 1935, Cambridge educated Catt is extremely progressive. His immediate replacement of earlier patents of his own when new developments arrive seems logical to him, although it can disturb those who invested in the previous design which has yet to make a profit.



The adjacent linking of chips into a two dimensional array in the Kernel Machine, is so-named from the 'kernels' in the corners of each chip which allow networking through the chip even if it has errors and is not used itself. Kernel computers are designed to have enough networking to avoid all of the problems of the Spiral wafer. Kernel's built-in 'self-repair' works by ignoring individual chips when they burn out, the concept of reliability through redundancy. There are sufficient spare chips available on each wafer to take over from failures.

Catt's intended scientific and commercial computing company calls for a three-stage investment of £0.5m, £8m, and £12m, respectively. The project outline states: "The scientific market and the commercial market need to be aware that there are two fundamentally different methods of computing: large, single processing engines performing single tasks one at a time, and parallel systems where there is an array of smaller engines that perform a series of tasks independently of each other until they are brought together by some management mechanism to give a result. The scientific market's major application areas are: scientific and engineering computing; signal and image processing and artificial intelligence.

"In the commercial world there are a number of application areas where the application of very fast numerical processing is extremely useful. As the limits of physical performance are now in sight for semiconductors, the next level of performance will be achieved by applying an array of processors to a particular task. To achieve even better price/performance ratios than is presently available, the architecture needs to be flexible enough to use any one of a number of computer processor types.

"Having proven the technology and its ability to be applied to specific operational areas, the company will set to licence the technology within these application areas. The company will also develop intermediate and peripheral products on its route to the major goal; that of a parallel-processing super-computer using patented technology.

"In common with all companies first entering a high technology market, this company will make a loss during the initial stages. The various stages of product development will be interposed with the marketing of that development. It is anticipated that this will reduce the negative cash flow impact inherent in an R&D environment. Industry norms have been applied to the cost of sales, marketing and administration expenditures, and to the capital costs."

In order to develop the software for the Kernel Computer, current computer technology will be used, networked in the Kernel adjacent processor array. Software, for all of the challenges facing the Kernel Computer, can be tested and debugged on this inexpensive mock-up. The next phase will be the production of the first large scale super-computers using the Kernel system of wafer-scale integration.

Catt comments: "The first Wafer Scale Integration (WSI) product, a solid state disc called Wafer Stack, came to market in 1989, based on 'Catt Spiral'. We can now advance to a WSI array processor, the Kernel machine, with one million processors giving one million million operations per second. The Kernel machine, when built from an array of 100 wafers, will retail for £500,000. The external control system maps out the good and bad chips, and devises a strategy for building a volatile, perfect square two-dimensional array of 1,000,000 processing elements (PE's) out of a larger, imperfect array. Reliability is achieved through redundancy; having spare PEs available.

"The project costs £20 million spread over four years. A proper figure for profit in this market would be 20% of retail price. The $0.2Bn turnover needed to justify the Kernel project is dwarfed by the $50Bn world computer market." The Kernel array computer is the machine of the future, replacing the single processor von Neumann machine of the present day. ■

Visit our website www.distel.co.uk

THE *ORIGINAL* SURPLUS WONDERLAND!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

Surplus always wanted for cash!

GIANT 10" 7 SEGMENT DISPLAYS

A bulk purchase enables us to bring to you these GIANT 7 segment digital displays at a most affordable price!! The **10" character size** gives exceptional readability at long distances and enables a host of applications including, score boards, digital clocks, counters, event timers etc. As the units are a simple electromechanical device and operate from 12 V DC, simple switching via switches, relays, PIC or PC may be used to control single or multiple digits. Units feature integral 'Zero Power' memory which greatly simplifies design. For an **excellent DIY practical article**, see the May issue of **Everyday & Practical Electronics' magazine. Ideal School / College construction project**. Supplied in good RFE condition, complete with data sheet.

Less than 30% of makers price! **Only £29.95**(B) **or 4 / £99.00**(D)
Order RW44 — Order PH26

THE AMAZING TELEBOX

*TV SOUND & VIDEO TUNER CABLE COMPATIBLE**

Converts your colour monitor into a QUALITY COLOUR TV!!

The TELEBOX is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors or AV equipment which are fitted with a composite video or SCART input. The composite video output will also plug directly into most video recorders, allowing reception of TV channels not normally receivable on most television receivers* (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. TELEBOX MB covers virtually all television frequencies VHF and UHF including the HYPERBAND as used by most cable TV operators. Ideal for desktop computer video systems & PIP (picture in picture) setups. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard. Brand new - fully guaranteed.

TELEBOX ST for composite video input type monitors	£36.95
TELEBOX STL as ST but fitted with integral speaker	£39.50
TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner	£69.95

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Telebox's, code (B)

NEW — **State of the art PAL (UK spec) UHF TV tuner module with composite 1V pp video & NICAM hi fi stereo sound outputs. Micro electronics all on one small PCB only 73 x 160 x 52 mm enable full tuning control via a simple 3 wire link to** an IBM pc type computer. Supplied complete with **simple working** program and documentation. Requires +12V & + 5V DC to operate.
BRAND NEW - Order as MY00. Only £39.95 code (B)
See www.distel.co.uk/data_my00.htm for picture + full details

HARD DISK DRIVES 2fi" - 14"

2fi" TOSHIBA MK1002MAV 1.1Gb laptop(12.5 mm H) *New*	£59.95
2fi" TOSHIBA MK4313MAT 4.3Gb laptop (8.2 mm H) *New*	£105.00
2fi" TOSHIBA MK6409MAV 6.1Gb laptop (12.7 mm H) *New*	£98.00
2fi" TOSHIBA MK1814GAV 18 Gb laptop (12 mm H) *New*	£149.95
2fi" to 3fi" conversion kit for Pc's, complete with connectors	£15.95
3fi" COMPAQ 313706-B21 (IBM) 9 gb ULT/SCSI3 *New*	£199.00
3fi" FUJI FK-309-26 20mb MFM I/F RFE	£59.95
3fi" CONNER CP3024 20 mb IDE I/F (or equiv.) RFE	£59.95
3fi" CONNER CP3044 40 mb IDE I/F (or equiv.) RFE	£69.00
3fi" QUANTUM 40S Prodrive 42mb SCSI I/F, New RFE	£49.00
5" MINISCRIBE 3425 20mb MFM I/F (or equiv.) RFE	£49.95
5" SEAGATE ST-238R 30 mb RLL I/F Refurb	£69.95
5" CDC 94205-51 40mb HH MFM I/F RFE tested	£69.95
5" HP 97548 850 Mb SCSI RFE tested	£99.00
5" HP C3010 2 Gbyte SCSI *differential* RFE tested	£195.00
8" NEC D2246 85 Mb SMD interface. *New*	£99.00
8" FUJITSU M2322K 160Mb SMD I/F RFE tested	£195.00
" FUJITSU M2392K 2 Gb SMD I/F RFE tested	£345.00

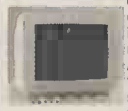
Many other floppy & H drives, IDE, SCSI. ESDI etc from stock, see website for full stock list. Shipping on all drives is code (C)

IC's -TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK
10,000,000 items EX STOCK
For *MAJOR SAVINGS*
CALL or see web site www.distel.co.uk

COMPUTER MONITOR SPECIALS

Legacy products
High spec genuine multysync.
CGA, EGA, VGA, SVGA



Mitsubishi FA3415ETKL 14" SVGA Multisync colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including IBM PC's in CGA, EGA, VGA & SVGA modes, BBC, COMMODORE (including Amiga 1200), ARCHIMEDES and APPLE. Many features: Etched faceplate, text switching and LOW RADIATION MPR specification. Fully guaranteed, in EXCELLENT little used condition. Tilt & Swivel Base £4.75

VGA cable for IBM PC included. **Only £129** (E) Order as CG73

External cables for other types of computers available - CALL

Generic LOW COST SVGA Monitors

We choose the make, which includes Compaq, Mitsubishi, IBM, etc. Supplied ready to run with all cables, Standard RTB 90 day guarantee.

14"	15"	17"
£59.00	£69.00	£79.00
order TD84	order TG21	order TJ66

Supplied in good used condition. Shipping code (D)

VIDEO MONITORS

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with both RGB and standard composite 15.625 Khz video inputs via SCART socket and separate phono jacks. Integral audio power amp and speaker for all audio visual uses. Will connect direct to Amiga and Atari BBC computers. Ideal for all video monitoring / security applications with direct connection to most colour cameras. High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed **Only £99.00** (D)
Dimensions: W14" x H12fi" x 15fi" D.

PHILIPS HCS31 Ultra compact 9" colour video monitor with standard composite 15.625 Khz video input via SCART socket. Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13fi" D. 240 V AC mains powered. **Only £79.00** (D)

INDUSTRIAL COMPUTERS

Tiny shoebox sized industrial 40 Mhz 386 PC system measuring only (mm) 266 w X 88 h X 272 d. Ideal for dedicated control applications running DOS, Linux or even Windows ! Steel case contains 85 to 265 V AC 50 / 60 hz 70 Watt PSU, a 3 slot ISA passive backplane and a Rocky 318 (PC104) standard, single board computer with 8 MByte NON VOLATILE solid state 'Disk On Chip' RAMDISK. System comprises: Rocky 318 (PC104) SBC ISA card with 40MHz ALi 386SX CPU, 72 pin SIMM slot with 16 Mbyte SIMM, AMI BIOS, battery backed up real time clock. 2 x 9 pin D 16550 serial ports. EPP/ECP printer port, mini DIN keyboard connector, floppy port, IDE port for hard drives up to 528 MByte capacity, watchdog timer and PC/104 bus socket. The 8 MByte solid state 'disk on a chip' has its own BIOS, and can be fdisked, formatted & booted. Supplied BRAND NEW fully tested and guaranteed. For full data see featured item on website. Order as QG36

100's of applications inc: firewall, routers, robotics etc **Only £99.00** (D)

19" RACK CABINETS

Save £££'s

Europe's Largest Stocks of quality rack cabinets, enclosures and accessories. Over 1000 Racks from stock

This month's special
33 / 42 / 47 U - High Quality All steel Rack Cabinets
BIG £ SAVER

Made by **Eurocraft Enclosures Ltd** to the **highest** possible spec, rack features **all steel construction** with removable side, front and back doors. Front and back doors are **hinged for easy access** and all lockable with five **secure 5 lever barrel locks**. The front door is constructed of double walled steel with a **'designer style'** smoked acrylic front panel to enable status indicators to be seen through the panel, yet remain unobtrusive. Internally the rack features fully slotted reinforced vertical fixing members to **take the heaviest of 19" rack equipment**. The two movable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A mains **distribution panel** internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin **switched utility socket**. Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvres. The top panel may be removed for **fitting of integral fans** to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower **rear** for cable / connector **access** etc. Supplied **in excellent**, slightly used condition **with** keys. Colour Royal blue. some grey available - CALL - Can be supplied in many other configurations.

33U	42U	47U
Order as BC44	Order as DT20	Order as RV36
External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23fl" W)	External dimensions mm=2019H x 635D x 603 W. (79.5" H x 25" D x 23fl" W)	External dimensions mm=2235H x 635D x 603 W. (88" H x 25" D x 23fl" W)
Only **£245**	Only **£345**	Only **£410**

Call for shipping quotation

COLOUR CCD CAMERAS

BIG £ SAVER

Undoubtedly **a miracle of modern technology** & our special buying power ! A **quality** product featuring a fully cased **COLOUR CCD** camera at a give away price ! Unit features full autolight sensing for use in **low light & high light applications**. A 10 mm fixed focus wide angle lens gives **excellent focus and resolution** from close up to long range. **The composite video output** will connect to any composite monitor or TV (via **SCART socket**) and most video recorders. Unit **runs from 12V DC** so ideal for security & **portable applications** where mains power not available.

Overall dimensions 66 mm wide x 117 deep x 43 high. Supplied BRAND NEW & fully guaranteed with user data, 100's of applications including Security, Home Video, Web TV, Web Cams etc, etc.

Order as LK33 *ONLY £79.00 or 2 for £149.00* (B)

SOFTWARE SPECIALS

NT4 WorkStation, complete with service pack 3 and licence - OEM packaged. *ONLY £89.00* (B)

ENCARTA 95 - CDROM, Not the latest - but at this price !	£7.95
DOS 5.0 on 3fi" disks with concise books c/w QBasic .	£14.95
Windows for Workgroups 3.11+ Dos 6.22 on 3.5" disks	£55.00
Windows 95 CDROM Only - No Licence -	£19.95
Wordperfect 6 for DOS supplied on 3fi" disks with manual	£24.95

shipping charges for software is code B

SOLID STATE LASERS

Visible red, 670nm laser diode assembly. Unit runs from 5 V DC at approx 50 mA. Originally made for continuous use in industrial barcode scanners, the laser is mounted in a removable solid aluminium block, which functions as a heatsink and rigid optical mount. Dims of block are 50 w x 50 d x 15 h mm. Integral features include over temperature shutdown, current control, laser OK ouput, and gated TTL ON / OFF. Many uses for experimental optics, comms & lightshows etc. Supplied complete with data sheet.

Order as TD91 *ONLY £24.95* (A)

DC POWER SUPPLIES

Virtually every type of power supply you can imagine.Over 10,000 Power Supplies Ex Stock - Call or see our web site.

RELAYS - 200,000 FROM STOCK

Save ££££'s by choosing your next relay from our Massive Stocks covering types such as Military, Octal, Cradle, Hermetically Sealed, Continental, Contactors, Time Delay, Reed, Mercury Wetted, Solid State, Printed Circuit Mounting etc. , CALL or see our web site www.distel.co.uk for more information. Many obsolete types from stock. Save ££££'s

TEST EQUIPMENT & SPECIAL INTEREST ITEMS

Unless marked NEW, items in this section are pre owned.

MITSUBUSHI FA3445ETKL 14" Ind. spec SVGA monitors	£245
ARNELL 0-60V DC @ 50 Amps, bench Power Supplies	£995
ARNELL AP3080 0-30V DC @ 80 Amps, bench Suppy	£1850
INGSHILL CZ403/1 0-50V @ DC 200 Amps - NEW	£3950
kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
BM 8230 Type 1, Token ring base unit driver	£760
Wayne Kerr RA200 Audio frequency response analyser	£2500
NFODEC 1U, 24 port, RJ45 network patchpanels. #TH93	£49
COM 16670 12 Port Ethernet hub - RJ45 connectors #LD97	£69
COM 16671 24 Port Ethernet hub - RJ45 connectors	£89
COM 16700 8 Port Ethernet hub - RJ45 connectors NEW	£39
BM 53F5501 Token Ring ICS 20 port lobe modules	£POA
BM MAU Token ring distribution panel 8228-23-5050N	£45
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE I/O	£550
LLGON 8360.11805-1880 MHz hybrid power combiners	£250
rend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
arconi 6310 Programmable 2 to 22 GHz sweep generator	£4500
arconi 2022C 10KHz-1GHz RF signal generator	£1550
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & HP3782A Error Detector	£POA
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
P6264 Rack mount variable 0-20V @ 20A metered PSU	£475
P54121A DC to 22 GHz four channel test set	£POA
P8130A opt 020 300 MHz pulse generator, GPIB etc	£7900
P A1, A0 8 pen HPGL high speed drum plotters - from	£550
HP DRAFTMASTER 1 8 pen high speed plotter	£750
EG+G Brookdeal 95035C Precision lock in amp	£1800
Keithley 590 CV capacitor / voltage analyser	£POA
acal ICR40 dual 40 channel voice recorder system	£3750
skers 45KVA 3 ph On Line UPS - New batteries	£4500
merson AP130 2.5KVA industrial spec.UPS	£1499
ann Tally MT645 High speed line printer	£2200
ntel SBC 486/133SE Multibus 486 system. 8Mb Ram	£945
HP6030A 0-200V DC @ 17 Amps bench power supply	£1950
Intel SBC 486/125C08 Enhanced Multibus (MSA) New	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
PHILIPS PM5518 pro. TV signal generator	£1250
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM high speed band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Siemens K4400 64Kb to 140Mb demux analyser	£2950
Perkin Elmer 299B Infrared spectrophotometer	£500
Perkin Elmer 597 Infrared spectrophotometer	£3500
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3250
LightBand 60 output high spec 2u rack mount Video VDA's	£495
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
B&K 2633 Microphone pre amp	£300
Taylor Hobson Tallysurf amplifier / recorder	£750
ADC SS200 Carbon dioxide gas detector / monitor	£1450
BBC AM20/3 PPM Meter (Ernest Turner) + drive electronics	£75
ANRITSU 9654A Optical DC-2.5G/b waveform monitor	£5650
ANRITSU ML93A optical power meter	£990
ANRITSU Fibre optic characteristic test set	£POA
R&S FTDZ Dual sound unit	£650
R&S SBUF-E1 Vision modulator	£775
WILTRON 6630B 12.4 / 20GHz RF sweep generator	£5750
TEK 2445 150 MHz 4 trace oscilloscope	£1250
TEK 2465 300 Mhz 300 MHz oscilloscope rack mount	£1955
TEK TDS380 400Mhz digital realtime + disk drive, FFT etc	£2900
TEK TDS524A 500Mhz digital realtime + colour display etc	£5100
HP3585A Opt 907 20Hz to 40 Mhz spectrum analyser	£3950
PHILIPS PW1730/10 60KV XRAY generator & accessories	£POA
VARIACS - Large range from stock - call or see our website	
CLAUDE LYONS 12A 240V single phase auto. volt. regs	£325
CLAUDE LYONS 100A 240/415V 3 phase auto. volt. regs	£2900

DISPLAY -ELECTRONICS-

ALL MAIL TO
Dept W, 29 / 35 Osborne Rd
Thornton Heath
Surrey CR7 8PD, UK
Open Mon - Fri 9.00 - 5:30

18 Million Items On Line Now !
Secure Ordering, Pictures, Information
VeriSign Secure Site
www.distel.co.uk
email = admin@distel.co.uk

ALL ENQUIRIES
0208 653 3333
FAX 0208 653 8888

Est. 26 Years

The Taiwan electronics industry has long been internationally famous for its manufacturing ability. However, as the environment changes, Taiwan manufacturers must transform and upgrade themselves to survive severe competition. As a consequence, production lines are being expanded to lower cost places for longer-term development. Charles Ward to reports on developments at the recent Taitronics exhibition.

TAITRONICS TAIWAN

Taiwan manufacturers are gradually switching the production of low-level products to overseas, while Taiwan serves as the base for developing and producing high-level products as well as marketing. With effort, Taiwan manufacturers will eventually be able to transform themselves from a manufacturing centre to an international supply centre of information, communication and consumer electronics products.

The ultimate goal is to make Taiwan the global electronics management centre, and the growing pattern of procurement in Taiwan and offshore distribution indicates that Taiwan - or "Silicon Island" as it likes to be called - is slowly achieving that goal. There is reason for firm conviction - well, there has to be - that with the advantages of superior flexibility and efficiency, Taiwan's electronics industry will continue is growth.Taiwan has over 40 years experience in consumer electronics manufacturing and in 2001 its exports of these products were valued at US$3.75 billion. Many Taiwanese companies have formed alliances with well-known foreign companies to bolster their market strength at home and around Asia. Following the entry of both mainland China and Taiwan into the World Trade Organisation in November 2001, the area's market potential is bound to bring vast opportunities.

TV

Taiwan may not be well known for its inventiveness of colour television receivers, particularly as there are only seven CTV manufacturers on the island, but things are changing. At the autumn Taitronics exhibition organised by The China External Trade Development Council (CETRA) and the Taiwan Electrical and Electronic Manufacturers' Association (TEEMA) held in Taipei, Taiwan's second biggest CTV manufacturer - Kolin - introduced a rear projection digital CTV that the company claims to be only the second of its type to be announced in the world.

Known as LCOS (Liquid Crystal on Silicon), this new technology significantly accentuates the colour on screen providing a brightness of 775 nits. Utilising three reflective light imagers and a sophisticated prism and lens system, light is transformed into a laser-like beam and imprinted with a high-definition image that is then magnified and displayed in a perfectly aligned widescreen format. For the past three to four years Kolin has focused its development on plasma TVs, but in the past 18 months the company has diverted its effort into the LCOS receivers.

Jeff Tsai, assistant vice-president of the investment management centre at the Kolin Group told Electronics World that the new receivers "would be around 40% lower in price than plasma and power consumption of LCOS was considerably lower than plasma". There is also around a 60% saving in weight compared with a conventional rear projection CTV. Mr Tsai added: "Plasma's limitations of short lifespan and ability to be repaired easily could see the system downgrade in two or three years with LCOS and its superb picture quality and longer lifespan, taking over."

The model on show by Kolin was a 50in 16:9 version with a front-to-back cabinet depth of 43cm Kolin hopes to reduce that to 35cm very soon. This new flicker free CTV has a high contrast and crisper picture that is immediately different to the eye from other TVs.

Apparently RCA has recently debuted a LCOS CTV in America and Toshiba and with its strength in rear projection CTVs, is said to be the most aggressive of the Japanese makers researching LCOS. In Europe, Philips is believed to have a prototype.

Kolin 50in 16:9 LCOS television

Remote controls

A number of companies at the Taitronics exhibition were introducing touch screen remote controls. Typical of these is a model from Sunwave that will mimic up to 16 remote controls and is ideally suitable for controlling home theatre systems.

DVD

Amongst a host of DVD players exhibited by a number of manufacturers was the Aboss ultra slim, combined player/amplifier from SliMax International. This young company - only six years old - has combined the servo and decoder functions into one IC. The DVD player will work on all power sources and TVs - Europe, Japan, US, etc, with no requirement for voltage or video converter.

The player also includes a digital photo playback system that allows the user to easily navigate among digital pictures on a TV screen. The built-in amplifier provides seven reverberative sound modes - concert/living room/hall/bathroom/cave/arena/church and seven preset audio EQ mode option (rock/pop/live/dance/techno/classic/soft).

Kits

Mechanical motorised kits have taken on a new meaning at Taiwan manufacturer CIC Components with the launch of a solar-powered range of kits. In designs that include dinosaurs, helicopters, skeletons, steam trains, robots and racing cars, these kits are supplied as wooden constructions with pulleys, gears, shafts, switches and motor. All the young 'engineer' requires to construct the kits are a knife, screwdriver and long nose pliers.

Also from CIC is a range of electronic education kits that includes a line tracking mouse and a robot car that reverses when it senses noise or touches obstacles. Kits include a motor, two sets of gears, metal shafts, gearbox and various other accessories.

Telecommunications

Taiwan's communications industry reached US$2.69billion in 2001, but like most of the world the telecommunications industry in Taiwan has been hit recently by the worldwide slump in sales of mobile telephones, etc. Severe competition from Chinese manufacturers has also put pressure on Taiwanese companies.

Local manufacturers blamed over-optimism of major international mobile phone brands for the lower than expected market performance, which resulted in tremendous stocks of finished products as well as components.

Main introductions at the exhibition were mobiles with the ability to control as many as 10 different telephone numbers on one SIM card; mobiles with coloured screens were popular innovations; hands free mobile systems; and Bluetooth headsets.

Email

Creating an email takes on a new meaning with the introduction of the PenSuite 3D drawing tablet with cordless pen and wireless mouse.

Available from UC-Logic Technology, the program allows the user to hand write emails, sign emails or even draw and sketch on emails.

Drum kit

One thing in common with most Far Eastern companies is their ability to create aggressive low pricing for products.

One such case is an electronic drum system by Taiwan First Line Electronics. The company has introduced a drum kit that includes five percussion pads, a kick treadle, an instruction CD, and 110 combinations of backing sound.

Similar drum kits by top name companies cost around £750 each whereas the Taiwanese company suggests a retail price of £220. ■

Contacts

Kolin: www.kolin.com.tw

Slimax: www.slimax.com.tw

CIC Components: www.cic-components.com

Sunwave: www.sun-wave.com

UC-Logic: www.UC-Logic.com

Taiwan First Line Electronics: www.bafo.com.tw

Modern impedance measurement techniques II

In his second in-depth article investigating modern methods of measuring impedance, Alan Bate* first rounds off his explanation of circuit blocks used in modern LCR measuring instruments. He then discusses how measurements are made and how the frequency range of instruments can be extended.

*Alan Bate BEng (Hon's) MIEE

In my previous article, I mentioned that the phase-sensitive detector, PSD, used in impedance measuring instruments is an analogue multiplier. Consequently, any harmonics in the PSD reference make the circuit susceptible to any harmonics of the same frequency in the stimulus.

A simple square-wave driven PSD is the most vulnerable to odd-harmonic distortion. This is because the reference contains an infinite range of odd harmonics. Ideally, the goal is a very pure, stepped sine wave reference having minimal harmonics and the simplest possible synthesis method.

By generating an approximate, or quasi, stepped sine wave, where each step level is matched to the integral of the sine for that time sample, the four-level-by-eight time-sample waveform has no harmonics below the seventh as discussed last month.

Only two switches are needed for this circuit. This is a major consideration, as each analogue switch will contribute charge injection into the PSD output.

Integration of the PSD current output will convert the injected charge into a DC offset, which grows proportionally with frequency. While this offset can be compensated for in the offset readings, the dynamic range is reduced as the offset shifts the phase detector's analogue-to-digital converter bias point. This effectively reduces the instrument's dynamic range.

In practice, the drive level may have to be reduced at the highest frequency settings to avoid slew rate distortion in the rest of the measuring chain.

Current output from the PSD is fed directly into the A-to-D converter's virtual earth. This avoids an unnecessary transimpedance stage, which would attempt to generate the fast voltage edges with consequent slew rate distortion.

By merging the detector and A-to-D converter, the PSD output waveform is integrated by the converter, avoiding the potential slew rate problem.

A-to-D conversion

The simplest approach to analogue-to-digital conversion is the dual-slope technique, as used in low-cost digital multi-meters for many years, **Fig. 1**.

Dual-slope converters have an integrator that samples the signal for a fixed integration period. This is usually made a multiple of the supply frequency in order to reject supply-related noise: the same principle is applied in the LCR instrument to reject PSD ripple.

Output from the integrator ramps linearly until the signal is turned off at the end of the fixed integration period. This also prevents overloading. Now, the integrator is reset by switching a reference current into the integrator input, causing the output to ramp back to zero.

During the ramp down, a counter is enabled allowing a count from a high frequency clock to accumulate. When the output ramp passes through zero, a zero-crossing comparator is set which stops the measurement counter and resets the integrator.

Because a ratio measurement is made between the integrate and de-integrate timings, all the tolerances in the integrator circuit are cancelled.

In an LCR instrument though, there's a very wide signal range, with the rapid succession of large followed by tiny measurements. It has been found that dual-slope A-to-D converters suffer from non-linearity due to;

- Dielectric distortion in the integrator capacitor.
- Ramp non-linearity at high signal levels due to the onset of amplifier slew rate distortion as the ramp approached the amplifier maximum output level.

Dielectric storage became noticeable because the instrument's dissipation factor degraded while measuring small capacitors with very low dissipation factor – small polystyrene capacitors for example. Here the tiny current reading would immediately follow a large voltage reading. The residual charge in the integrator capacitor would not have been removed during the A-to-D converter's reset period but became added to the following measurements.

The limited dynamic range of the integrator at near full output also affected the amount of tolerable PSD ripple, **Fig. 2**, possibly overloading the integrator output with large PSD ripple. As a result, dual-slope A-to-D converters are only used on low-cost LCR instruments.

Quantised feedback conversion

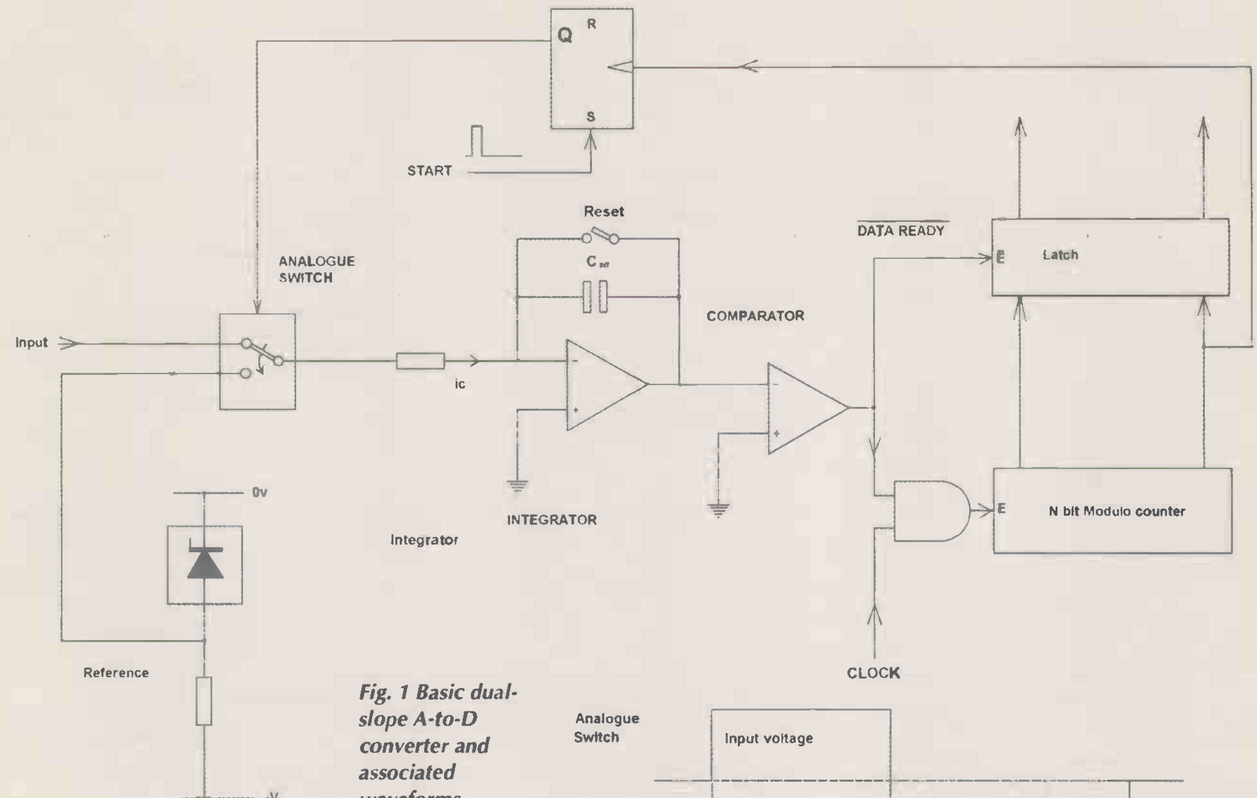
To overcome the limitations of dual-slope conversion, 'quantised feedback' or 'charge balancing' conversion is used. This method has none of the above limitations and some additional advantages.

In this approach, dielectric storage is simply avoided by never allowing the integrator capacitor voltage to develop. This also avoids slew-rate non-linearity of the integrator by maintaining small-signal amplifier operation.

In addition, because the amplifier output voltage range is never used, a theoretically infinite integration period could be applied in a microprocessor controlled system. This allows long integration periods to be used for enhanced noise suppression. In practice, very long integration periods are limited by the $1/f$ noise of the integrator amplifier and reference circuits.

Integrator output is regulated by a simple PWM control loop, which corrects the integrator output voltage by injecting a reference current or charge, **Fig. 3**, to return the output to zero.

The high/low comparator compares the output to 0V and sets the reference current accordingly. The on/off current



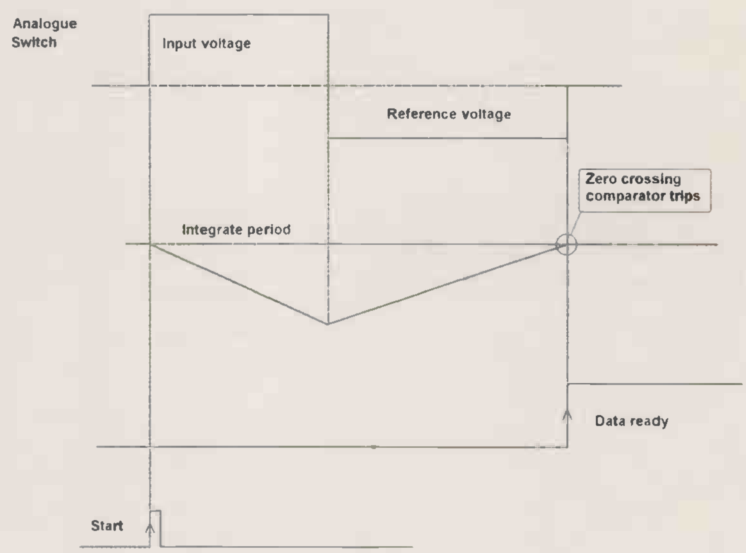


Fig. 1 Basic dual-slope A-to-D converter and associated waveforms.

waveforms are designed to have equal and opposite number of switching transitions to cancel switching charge injection at the integrator input, **Fig. 4**.

In order to reject the large amount of AC ripple from the PSD output, the integrator is synchronised to integrate over a whole number of stimulus cycles as mentioned earlier. At the end of the integrate period the PSD is turned off but the reference current is left full on. See Fig. 3, charge-balance waveforms.

Now, the integrator ramps to an arbitrary end of ramp comparator threshold. The comparator trips, sétting the end of the measurement sequence. The comparator includes hysteresis to lock out possible multiple transitions due to the slow ramp rate and noise.

The measurement is accumulated in a measurement counter that's enabled each time the integrator output is reset, or reference current applied. This includes the final ramp down to the end-of-ramp comparator threshold. Residual bits of the conversion are resolved by this final ramp.

As in the dual-slope method, the signal is integrated for a fixed period, but there is no waiting for the end of the integration period before applying the DC reference. Instead, the DC reference is summed with the input signal during the integration period.

Summing the DC offset with the signal avoids a separate DC offset measurement, enabling the conversion rate to be increased significantly compared to dual-slope conversion. On a large signal, the dual slope also takes longer to de-integrate. The integration period would be the same in each case.

The hardware measurement counter can be smaller than the full 22-bit resolution would imply by simply recording the number of counter overflows in the software. The charge-balance current must balance the maximum input

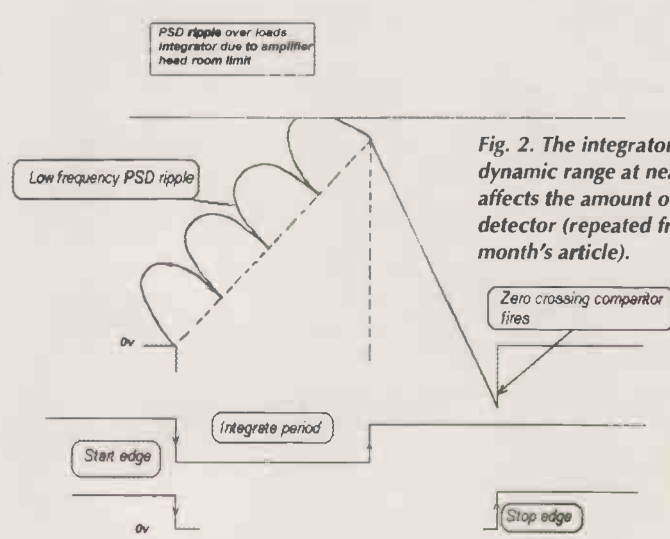


Fig. 2. The integrator's limited dynamic range at near full output affects the amount of ripple in the detector (repeated from last month's article).

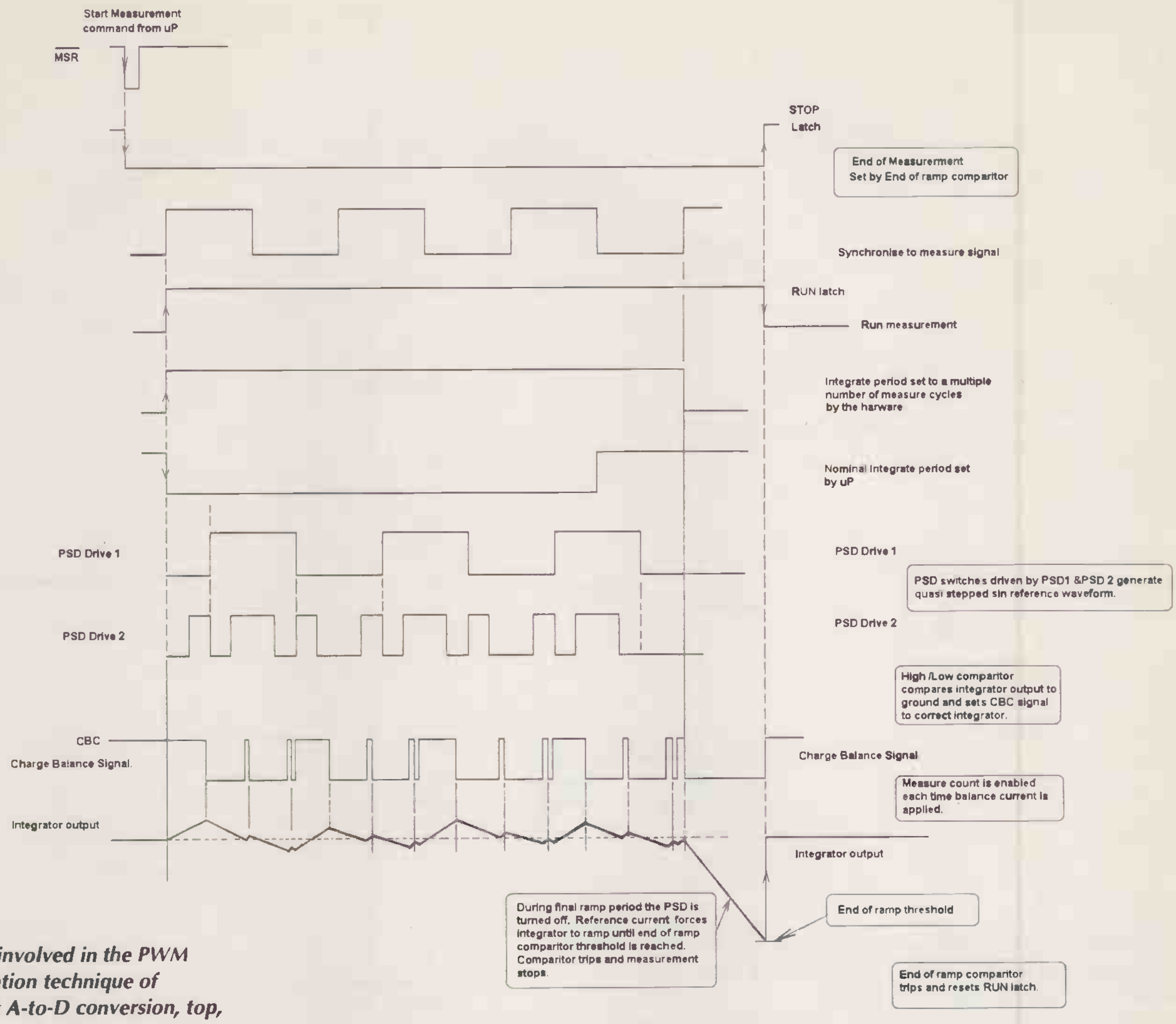
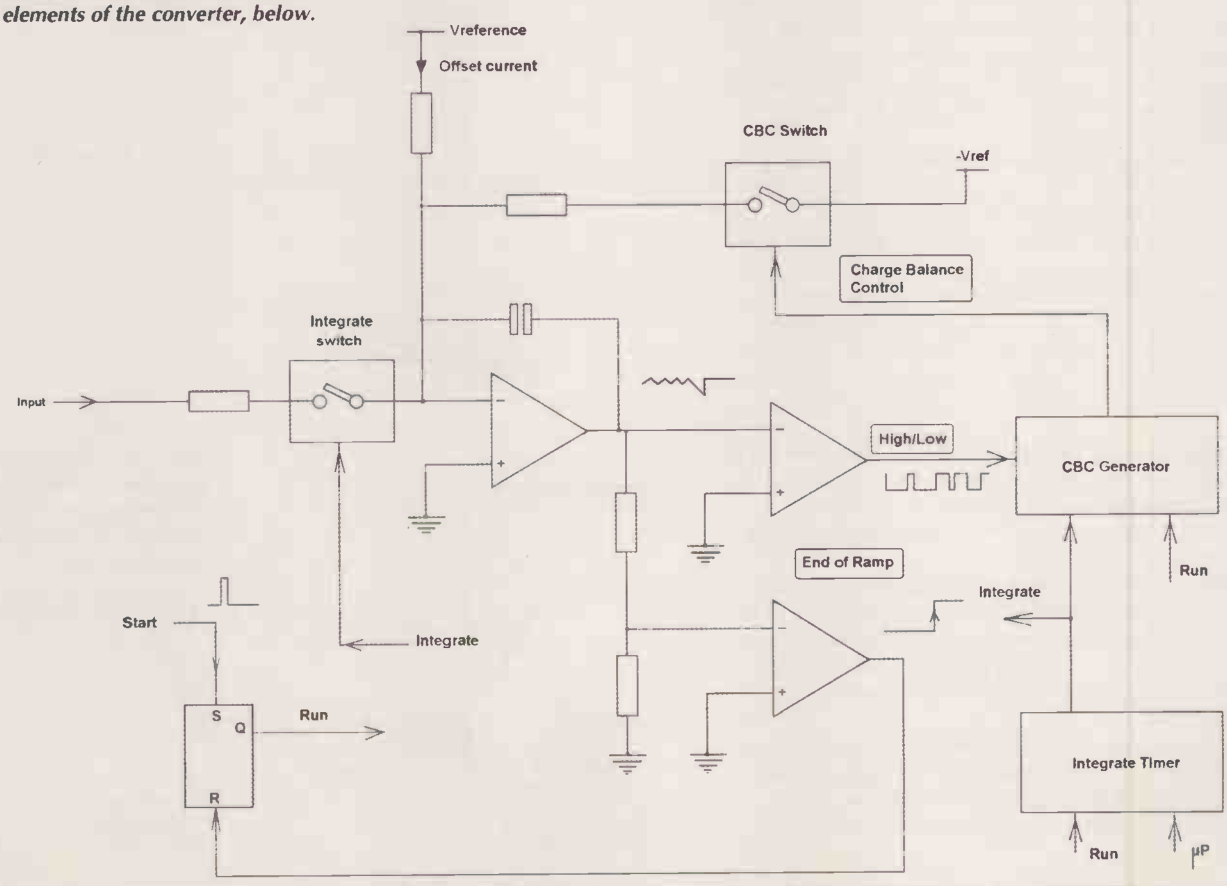


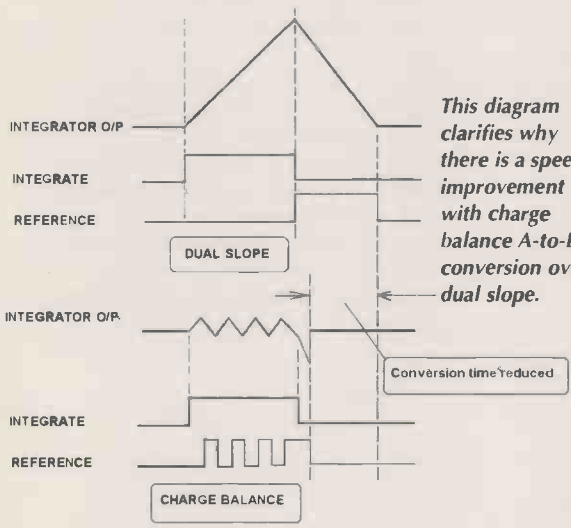
Fig. 3. Waveforms involved in the PWM control-loop regulation technique of quantised feedback A-to-D conversion, top, and basic elements of the converter, below.



current. This means that the notches in the two charge balance waveforms have the effect of reducing the theoretical dynamic range by the ratio of the notch time divided by the charge-balance conversion period at each end.

Frequency of the charge balance signal has to be chosen with care to avoid beats with the PSD ripple. Low-frequency signal ripple tends to be chopped by the charge balancing process, preventing ripple build up.

Increasing the ripple frequency improves the charge balancing and PSD ripple rejection. But it also increases the charge injection from the charge balance switching. Increasing the charge injection adds an unwanted offset along with the charge injected by the PSD switches.



This diagram clarifies why there is a speed improvement with charge balance A-to-D conversion over dual slope.

Overall, the charge balancing A-to-D converter gives excellent performance. With very long integration periods, the circuit is limited by low-frequency 1/*f* noise from the band-gap reference and integrator amplifier. The impedance range of the instrument is therefore reduced to maintain a practicable number of precision range settings.

Ranging

Like all signal-processing systems, we are limited in dynamic range. At maximum drive signal, overloading the detector must be avoided. If this occurred in a basic LCR instrument, where auto ranging is totally based on the impedance reading, the measurement process would go our of control.

Without a measurement, the software would have no reliable means of sensing which way to go in auto ranging or optimising the signal levels for best resolution. Consequently, the instrument must have a hardware range setting, that's 'bomb proof' and cannot overload in order to recover from any abnormal auto ranging situation. This is normally a lower mid range where the drive source is current limited with a swamp resistor to prevent overload into a short circuit.

Drive voltage and range gain settings are set to avoid detector overload with an open or short circuit. Normally, from the drive level set by the user, the firmware carries out an auto-range process by making a fast initial measurement and then testing for an impedance reading which is ±5% beyond the nominal impedance range upper or lower range limits. This prevents hunting at the range boundaries.

On lower impedance ranges, the drive signal must be set to current drive by selecting the swamp resistor. On higher impedance ranges, the swamp resistor is switched out to give voltage drive.

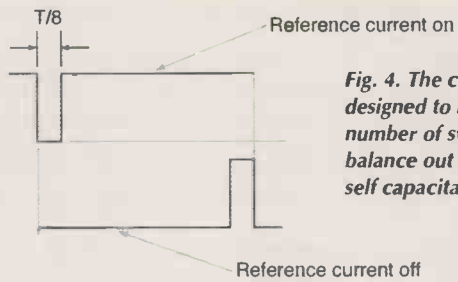


Fig. 4. The charge-balance waveforms are designed to have an equal and opposite number of switch transitions in order to balance out charge injection from switch self capacitance.

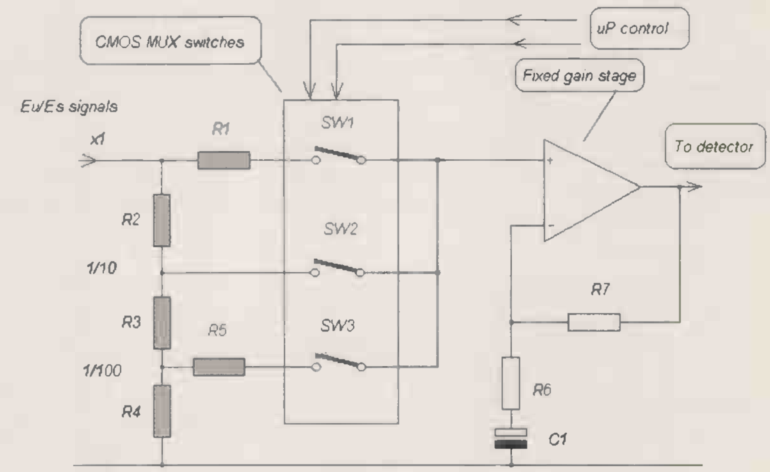


Fig. 5. Method of ranging using fixed gain and a precision attenuator.

Where the hardware changes in drive level or drive mode, (voltage or current), the user is informed via the display. While this approach makes for a 'user friendly' instrument, it can be unsatisfactory when making measurements of voltage-controlled impedances such as varicap diodes and high-permittivity ceramic capacitors. For this reason, some LCR instruments allow the user to have voltage drive for any impedance that is within the drive output power capability. For this functionality, additional firmware is required to detect for any overloading of the stimulus, E_u or E_s signals. These are the unknown and standard voltages discussed in last month's article.

With the wide range of operation required in impedance measurement, the typical LCR instrument will have at least seven range settings to cover a impedance range of typically 0.1Ω to 10MΩ, depending on the acceptable dynamic range of the detector.

Typically, the detector would be expected to work down to 1/10 of full range, giving 100:1 in impedance range for each combination of voltage and current range setting. With a high frequency high-speed precision bridge the detector range might be reduced to $1/\sqrt{10}$ of full scale to accommodate;

- Tighter error budget
- Additional non-linearity contribution from the frequency down conversion mixer. More on this in next section.
- Higher noise due to the conversion loss from the mixer.
- Shorter PSD/A-to-D integrate times with consequent higher PSD/A-to-D noise.

For the same measurement/accuracy conditions, this would require ten times as many fixed ranges for the same impedance coverage! The instrument range of impedance is therefore reduced to maintain a practical number of precision range settings.

The precision gain ranging is achieved by using wide band resistive attenuators and keeping the range amplifier gain constant, **Fig. 5**.

Amplifier gain is fixed at the level required for the lowest expected signal for full accuracy. The attenuator is set to minimum attenuation, giving maximum range gain. As the signal is increased, the firmware sets the attenuator to increasingly higher attenuation settings. This method gives consistent bandwidth, as the amplifier gain is not altered.

If the ranging was set by changing the amplifier feedback, the gain could not be set to sufficient accuracy and the phase would change at each setting due to the finite amplifier gain bandwidth. For this reason, this approach is also used in wide-band instruments such as oscilloscopes so that the waveform does not change with the vertical sensitivity setting. (This did happen with some older valve scopes).

While the signal is attenuated before the amplifier, which seems a bad idea noise wise, remember that this is only as the signal is increased. At the lowest level where the instrument noise performance is most important the voltage attenuation is zero.

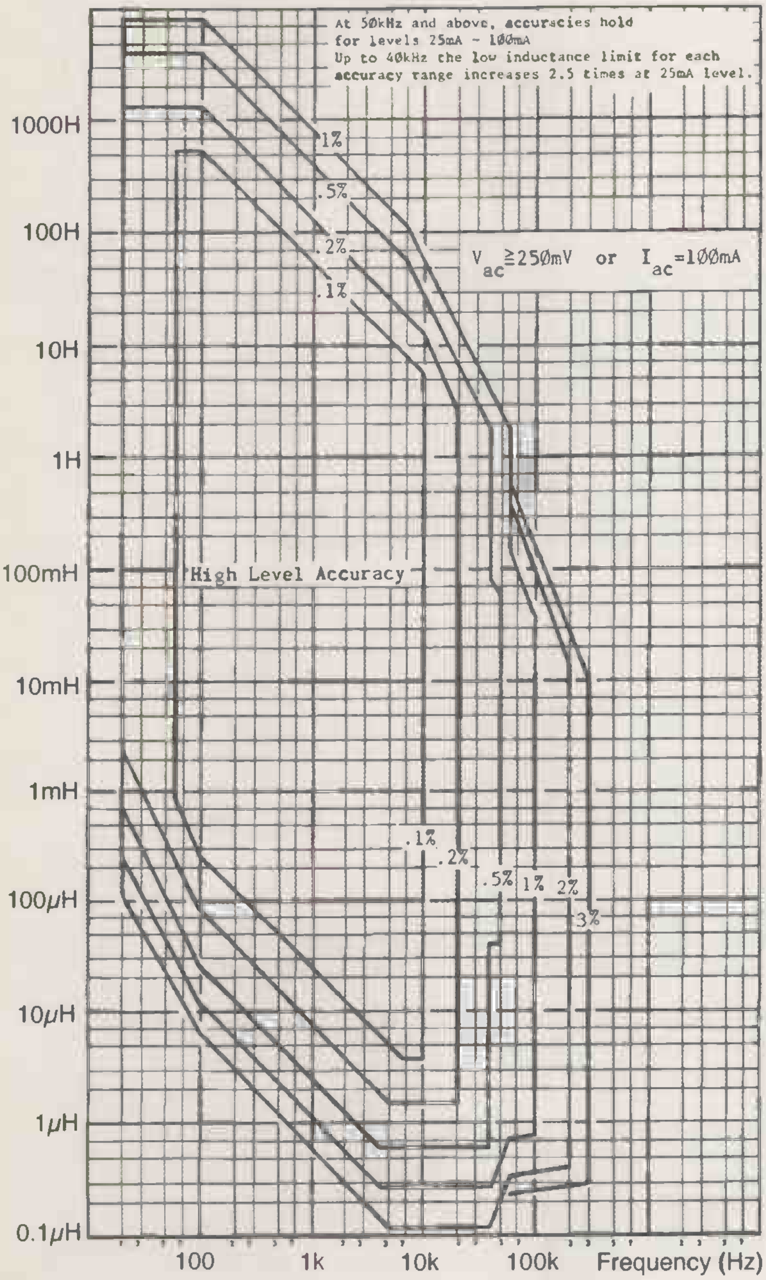


Fig. 6 Instrument error can be described as a bowl shaped three-dimensional surface. Here it is expressed as a contour map on a two dimensional piece of paper with impedance on the Y axis, frequency on the X axis and total percentage error in the Z axis. Courtesy Wayne Kerr Instruments.

The additional resistors at the potentiometer settings ensure constant source impedance is seen by the analogue switch capacitance and hence consistent time constant is maintained.

Calculation and display

The analogue-to-digital conversion results are formatted as 22-bit fixed-point numbers. Six readings are taken for a normal measurement, consisting of the real (*I*) and quadrature (*Q*) components of E_u and E_s.

In addition, DC measurements are made for E_u and E_s with the drive signal turned off. This gives the precise level of the DC offset inserted to bias the PSD/A-to-D-converter combination to mid range to enable bipolar operation.

Once the offset corrected values of a, b, c, & d are obtained, the impedance can be derived using only four-function maths (see equation below.)

For high accuracy, hence slow measurement, the DC drift between each in-phase and quadrature measurement is offset corrected, requiring another two dc measurements, giving eight readings. In the following, only normal to fast measurements are considered.

With unknown voltage $E_u = a + jb$ and current shunt voltage $E_s = c + jd$' and,

$$Z_{unknown} = \frac{E_u}{E_s} \times R_{standard}$$

$$= R_s \frac{a + jb}{c + jd}$$

hence:

$$Z_{unknown} = \frac{R_s(ac + bd) + j(bc + ad)}{c^2 + d^2}$$

First, the trim corrections are applied. For low impedances, typically below a 1000Ω range boundary, the series real and reactive terms are subtracted.

Parallel (open-circuit trim) values are converted to admittance and subtracted from the unknown admittance. Having removed the DC offsets in fixed-point maths for speed; the data is now converted to floating point numbers.

Omega is re-calculated and stored whenever a new frequency is selected.

Considering low impedances, the series resistance R_S is calculated. Using complex-number algebra:

$$Zj = \left\{\left(ac - bd^2\right) + j(bc - ad)\right\} \frac{1}{c^2 + d^2} \times range\ number$$

The in-phase series term,

$$R_s = \frac{ac - bd^2}{c^2 + d^2} \times range\ number$$

Series reactance term

$$X_s = \frac{bc - ad}{c^2 + d^2} \times range\ number$$

The range number is a scalar value. It takes account of any gain and standard resistor value selected in the hardware to cover that particular impedance range. The series trim values are then subtracted and the appropriate readout value calculated according to the auto range or user's display mode selection

For example, with a low impedance range selected, the bridge auto-ranging firmware would choose series impedance mode and select according to the sign of the reactance term either;

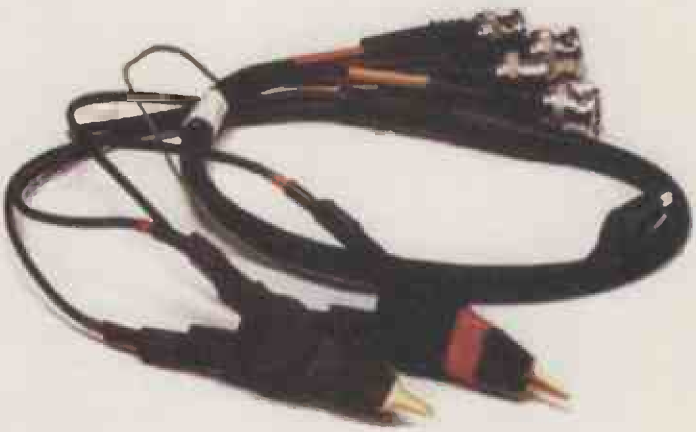


Fig. 8. Photo a) shows a Wayne Kerr four-terminal fixture, b) shows tweezers for measuring chip components using a two terminal connection method and c) shows Kelvin clips, again from Wayne Kerr.

$$R = R_s$$

and,

$$L = L_s = \frac{X_s}{\omega}$$

or,

$$C_s = -\frac{1}{\omega X_s}$$

Dissipation factor is given by,

$$D = \frac{R_s}{X_s}$$

and quality factor by,

$$Q = \frac{X_s}{R_s}$$

With a high impedance range selected, the auto ranging would choose parallel impedance mode and again select according to the sign of the reactance term;

$$R_p = R_s(1+Q^2) \text{ ohms}$$

and,

$$L_p = L_s(1+D^2) \text{ henries}$$

or,

$$C_p = \frac{C_s}{1+D^2} \text{ farads}$$

or,

$$G_p = \frac{1}{R_s(1+Q^2)} \text{ siemens}$$

If selected by the user, polar form would be displayed from;

$$Z = \sqrt{R_s^2 + X_s^2}$$

or angle,

$$\vartheta = \arctan\frac{X_s}{R_s}$$

Specifying LCR instrument accuracy

Specifying an impedance meter is a little involved, as impedance is three dimensional. It has a real part, a reactive part and a frequency. In addition, the bridge is primarily limited by the guard amplifier shunt load performance with frequency and amplifier noise.

At the extremities of the range of impedance magnitude, the bridge is either noise limited on the voltage signal E_u for very low impedances or the current shunt E_s signal for very high impedances. At very low frequencies, $1/f$ noise and drift come in to play. At high frequencies, the high impedance range required by the user falls, which offsets the E_s noise limitation.

However, distortion in the entire signal processing stages increases, hence the instrument error can be described as a bowl shaped three-dimensional surface. For a given stimulus level, this error bowl is best expressed as a contour map on a two dimensional piece of paper with impedance on the Y axis, frequency on the X axis and total percentage error in the Z axis, Fig. 6.

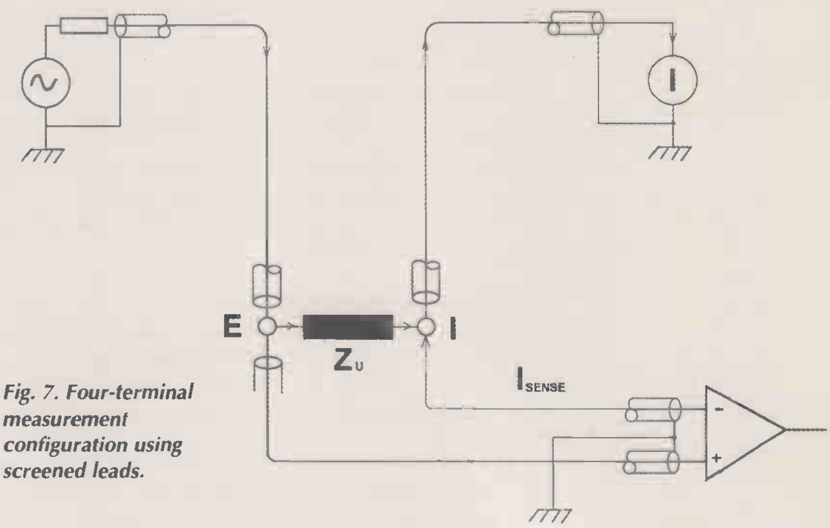


Fig. 7. Four-terminal measurement configuration using screened leads.

Adding DC resistance measurement

So far, I have only discussed AC impedance measurements. Resistance at DC can also be measured

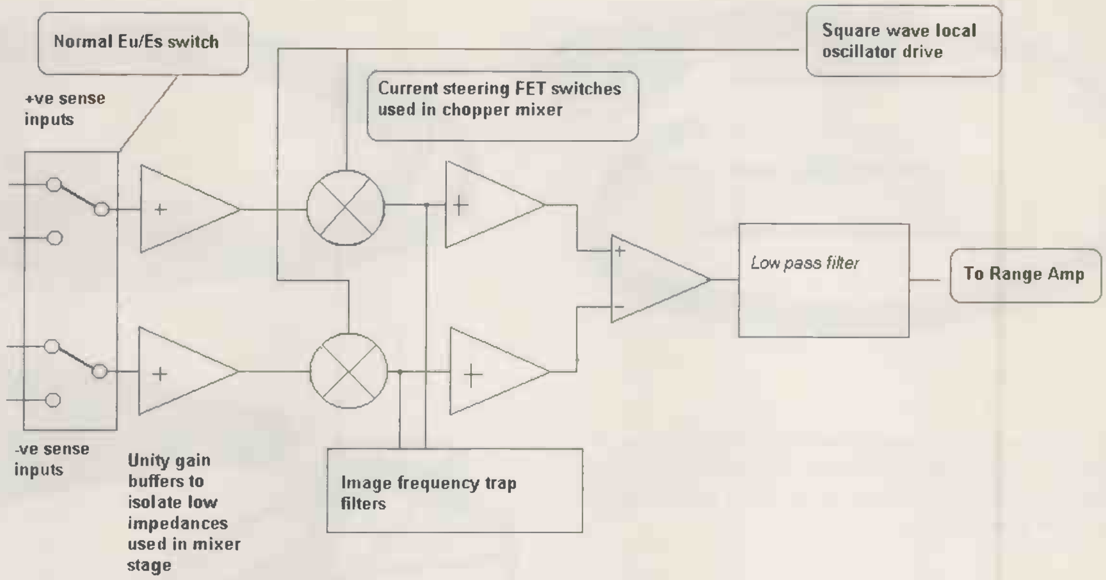


Fig. 9. Differential mixer system used by Wayne Kerr.

with good resolution and range by simply changing to a DC stimulus and chopping the E_u and E_s signals prior to passing to the ac coupled ranging and detector circuits.

Frequency of the chopper is arbitrary, but it is advantageous to choose a multiple of the instruments supply frequency in order to integrate out supply noise at the A-to-D converter. A good choice is 300Hz because it is a multiple of both 50 and 60 Hz supply frequencies without switching excessively fast and introducing unnecessary chopper noise.

The chopped signals enable normal AC measurement to be used. The DC stimulus level is usually kept small, at around 100mV, in order to minimise the risk of saturating small magnetic components. This extends the usefulness of the instrument in measuring sensitive tape heads. Measurement accuracies of 0.5% from 0.2Ω to 5kΩ with a resolution of 0.2mΩ is typical.

Transformer turns ratio

Transformer turns ratio measurement can also be included in the suite of measurements by simply connecting the primary in the drive path, between the *E* and *I* terminals. The primary and secondary voltage ratio are measured via the sense leads.

Typical accuracy would be 0.1% up to around 100:1 ratio. The sense leads are normally connected to the drive leads via limiting resistors, just as in power supplies, so that a missing sense connection defaults to two terminal operation and control is not lost.

For transformer measurements, these components must be switched out in order to monitor the transformer secondary unhindered. The firmware has to check the primary impedance for resonance to avoid possible overloading before making a measurement.

Connections for accurate measurements

Impedance measurement covers an infinite range from short circuit to open circuit and zero to infinite frequency. Good bridge design therefore will attempt to offer as wide a measurement range as possible, consistent with instrument cost.

The optimum method of measurement varies over the impedance range. As a result, different considerations have to be given regarding the type of component, impedance and parameter to be measured.

The most troublesome area for high accuracy measurements is low impedance components, below say 100Ω. Here the voltage drops down the measurement drive leads become increasingly significant as short circuit is approached.

To avoid this, the four-terminal or Kelvin connection takes voltage sense connections directly across the unknown impedance, **Fig. 7**. Assuming a high input impedance sense amplifier, the effect of the drive lead resistance can be eliminated using this method.

All four leads should be screened for electrostatic shielding. In addition, the drive leads should be coaxially linked by maintaining a return path back through the coaxial screens to maintain electromagnetic shielding.

A second problem with low-impedance measurement is that increasing drive current creates mutual coupling of the drive signal to the sense connections. Ideally the drive circuit should be floating from the instrument ground and a coaxial signal maintained for the drive circuit from *E* terminal, through the unknown to the *I* terminal. This avoids a possible loop current and consequent coupling to the sense leads.

This facility was made available on an early GenRad bridge by using an isolating output transformer at the drive terminal. This is not practical with a wide frequency range instrument, or for ease of use. Therefore, a compromise is made, namely the measurement port grounds are linked at the instrument's front panel.

For accurate low impedance measurements, the drive leads should be twisted and the coaxial screens linked at the unknown end for minimal loop area. From the higher audio frequency range, the drive leads can be wound on a high-permeability tape-wound toroidal core to form a common-mode transformer. This tends to force the drive current to flow only in the drive coaxial screens and not the instrument ground, giving the same effect as an isolated stimulus.

Again, for accurate low impedance measurement the physical positioning of all the measure leads must be kept constant so that any mutual couplings are constant and the short circuit trim will remain valid.

Test fixtures have been developed to meet the four-terminal requirement for leaded and surface-mount components. For leaded components, Wayne Kerr developed a fixture that used curved Beryllium copper fingers in the mid eighties. It had a pressed out ridge on each finger to contact and hold an axial or radial component.

The component is inserted between the fingers that are housed in a plastic jaw and the whole jaw assembly slides on a support bar with sliding contacts. The two jaws are slid to adapt to the component lead spacing with axial component inserted horizontally and radial components vertically, **Fig. 8a)**.

Low-impedance measurement of surface-mount components are trickier due to their increasingly smaller sizes. HP Instruments used a test fixture like a small vice to hold the SMD chip and make a four-terminal connection that was mechanically stable.

Fixtures for measuring chip components at low impedance are still in the development stage as surface-mount components continue to shrink in size due market requirements such as smaller, lighter mobile phones. High-impedance chip components are not a problem for the reasons explained and can be measured with a tweezer style two terminal clip on probe, Fig. **8b)**. For general four-terminal connections, Kelvin clips are very useful, Fig. **8c)**.

Extending the frequency range

Using a mixer to down-convert the stimulus frequency into the more manageable audio range can extend the frequency range of an LCR instrument using the techniques described.

Again, as for the phase-sensitive detector, an ultra-linear mixer is essential to accurately translate all the amplitude and phase information in the E_u and E_s signals to between one and 10kHz where the detector circuits can operate at maximum efficiency. This in turn requires an accurate, low-drift crystal local oscillator.

Imagine for example that you design an instrument to have 0.1% basic accuracy and operate at 1MHz with a down conversion to 10kHz. The crystal oscillator frequency must be 0.990MHz with an accuracy of around 0.005 to 0.01% in order to budget for other error contributions. Assuming an operating temperature range of 20 to 30°C, you would need a crystal temperature drift better than 50/10, or 5ppm.

For minimum switching the down converter uses the simple half wave PSD circuit described earlier driven by a square wave at the local oscillator frequency. In practice, the circuit needs to be differential, requiring two sampling switches for the high and low sense inputs, **Fig. 9**.

Current steering with very precise make before break switching is needed to minimise charge injection from the switch self-capacitance. The momentary transient on the virtual earth is too short to be seen by the operational amplifier, which is in effect isolated by the self-inductance of the virtual ground. The large unwanted low-order IP or mixing products at 1.97MHz – the difference between the third local oscillator harmonic and 1MHz stimulus – and 1.99 MHz – the sum of local-oscillator fundamental and stimulus – is removed by the series resonant trap filters. All the other remaining higher frequency products are rejected by band limiting the following stages.

Once down-converted and filtered, the E_u and E_s signals are processed as before. This technique works well for pure components like polystyrene capacitors where the unknown impedance is very linear and will not add inter modulation products.

Using this method, specialised *LCR* instruments have been developed for accurate high-speed production testing of plastic film capacitors where *D* factor measurement at 1MHz and capacitance measurement at 10, and 100kHz are required.

Apart from air-cored types, inductive components are usually more quasi-linear due to their core materials. Either the inductor accuracy specification must be loosened or higher order filtering provided in the detector circuits to prevent inter modulation products appearing at the PSD. ■

In his next article on this topic, Alan looks at LCR measurement developments, aliasing and FFT. He also presents a review of A-to-D converter technologies that are appropriate for high precision measurements – including sigma-delta.

Example of a modern LCR meter

The LCR400 is a mid-range precision instrument costing around £600 excluding VAT. Its basic accuracy is 0.1% for L, C and R measurements. Three measurement frequencies are available between 100Hz and 10kHz. The instrument is fully autoranging (with range hold) and can also automatically select the function based upon the component inserted. It has dual five-digit displays using large and bright LEDs. The second display is used for the secondary parameter of Q or D and is also used with the limits comparator for showing binning information.

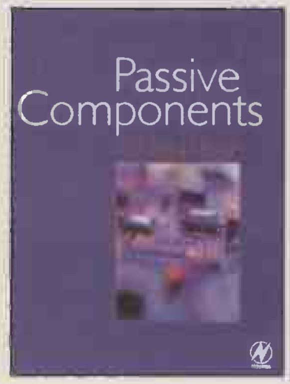
The LCR400 has a built-in four-terminal test fixture that accepts most wire-ended components directly. A pair of plug-in pillar adapters enable axial components, such as bandoliered resistors, to be measured directly without bending the wires. The position of the test fixture on the instrument ensures that component bandoliers can be handled without interfering with the display or keyboard.

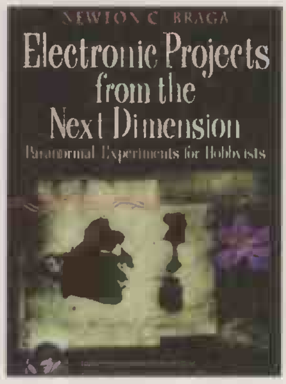
An external test fixture can also be used and a capacitance null function allows up to 100pF to be nulled out. A switchable bias voltage is provided for polarising electrolytic capacitors. The instrument incorporates a full limits comparator with binning. Up to 8 pass bins can be defined along with two fail bins and binning can be used can to sort different tolerances of the same value or multiple different values.

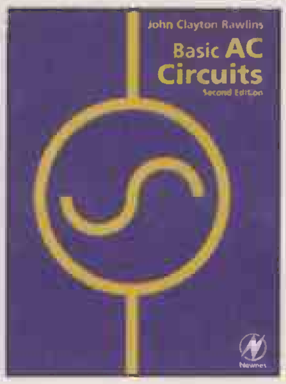
A numeric keyboard allows rapid setting up of binning values. Non-volatile memory is provided for the storage of up to nine complete instrument set-ups. Distributed by TTI, the LCR400 has a steel case and large high-grip feet that keep it in position while components are passed through the test fixture. This is an essential requirement when measuring large numbers of components in an inspection area.

An RS232 interface is incorporated which allows connection to a PC and can be used to set up all measurement and sorting functions as well as store readings. PC software is supplied which allows both set-up and results logging. http://www.tti-new.com/

BOOKS TO BUY







PASSIVE COMPONENTS FOR CIRCUIT DESIGN

Passive Components for Circuit Design is a unique introduction to this key area of analog electronics designed for technician engineers and anyone involved in circuit design. The coverage encompasses all component types capable of power amplification: resistors, capacitors, transformers, solenoids, motors and transducers. The behaviour of the components is explored along with the different types available and the principles of circuit design. Tolerances, stability, variation with temperature, reliability and manufacturing standards are all covered. Reading this book will improve your skills in component selection and analog circuit design. These are essential skills not only for the analog designer, but for all circuit designers, professional or amateur.

Contents: Preface; Fundamentals; Fixed resistors; Variable resistors, potentiometers and diodes; Capacitors; Inductors and inductive components; Inductive devices; Transducing components; SMT; Hardware; Index

Readership: Technician engineers, circuit designers, advanced hobbyists

Pages: 304pp

Price: UK £23.00
Europe £24.00
ROW £27.00

ELECTRONIC PROJECTS FROM THE NEXT DIMENSION

For years paranormal scientists have explored the detection and documentation of spirits, auras, ESP, hypnosis, and many more phenomena through electronics. Electronic Projects from the Next Dimension provides useful information on building practical circuits and projects, and applying the knowledge to unique experiments in the paranormal field. The author writes about dozens of inexpensive projects to help electronics hobbyists search for and document their own answers about instrumental transcommunication (ITC), the electronic voice phenomenon (EVP), and paranormal experiments involving ESP, auras, and Kirlian photography.

Although paranormal studies are considered esoteric, Electronic Projects from the Next Dimension teaches the technical skills needed to make devices that can be used in many different kinds of experiments. Each section indicates how the circuit can be used in paranormal experiments with suggestions about procedures and how to analyze the results.

Contents: White noise generators for use in instrumental transcommunication (ITC) and electronic voice phenomenon (EVP) experiments; Practical circuits for image experimentation, such as a wireless sparkling image generator, horizontal bar generator, brontophic sound, magnetic field generator, high-voltage generators (Kirlian Machine's I & II); Paranormal skills experiments with temperature change, polygraph, electro-shock, random number generation, UFO detection, and ghost-finding.

Readership: Hobbyists, Electronics Enthusiasts

Pages: 256pp

Price: UK £28.00
Europe £30.00
ROW £37.00

BASIC AC CIRCUITS

This is the step-by-step approach for beginners. This self-paced individualized learning tool covers concepts, terms, and the mathematics required to understand AC circuit problems. It has been designed to improve analysis techniques for prediction and control development.

Readership: Beginners meeting AC circuits for the first time: students; technicians

Pages: 921pp

Price: UK £34.00
Europe £36.00
ROW £38.00

INTERFACING WITH C

A practical and painless way of becoming an expert C programme New edition also covers C++ and the Windows environment Get up to speed with the essential maths needed for C without having to buy a university maths text!

Price: UK £20.00
Europe £22.00
ROW £24.00

Post your completed order form to:-

Jackie Lowe,
Highbury Business Communications,
Anne Boleyn House, 9-13 Ewell Road,
Cheam, Surrey, SM3 8BZ

How to order

Book Title____________________

❑ I enclose a cheque/bank draft for £________
(payable to ELECTRONICS WORLD)

Please charge my credit/charge card
❑ Mastercard ❑ American Express ❑ Visa ❑ Diners Club

Credit Card No: Expiry Date:

____

Signature of Cardholder____________________

Cardholder's statement address: (please use capitals)

Name____________________

Address____________________

____

____

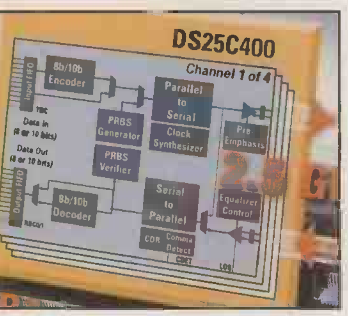
Post Code__________Tel:__________

NEWPRODUCTS

Please quote *Electronics World* when seeking further information

Four channel serdes for 2.5Gbit/s

National Semiconductor has introduced a four-channel 2.5Gbit/s serialiser/deserialiser (serdes). The transceiver is optimised for backplane, cable and fibre optical applications.
The DS25C400 four-channel serdes is designed to provide a robust and reliable backplane interconnector between line cards and switch cards in routers, switches, cross connects and multiplexers. It is ideal for existing FR4 backplanes designed for lower speeds, enabling huge cost savings and "as needed" capacity upgrades, said the firm.
The device's configurable transmitter pre-emphasis compensates for inter-symbol interference (ISI) even when driving cables up to 10-20m. On the receiver end, its configurable equalisation and tight thresholds allow it to reliably recover data–even from signals with severe ISI distortion.
The DS25C400 operates over the full –40 to +85°C industrial temperature range. Power is claimed to be less than 2W typical with all channels driving and receiving 2.5Gbit/s. A thermally-enhanced 324-ball PBGA package minimises thermal management and airflow issues.
Samples are available now, priced at $58.45 each in quantities of 1000
National Semiconductor
Tel: +44(0) 870 242171
www.national.com



Video driver with on-chip input filters

Rohm's latest five–channel video driver IC combines built-in low-pass and band-pass input filters with integrated mute functions. Capable of driving 75Ω loads, the BH7860FP has on-board sag correction circuits. The driver lets all five channels (Y, C, Y/C Mix, Cb and Cr) be muted simultaneously, while the Cb and Cr channels also have separate mute features. The Y signal can drive four loads, while each of the other signals will drive two loads. Operating with a supply between 4.5 and 5.5V, the device delivers a maximum rated output of 3.0Vp-p and a maximum rated power dissipation of 1.45W. the driver's Y channel is configured for a diode clamp input, while the C, Cb and Cr signals use bias inputs. It is supplied in an HSOP25 package measuring 13.6 x 7.8 x 1.9mm. Operating range is –10 to +70°C.
Rohm
Tel: +44(0) 1908 282666
www.rohm.co.uk

Emulator can be reprogrammed on fly

Hitachi's latest microcontroller emulator has been designed using FPGA technology, which lets emulator functions be reprogrammed during use for the first time. According to the supplier, this lets the emulator offer many features that have not been available before, including enhanced breakpoints and Pin View and Pin Set. The use of FPGAs will also let new features be added electronically in the future, for example as a download. The Pin View and Set features allow a device's I/O pins to be viewed and stimulated before the users hardware is available. at any time, users can both toggle an I/O pin from the keyboard and read the set value of the pin. The compact Emulator is integrated into the Hitachi Debugging Interface (HDI) version five front-end, giving the developer seamless

RD Research launches new version of B2 Spice

The new B2 Spice v4.2 features circuit animation, which shows wires changing shape to reflect current and voltages, and parts changing colour to reflect heat dissipation. Relative voltages are colour-coded to magnitude and arrows display the actual current paths as they flow within the circuit. Circuits can be animated with respect to dc stepping, frequency sweep and time.

With version 4.2, users of Eagle PCB software can now transfer their circuit schematics to B2 Spice and run simulations. According to Rudi Hofer, of CadSoft Computer, "Without B2 Spice, the only way to simulate an Eagle circuit was to export a spice netlist, then insert spice models and simulation commands into the netlist by hand, and then run simulations through a spice engine. With this new collaboration, Eagle users can transfer their schematics into B2 Spice where they can simulate them quickly and easily."

In the process of this integration, the developers have generated 15,000 new parts for Eagle's parts library, and B2 Spice added an additional 10,000 schematic parts to its library. Schematics can also be transferred from B2 Spice to Eagle schematics and from B2 Spice to Eagle PCB.

A user can design analogue and digital circuits quickly and easily and, as with previous versions of B2 Spice, this new version supports the design of RF circuits.

The user interface has been redesigned, and the resulting graphs and diagrams produce accurate data that is of practical use to professional designers and students alike. Many software packages provide 'nice looking' output graphs, which are of limited practical use under real conditions. B2 SPICE Version 4.2 enables each trace to be selected, processed and measured at any point for an exact result. The data can also be viewed in a range of formats to suit the user and exported for further processing.

The developers have made sure that B2 SPICE Version 4.2 sets no limit on the size of the circuit. It can be as large or as complex as the user wants. The software comes with a comprehensive 400-page user manual with clear tutorials for those not familiar with SPICE.

This is backed up by free unlimited technical support, which aims to answer questions quickly by telephone or email.
RD Research
Tel: +44(0) 1603 872331
www.spice-software.com

Please quote *Electronics World* when seeking further information

access to its advanced debugging capabilities. The tool does not need an internal interface card to communicate with the host machine as it uses the USB port now shipped as standard on most PCs. The first version of the Compact Emulator, the CE2148R, has been released to support the H8S/2148F series of 16-bit microcontrollers, which includes more than 30 devices in various package and memory sizes. Members of the series have various 8 and 16-bit timers, on-chip watchdog timers, up to five serial interfaces, up to 24 channels of A/D and up to 82 I/O pins.
Hitachi
Tel: +44(0) 1628 585161
www.hitachi.-eu.com

Free C compilers PIC16 variants

Computer Solutions is offering a range of C compilers that support the latest range of Picmicro processors from Microchip, along with a free version for some PIC16 variants. The Hi-Tech PICC compilers are based on the full ANSI C specification, and incorporate an integrated edit, make and link environment that allows compilation, assembly and linking to be carried out using a single command. Also included is a command line driven compiler that lets it be used with in-circuit emulators such as the popular MPLab. Features of the compilers include multiple optimisation levels which take particular note of the PIC

architecture. For example, the linker includes overlaying of local variables to reduce RAM use. A library includes source code and 24 and 32-bit floating-point support. The compiler also has the ability to carry out mixed C and assembler programming.
Computer Solutions
Tel: +44(0) 1932 829460
www.computer-solutions.com

Voltage regulator has 9.5µV noise figure

Micro Analog Systems is offering a low noise regulator (MAS9123) in a true CSP package measuring 1.0 by 1.3mm. Package height is 0.65mm. It has a noise level of 9.5µVrms (10Hz to 100kHz). Also, noise spectrum drops rapidly to a low level at low frequencies (about 6kHz), said the supplier. The device's start-up time with load is 20µs. This package is also available for other MAS single output regulators.
Micro Analog Systems
www.mas-oy.com

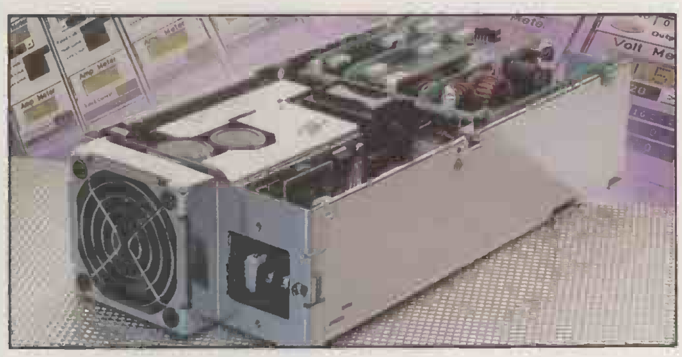
Dual digital pot with 32 taps

Xicor has introduced a dual 32-tap digitally programmable potentiometer IC for audio

applications.A resolution of 6-bit for 0 to –62dB of audio level control range, plus a 90dB mute, make it suitable for adjusting audio signals in preamp stages. The X9460 has –102dB of channel crosstalk, and noise plus distortion at 95dB below signal levels. A zero-crossing detection circuit eliminates audible clicks during wiper changes. Its digital interface allows either serial two-wire communications or basic up and down control of the wiper positions. Up to four X9460 devices can be addressed within the same system by using the two address pins.
Xicor
Tel: +44(0) 1993 700544
www.xicor.com

Users can configure AC-DC power supplies

Lambda has extended the configurability of its Vega range of switch mode AC-DC power supplies with a controller board and software that allows users to set up and monitor the performance characteristics of supplies.
According to Martin Southam, Lambda's sales and marketing director, the intention has been to provide a level of user control which was previously only available in full custom design supplies. "It will allow users to program the power supply parameters beyond simple voltage and current programming," said Southam. Called Vega Smartplus, the supplies include an 8-bit microcontroller board which can be programmed via a standard RS232 or RS485 serial interface. This can be used to monitor and adjust functions such as output voltage, current limit, sequencing, status signals, operating hours and fan speed. Up to 32 output units can be controlled by the controller's associated soft-parameters, such as fan fail signal polarity and DC good signal polarity. There are up to five outputs in the unit, which can be individually set up and configured by the user. Each output can have its voltage set point adjusted and startup delays can be applied for sequencing outputs. The supplies are compatible with the existing Vega range and come with 450 and 600W ratings. Input voltage is from 90 to 264V AC. Adjustable outputs are from 1.8 to 62 V.
Lambda
Tel: +44(0) 1271 856666



USB debug probe downloads without ROM

A plug-and-play USB hardware debug probe from Green Hills Software together with the Green Hills Multi 2000 source-level debugger and integrated development environment (IDE), for debugging embedded programs by providing program download and run control without the need for a ROM Monitor.
The Slingshot probe will support most major 32-bit and 64-bit embedded CPU and DSP architectures, including PowerPC, ARM, MIPS and ColdFire . It gives users access to and control over target processor's so they can upload data from the target processor, run, halt, and reset the processor, read from and write to processor registers and memory, single-step through code, and set breakpoints. The probe is available for Windows 98/ME/XP/2000 and connects to

122002

ESR ELECTRONIC COMPONENTS

Station Road, Cullercoats, Tyne & Wear, NE30 4PQ

Prices Exclude Vat @17½%.
UK Carriage £1.50 (less than 1kg)
£3.50 greater than 1kg
Cheques / Postal orders payable to
ESR Electronic Components.
PLEASE ADD CARRIAGE & VAT TO ALL ORDERS

See Next / Last Months Ad. for ELECTRONIC COMPONENTS

PCB Production - Processing Equipment

We carry a large range of the photographic & chemical processing equipment for PCB production, a full list with full technical specifications is available in our catalogue or visit our web site.

UV Exposure units

2 x 8W Tubes, 6 min timer
229 x 159mm working area
Model 332-002 £88.78
4 x 15W Tubes, 7½ min timer
330 x 260mm working area
Model 332-004 £194.51

Chemical Processing

Low cost plastic tray £1.50
Process tanks feature electrically operated pumps and/or heaters with thermostat control, suitable for boards upto 320 x 260mm.
Universal Tank with heater
Model 333-007 £161.60
Bubble etch Tank with heater & bubble pump.
Model 333-004 £198.50

Any of these items, carriage £5.50

PCB Production - Laminates

Copper clad - paper

Single sided low cost paper composite board

100 × 160mm Board	£0.44
100 × 220mm Board	£0.62
160 x 233mm Board	£1.02
220 x 233mm Board	£1.40
8" x 12" Board	£1.70

Copper clad - glass fibre

Single & Double 1.6mm 305g/m²

100 × 160mm Single	£0.85
100 × 220mm Single	£1.18
160 x 233mm Single	£2.29
220 x 233mm Single	£2.88
8" x 12" Single	£3.44
100 × 160mm Double	£0.88
100 × 220mm Double	£1.25
160 x 233mm Double	£2.30
220 x 233mm Double	£2.90
8" x 12" Double	£3.22

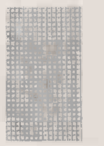
Photoresist Coated

1.6mm 35 micron Pre-coated with a high quality photoresist layer. Available in low cost paper composite or Glass fibre, Single & Double sided. Other sizes also available.

	Paper		Glass Fibre	
Size	Single	Double	Single	Double
4 × 6"	£1.47	£1.82	£1.89	£2.17
6 x 12"	£4.20	£5.04	£5.60	£6.23
9 x 12"	£6.30	£7.70	£8.40	£9.38
10 x 12"	£8.19	£10.01	£10.78	£11.83
12 x 12"	£8.26	£10.08	£10.99	£12.25
100 x 160mm			£2.38	£2.66
203 x 114mm			£3.01	£3.43
220 x 100mm			£3.08	£3.71
233 x 160mm			£4.83	£5.32
233 x 220mm			£6.83	£7.70

PCB Production - Development

0.1" Copper Stripboard



Size	Tracks/Holes	
25 x 64mm	9T / 25H	£0.24
64 x 95mm	24T / 37H	£0.87
95 × 127mm	36T / 50H	£1.41
95 × 432mm	36T / 170H	£4.39
100 × 100mm	39T / 38H	£1.40
100 × 160mm	39T / 63H	£1.80
100 × 500mm	39T / 199H	£6.20
119 × 455mm	46T / 179H	£5.40
Stripboard track cutter		£1.99

Solderless Breadboard

Tie Points	Size	Power Rails	
390	81 x 60mm	2	£2.75
840	175 x 67mm	2	£4.86
740	175 x 55mm	1	£4.03
640	175 x 42mm	0	£3.08

Many other sizes available, also jump wires & matrix board.

PCB Production - Tools

Drill Bits

HSS parallel shank bits available in sizes from 0.3mm to 2.0mm

0.3-0.95mm in 0.05mm steps £0.60ea £4.00/10
1.0-2.0mm in 0.1mm steps £0.40ea £3.60/10
HSS Reduced shank (2.35mm) bit available in sizes from 0.6mm to 1.7mm in 0.1mm steps £0.84ea £7.60/10
Reground Tngsten carbide reduced shank (3.2mm) available in sizes from 0.6 to 1.6mm in 0.1mm steps £1.90

Drilling Machines

Expo reliant 12V drill, 3.8mm capacity, 8400rpm £12.78

Minicraft MX1 230V, 8000 - 21000rpm with chuck & collet.
Model EPE270-390
Normal price £48.51

** SPECIAL OFFER PRICE £31.02 **

PCB Production - Chemicals

100ml	Aerosol Photoresist spray, covers 2m²	£4.25
50g	Powder developer, makes 1lt	£1.09
500g	Powder developer, makes 10lt	£7.08
250g	Ferric Chloride Pellets, makes 500ml	£1.68
500g	Ferric Chloride Pellets, makes 1lt	£3.04
2.5kg	Ferric Chloride Pellets, makes 5lt	£9.84
1.1kg	Clear Fine etch crystals, makes 5lt	£17.58
90g	Tin Plating Powder, makes 1lt	£11.58
200ml	Aerosol Flux spray	£3.41
110ml	Aerosol PCB Laquer spray	£3.63

PCB Production - Drafting Materials

A4 Artwork Film (per 10 sheets)

Clear Manual Film £1.25
Clear Laser Film £1.75
White HQ Laser Film £4.62

Etch Resist Pens

"Dalo" Pen £2.70
"Staedtler" Fine Pen £0.88

Etch Resist Transfers

Seno mixed DIL pads £2.24
Seno mixed Rnd pads £2.24
Alfac mixed pods £1.74
Alfac mixed lines £1.74
Transfer Spatular £1.25

We carry the full range of Seno & Alfac PCB transfers, see our catalogue for full details.

Servisol Products

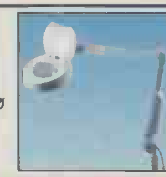
Aerosols

200ml	Switch Cleaner	£1.96
200ml	Freezer	£3.97
400ml	Foam Cleanser	£2.13
400ml	Cleaner / lubricant	£2.79
75ml	Vide Head Cleaner	£1.94
200ml	Aero Klene	£2.85
200ml	Aero Duster	£4.66
250ml	Cold Clean	£3.14
200ml	Label remover	£3.52
400ml	Isopropyl alcohol	£3.36

Tubes

25g	Heatsink Compound	£2.60
50g	Silicone grease	£2.50

Magnifying Desk Lamp



A high quality scratch resistant magnifying glass fitted to a balanced swivel arm and desk mount. An integral flourescent tube provides illumination.
Magnification: 3x Lens: 120mmØ
Tube: 22W Daylight simulation.

Model: 028-205 £28.80

Soldering Irons

We carry in stock a wide range of soldering iron and soldering accessories. Irons from 12 to 100 Watts.

15W 240V Low cost £2.80
20W 240V Basic £3.74
25W 240V Ceramic £14.05
30W 240V Basic £4.68

Desolder Pumps

Basic 165 x 18mmØ £2.85
Antistatic 195mm £3.92
Antex Mini 198mm £6.02
Antex Pro 210mm £10.26

NEW CATALOGUE OUT NOW

available from **www.esr.co.uk**

Tools - Cutters & Strippers

We carry a wide range of specialist tools for the electronics industry including:

Side Cutters

130mm Low cost £1.99
115mm Draper £2.38
115mm Box Jointed £4.26
145mm Long reach £3.40

Wire Strippers

130mm Low cost £2.30
150mm Draper 5mmØ £5.86

Soldering Station

A 30W adjustable temperature soldering station with a rotary dial, on-off switch, iron holder and tip cleaning sponge. This station features a quick start circuit for rapid heating, adjustable temperature range of 250 - 450°C, Silicone cable and silicone covered handle.
Supply: 240V, Iron: 240V 30W

Model 167-510 £32.18

Educational Kits

These kits are an ideal way to stort you interset in electronics. They freature re-useable components which are attached via springs & wires and easy step by step guides to make a range of exciting projects. The 300-in-1 featurs a breadboard for more complex circuits.

30-in-1 £12.80
130-in-1 £32.00
300-in-1 £55.20

Tools - Ratchet Crimping Pliers

High quality ratchet crimping pliers for various terminals including Automotive, Data, Power and Data connections.

Red / Blue / Yellow £16.00
BNC /TNC RF series £15.68
RJ11/12 Data Series £18.97
RJ45 Data Series £21.20
RJ11/12 & 45 Series £16.80

CK® Tools Crimp Pliers

Green/Red/Blue £24.38
Red/Blue/Yellow £21.42
0.24-2.5mm² crimps £24.35
0.5-6.0mm² crimps £24.35
Non insulated crimps £24.38

Soldering Station

A 48W adjustable temperature soldering station with a rotary dial, LED Temperature metering, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 420°C, Low voltage iron with Silicone cable.
Supply: 240V, Iron: 24V 48W

Model 167-540 £44.50

Tools - Insulation Displacement Connectors (IDC)

Two tools suitable for use with IDC ribbon cable connectors and Krone® sytle data connectors.

IDC Ribbon Cable £11.80
Krone Punch down £10.32

Soldering Station

A 48W adjustable temperature soldering station with a rotary dial, Digital Temperature Indication, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 480°C, Low voltage iron with Silicone cable.
Supply: 240V, Iron: 24V 48W

Model 167-570 £58.75

Panel Meters

High quality analogue panel meters, class 2, zero point correction, mirror scale and prewired for panel illumination. Meter size 46 x 60mm, Cutout size: 38mmØ.

Range	Int Ω
0-50µA	6k5
0-100µA	1k0
0-500µA	430Ω
0-1mA	200Ω
0-10mA	2Ω6
0-50mA	1Ω2
0-100mA	0Ω65
0-500mA	0Ω12
0-1A	60mΩ
0-3A	20mΩ
0-5A	12mΩ
0-15A	4mΩ
0-10V	10k
0-15V	15k
0-30V	30k
±50µA	1k9

All meters £5.89 each
6V Lamps £1.23 /pair

Cable - Ribbon

7/0.127mm Grey ribbon cable on a 0.05" 1.27mm pitch with a red identifying stripe. Supplied by 305mm (1ft) or on full 30.5m (100ft) reels.

Size	per 305mm	per Reel
10 Way	£0.10	£5.36
14 Way	£0.14	£7.50
16 Way	£0.16	£8.58
20 Way	£0.20	£10.72
26 Way	£0.26	£13.94
34 Way	£0.34	£18.22
40 Way	£0.40	£21.44
50 Way	£0.50	£26.80
60 Way	£0.64	£33.92

CCTV - Black & White Module

A miniature CMOS camera module with a 3.6mm F2 Lens, video output & power via connectors provided.

Specs

Power: 12Vdc 50mA
Video System: CCIR
Pixels: 352 x 288
Min Illumination: 0.5Lux
Video Output: 1 Vpp, 75·
Dims: 35 x 35 x 28mm 20g **£27.73**

CCTV - Colour Module

A miniature colour CMOS camera module with a 3.6mm F1.2 Lens, video output & power via connectors provided.

Specs

Power: 12Vdc 150mA
Video System: PAL
Pixels: 628 x 582
Min Illumination: 3Lux
Video Output: 1 Vpp, 75·
Dims: 28 x 28 x 28mm 20g **£33.75**

CCTV - Complete Systems

We carry the full range of *Micromark* Black & White and Colour CCTV systems for the home or office.
These complete easy install systems are supplied complete with power supply, cables and all fixings. Simple plug-in connections - no soldering required, for use with any TV or Video with a scart socket.

Black & White Systems from £22.97

Tel: 0191 2514363 Fax: 0191 2522296 Email: sales@esr.co.uk http: //www.esr.co.uk

Please quote *Electronics World* when seeking further information

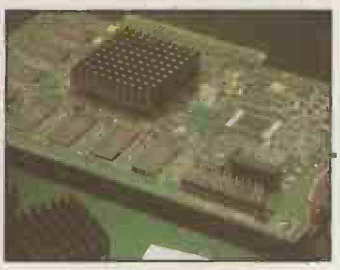
the host computer via a USB port. Connection to the target processor is via industry-standard debug ports such as JTAG, EJTAG, COP and BDM. The probe is equipped with an embedded 32-bit processor that enables it to achieve host/target download speeds of 10 to 100kbytes. It requires no external power supply and consumes no target power, deriving its power from the host via the USB port.
Green Hills Software
Tel: +44(0) 1844 267950
www.ghs.com

15V digital pot has four channels

Analog devices has introduced the AD5263, its first 15V, quad channel, 256-position digital potentiometer with a selectable digital interface. A 15V supply can be used with 0 to 15V signals, or a dual ±5V supply can be used with ±5V signals. Controlled from a pin-selectable three-wire SPI or a two-wire I^2C-compatible data interface, the device performs the same electronic adjustment function as a mechanical trimmer, variable resistor or potentiometer. Each of the four channels contains a fixed resistor (20k, 50k or 200kΩ) with a wiper contact that taps the fixed resistor at a point determined by the digital code loaded into its register. It places the wiper in the mid-scale position at power on. A hard drive override shutdown feature shorts the wiper to the A terminal without disturbing the wiper register contents. In I^2C interface mode, reset and shutdown can be individually set for each wiper, and the current wiper position can be read back by the microcontroller. It is available in a TSSOP-24 package and operates from –40 to +125°C.
Analog Devices
www.analog.com

Taping down heatsinks to plastic BGAs

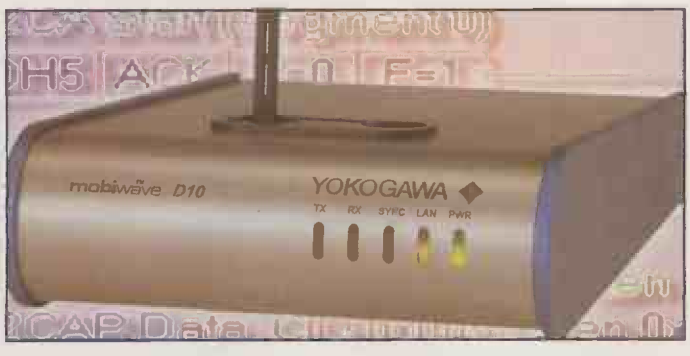
Thermatch T410 thermal tape from Chomerics has been developed for bonding heatsinks to hot running devices. The thermally conductive material is suited to applications that require heatsinks to be bonded to plastic



Ball Grid Array (BGA) devices. The thermal tape has an overall thickness of 0.18mm, and features a 0.05mm aluminium foil carrier that is coated on one side with a silicon based pressure sensitive adhesive (PSA).
Chomerics
Tel: +44(0) 1628 404000
www.chomerics.com

Low-cost Bluetooth protocol analyser

Available from Yokogawa Martron, the Mobiwave D10 is a low-cost Bluetooth protocol analyser that is designed to test to see if equipment is performing to design standards without interfering with network traffic.
The non-intrusive test capability is important in monitoring the communication status across a network, since Bluetooth performs master/slave interactions and uses frequency hopping to reduce noise effects and maintain data security.
Costing only one-third the price of any existing non-intrusive protocol analyser with equivalent capabilities, the unit is capable of analysing the baseband and upper layers. The user interface allows synchronisation and data capture to be performed, and analysis and display software allows each layer to be examined in detail.
Captured information is relayed to a host PC via an Ethernet connection real time, allowing remote logging and equipment sharing. The network interface supports both stand-alone and LAN configurations.
An audio extension module allows audio data extracted from SCO packets to be played back or stored in PCM Wave or CVSD format. This offers a means of verifying audio-related problems like echo, static noise and battery power consumption for developers working on headset, handset, audio gateway or telephony products.
The instrument supports Bluetooth protocol layers.
Yokogawa Martron
Tel: +44(0) 1494 459200
www.martron.co.uk



40Gbit/s optical test

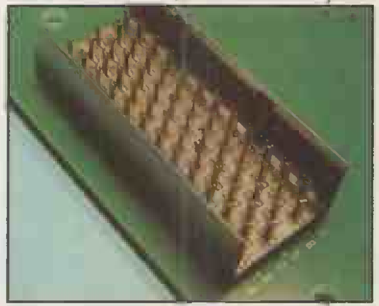
Agilent Technologies has introduced its Omniber OTN 40Gbit/s communications analyser, a multi-rate test set for developing and qualifying line cards, modules and subsystems. equipped with all line rates from 52Mbit/s to 40Gbit/s plus 10.71/43gbit/s optical channel (OTU-2 and OTU-3), the analyser's capabilities include intrusive through mode for Sonet, SDH and OTN at 40 and 43Gbit/s. At 43gbit/s, the analyser provides ITU-T G.709-compliant. OTU-3 testing with forward error correction analysis and error-add capability.
This lets engineers simulate realistic network conditions and speeds network equipment makers' transition to OTN.
There is validation of device conformance to Telcordia and ITU-T through the analyser's ability to generate structured sonet, SDH and OTN signals and test compliance in one box.
Agilent Technologies
Tel: +44(0) 117 952 8405
www.agilent.com

Low power analogue switches

Intersil has added to its low-voltage analogue switch line. The ISL84514 and the ISL84515 are single-pole single-throw (SPST) switches. The ISL84514 has normally-open (NO) contacts while the ISL84515's contacts are normally-closed (NC).
Aimed at battery-powered applications, power consumption is less than 5μW. Leakage current is up to 1nA. Switching speeds are specified at t_{on} = 150ns maximum and t_{off} =100ns maximum. The supplier provides

Differential connectors

High-speed differential signal connectors for next generation 6.4Gbit/s telecoms and Internet backplanes and measurement and control systems have been added to Honda's NCB hard metric series. Based on current 2mm hard metric packaging, the range has IEC917 (DIN43355) and IEC61076-4-101 compliant contacts offering high signal density for compact performance. Using contacts with C-shaped configuration, the backplane connectors are designed to ensure good mechanical contact stability and eliminate PCB through-hole damage. They are based on press-fit technology (solderless connection), and are thus unaffected by heat stress or flux cleaning. The firm is offering the range with 55, 95, 110 or 125 contacts.
Honda
Tel: +44(0) 1793 523388
www.hondaconnectors.co.uk.



Signal Wizard 1.6

Real-Time Digital Filter

Signal Wizard 1.6 (formerly RTDF) is a unique real-time audio-bandwidth digital filter system with infinitely adjustable characteristics – all available at the click of a button. It uses a DSP unit that runs the filter and a friendly Windows-based interface that allows you to design and download any kind of filter you like, all within seconds. You don't need to know about filter maths, DSP or analogue filter design – all you need to know is what kind of filter you want. With Signal Wizard you can do more than specify the gain of the frequency response – you can also specify the phase of any frequency, with a resolution of one hundred thousandth of a degree! If you don't want to bother with phase, Signal Wizard will design with total phase-free distortion, no matter how complex or sharp the filter is. You are not limited to the design tool interface either - you can also import frequency responses as text files, specifying just magnitude or magnitude and phase. Once you are happy with the design, just download the filter and run it in real-time. Low-pass, High-pass, multiple-band or arbitrary are all possible.

Signal Wizard 1.6 – Key features

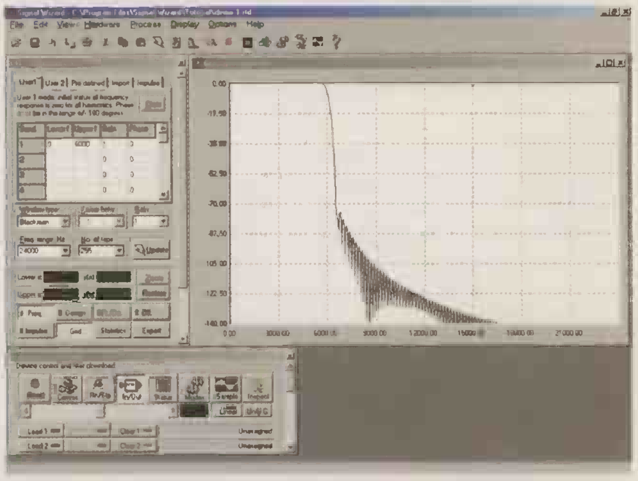
- Runs under Windows 95, 98, Me, 2000, NT and XP.
- Multiple pass, stop or arbitrary filters.
- Import mode for arbitrary frequency response.
- Zero-phase distortion or arbitrary phase.
- Rectangular, Bartlett, Hamming, Hanning, Blackman or Kaiser window functions.
- Deconvolution (inverse) or flipped filter options.
- Single (18-bit) or dual channel (16-bit) modes.
- Plots impulse and frequency responses as magnitude, dB, square, root, real, imaginary or phase.
- Extensive filter analysis statistics.
- Animate facility for tap adjustment.
- Impulse and frequency responses exportable as text files for off-line processing and spreadsheet analysis.
- Real-time gain and sample rate control.
- Filter module holds up to 16 filters.
- Eleven sample rates from 48kHz down to 3kHz.
- Normal or turbo mode.
- Maximum input and output level 3.5V pk-pk.

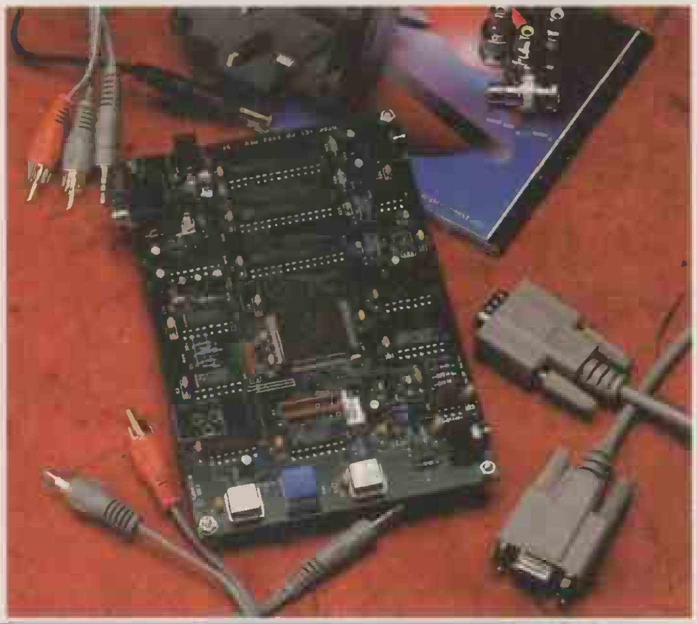
System includes:

- DSP filter board.
- Signal Wizard 1.6 CD.
- Integrated help files and tutorial.
- RS232 and analogue I/O cables with adaptors.
- Power supply.

Visit the website at:

www.umist.ac.uk/dias/pag/signalwizard.htm





Use this coupon to order Signal Wizard

Please send me.......... filters at £299.00 excluding shipping and UK special delivery and VAT (£359.55 fully inclusive)

Name ________________________

Address ________________________

____

____

____

Phone/fax: ________________________

Total amount £........

I enclose a cheque___

Please charge to my credit/debit card
Card type (Mastercard/Visa/Switch etc)

Card No _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Expiry Date:____/____

Please mail this coupon to *Electronics World*, together with payment. Alternatively fax credit card details with order on **020 8722 6098.**

Address orders and all correspondence relating to this order to Signal Wizard Offer, Electronics World, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey, SM3 8BZ
email j.lowe@cumulusmedia.co.uk
Make cheques payable to Electronics World

Please quote *Electronics World* when seeking further information

data sheets with enhanced device characterisation data for these switches, which include complete specification tables at +3.3, +5 and +12V and specifications measured over the full temperature range.

They are available in eight-lead SOIC and five-lead SOT-23 packages.

Intersil
Tel: +44(0) 1276 686886
www.intersil.com

Motor controller has DMOS drivers

The A3936 from Allegro Microsystems is a three-phase brushless DC motor controller-driver IC with 3A DMOS outputs and on-chip commutation logic.

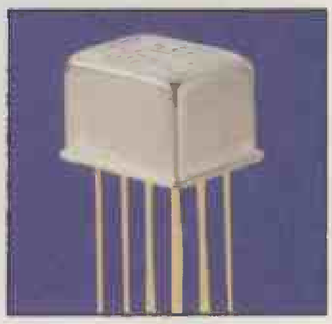
Features include DMOS 50V outputs, synchronous rectification, 3 and 5V logic compatibility and configurable slow, fast and mixed-decay modes. Synchronous rectification of the DMOS outputs is done on chip. This improves the thermal efficiency of the IC during PWM operation, and eliminates the need for external diodes. The device will operate with motor supply voltages up to 50V and motor winding currents of 3A.

Allegro Microsystems
Tel: 00 33 4505 12359
www.allegromicro.com

4.5GHz relay uses magnetic latch

Teledyne Relays is offering a 4.5GHz magnetic-latching relay that features low inter-contact capacitance for RF performance through and beyond the UHF spectrum. Designated the RF180, it has been designed for use in RF attenuators, RF switch matrices, automated test equipment, spacecraft and other applications that require high-frequency performance. The hermetically sealed relay is available in three coil voltages - 5, 12 and 26.5V DC. It has all-welded construction and features high force/mass ratios for resistance to shock (100G for 6ms) and vibration (30G to 3000Hz). The relay measures 0.475 x 0.375 x 0.300in. (12.06 x 9.53 x 7.62mm). excluding leads, and weighs 0.1 ounce (2.9g). Unique construction features and manufacturing techniques provide overall high reliability and excellent resistance to environmental extremes, including temperatures ranging from –65°C to +125°C. The relay can be operated with a short-duration coil voltage pulse. After the contacts have transferred, no coil power is required. The magnetic-latching feature of the RF 180 provides a nonvolatile memory capability, because the relay will not reset upon removal of coil power.

Teledyne Relays
www.teledynerelays.com



Converter supplies 15A

SynQor has introduced an eighth-brick format isolated DC-DC converter. The PowerQor Mega series can deliver up to 15A of total output current at 3.3V and below and 50W at 5V and above, without a heatsink. The EML series has a 48V nominal input (35V to 75V range) and meets input voltage transient requirements up to 100V for 100ms.

Employing the newly established industry standard eighth-brick footprint and pin-out, the units measure 0.9 x 2.3 x 0.35in, (22.9 x 58.4 x 9.0mm). They occupy 60 per cent of the board space of a standard quarter-brick and they deliver full power up to 70°C with no airflow (2.5V and below). The converter family will initially be offered at 3.3V, 2.5V, 1.8V, and 1.5V with additional output voltages of 1.2V and 5V being released shortly. The EML series is currently offered with through-hole mounting and will also be available in a surface mount configuration in Q4 2002.

SynQor
Tel: 0049 9621 600777
www.synqor.com

One chip PBX design handles 64 channels

Mindspeed Technologies has introduced a packet private branch exchange (PBX) on a single chip. Designed for both enterprise and residential telephony equipment, the Chagall M825xx enables the development of packet voice systems with "handset to Ethernet" capabilities for business and residential phone applications. The M825xx integrates signalling, encryption, packet processing and signal processing functions, handling up to 64 channels of highly compressed packet voice on a single chip. The device comprises a DSP core soft encryption engine, programmable packet processor and a user-programmable embedded host controller which is 100 per cent available for user applications and signalling, and can support a number of telephony and packet signalling protocals including SIP, H.323 and H.248. The voice processing subsystem runs up to 64 channels of carrier-class G.7xx codecs and echo cancellation, supporting packet-to-TDM, packet-to-packet, TDM-to-TDM operation for up to 512 subscriber lines. ■

Mindspeed Technologies
www.mindspeed.com

Reference for real-time clock

Xicor has a real-time clock reference design that it says is a complete timing circuit for industrial, enterprise network applications and with embedded control systems. Based around a temperature sensor, microcontroller and the firm's real-time clock devices with EEPROM and standard crystal oscillators, it includes circuit design schematics and board design layout files with software drivers for Windows interface and example files for C-code developments. The company said the design also addressed precision timing for localised and distributed-network clocking systems. These range from synchronisation with an accurate timing source at the network level to compensating for electronic component variation due to different environmental effects. The aim is to demonstrate that real-time clock devices containing analogue and digital timing adjustments can compensate for crystal oscillator drift over temperature and ageing. Initially, temperature values versus oscillator compensation adjustments are mapped into a lookup table.

Xicor
Tel: +44(0) 1993 700544
www.xicor.com

Fact: most circuit ideas sent to *Electronics World* get published

The best circuit ideas are ones that save time or money, or stimulate the thought process. This includes the odd solution looking for a problem – provided it has a degree of ingenuity.
Your submissions are judged mainly on their originality and usefulness. Interesting modifications to existing circuits are strong contenders too – provided that you clearly acknowledge the circuit you have modified. Never send us anything that you believe has been published before though.
Don't forget to say why you think your idea is worthy.
Clear hand-written notes on paper are a minimum requirement: disks with separate drawing and text files in a popular form are best – but please label the disk clearly. Where software or files are available from us, please email Jackie Lowe with the circuit idea name as the subject.
Send your ideas to: Jackie Lowe, Highbury Business Communications, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey SM3 8BZ email j.lowe@highburybiz.com

Simple stepper-motor driver with forward and reverse

Only one dual D-type flip-flop is needed here to generate a two-phase drive. A further quad NOR gate is used to derive the correct wave drive for the stepper motor and a 555 configured as an astable multivibrator clocks the flip-flop, **Fig. 1**.

Output D1 of the first flip-flop connects to /Q2 of the second flip-flop while Q1 of the first flip-flop connects to D2 of the second. Inputs S1 and S2 set the flip flops while R1 and R2 reset them. These are driven by push buttons S and R. A third push button, R, reset the astable multivibrator.

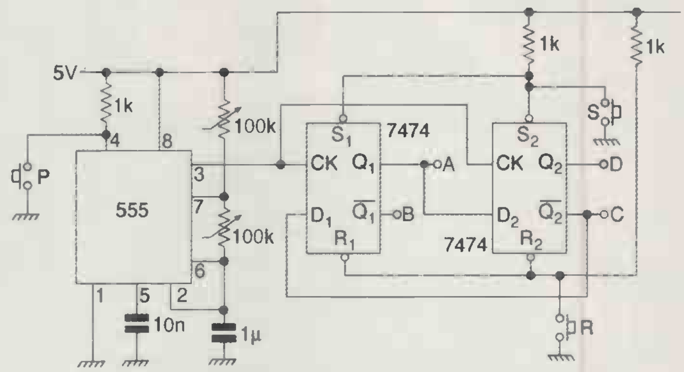


Fig. 1. This two-phase sequencer is clocked by an astable multivibrator.

To start with, the flip-flops are reset using P momentarily. Output /Q2 goes high and D1 of the flip-flop is thus held high. At the low-to-high clock transition of the first pulse, Q1 goes high and D2 of the second flip-flop goes high. Thus a sequence represented by A=1, B=0, C=0 and D=1 is obtained at the first clocking.

Now, as /Q2 of the second flip-flop becomes low, at the next clock pulse, the sequence is A=0, B=1, C=1 and D=0 is obtained.

The sequence repeats. Thus a two-phase drive sequence is obtained to run the motor in one direction.

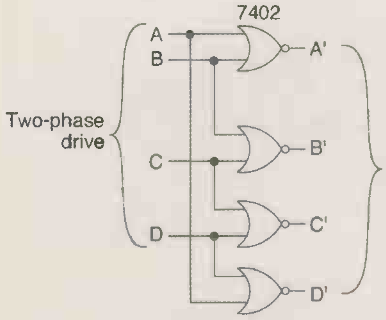
To reverse the direction, the set push button switch is pressed momentarily. Now the sequence at the first clocking becomes A=0, B=1, C=1, D=0 and A=1, B=0, C=0 and D=1 at the second clock pulse.

Figure 2 shows the wave drive interface using NOR gates. For one direction, the wave sequence is A'=0, B'=1, C'=0, D'=0 for the first pulse and A'=0 , B'=0, C'=0, D'=1 for the second. If the stepper motor gets stalls due to noise for example then set press the set or reset push button.

Figure 3 is the power amplifier for one phase only. The remaining three are the same.

V. Gopalakrishnan
Bangalore
India

Fig. 2. Interface for creating the stepper motor drive sequence.



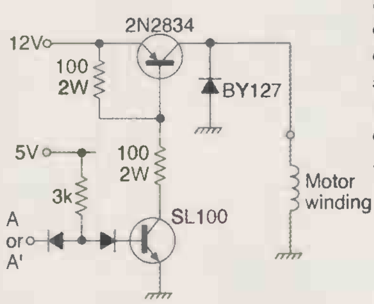


Fig. 3. Drive circuit for one of the four stepper motor windings. The other three are identical.

Precision full-wave rectifier

Here is a circuit that rectifies alternating signals. Such a circuit has quite a few different names and can be used in a variety of applications.

In a wireless, the circuit would be called an AM full envelope detector. This circuit would be equally at home positioned in the front end of an RMS detector and is then referred to as an absolute circuit. I will refer to the circuit as a full-wave rectifier, or FWR, from now on.

Using the components shown in the diagram, this FWR will rectify up to about 2MHz, with input signals as low as 10μV. I originally used it for full envelope detection in a 455kHz IF chain. It may be possible to squeeze more speed out the circuit by reducing R_8/R_{10}.

The input can be driven differentially or from a single-ended source. Assuming a single-ended input then the input signal is split into two equal parts, 180° out of phase with one another.

Splitting is performed by the long-tailed pair Tr_1 and Tr_2. The two resulting signals drive two emitter followers, Tr_4 and Tr_5, connected in conjunction with Tr_7 and Tr_6, which serve as local current feedback pairs. This action ensures super linearity right down to the micro-volt region-i. e. constant bandwidth with wide dynamic range.

Transistors Tr_4 and Tr_5 conduct alternately and the summation of the two emitter currents results in full wave rectification across R_{22}.

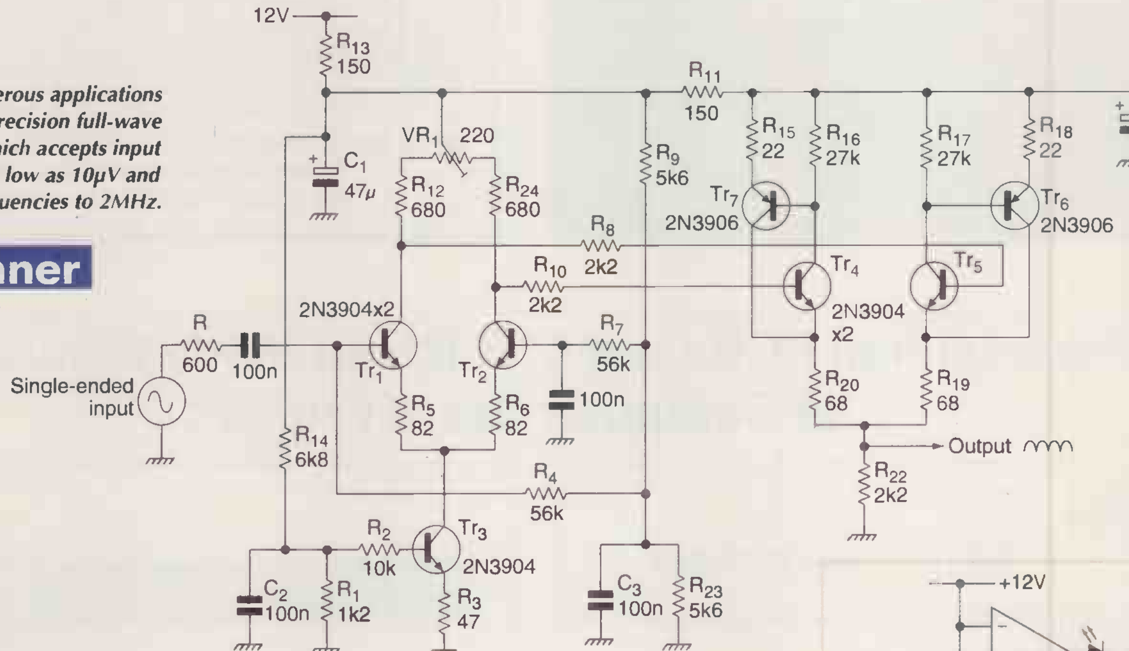
The DC static offset voltage will be in the region of 6V or about $V_{cc}/2$. It can easily be removed by an op-amp, leaving just the rectified signal for further processing. The gain produced by long-tailed pair Tr_1 and Tr_2 is about seven. This suited my needs at the time. Obviously though, this gain can be changed to suit other applications.

Adjust VR_1 to balance the rectification action with the aid of an oscilloscope. The whole circuit runs from a single 12V supply. Most importantly, the circuit is incredibly cheap.

Darren Heywood
Buckley
Flintshire

There are numerous applications for this precision full-wave rectifier, which accepts input signals as low as 10µV and frequencies to 2MHz.

£50 winner



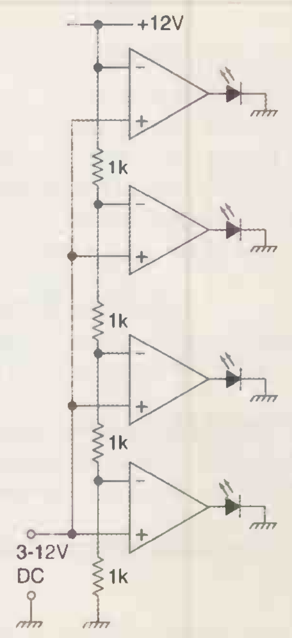
Simple bar graph

Four 741 op-amps are used here to indicate voltage via four on four LEDs. These LEDs indicate turn on sequentially as the voltage exceeds 3, 6, 9 and 12V respectively.

Inverting inputs (pin 2) of ICs 1-4 are supplied with 3, 6, 9 and 12 volts from the resistive divider chain. The non-inverting inputs of all four op-amps are tied together and form the meter's input terminal.

As soon as the applied voltage exceeds the reference voltage of one of the o~amps, it will bring its output high and activate the appropriate LED indicating that the voltage has been reached. You could use a quad device, such as an LM324 instead of the four op-amps.

Raj Gorkhali
Kathmandu
Nepal



USB-powered high-precision hi-fi phono preamp

Table 1. Frequency response of the preamplifier.

Freq. (Hz)	Test (dB)	Ref (dB)	Error
11.8	61.4		
20	59.17	59.3	0.13
40	57.44	57.8	0.36
100	53.68	53.1	−0.58
200	48.52	48.2	−0.32
500	43.12	43.2	0.08
1000	40.83	40	−0.83
2000	38.41	37.4	−1.01
5000	33.28	31.8	−1.48
10000	27.82	26.3	−1.52
15000	23.85	22.8	−1.05
20000	21.53	20.4	−1.13

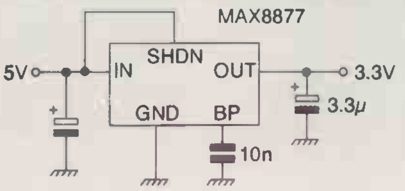


Fig. 1. Power for the preamplifier is derived from the +5V line of a computer's USB interface. This circuit converts the noisy 5V output to a regulated +3.3V for driving the preamplifier.

A phono preamp is needed for preamplifying and equalisation the analogue output of the good old record player. Former hi-fi amplifiers included a phono input. Now though, phono preamplifiers are rare. CD players have a linear output that don't need linearisation.

If you still want to play your records or you want to archive LPs using your computer's sound card you may find this phono preamp useful. This application is easily powered by +5V from the computer's USB port supply. No external power supply, dual supply, or mains connection is needed.

The circuit diagram shows a 3.3V powered phone preamplifier with RIAA equalisation curve. Compared to other op-amp solutions, the main advantage of this one is that it is a low power, low voltage design and runs from a single supply.

A MAX4478 quad, low noise, rail to rail op-amp is at the core of the design. A small MAX8877 linear regulator regulates the noisy +5V from the USB supply down to +3.3V, **Fig. 1**. Additionally the MAX4478 op-amp offers a very high power-supply rejection ratio of 120dB. This circuit, **Fig. 2**, is intended for use with the standard moving magnet type phono pickup.

The high value capacitors of 100μF, 22μF and 10μF could be tantalum or standard electrolytic types. The 82nF and 22nF capacitors should be 2.5% tolerance if obtainable, otherwise you may be able to measure a selection of standard tolerance caps to find those that are closest to the required value. Some deviation from the ideal RIAA equalisation curve will occur if these capacitors are too far from the designated values. More important is the matching between channels. This should be as accurate as possible.

Resistors should be 1% metal film for close tolerance and low noise. This design is done with active low frequency and passive high frequency filtering. Based on the RIAA specification, **Table 1** shows the performance with frequency. There is no rumble filter for frequencies below 20Hz so be careful with 50-60Hz noise. This application requires high amplification for low frequencies, at around 60dB (1000) for 20Hz.

As you can see from Table 1 or Fig. 3, the accuracy is about 1dB. This might be increased if a more accurate capacitor for the high frequency filtering is used. Gain at 1kHz is about 40dB (100) so a nominal 5mV cartridge output will give 500mV output. This may be increased, if necessary, by increasing the value of the 100kΩ resistor in the second stage.

Martin Baumbach
Maxim Integrated Products

Fig. 2. One channel of the phono preamplifier.

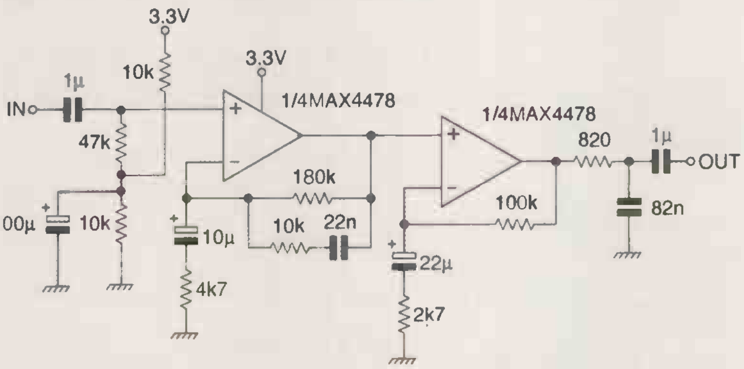
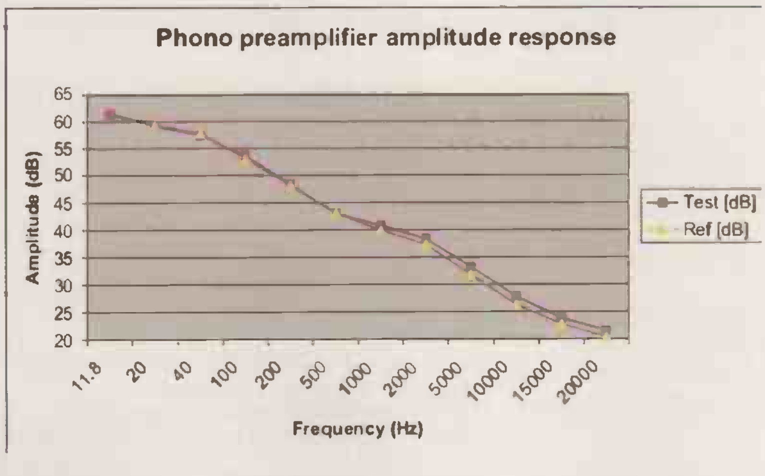


Fig. 3: Frequency response versus the RIAA reference.



Self on Audio

Douglas Self

The cream of 20 years of Electronics World articles (focusing on recent material)

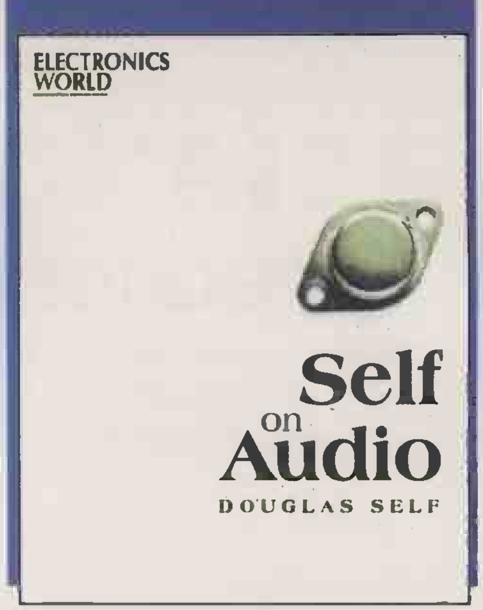
A unique collection of design insights and projects - essential for all audio designers, amateur and professional alike.

Scientific electronics based on empirical data

Douglas Self has been writing for Electronics World and Wireless World over the past 20 years, offering cutting-edge insights into scientific methods of electronics design.

This book is a collection of the essential Electronics World articles, covering twenty years of amplifier technology but with a very strong bias towards more recent material. The articles include self-build projects as well as design ideas and guidance for the professional audio designer. The result is a unique collection of design insights and projects - essential for all audio designers, whether amateur or professional.

Contents: Introduction; PRE-AMPLIFIERS: An advanced preamplifier MRPI;
High-performance preamp MRP4; Precision preamp MRP10; Moving-coil head amp; Preamp '96 I; Preamp '96 II; "Overload Matters" (RIAA overload); Balanced line inputs and outputs, part 1; Balanced line inputs and outputs, part 2;
POWER AMPLIFIERS: FETs less linear than BJTs; Distortion in power amplifiers 1-8; Distortion residuals; Trimodal part 1, 2; Load-invariant power amp INVAR.DOC; Common-emitter amps; Two-stage amplifiers; SPEAKERS: Excess speaker currents; Class distinction (amp classification); Relay control;
Power partition diagrams; Audio power analysis.



Douglas Self has dedicated himself to demystifying amplifier design and establishing empirical design techniques based on electronic design principles and experimental data. His rigorous and thoroughly practical approach has established him as a leading authority on amplifier design.

Readership: Audio electronics enthusiasts; Professional amplifier designers;
Power amp users
Paperback
Pages: 416pp

UK Price: £27.50 Europe £28.50 ROW £30.00

Return to Jackie Lowe, Highbury Business Communications Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey, SM3 8BZ

Please supply the following title:

SELF ON AUDIO

Total________

Name

Address

Postcode

Telephone

Method of payment *(please circle)*

Mastercard/Visa/Cheque/PO

Cheques should be made payable to Electronics World

Credit card no________________________

Card expiry date

Signed

LETTERS to the editor

Letters to "Electronics World" Highbury Business Communications, Anne Boleyn House, 9-13 Ewell Road, Cheam Road, Surrey SM3 8BZ e-mail j.lowe@highburybiz.com using subject heading 'Letters'.

Valve amp protection

A word of caution regarding the valve amp protection circuit (circuit ideas, p31 September 2002). In any application of the floating cathode technique it is advisable to check that the heater supply is isolated from chassis. I remember this system being used to key transmitters. Where the heater supply was returned to chassis the output valves frequently suffered heater/cathode shorts due to the high voltage developed between these elements when the cathodes were allowed to float,

W. J. Williamson,
North-a-Voe, Yell, Shetland, UK

Free ads page, anyone?

May I take this opportunity of congratulating you on your new post of editor of such a valuable and interesting publication. Now, during my retirement from radio design/development engineering posts, I still find it very useful.

I strongly endorse the suggestion of a free reader's ads page to help readers locate sources of components and technical articles.

I would also appreciate it if full postal addresses could be published in adverts, etc., as I find it very frustrating when only a website address is given. I am reluctant to run to the extra expense of buying a PC at the age of 72 – I'm very much in favour of written text.

***S J Harris** C Eng MIEE*
Whitleigh, Plymouth, Devon, UK

Cable testing

Cyril Bateman seems slightly to have missed the point of my article on distortion testing of loudspeaker cables using audio hardware and software. It seems I was not sufficiently clear in explaining my aims and intentions: I apologise.

First, the choice of speaker cable as a subject for the test was only intended to be illustrative of some of the techniques one can employ with such software (incidentally, the new version of Cool Edit Pro, admittedly more expensive at $250, has a fully zoomable spectrum display and the option of exporting the spectrum, which makes it potentially nearly as powerful as the very nice Spectra software Cyril uses and avoids some of the tedious signal-manipulation tricks I described in earlier articles).

More importantly, however, I should explain my rationale in choosing the test setup. The entire reproduction chain (CD player and amplifiers) was exactly as I use it for subjective reviewing of speaker cables, in which situation I believe I can hear differences between cables. Typically, the distortion of the system is dominated by the power amplifier, but what I was looking for was any evidence that changing cable changed the spectrum - in which case by far the most likely explanation is that the amplifier's performance was subtly modulated by the cable's parameters, rather than that the cable itself is producing distortion. In using a CD as the signal source (with a 'perfect' dithered 16-bit digitally generated test signal of four sinusoids) and a CD recorder (16-bit, of course) as the analogue-to-digital converter, I was imposing restrictions no greater than those of the recordings with which I believe I can hear differences between cables. The test is thus fair and legitimate. Of course, real audio is typically considerably more complicated than a mere four sinusoids, but one must draw the line somewhere.

Vibration meter?

After 30 years in Australia, I'm residing for a while in Yorkshire, and enjoying Electronics World. As a 66 year old retired ex-industrial instrumentation technician, I'm still keenly interested in the subject of noise and vibration. My interest stems from work pioneered by Holset Engineering of Huddersfield, a company renowned for turbochargers, torsional vibrational dampers and couplings.

My hearing suffered from many years in the RAF, power stations, and noisy industrial environments, long before adequate protection legislation existed. This is mainly 2 - 4 kHz loss in my left ear. This is particularly frustrating when trying to hear the radio or CD in my car.

Most car noise now seems to emanate from hard compound tyres running on rough tarmac surfaces. It is exacerbated by non-solid bulkheads in the boot, namely drop down seat backs and is even worse in hatchbacks! Thus without adequate vibration insulation between body and suspension, most cars short of Jaguar, Rolls Royce' etc., are to me very noisy.

Ah, you might say, that's your opinion. That's where my plea to E.W. readers comes in. How about some articles on vehicular noise and vibration measurement? In my day Kistler and VibroMeter Corp ruled that roost, but searching the Web for practical/theory articles on charge amplifiers/electrometers, cheap piezo accelerometers and microphones, usually turns up medical papers.

I'm particularly interested in a frugal design for a battery, hand held device, which can measure and display audio noise -weighted A scale (?) 40 - 90 dbA, and vibration 0 - 5g. A sort of poor man's NVH -noise, vibration and harshness-meter.

The microphone would be integral with the meter. The simple accelerometer could be screwed into a small lead block. A moving coil meter indicator would suffice.

Providing the instrument is reliable and reasonably repeatable, simple subjective calibration could be achieved using a very quiet car - got any Bentley owning friends? - a noisy bus, or a particularly nasty small hatchback.

Have I set a challenge to any E.W. readers? Do you have any circuits for charge amplifiers? Does pC/g spark off any memories? Over to you!

Robert Gott
Keighley, West Yorkshire, UK

Homage to Baxandall

In their original paper Baxandall and Shallow[1] gave a qualitative description of and measured results for, the circuit (see figure) referred to in the 'Letters' section of the April 2002 issue of Electronics World.

For readers wishing to exploit the unique advantages of their ingenious scheme, the formulae and design approach given below are appropriate.

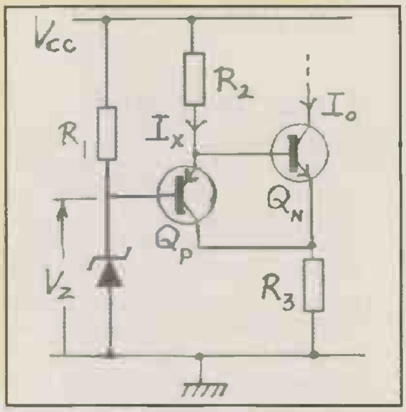
In them: $\alpha(\beta)$ = common base (emitter) current gain, with corresponding letter subscript to denote Q_N, Q_P; V_A = 'early' voltage; V_T = 'thermal' voltage; R_O = L.f. incremental output resistance, calculated using the approach described in ref 2.

$I_O = (V_Z/R_3) - \alpha_P I_X$, where $I_X = (V_{CC} - V_Z - V_{EB})/R_2$

Let $\alpha_P I_X = V_Z/10R_3$, then $I_O = 0.9\, V_Z / R_3$

Select $V_Z(\leq 12V)$ and calculate R_3 and R_2 for a specified I_O assuming $V_{EB} = 0.7V$. Then calculate $R_O \cong 0.9(V_A/V_T)(V_Z/I_O)$.

For $I_O = 1mA$, $V_Z = 10V$, $V_T = 25mV$ (room temp value), $V_A = 100V$ (typical value for a low power NPN device), $R_O = 36M\Omega$: if $V_A = 125V$, then $R_O = 45M\Omega$. If R_3 is replaced by the output circuit of a high resistance current sink (e.g. a common base stage) then $R_O \cong \beta_N\beta_P(V_A/I_O)$. For $\beta_N = \beta_P = 100$ and VA = 100V, this gives at $I_O = 1mA$, $R_O = 1000M\Omega$, the value found by Baxandall and Shallow for their modified circuit.



References

1. Constant-current source with unusually high internal resistance and good temperature stability'. Baxandall P.J. and Shallow E.W., Electronics Letters Sept 1966, Vol 2, No. 9, pp 351-352
2. 'Early Applied', Bryan Hart, *Electronics World*, July 1999, pp 591-594.

***Bryan Hart** Leigh on Sea, Essex, UK*

Cyril's high resolution distortion tests are impressive and may even show up effects due to cables, but having myself conducted spot-frequency THD tests that failed to show any cable-induced distortion down to about −110dB I wished to investigate other lines of attack that might perhaps show up something at a higher (more plausibly audible!) level.

In conclusion, Cyril's excellent work on capacitors is clearly much more rigorous than my own: I merely wished to present some food for thought and a few possibilities for further development on the good old engineering principle of 'what if....?'

Richard Black
London, UK

More microcontrollers, please

I was going through some recent issues of *Electronics World* and found the article "Designing with VHDL" in the May 2002 issue. The article was interesting to me because I like to see what others do with one of my favourite subjects. I thought the author had done very well to introduce what amounts to quite a complicated subject in a short article. I did notice quite a few typographical errors in the text of the article but the article was readable nonetheless.

The article promises a concluding article with a practical application. I have not been able to find this concluding article so far and this has been a disappointment. Of course we are a couple of months behind receiving the magazine here in Australia but if the article has not yet been printed I would be glad to see it in a future issue of the magazine.

In another letter in your magazine one correspondent joked that the magazine should be called *Wireless World*, after a very popular magazine that disappeared off the newsagents shelves some years ago. As I recall the price of the magazine suddenly doubled when the magazine went glossy and this must have lead to the demise of the magazine.

It does seem to me that your articles are heavily biased in favour of audio and RF articles with just the occasional good digital article. Maybe your editor is from the old school when ham radio was the hobby of choice for the technically inclined. I left ham radio behind about 40 years ago. Microcontrollers and programmable logic are the in hobbies for me these days and I am not averse to a bit of theory if it makes an important point.

Maybe your editor and readers are unaware of how cheaply you can get started with programmable logic these days. Very sophisticated software can simply be downloaded from the internet or some of the companies will send you a CDROM free of charge if you request one from their web site. With this you can create quite elaborate projects with little expense on hardware. If you need help getting started you can probably do a course at your local technical institute or read the article "Designing with VHDL". Check out my web site at: http://users.senet.com.au/~dwsmith

***David Warren-Smith,** CPEng, MSc.*
Elizabeth Downs,
South Australia

More microcontrolers 2

As a radio ham, the old school of Morse tappers, I hold onto the study of Morse code as a criteria of holding a licence and I understand why people who have spent their whole lives in a particular discipline are reluctant to change, especially when the decaying brain-cells cannot keep up with the latest developments. But technology marches on relentlessly, and I am afraid that the old-timers are going to have to give way to the youngsters, but us wrinklies can rest assured that the youngsters are standing on the shoulders of giants.

I would certainly like to see more computing articles, particularly PICs and DSP, in the future. EW has a reputation for a more academic approach to electronics than some magazines on the newsagents shelves (such as Elektor and EPE) so please do not dumb down the magazine. The point of your illustrious journal is that we are getting something that is state of the art, or in some way unique, and unavailable in textbooks. Isn't it about time EW had a website and a CD-ROM archive of past articles.

***Stan Thomas,** UK.*

Non-ionising radiation

At times I feel I should respond to commentaries by the editor, and others ...; since I need to send this email now, a comment on 'mobile phones' and radiation, etc.

A few years ago, 40+, I was asked to look at the electromagnetic spectrum for any adverse effects it could have on humans. I was given; 'start at Rugby (16kHz) up to the latest radars' (2GHz), and 0.3μM to 15μM, the then laser frequencies.

I vaguely remember my findings were that there were many frequency spots and ranges, and threshold power levels and continuous power levels that appeared to have some human effect. These ranged from local burning, headaches, mood changes, etc.

In Australia someone used chickens to determine any effects by mobile phones;

what a load of rubbish! Non-ionising radiation can be very subtle; so I would say, "Be careful".
Remember, I can get drunk on, whisky and soda, vodka and soda, ... therefore soda makes you drunk.
If this makes sense to you.
John Ingram. *Gawler, 5118.*
South Australia.

Capacitor sound

Cyril Bateman's series on capacitor sound brings to mind that modern capacitors are in fact quite complex 'devices'. Firstly, fundamental physics by way of the causality principle, of which some might be aware, leads to the famous Kramers-Kronig relation, basically stating that an 'ideal' capacitor or for that matter an inductor (i.e. a component with pure reactance) is impossible at all frequencies.

Secondly, modern capacitors in particular (and perhaps even for inductors on special toroids) should be strictly viewed as semiconductor devices. The interface between the metal contacts and dielectrics are actually junction devices of one sort or another, notably Schottky like. Ohmic behaviour at all voltages, current levels and especially at higher frequencies cannot be expected. Indeed the second and third harmonic generation reported by Bateman, are classic examples of non-linear transfer characteristics typical of semi conducting device properties.
Capacitor manufacturers should thus publish data sheets that give device performance, such as S-parameters (like RF MOSFETs) and even more such as thermal properties, as modern capacitors for SMPS are required to dissipate considerable power. There is no excuse for this lack of detail, as these 'devices' are costing more than some average power MOSFETs on the market.
Tuck Choy *PhD SMIEE MCIM*
Manchester, UK

Spectrum pricing

Loved the spectrum pricing article. It was something I had suspected, but I didn't realise how unfair it had been until that article. It was clear and well structured. Would like to see more stuff like Ivor Catt (is he still about ?), he had interesting ideas, and the maths articles relating to electronics as Joules Watt used to write. What about a series on quantum mechanics and electrons. Also valves are fun, what about an article describing triodes, tetrodes and pentodes and what all the plates do advantages/disadvantages, etc. I'd like to see a description mathematical and descriptive of how co-ax works too, loss-less in theory..... I guess 'difficult' maths or physics stuff does no harm, if people can't follow it they turn the page and look at some adverts or something. But true engineers will treat it the same way a Guardian reader treats his crossword. Something to exercise the mind! Feed our minds, that's why we became engineers in the first place... I'd like a build your own Theremin article too. I'll build it. I built the hot audio power amp in March 1995.
Robin Clark *UK*

Help wanted

I am looking for a circuit diagram of a 'leak detector' and also a 'cable and pipe locator'. I hope that these diagrams will be published in the next issues of EW magazine.
Davut ÇEL_K Ankara, Turkey

Any designers with a leaning towards plumbing care to contribute? - Ed

No Conspiracy

Pigeon has homed in on a likely cause of RF radiation induced brain pathologies ('Psychosomatic effects'), which suggests keen insight on this topic – an article by Pigeon wouldn't go amiss?

However, a few important signposts have been missed: A Spokesman for the industry, interviewed for TV news recently, said "it's not a conspiracy..." Apparently Cellnet antennae are hidden in petrol filling station price hoardings for cosmetic reasons, because they're unsightly; trees and church turrets are also used! In addition, the news item assured viewers that an expert (unnamed) stated that "...the radiation poses no harm", and this, only a few days following news items about the results of several studies showing strong correlations between right or left hand use of mobile phones and corresponding brain pathologies being treated in three countries.

A better study than amphetamine induced psychosis would be to repeat Plenz and Kitai's experiment in the presence of 1.87Hz, which incidentally, was first reported by 'Electronics World' in di Mario's article on a self build ELF counter. Dom couldn't find the source of the 1.87Hz frequency – he thought it might be from his refrigerator – but it's important to realise that 1.87 is equal to the quotient of F1 and F2, the bifurcation constants: 4.669...., 2.502....Malament suspected that gravitational forces are determined by the ratio (negative) of the Minkowski lengths which he dubbed "ponderacmotive". If we put 1.87Hz in the place pendulum equation ($t = f^{-1} = 2\pi\sqrt{l/g}$) we can see that '$g/l$' is very close to 137, which Eddington called the fine structure constant, considering it to be a prime arbiter of natural dynamics ($2^7 + 2^3 + 2^0$ degrees of freedom for intervals on four events, t x y z). If, however, 1.87Hz is substituted in $E = h\nu = mc^2$ it gives m equal to 1.375×10^{-54} $J.S.cm^{-2}$ compared to Eddington's value of $9.8 \times 10^{-55} cm^{-2}$, for λ the cosmological constant, which Eddington dubbed the cosmical constant.

The difference in units is a clue to where the 'hard problem' lies in contemporary physics (quantum gravity, GUT, whatever?), a fact borne out by Eddington's prognostications in 'The Expanding Universe' (c.u.p 1933). Wey's calculation (1917) shows this most clearly with an order of magnitude error of 27 ($8\pi k/c = 1{,}87.10^{-27}$ $cm.gr^{-1}$), which isn't removed by changing the MKS or cosmological units; p/q (Malament) = F_1/F_2 (Feigenbaum) is the gold standard now – for physics and mind!

References:

1. Deitmar Plenz & Stephen T. Kitai, 'Nature', 400, 12th August 1999, pp 677-682; ibid 621-2
2. Lawrence Sklar, 'Philosophy and Spacetime Physics', University of California Press, 1985, page 112.
3. Herman Weyl, 'Space, Time, Matter', 4th edition, Dover Publishers (English), 1952, page 243.
4. Roger Penrose FRS, 'The Large, the Small and the Human Mind', C.U.P., 1997, page 130 et seq.
5. H. Minkowski, Lecture, Cologne, 21st September 1908; trans. In 'The principle of Relativity', W. Perrett and G.B. Jeffrey, Methuen, 1924.
6. Sir A. Eddington FRS, 'The Expanding Universe', C.U.P. (1933), page 114; λ can be used to calculate the radii of empty and the Einstein universes: $R_S = \sqrt{3}$. Re, $\lambda = 3/R^2_S$; ibid 'The Mathematical Theory of Relativity', Chelsea Pub, (NY), 3rd edn, (1975), page 235, $\lambda = 10^{-50}$ cm^{-2} or much smaller, written in 1922.

A G Callegari *BSc., MPHIL. (Lond)*
Much Hadham, Hertfordshire, UK.

I can't quite work out why it is dangerous to use a mobile phone in a petrol station, but quite safe to have a more powerful transmitter in the same place. Does anybody have an explanation? Ed.

MFB Reply

I read with interest John Watkinson's comments about my MFB speaker system. A simple proof that the circuit acts as a servo can be easily obtained. If you connect an oscilloscope between the output of the amplifier and ground and displace the cone manually the amplifier's output voltage will be seen to alter as it tries to correct the error. The error of course is the back emf generated when the cone is displaced. No matter how large a magnet you might use on a driver you will never provoke the amplifier to correct errors generated in this way. Moreover, this action works across the piston range of the driver reducing, for example, re-radiation of internally reflected sound. A common cause of colouration in real, as opposed to theoretical speaker systems. The definition of a motional feedback system is that the cone's motion is detected and used to control it's own motion via the power amplifier. I rest my case.

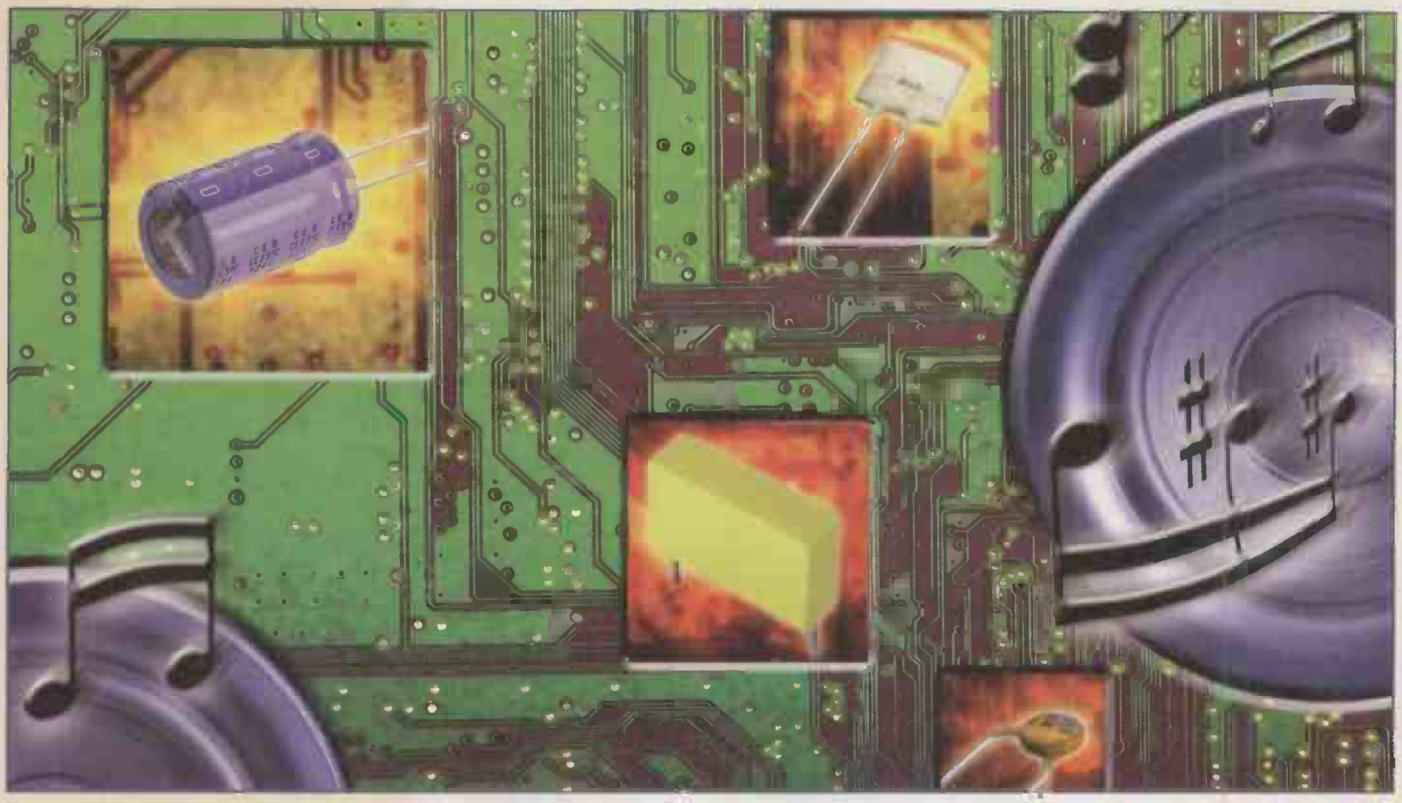
Actually most of the points raised by John can be seen as red herrings if the circuit is closely examined. The voltage generated across the 0.47R resistor, connected in series with the speaker is directly proportional to the impedance of the driver which in turn is directly proportional to the back emf. This voltage is compared to the input signal by the op-amp. Where John is right, however, is that the circuit is not a conventional servo system. In a normal servo the control element would have large open loop gain reduced by signals from the sensor. Any performance improvement would be due to the excess loop gain of the circuit.

The servo used here employs positive rather than negative feedback. The circuit is therefore arranged to have a low forward gain defined by a conventional negative feedback loop. Control of the loop gain, and cone motion is obtained by the amount of positive feedback applied. The use of positive feedback in this way is an advantage since the control range is theoretically infinite without fear of promoting oscillation with any reasonable component values. The circuit produces a modification in the deep bass response by modifying the 12db/octave slope below resonance to 6db/octave. FFT analysis of the acoustic output of the system at 20Hz showed that the THD was reduced from 22% to 3%. Addition of the equalisation will actually reduce this further since the THD measured is a function of the roll-off rate, among other things. 40% 2nd harmonic distortion at 40Hz is inaudible in the presence of programme in any event, to put the above figures into some perspective.

A conventional MFB system as outlined by John is quite a problem to produce in practice. Unless an acceleration sensor is employed, some form of equalisation will be necessary. Even then you'd need to curtail sub audio response unless you could provide truly infinite gain in the amplifier. Another problem would be sensor linearity. How could you be sure that your sensor was telling the truth? It's seems churlish in the extreme to ignore the back emf freely provided by the driver. Velocity, acceleration or displacement proportional signals can be obtained. Of course acceleration or displacement signals would need differentiation or integration of the basic velocity signal. Integrators and differentiators are of course a form of equalisation!

Finally If John has some new thoughts, or even better a radical design that works, I will be grateful to read the article(s). If not watch this space!

Jeff Macaulay *UK*



Capacitor sound 6

10-100µF capacitors and 100Hz measurements

Many capacitors introduce distortions onto a pure sinewave test signal. In some instances distortion results from the unfavourable loading which the capacitor imposes onto its valve or semiconductor driver, though more often, the capacitor generates the distortion within itself. Cyril Bateman concludes his capacitive deliberations

For the 1µF value, choosing a film capacitor or a bi-polar electrolytic generates the lowest distortions. In the tests, polar aluminium electrolytics produced considerably larger distortions, even with small AC signals.[1]

While high capacitance electrolytic capacitors can be obtained from distributors at low cost, cheap metallised film capacitors are restricted typically to 10µF at 100 volt and 22µF at 63 volt. In this final article, which completes last month's discussion on electrolytic capacitors, we explore whether a metallised film capacitor or an electrolytic is our economic, low distortion choice for capacitor values between 10µF and 100µF.

Test frequency

To avoid overstressing large value electrolytic capacitors, we should reduce our test signal frequency towards 100Hz. But sufficiently above or below this frequency to discriminate between harmonics of the supply mains and the test capacitor. With minor changes in capacitance values, the PCB used for our 1kHz oscillator can provide an exceptionally low distortion 100Hz test signal.[2] In similar fashion the PCB used for our 1kHz notch filter and pre-amplifier can also be used at this frequency.[3]

The AD811 low distortion buffer can output 40mA. At 100Hz using a 100Ω series resistor, it can develop a 5 volt test signal across a 10µF capacitor. Using a 10Ω resistor, 0.5 volts could be developed across a 100µF capacitor. These test voltages are more than sufficient to distortion test any electrolytic capacitor up to 100µF. However, when I designed the test instruments I decided to provide the ability to measure both values of film capacitors to 5 volts. To produce a larger test signal with 100µF capacitors, a more powerful buffer must be used. A low distortion circuit able to drive up to 400mA has been designed but needs a different PCB. **Fig. 1**

When testing large value capacitors, a four terminal test system is preferred and four BNC connectors are provided which accept either Hewlett Packard capacitor test jigs or four discrete cables and crocodile clips. **Fig. 2**

Tantalum and aluminium electrolytic myths.

Some audio power amplifier designs have used small tantalum bead capacitors, with apparent success. Initial measurements of a

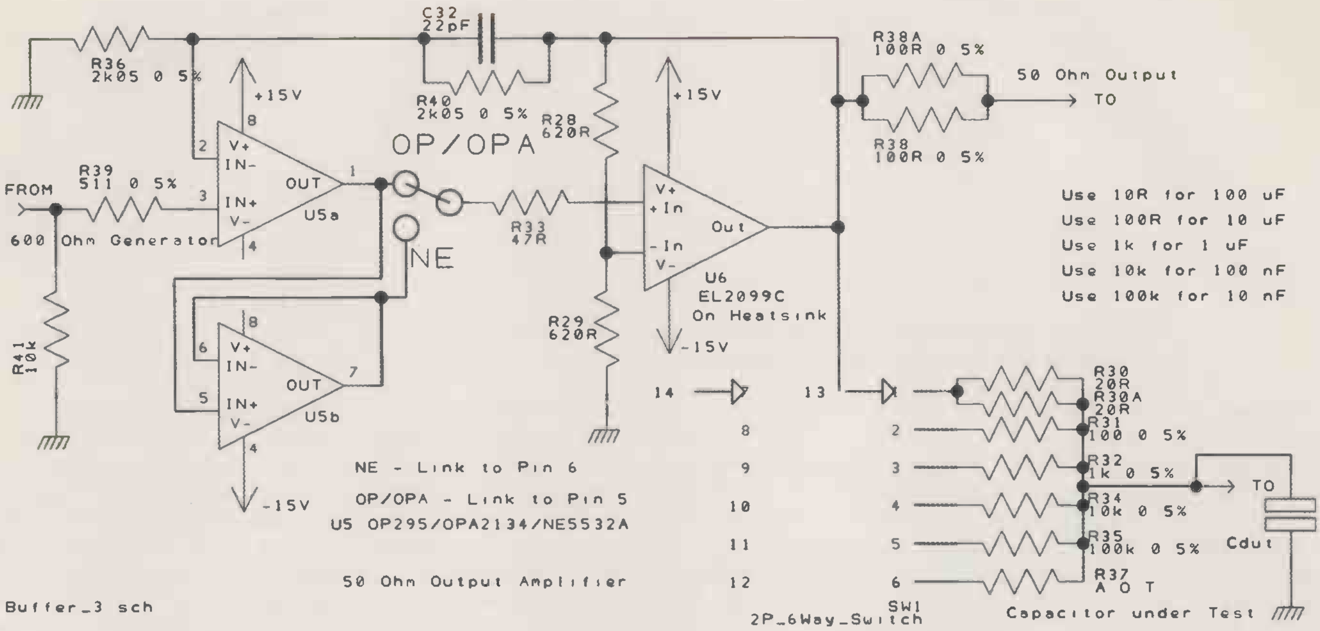


Figure 1: High power buffer provides low distortion, a gain of two and a 400mA output. It can develop more than five volts across a 100μF capacitor via a 10Ω current limiting resistor.

number of tantalum capacitors revealed large distortions. Measured at 0.3 volts with and without DC bias, my tantalum capacitor stocks produced at least ten times more distortion than found with low cost polar aluminium electrolytics. I decided to exclude tantalum bead capacitors from further tests. Fig.3

As with other capacitor types, much has previously been written about the sound distortions electrolytics produce. Most were discussed in my last article and the remainder will be in this.

a) High ESR electrolytics degrade sound quality, low ESR is always best.
b) Electrolytics are highly inductive at audio frequencies.
c) Polar electrolytics should be biased to half rated voltage to reduce distortion.
d) Electrolytic capacitor distortion is mostly third harmonic.

A working knowledge of electrolytic construction combined with careful measurements, leads to somewhat different conclusions.

Inductance

Radial lead electrolytics are assembled with their connecting tabs attached towards the centre of their anode and cathode foils. Wound together this produces a near non-inductive winding. The main contribution to the capacitor's self inductance then comes from the connecting lead wires and tabs and not the wound element.[4]

This is quickly proved. The largest capacitor I measured for distortion, the Nitai 220μF 63 volt bi-polar, has a case size 25×16mm. I mounted one on a test jig and measured its self-resonant frequency. It was 250kHz, well above audible.[5]

Polar & bi-polar electrolytics

In my last article we saw that every polar aluminium electrolytic capacitor comprises two polar capacitors in series, back to back.[1] Wound with an anode and cathode foil, each foil with the electrolyte, comprises one capacitor. The cathode foil provides a larger

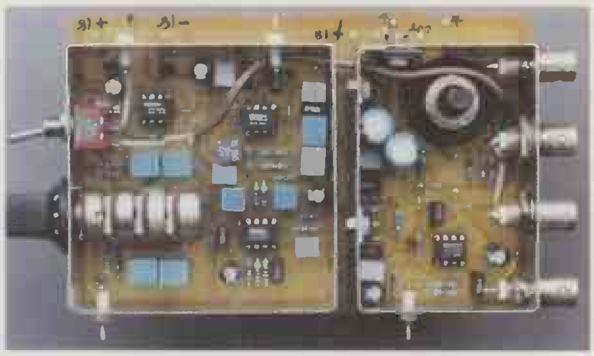


Figure 2: The higher power 100Hz test system. Four BNC connectors are arranged to accept Hewlett Packard test fixtures. The DC bias network inserts between the buffer amplifier and test fixture.

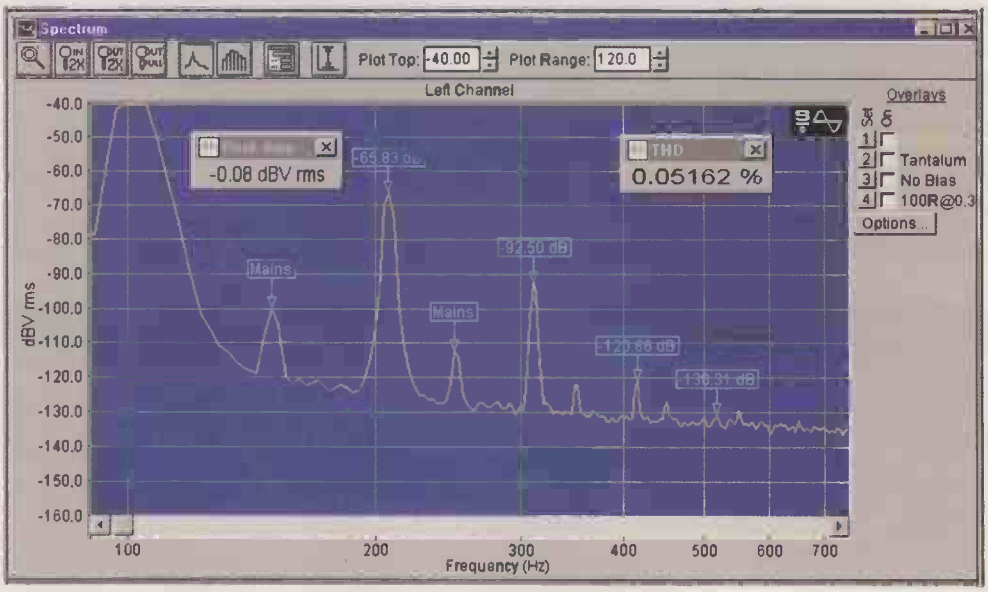


Figure 3: Distortion of this tantalum capacitor, ten times more than found with aluminium electrolytic capacitors, does reduce slightly with DC bias.

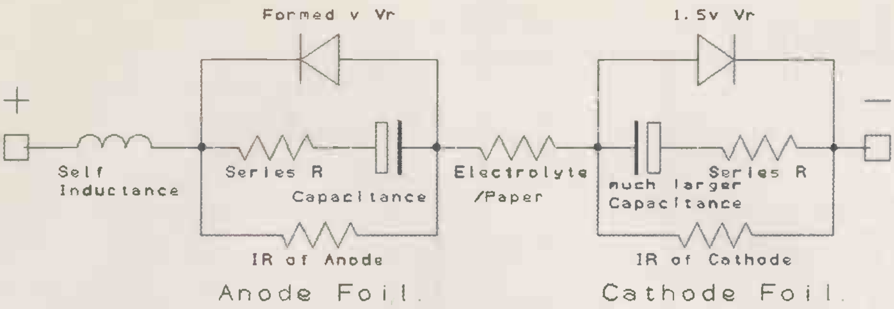


Figure 4: Simplified equivalent schematic shows how a polar electrolytic capacitor behaves with AC signals, with and without DC bias.

capacitance, lower working voltage, than the anode foil.

With no bias voltage, the capacitor produced predominantly second harmonic distortion. In some instances, application of a small optimum DC bias did minimise this second harmonic. Increased bias, however, resulted in increased second harmonic distortion. For the 100μF 25 volt capacitors tested, optimum bias varied by capacitor, from 1.1 to 4.2 volts.

Bi-polar capacitors

A bi-polar electrolytic is made in exactly the same way as a polar capacitor, with one difference, in place of the unformed cathode foil a second, formed, anode foil is used. We still have two polar capacitances in series, back to back, both now the same value and voltage. To make the desired value, two anode foils of double capacitance are used.

Aluminium electrolytic capacitor designers are accustomed to mixing and matching their available materials, to suit the capacitor's end application. So it should come as no surprise that some designs are semi bi-polar, i.e. they are made using a lower voltage deliberately 'formed' anode foil as cathode.

Using this constructional background, we deduced an equivalent circuit for a polar aluminium electrolytic capacitor. **Fig. 4.**

Dielectric Oxide

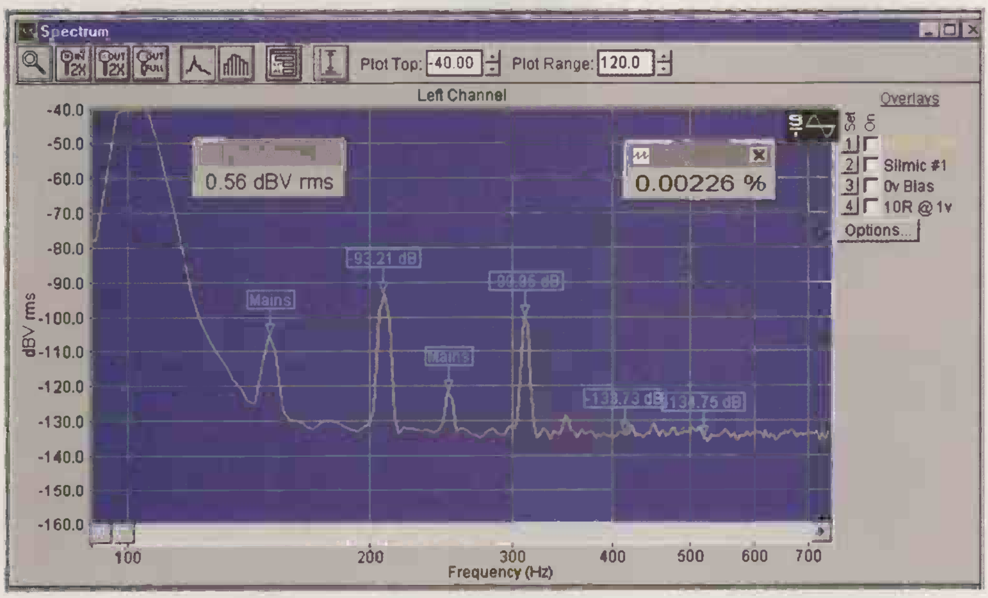
Aluminium oxide has a 'k' of eight, similar to that of COG ceramics or some impregnated paper capacitors.[6] It is higher than PET, which at 3.3, has the highest 'k' of commonly used film dielectrics. It is a low value compared to the 'k' of some thousands, found in 'high k' X7R and Z5U ceramics.

More significant, though, is dielectric thickness. Aluminium electrolytic dielectric is much thinner than that used in other capacitors and the dielectric oxide film has a small but easily measured voltage coefficient of capacitance, typically +0.1% with +18v DC bias, but this is overshadowed many times by its much larger dielectric absorption. An electrolytic capacitor is exceptionally sensitive to dielectric absorption effects and the applied AC and DC voltages.

When our 1μF 63 volt polar electrolytic was tested using two 0.7 volt frequencies, its third harmonic was -110dB or 0.0003%. It created visible intermodulation distortion. We also noted small capacitors rated at 40 to 63 volt exhibiting near optimum quality.[1] Many 100μF capacitors will be made with lower voltage, thinner dielectric oxide, anode foil. This capacitance requires lengthy anode and cathode foils, housed in a larger diameter can. To generate the test voltage across the capacitor, increased current must pass through the tab connections into the winding, amplifying the affects of any non-linear resistance. It seems probable that similar harmonic and intermodulation levels will be found at smaller test voltages.

To allow direct comparison between the low cost 1μF 63 volt polar capacitor and the physically larger Elna Silmic 100μF 25 volt, I show its distortions measured at

Figure 5: The lowest distorting 100μF 25 volt polar capacitor of those tested, at 1 volt. It should be compared with Figure 7 of my last article. Both capacitors produced similar second harmonics. Third harmonic of the 100μF has increased by 4.5dB.



Distortion with voltage

We have seen how the test voltage used influences various capacitors. With sufficient test signal, most film and all electrolytic capacitors distort. It is prudent in any audio design to minimise the level of AC signals which are developed across any capacitor.

At low frequencies this becomes difficult and may force a trade off between capacitor size and distortion. Equally important is the level of DC bias voltage the capacitor must sustain. If more than a few volts, then for low distortion a low dielectric absorption material is essential. Because distortion results from non-linearities inside the capacitor, inevitably it increases disproportionately both with capacitance value and applied voltage.

The change in amplitude of the second harmonic, when tested at a constant signal with and without DC bias, clearly results from the DC bias voltage used, dielectric absorption and dielectric thickness.

Regardless of capacitance value, to minimise second and third harmonic distortions with increased AC and DC voltages, such as found in valve amplifiers, then a foil and Polystyrene, foil and Polypropylene or double metallised foil, two-series, MKP Polypropylene capacitor, should be used.

1 volt. This capacitor provided the best 1 volt, no bias, results of the 100µF polar types in this article. **Fig. 5.**

Lower voltage measurements

Accurate 100Hz distortion measurements using test signals smaller than 1 volt become quite difficult, for two main reasons.

1) Supply mains harmonics intrude everywhere and are difficult to reduce using a computer based system.
2) Inevitably, the smaller test signal reduces the dynamic range of our measurement, dramatically inflating indicated distortion.

For example, using a 0.1 volt test signal, my noise floor is around -112dB, hence a perfect capacitor producing no distortion at all will still register some 0.0005%. However, if we compare the measured harmonic levels of our electrolytic with those found for the identical measurement using a metallised film capacitor, we will see any increase in distortion caused by the electrolytic capacitor.

To distinguish between harmonics from the mains and the test capacitor, my test frequency was displaced a few Hz away from 100Hz. The Spectra software then ignores mains harmonics when calculating distortions. To assist visual identification, I used frequency markers to identify mains harmonics and amplitude markers to indicate the first four harmonics from the test capacitor.

At 100µF, a metallised Polypropylene capacitor is both large and costly. I used an assembly of 10µF Evox Rifa MMK metallised PET capacitors. This works well for small test voltages as a low distortion 'reference' capacitor. **Fig. 6.**

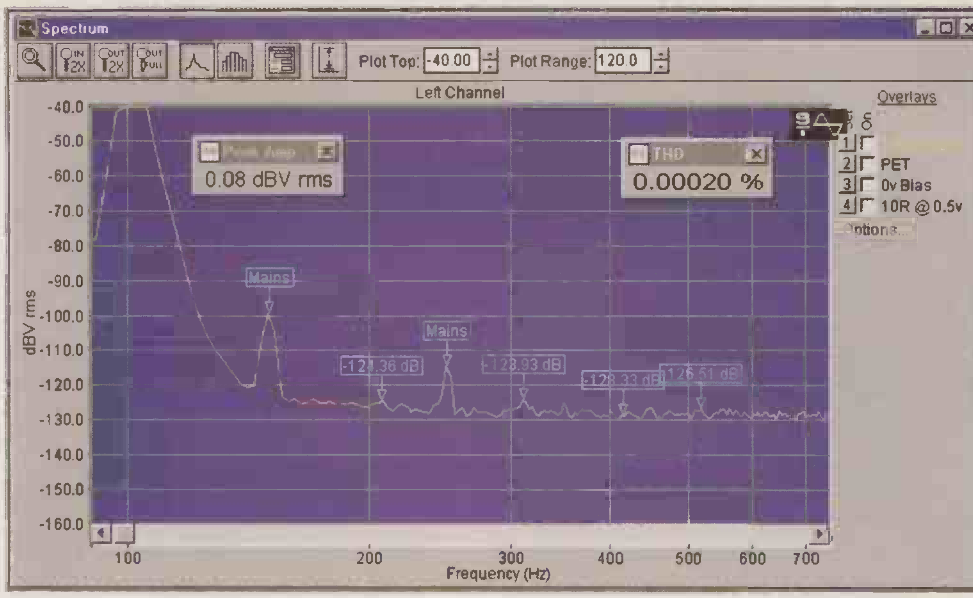


Figure 6: Distortion plot of an assembly of ten Evox Rifa 10µF 63 volt MMK metallised PET capacitors, tested at 0.5 volt. This 100µF assembly was used as the distortion reference for each test.

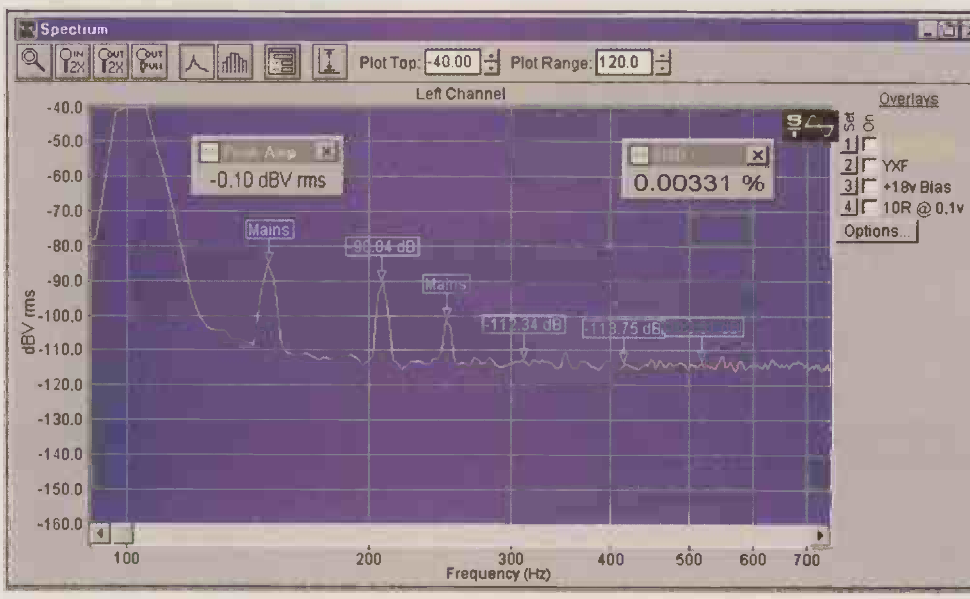


Figure 7: Distortion of a low cost, very small Rubycon YXF capacitor, tested at 0.1 volt with 18 volt DC bias, was less than 50% worse than the two larger, more expensive capacitors.

Electrolytic distortion

As I've said before, despite some marketing claims, capacitors are not categorised for distortion, so a distorting capacitor would not be considered defective by its maker. It is the responsibility of the equipment designer to select the correct capacitor for each circuit.

During this investigation I measured many other polar electrolytics, rated from 10 to 100 volt and capacitance to 220µF, produced by major manufacturers. To illustrate this article, I decided to measure three quite different 100µF 25 volt polar electrolytic capacitors and my PET assembly. I tested the low cost Rubycon YXF, the larger more expensive Elna Silmic and the considerably more expensive Black Gate FK.

The Black Gate FK is a 21×10mm semi bi-polar, built using a low voltage anode as its cathode foil. The Silmic is 17×10mm and uses a special separator paper incorporating silk extracts. Both were purchased from Audiocom UK. The Rubycon YXF is a 12×6.5mm conventional, miniature, low ESR low cost capacitor purchased from Farnell.

Tests were performed using 0.1 volt AC to 0.5 volt AC in 0.1 volt steps, each using DC bias voltages of 0 volt, 6 volt, 12 volt and 18 volt, a total of 64 separate distortion measurements.

100µF 25 volt tests

With the 0.1 volt test signal, the measurement noise floor was reduced to -112dB. With no bias, distortions for the PET reference capacitor and the Black Gate FK were lost in noise. Second harmonic for the Silmic measured -106.1dB and the YXF measured -102.8dB

With 18 volt DC bias, second harmonic for all three electrolytic capacitors increased to between -90 and -94dB, distortions measured some three times greater than the PET assembly. **Fig. 7**

Using a 0.2 volt test signal, the noise floor improved to -118dB.

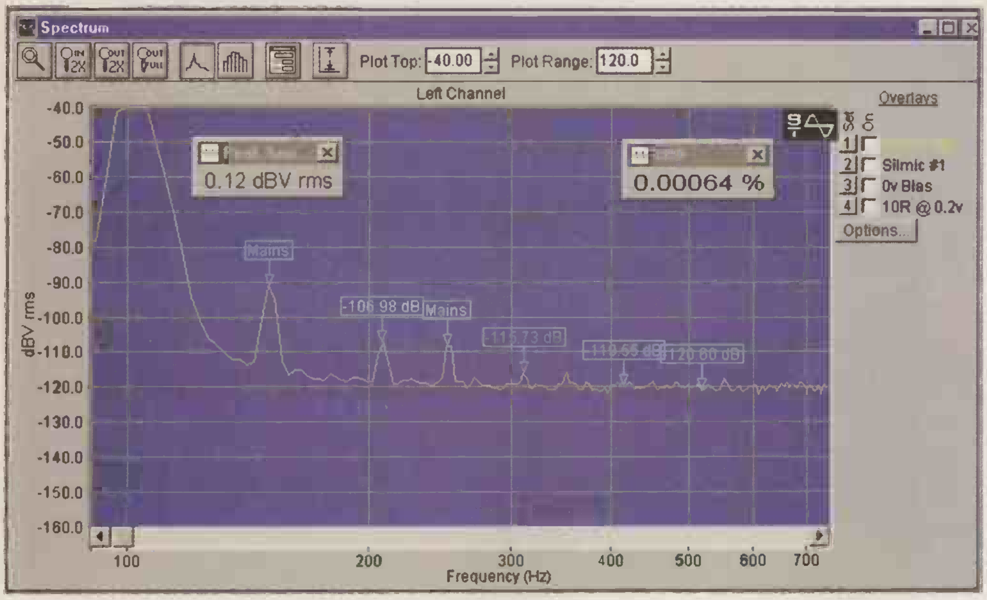


Figure 8: The 100µF 25 volt Silmic capacitor of Figure 5, tested at 0.2 volt. With no bias, second harmonic is 6dB smaller and distortion little more than half that of the more expensive Black Gate FK.

With and without bias, all electrolytic distortions increased more than the change of test signal. With no bias the Silmic performed best of the three electrolytics, outperforming the Black Gate FK by almost 6dB. **Fig. 8.**

With 18 volts DC bias, dielectric absorption effects increased the second harmonic of the Silmic by 21.7dB and it's distortion to 0.0054%. The Black Gate was less affected and its distortion increased to 0.0037%. The YXF distorted rather more, at 0.0063%. Third harmonic distortions were visible above the noise floor, but not sufficient enough to produce measurable intermodulation distortion.

With a 0.3 volt test signal, the measurement noise floor improved to -123dB but the PET reference capacitor harmonics remain buried in noise. Second and third harmonics of the polar capacitors are now clearly visible, their distortions having increased much faster than the test signal level.

With a 0.3 volt test signal and no bias, the Silmic, at 0.00098%, produced the least distortion of the three electrolytics. Its second harmonic measured -100.6dB, the Black Gate -98.5dB and the YXF -89.1dB. The best electrolytic produced more than three times the distortion of the PET assembly. **Fig. 9.**

With a 6 volt DC bias, the Silmic and Black Gate, with second harmonics around -90dB, produced similar 0.003% distortion. The YXF second harmonic was -87.3dB for 0.0043% distortion.

With 18 volt DC bias the Black Gate develops fifteen times more distortion than the PET assembly but distorts less than the other two electrolytics. Its second harmonic at -84.1dB was some 3dB better than the Silmic and 4dB better than the low cost YXF type. Distortions now measured 0.00637%, 0.00840% and 0.00951% respectively.**Fig. 9B.**

Third harmonics for all three electrolytics have reached the level for measurable intermodulation, which was confirmed by more tests, using 18Hz as the second frequency.

All three electrolytics produced significant distortions in this 0.3 volt test. Almost five times larger with no bias, at least fifteen times larger with bias, than my PET assembly. I consider distortions from these 100µF polar capacitors tested at 0.3 volt, exceed the sensible limit for use in the signal path of high quality audio.

Some writers advocate using a low

100 Hz test equipment

The oscillator and notch filter/preamplifier printed boards can be used at other frequencies by scaling the values of a few capacitors.[2]

Oscillator board

For 100Hz, use 100nF 1% metallised Polypropylene for C1, C2, and C3. Bypass R16 by a wire link. To differentiate between test capacitor and mains frequency harmonics, replace R23, R24 and R25 with wire links.

Twin-Tee notch filter/pre-amplifier board

For 100Hz, use 100nF 1% metallised Polypropylene for C41, C42, C43, C44, C47 and C48. Use 47nF 1% metallised Polypropylene for C45 and C46. Use 10nF 1% metallised Polypropylene for C49.

Output Buffer.

At 100Hz, 10µF capacitors can be tested to 5 volts, using the AD811 output buffer amplifier described.[3] Adding a 10 Ohm current limiting resistor allows 100µF to be tested to 0.5 volts.

To fully test 100µF capacitors, a higher power buffer amplifier is needed. It should develop at least 5 volts signal across a 100µF capacitor via a 10Ω current limiting resistor.

I have designed a buffer amplifier and printed circuit board, able to drive up to 7 volts or 400mA, with extremely low distortion. An Elantec EL2099CT output amplifier is used with an input buffer. This can be an OP295, OPA2134 or an NE 5532A, by connecting one link. I used an OPA2134 in my prototype. **Fig. 1**

Larger decoupling capacitors are used with 1.5 Amp stabilisers. A Perancea 75 by 50mm PCB case serves as heat sink for the EL2099CT and the stabilisers.

Apart from these changes, the buffer amplifier schematic circuit and the current limiting resistors/switch follow the approach previously used for my 1kHz AD811 output buffer.

When testing 100µF, a four wire test method should be used. Four BNC connectors, two to output the test current and two to measure the capacitor distortions, are spaced at 22mm centres to fit Hewlett Packard capacitor test jigs. Alternatively, four discrete BNC cables and crocodile clips can be used.

To measure capacitors larger than 10µF with DC bias voltage, a DC blocking buffer circuit as already described but made with larger capacitors is essential.

Two 50µF 450 volt metallised Polypropylene motor run capacitors replaced the 11µF current carrying capacitors of my 1kHz design. Three 3.3µF MKP capacitors provide 10µF for the voltage measuring circuit. These components were mounted in a die-cast box and hardwired.

Four BNC connectors were mounted on opposite sides of this box, to mate with my 100Hz output buffer amplifier and the Hewlett Packard capacitor test jigs. **Fig. 2**

A selectable DC bias voltage was provided, by mounting 20 AA cells and a range switch, in a second die cast box. This was used with both DC blocking buffer designs.

distortion film capacitor in parallel with an electrolytic, to reduce distortion. Does it work?

Using a film shunt

To find out, I made a few measurements on these capacitors using a 1 volt test signal, unbiased then with 18 volt DC bias. As a shunt I used my low distortion 1μF MKP and also a 10μF bank of three 3.3μF low distortion metallised PPS capacitors.

With 1μF shunt, second and third harmonics of the Silmic reduced by just 1dB. Using the 10μF, both harmonics reduced by a further 1dB. This small reduction is not worth the additional PCB space and extra cost, because even with a 10μF shunt, distortions far exceed those of my metallised PET assembly.

Perhaps a higher voltage capacitor would measure better, or would its longer anode and cathode foils simply make matters worse?

100μF 50 volt tests

Examination of my earlier distortion plots suggested the only suitable 100μF electrolytic types I had which might measure lower distortion were the 22×12.5mm 50 volt Silmic and the 26×12.5mm 50 volt Panasonic S bi-polar, Farnell 218-698. With a 0.3 volt test signal and no bias, the 50 volt Silmic distorted more than the 25 volt version. Because of its much longer foils, the second harmonic increased 2dB, the third, 7dB and distortion measured 0.00134%. **Fig. 10.**

Due to the thicker dielectric used for the 50 volt capacitor, with 18 volt DC bias, the second harmonic increased less, now almost 6dB smaller than the 25 volt version. Distortion at 0.00460% was just over half that of the 25 volt version.

Bi-polar tests

The Panasonic S bi-polar capacitor at 0.3 volt with no bias produced less than half the distortion of the 25 volt

Technical Support

Interested readers are free to build a system for personal use or educational use in schools and colleges. Commercial users and replicators should first contact the author.

A professionally produced set of three FR4 printed circuit boards, with solder resist and legends, for the 1kHz signal generator, output buffer amplifier/notch filter/pre-amplifier and the DC bias buffer network, comprising a 'with DC bias, single frequency, distortion test system', complete with heat bound hardcopy 28 pages A4 assembly notes, parts lists and drawings and with PCB's costs £32.50.

To reduce your costs, I now offer PCB's with the 28 page assembly notes, parts list and PCB drawings, as PDF files on floppy disc, for £30.

If ordered at the same time as either of the above, additional sets of PCBs cost £27.50, but please double the post/packing costs.

The CD ROM with 28 page manual, parts lists, PCB drawings, added distortion measurement results and even more capacitor information but no PCBs, costs £15

Post/packing to UK address £2.50. Post/packing to EU address £3.50, rest of world £5.50.

As a service to non-UK readers, if ordered with the above PCBs, a four gang potentiometer, re-tinned and tested, with each set of boards, costs an additional £5.00 inclusive of postage.

Falcon Electronics tel:01508 578272 (EW September) has these potentiometers in stock.

Postal Orders or Cheques, for pounds sterling only, to C. Bateman. 'Nimrod' New Road. ACLE. Norfolk, NR13 3BD, England.

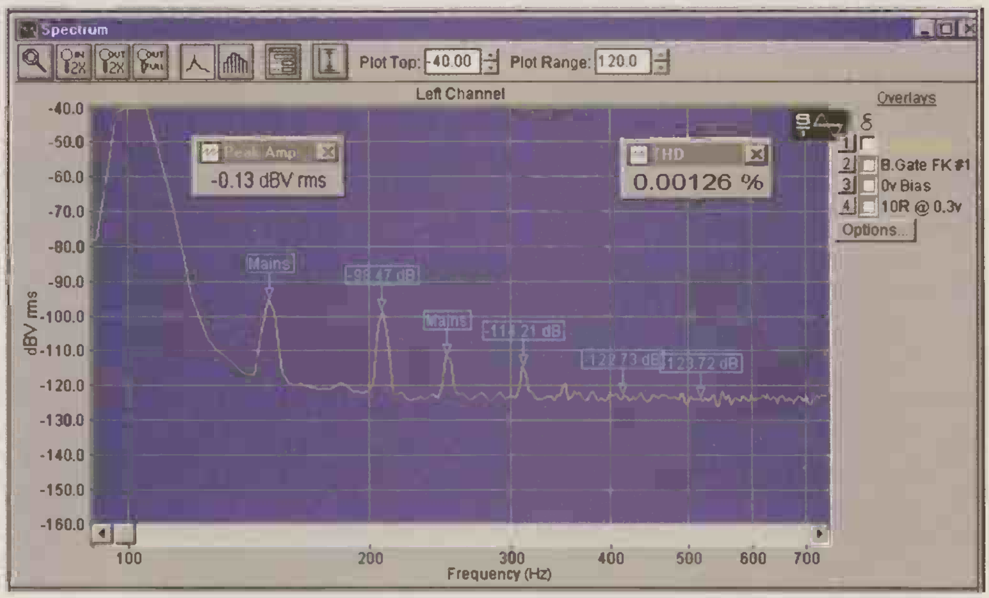


Figure 9: Tested at 0.3 volt with no bias, the 100μF 25 volt Silmic produced the smallest second harmonic, 2dB better than the Black Gate FK shown and 11dB better than YXF. Third harmonic was -112.8dB Silmic, -110.5dB for YXF.

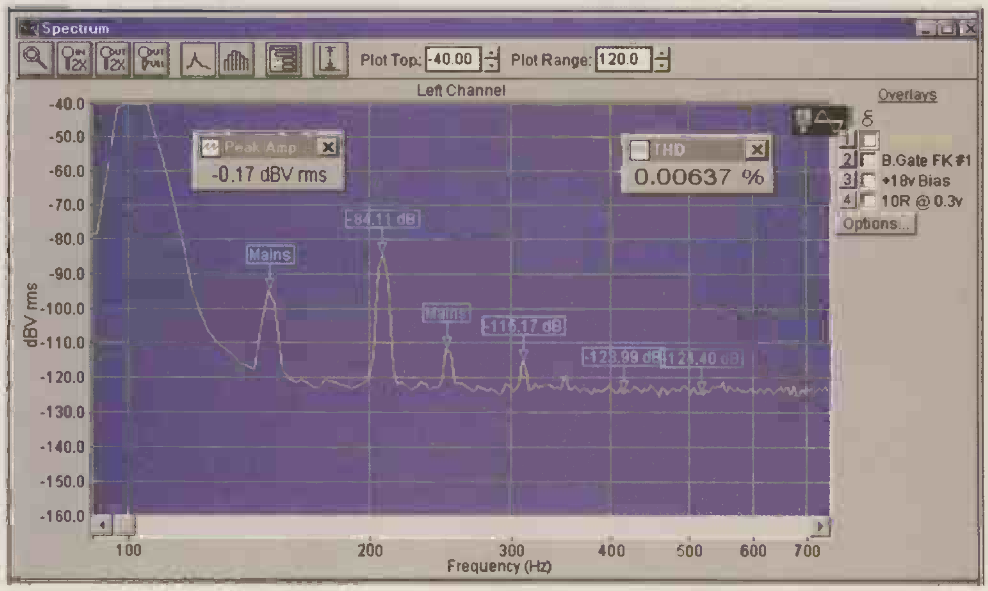


Figure 9B: As Figure 9 with 18 volt DC bias, the Black Gate FK second harmonic increased 14.4dB, distortion is now 3dB smaller than the Silmic but fifteen times bigger than the PET assembly.

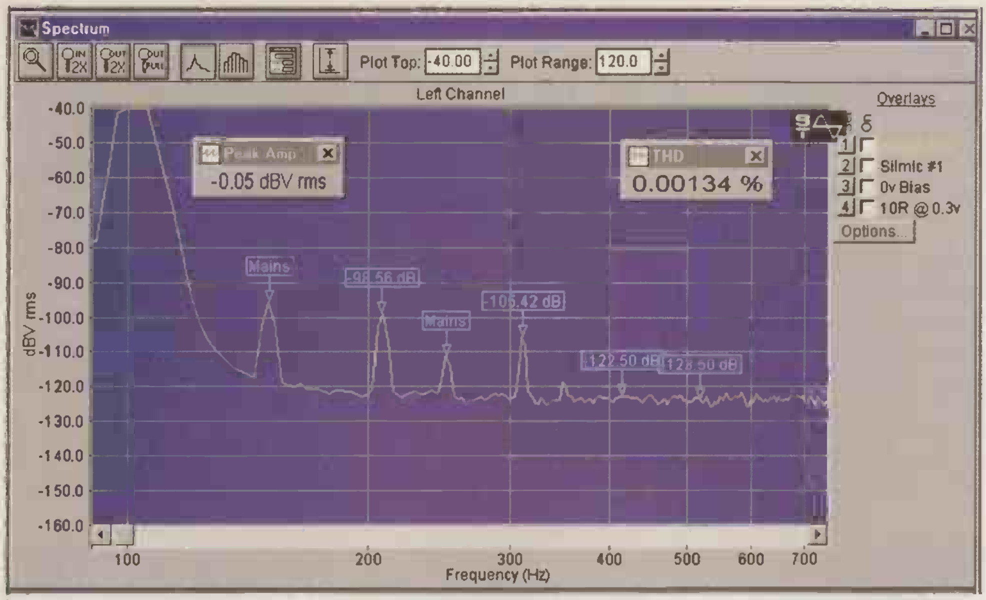


Figure 10: Tested as Figure 9, this 100μF 50 volt Silmic shows 2dB more second harmonic and 7dB higher third harmonic. Its longer foil lengths produced a 35% increase in distortion.

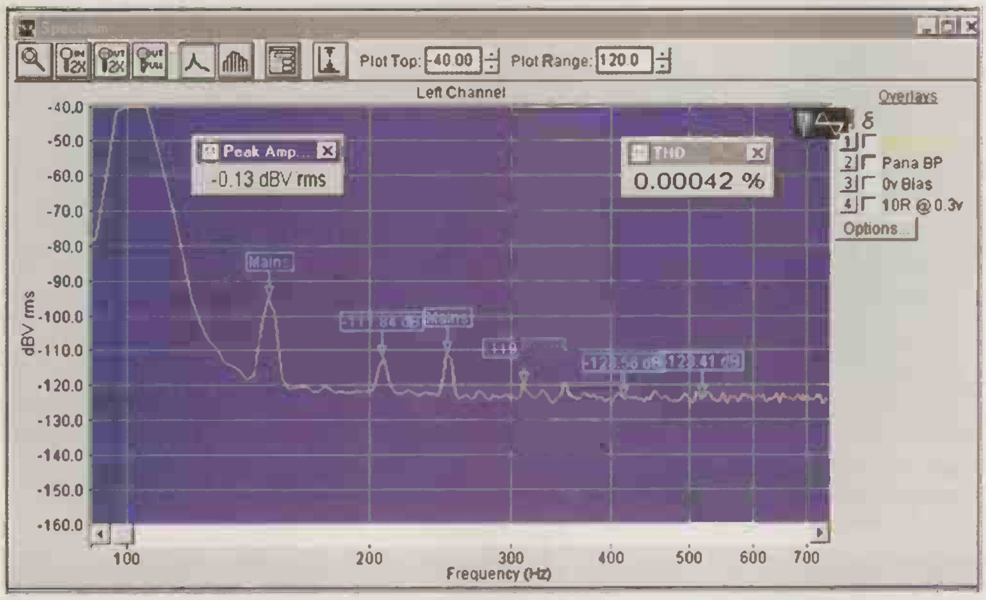


Figure 11: Tested as Figure 9, this 100μF 50 volt Panasonic bi-polar measured just 0.00042%, less than half the distortion of the best polar capacitor.

Silmic. The second harmonic measured -111.8dB, the third -119.6dB and distortion was 0.00042%. With an 18 volt DC bias, the second harmonic increased to -92.7dB and distortion to 0.00237%, that's half the distortion of the 50 volt Silmic.

The Panasonic S bi-polar produced the lowest distortion of all single 100μF electrolytic capacitors I tested, using a 0.3 volt signal and DC bias from 0 volt to 18 volts.**Fig. 11.**

In my last article we saw how using two polar capacitors in series could reduce distortion. Let us explore using two bi-polar capacitors in series.

Two better than one?

I already had some 220μF 63 volt Nitai bi-polar electrolytics, Farnell 317-4906. Two connected together in series would approximate 100μF.

Measured at 0.3 volts with no bias, the second harmonic level was reduced by 6dB compared to the Panasonic S bi-polar. With the second and third harmonics buried in the noise floor, distortion at 0.00033% measured the same as the PET assembly. With 18 volt DC bias, second harmonic measured -105.3dB and distortion 0.00063%. A near four-fold improvement compared to the Panasonic S bi-polar, more than seven times better than the best polar capacitor tested.

To better compare harmonics we examined performances using a 0.5 volt signal. With no bias, those for my PET assembly can just be seen emerging from noise. The second harmonic was at -124.3dB, the third -123.9dB and distortion was 0.00020%. Fig. 6.

The double 220μF 63 volt bi-polar second harmonic was -117.7dB, the third -124.1dB and distortion was 0.00023%, practically the same distortion as the PET assembly. **Fig.12.**

With 18 volt DC bias, the second harmonic of the double bi-polar increased to -100.7dB and distortion to 0.00093%, slightly more than double the distortion measured on the PET assembly with this bias.

This is an excellent performance from electrolytic capacitors, but how does this series pair of bi-polar capacitors stack up for size and cost? Can this bi-polar series pair produce low distortion with a 1 volt signal?

Double bi-polar v alternatives

The series pair requires less PCB area, is lower cost and dramatically outperforms a polar capacitor with a film shunt.

At 1 volt with no bias, the noise floor improved to -132dB. Distortion of the PET assembly measured 0.00011%, a single Panasonic S bi-polar 0.00054% and the Silmic 25v with 10μF shunt 0.00151%. The 220μF 63 volt Nitai series pair measured 0.00016%, practically equalling that measured on the PET assembly, ten times less distortion than the Silmic capacitor.

With an 18 volt DC bias, the 220μF 63 volt Nitai series pair distortion measured 0.00217%. Slightly more than six times that of the PET assembly but nearly seven times less distortion than using the 50 volt Silmic polar capacitor. This series pair of 220μF 63 volt Nitai bi-polar capacitors costs one eighth and takes just one fifth the PCB area of my PET assembly. To explore other double bi-polar options, I purchased 35 volt and 16 volt 220μF Nitai bi-polar capacitors for tests.

Smaller, doubled bi-polar

With no bias and tested at 0.5 volt, distortion for all three voltage bi-polar doubles measured almost the same as the PET assembly, but 18 volt DC bias revealed large differences. The 16 volt series pair measured 0.00693%, the 35 volt series pair 0.00230% and the 63 volt series pair 0.00093%.

For the lowest possible distortion

when DC blocking/signal coupling, I suggest the 16 volt pair is only used with negligible DC bias, the 35 volt pair be used to say 6 volt bias and the 63 volt pair to say 12 - 15 volts bias. With such small DC voltages, no voltage sharing resistors are needed.

Used in a 'Long Tailed Pair' amplifier feedback network to ensure unity gain at DC, the 63 volt series pair could be used with supply rails up to 63 volts, without voltage sharing resistors. For higher voltages use a series pair of 100 volt bi-polar.

This 63 volt series pair can also benefit local supply rail decoupling, but for this use, voltage sharing resistors, passing a few milliamps from the supply to the capacitors central connection and ground, must be used.

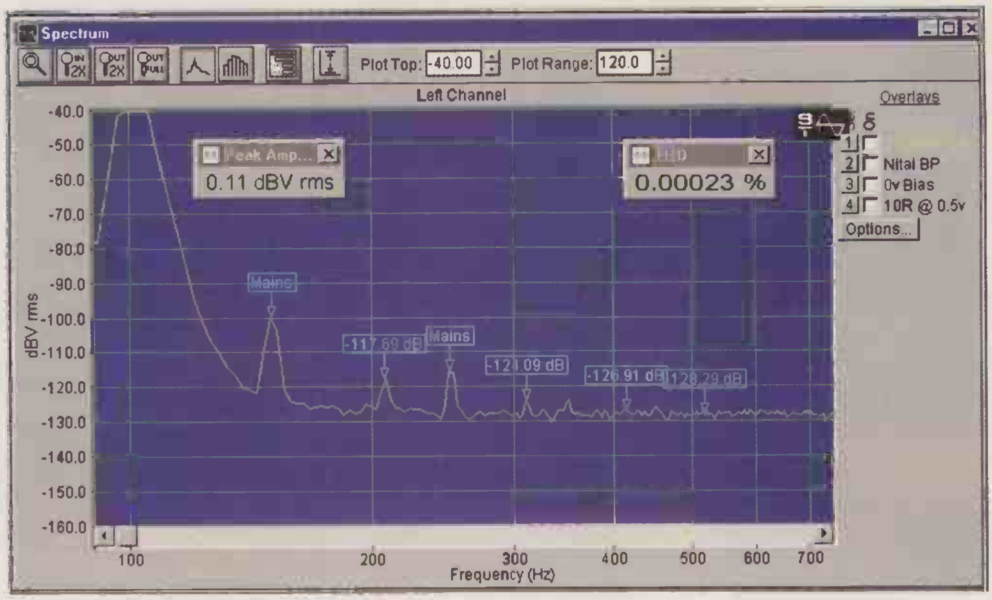


Figure 12: A series pair of 220µF 63 volt Nitai bi-polar capacitors with 0.5 volt test signal. With no bias distortion was similar to my metallised PET assembly, five times smaller than the best polar capacitor tested. With 18 volt DC bias, 0.00093% distortion is nine times smaller than the best polar capacitor.

ESR/tanδ

The most nearly perfect capacitor would exhibit near zero ESR. Low ESR is essential for use in switched mode power supplies, but does a low ESR electrolytic ensure low audio distortion?

Of the 100µF capacitors I tested, the 10 volt Oscon measured the lowest 100kHz ESR of all, 0.012 Ohms and 100Hz tanδ of 0.035. It would be unreasonable to compare a 10 volt capacitor with higher voltage types so I also measured 10 volt Rubycon YXF and Elna RSH types. The YXF ESR measured 0.550 Ohms and tanδ 0.091. The RSH ESR was similar, at 0.505 Ohms and tanδ at 0.104.

Tested at 0.5 volt with and without 6 volts DC bias, the Rubycon YXF produced the least distortion, 0.0351% with DC bias and 0.00331% unbiased. The Oscon distorted worst of the three, measuring 0.05321% with DC bias and 0.02499% unbiased.

Clearly low tanδ at 100Hz and low ESR at 100kHz does not ensure low audio distortion.

Conclusions

Having measured a considerable number of aluminium electrolytics using test voltages from 0.1 volt to 3 volt, with and without bias, a single bi-polar type produced lower distortion than larger, more expensive, specialist polar capacitors.

Much better results were obtained by connecting two double value bi-polar electrolytics in series. Using 1 volt or smaller test voltages and no bias, distortions for a double bi-polar and the metallised PET assembly were similar.

With increasing bias or with increasing test voltage, the metallised PET assembly produced less distortion than any electrolytic I tested.

100µF choice

Provided the AC voltage developed across the capacitor at the lowest audio frequencies is 1 volt or less and no significant DC bias is used, a double bi-polar series pair provides an economic solution.

When higher AC signal voltages, especially combined with significant DC bias, must be applied, the metallised PET combination produces less distortion. It costs eight times more and takes five times more PCB area than the double bi-polar.

For the least practical distortion, an assembly of metallised Polyphenylene Sulphide capacitors might be feasible. It needs double the board area and is five times more expensive than the PET assembly.

For small AC signals with modest DC bias and for supply rail decoupling, I choose the double bi-polar 63 volt solution.

10µF choice.

We have three possibilities. A double bi-polar using two 22µF 50/63 volt bi-polar electrolytics, a 10µF metallised PET or an assembly of three 3.3µF PPS capacitors.

The lowest cost solution for use with signal voltages less than 1 volt and no significant bias is a double bi-polar series pair. A 10µF MMK metallised PET takes the same PCB area and distorts less with DC bias.

The PPS capacitor assembly ensures lower distortion, especially when used with increased AC signals or DC bias voltage. However it occupies more board area and is expensive.

An assembly of Polypropylene capacitors, as used in the DC bias network, would provide the lowest possible distortion, but requires a five times larger board area and is most expensive.

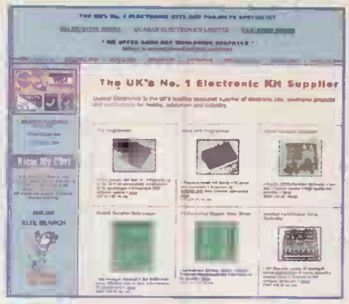
For small AC signals and modest DC bias, I choose the 10µF MMK metallised PET capacitor. ■

References.

1. Capacitor Sound part 5 C. Bateman EW December 2002 p.44
2. Capacitor Sound? C. Bateman Electronics World July 2002 p.12
3. Capacitor Sound 2 C. Bateman Electronics World September 2002 p.16
4. Understanding capacitors - aluminium and tantalum Electronics World June 1998 p.495. C. Bateman
5. Evaluate capacitors for SMPS designs. C. Bateman Electronics World Sept 2000 p.696
6. Reference Data for Radio Engineers. Howard Sams & Co. Inc. New York

Certain aspects of this article are the subject of a patent application.

WEB DIRECTIONS



Put your web address in front of 18,000 electronic fanatics. Electronics World acknowledge your company's needs to promote your web site, which is why we are dedicating 2 pages in every issue to WEB ADDRESSES.

Linage only will cost £150 + vat for a full year.

Linage with colour screen shot will cost £350 + vat for a full year, this will include the above plus 3cm shot of your web site which we can produce if required.

To take up this offer or for more information telephone

Reuben Gurunlian

Tel 0208 722 6028

E-mail

r.gurunlian@highburybiz.com

ANASOFT LTD

http://www.anasoft.co.uk

SuperSpice, the affordable, mixed-mode windows circuit simulator. Wrote by an analogue design engineer for those Teletubbies who like keeping things simple.

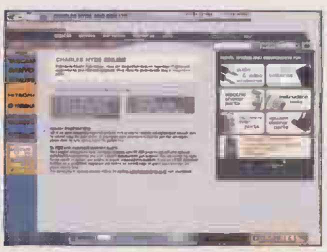
BEDFORD OPTO TECHNOLOGY LTD

http://www.bot.co.uk

Optoelectronic products UK design development manufacture standard and custom, LED bargraphs, circuit board indicators, stand offs, transmissive/reflective switches, baseefa optocouplers tubular and surfacemount, pannel mount LED assemblies.

CHARLES HYDE & SON Ltd

http://www.charleshyde.co.uk

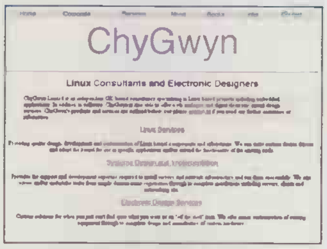


Search for both original and copy spare parts in our extensive database covering Akai, Alba, Bush, Ferguson, Goldstar, Hitachi, LG, Marantz, Matsui, Nokia, Saisho, Sanyo, Sony, Sharp, Thomson, Panasonic, Philips, Samsung, Tascam, Teac, Toshiba, Yamaha and many more. In addition huge ranges of Lasers, Lopts, Remote controls and Semiconductors may be accessed.

CHYGWYN

http://www.chygwyn.com

ChyGwyn Limited offers electronic design and embedded software development for



remote monitoring, embedded appliances, set-top boxes and similar devices. We are experts in customisation of Linux and write device drivers for custom hardware.

CRICKLEWOOD ELECTRONICS

http://www.cricklewoodelectronics.co.uk

Cricklewood Electronics stock one of the widest ranges of components, especially semiconductors including ICs, transistors, capacitors, all at competitive prices.

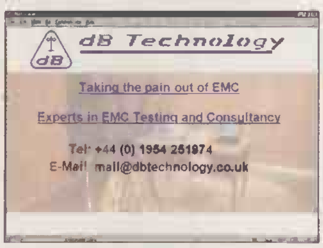
CROWNHILL ASSOCIATES LTD

http://www.crownhill.co.uk

Crownhill supply low cost development tools for use with Micro-Controllers and Smart Cards. Products include Smart Card development tools, Smart cards, Micro Development tools and Bespoke Design Services.

DB TECHNOLOGY

http://www.dbtechnology.co.uk/

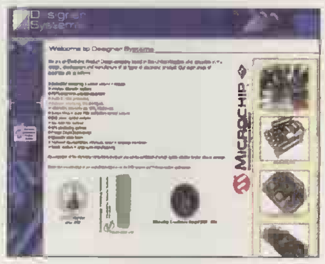


EMC Testing and Consultancy.
Anechoic chamber and open area test site.

- Compliance Tests
- Rapid, accurate pre-compliance tests.
- Fixes included. FCC Listed.
- Flexible, hourly booking available.

DESIGNER SYSTEMS CO.

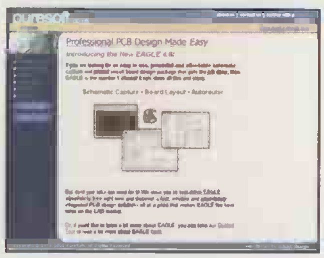
http://www.designersystems.co.uk



Electronic product design company with over a decade of experience promoting it's own product range and designing and manufacturing innovative products for client companies/individuals.

EAGLE PCB DESIGN SOFTWARE

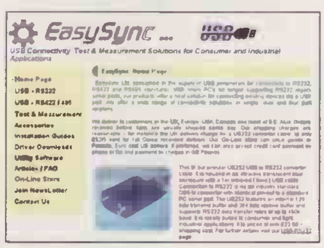
http://www.puresoft.co.uk



- Professional PCB design made easy!
- Fully functional freeware download.
- Schematics, Layout & Autorouting.
- Free tech support

EasySync

http://www.easysync.co.uk

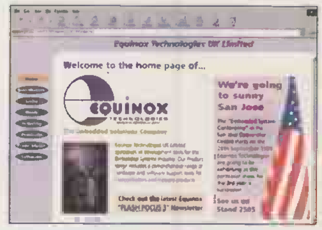


EasySync supplies a wide range of USB-RS232 and USB-RS422/485 converters. It also specialises in USB test and measurement devices.

To reserve your web site space phone Reuben Gurunlian

Tel: 020 8722 6028

Fax: 020 8722 6096



EQUINOX TECHNOLOGIES UK LTD

http://www.equinox-tech.com

Equinox Technologies UK Ltd., specialise in development tools for the embedded microcontroller market.

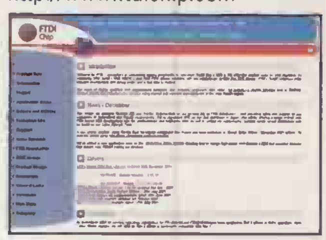
FELLER UK

http://www.feller-at.com

Feller (UK) Ltd. manufacture Fully approved cordsets (Moulded mains plugs and connectors) and Power Supply Cables for all industrial Countries to National and International Standards

FUTURE TECHNOLOGY DEVICES INTL. LTD.

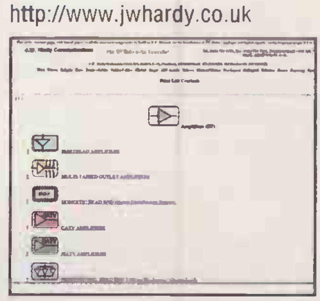
http://www.ftdichip.com



FTDI designs and sells USB-UART and USB-FIFO interface i.c.'s. Complete with PC drivers these devices simplify the task of designing or upgrading USB peripherals

J W HARDY COMMUNICATIONS

http://www.jwhardy.co.uk



R.F. Network Specialist.
Shop online - for R.F.network components. We supply a full range of TV, radio reception equipment to receive analogue/digital signals from both terrestrial and satellite sources. We provide a free planning service for your R.F. networks, MATV and SMATV etc

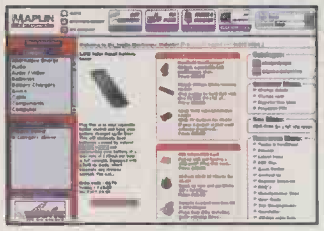
LOW POWER RADIO SOLUTIONS

http://www.lprs.co.uk

LPRS produces radio modules with embedded "easy-Radio" software protocols for short range radio applications. We also represent Circuit Design narrow band modules in the UK.

MAPLIN ELECTRONICS

http://www.maplin.co.uk



A fully secure and interactive internet ordering system from Maplin Electronics, the specialist electronic retail and mail order company to business and retail consumers alike. 15,000 products available on line.

MATRIX MULTIMEDIA LTD

www.matrixmultimedia.co.uk

Matrix Multimedia publishes a number of highly interactive CD ROMs for learning electronics including: Complete electronics course, Analogue filter design, and PICmicro(R) microcontroller programming (C and assembly).

NORCALL Ltd

http://www.norcall.co.uk

e-mail Norcall@aol.com

Suppliers programmers and repairers of new and refurbished two-way radio equipment. Retuning and recrystalling service available. All types of batteries chargers and aerials supplied.

QUASAR ELECTRONICS

www.quasarelectronics.com

Over 250 electronic kits, projects and ready built units for hobby, educational & industrial applications. TEL: 01279 467799, FAX: 07092 203496 or EMAIL: ewsales@quasarelectronics.com

PHAEDRUS LTD

www.phaedrusltd.co.uk

Manufacturer and supplier of low cost general purpose and serial I/O digital modules and accessories. PC based software for data logging and control applications.

RADIOMETRIX

http://www.radiometrix.co.uk

Radiometrix specialises in the design and manufacture of VHF & UHF, RF data modules. We offer a broad range of PCB mounted miniature transmit, receive and transceiver modules for OEM use. They comply with European harmonised standards EN300 220-3 and EN301 489-3 and are CE certified by an independent Notified Body.

RALFE ELECTRONICS

professional test & measurement

www.ralfe-electronics.co.uk

RADIO-TECH LIMITED

http://www.radio-tech.co.uk

Radio modules, modems, telemetry, audio transmitters, pagers, antenna, remote controls and much more. All UK designed and manufactured.

SOFTCOPY

http://www.softcopy.co.uk

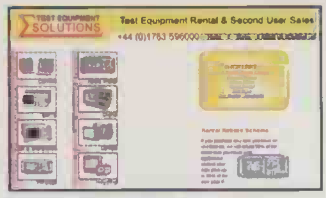
As a PC data base or hard copy, SoftCopy can supply a complete Index of Electronics World articles over the past ten years. Photo copies of articles from back issues are also available.

TELNET

http://www.telnet.uk.com

Top quality second-user Test and Measurement Equipment

eMail sales@telnet.uk.com



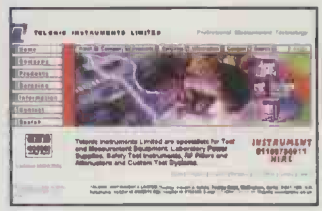
TEST EQUIPMENT SOLUTIONS

http://www.TestEquipmentHQ.com

Test Equipment for rental or second user sale at the industry's lowest prices. All types of equipment from all leading manufacturers including general purpose, communications and industrial test. Items fully refurbished with 1 year warranty. Rental rebate given on purchases.

TELONIC

http://www.telonic.com



Telonic specialists in laboratory AC & DC Power Supplies, Electronic AC & DC Loads, Electrical Safety Testing and complete test systems. Plus RF Filters, Attenuators, Diesel Engine Smoke Measurement, Quartz Crystal Microbalances.
Tel +44 (0) 118 9786911
eMail sales@telnet.uk.com

TECHNICAL AND SCIENTIFIC SUPPLIES

http://www.technicalscientific.com

Suppliers of pre-1985 equipment and components.
- Test/Measurement equipment
- Valves and semiconductors
- Transducers and pressure gauges
- Scientific books and catalogues
- Manuals and data sheets

TELEVES

http://www.televes.com

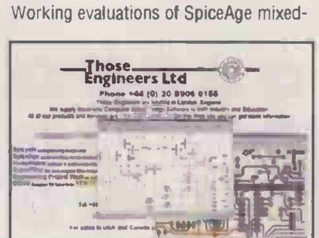
Tel: 44(0) 1633 875821
email hbotas@televes.com

Televes website was launched as an easier way to keep in contact with our World-wide Network of Subsidiaries and Clients. This site is constantly updated with useful information/news plus you can download info on our range: TV Aerials & accessories, Domestic and Distribution amplifiers, Systems Equipment for DTT and Analogue TV, Meters and much more.

THOSE ENGINEERS LTD

http://www.spiceage.com

Working evaluations of SpiceAge mixed-



mode simulator, Spicycle PCB design tools and Superfilter demo (synthesises passive, active, digital filters). Tech support, sales links and price list.

TOTAL ROBOTS

http://www.totalrobots.co.uk

Robot Kits and Control Technology products, including OOPic the first Object-Oriented Programmable Integrated Circuit. Secure on-line ordering and fast delivery.

ULTRA-CREA OY

http://www.ultra-crea.fi

Our business idea is to provide our customers complete service, i.e. design from the customer specification to the delivery of finished and tested products.

Our offerings are as follows:
- RF transmission line filters from 100MHz to 3GHz
- Special antennas to frequencies as above
- Transmitter and Receiver modules
- RF-subunits such as amplifiers, oscillators, directional couplers etc.

VUTRAX PCB DESIGN SOFTWARE

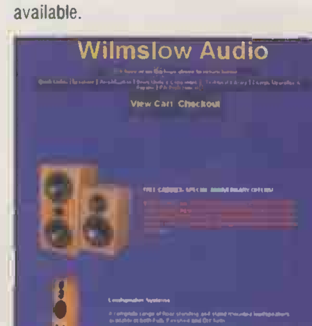
http://www.vutrax.co.uk

Vutrax electronic schematic and pcb design system for Windows 95/98, ME, NT, 2000, XP and Linux. Limited Capacity FREE version downloads available, all upgradeable to various customised level.

WILMSLOW AUDIO

http://www.wilmslow-audio.co.uk

'Uk's largest supplier of high quality loudspeaker kits and drive units. Comprehensive range of components and accessories, including damping products, connectors and grilles materials. Demonstration facilities available.



Electronics World reader offer:
x1, x10 switchable oscilloscope probes, only £21.74 a pair, fully inclusive*

*Additional pairs as part of the same order, only £19.24 each pair.

Please supply the following:

Probes

Total__________

Name____

Address____

____

____

Postcode________________ Telephone________________

Method of payment *(please circle)*

Cheques should be made payable to ELECTRONICS WORLD

Access/Mastercard/Visa/Cheque/PO

Credit card no____

Card expiry date Signed

Please allow up to 28 days for delivery

Seen on sale for £20 *each*, these high-quality oscilloscope probe sets comprise:

- two x1, x10 switchable probe bodies
- two insulating tips
- two IC tips and two sprung hooks
- trimming tools

There's also two BNC adaptors for using the cables as 1.5m-long BNC-to-BNC links. Each probe has its own storage wallet.

To order your pair of probes, send the coupon together with £21.74 UK/Europe to ***Probe Offer, Jackie Lowe, Highbury Business Communications, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey, SM3 8BZ***

Readers outside Europe, please add £2.50 to your order.

Specifications

Switch position 1

Bandwidth	DC to 10MHz
Input resistance	1MΩ – i.e. oscilloscope i/p
Input capacitance	40pF+oscilloscope capacitance
Working voltage	600V DC or pk-pk AC

Switch position 2

Bandwidth	DC to 150MHz
Rise time	2.4ns
Input resistance	10MΩ ±1% if oscilloscope i/p is 1MΩ
Input capacitance	12pF if oscilloscope i/p is 20pF
Compensation range	10-60pF
Working voltage	600V DC or pk-pk AC

Switch position 'Ref'

Probe tip grounded via 9MΩ, scope i/p grounded

WATCH SLIDES ON TV MAKE VIDEOS OF YOUR SLIDES DIGITISE YOUR SLIDES

(using a video capture card)

"Liesgang diatv" automatic slide viewer with built in high quality colour TV camera. It has a composite video output to a phono plug (SCART & BNC adaptors are available). They are in very good condition with few signs of use. For further details see www.diatv.co.uk .... £91.91+ vat = £108.00

Board cameras all with 512x582 pixels 8.5mm 1/3 inch sensor and composite video out. All need to be housed in your own enclosure and have fragile exposed surface mount parts. They all require a power supply of between 10 and 12v DC 150mA.

47MIR size 60x36x27mm with 6 infra red LEDs (gives the same illumination as a small torch but is not visible to the human eye)........ £37.00 + vat = £43.48

30MP size 32x32x14mm spy camera with a fixed focus pin hole lens for hiding behind a very small hole........ £35.00 + vat = £41.13

40MC size 39x38x27mm camera for 'C' mount lens these give a much sharper image than with the smaller lenses........ £32.00 + vat = £37.60

Economy C mount lenses all fixed focus & fixed iris

VSL1220F 12mm F1.6 12x15 degrees viewing angle........ £15.97 + vat = £18.76

VSL4022F 4mm F1.22 63x47 degrees viewing angle........ £17.65 + vat = £20.74

VSL6022F 6mm F1.22 42x32 degrees viewing angle........ £19.05 + vat = £22.38

VSL8020F 8mm F1.22 32x24 degrees viewing angle........ £19.90 + vat = £23.38

Better quality C Mount lenses

VSL1614F 16mm F1.6 30x24 degrees viewing angle........ £26.43 + vat = £31.06

VWL813M 8mm F1.3 with iris 56x42 degrees viewing angle........ £77.45 + vat = £91.00

1206 surface mount resistors E12 values 10 ohm to 1M ohm 100 of 1 value £1.00 + vat 1000 of 1 value £5.00 + vat

866 battery pack originally intended to be used with an orbitel mobile telephone it contains 10 1.6Ah sub C batteries (42x22dia the size usually used in cordless screwdrivers etc.) the pack is new and unused and can be broken open quite easily........ £7.46+vat = £8.77

Please add 1.66 + vat = £1.95 postage & packing per order

JPG ELECTRONICS

Shaws Row, Old Road, Chesterfield, S40 2RB

Tel 01246 211202 Fax 01246 550959 Mastercard/Visa/Switch

Callers welcome 9:30 a.m .to 5:30 p.m. Monday to Saturday

The Stereo Headphone Amplifier Box

Balanced or unbalanced line inputs to stereo headphone output

Professional portable units operating from an internal PP3 battery or external mains adaptor

* Precision transformerless differential left and right inputs * Wide range of headphone drive impedances * High common mode rejection * Low noise and distortion * Low quiescent power consumption for extended battery life * Extensive RFI protection

The Balance Box (mic/line amplifier) – **The Phantom Power Box** – **The *OneStop*** DIN rail mounting radio frequency interference filter and voltage transient protector for voltage and current loop process signal lines

Conford Electronics **Conford Liphood Hants** GU30 7QW

Information line 01428 751 469 Fax 751223

E-mail: contact@confordelec.co.uk

Web http://www.confordelec.co.uk/

SPECIAL OFFERS

TEKTRONIX 2445A 4 Ch 150MHz Delay, Cursors etc. Supplied with 2 Tektronix probes — ONLY **£425**

TEKTRONIX 2232 Digital Storage Scope. Dual Trace 100 MHz,100m/s with probes........ £525
H.P. 54501A Digitizing Oscilloscope100MHz, 4Ch £425
H.P. 3312A Function Gen 0.1Hz-13MHz AM/FM Sweep/Tri/Gate/Burst etc........ £300
FARNELL Dual PSU XA35-2T 0-35V 0-2A Twice QMD LCD Display........ £180
CIRRUS CRL254 Sound Level Meter with Calibrator, 80-120dB, LEQ........ £150
EDDYSTONE 1002 Receiver 150kHz-30MHz + Broadcast FM........ £125
FARNELL AMM255 Automatic Mod Meter 1.5MHz-2GHz Unused........ £300
FARNELL DSG1 Low Frequency Syn Sig Gen 0.001Hz to 99.99kHz, Low Distortion TTL/Square/Pulse Outputs etc........ £95
FLUKE 8060A Handheld True RMS DMM $4\frac{1}{2}$ digit........ As new £150. Used £95
BECKMAN HD110 Handheld $3\frac{1}{2}$ digit DMM, 28 ranges with battery, leads and carrying case........ £40

H.P. 3310A Function Gen 0.005Hz-5MHz Sine/Sq/Tri/Ramp/Pulse........ £125
FARNELL FLM4 Sine/Sq Oscillator 10Hz-1MHz low distortion. TTL Output. Amplitude Meter........ £125
H.P. 545A Logic Probe with 546A Logic Pulser and 547A Current Tracer........ £90
FLUKE 77 Multimeter $3\frac{1}{2}$ digit Handheld........ £60
FLUKE 77 SERIES II........ £70
HEME 1000 LCD Clamp Meter 0-1000A. In Carrying Case........ £60

Racal 9008 Automatic Modulation Meter AM/FM 1.5MHz - 2GHz — *ONLY* **£95**

Datron 1061 High Quality 5.5 Digit Bench Multimeter True RMS/4 wire Res/Current Converter/IEEE — **£150**

Datron 1061A High Quality $6\frac{1}{2}$ digit Bench Multimeter True RMS/4 wire/Current Converter — **£225**

Racal Receiver RA1772 50KHz - 30MHz LED Display. Basically Working. — **£250**

MARCONI 2019A

AM/FM synthesised signal generator 80kHz - 1040MHz

NOW ONLY **£400**

MARCONI 893C AF Power Meter, Sinad Measurement........ Unused £100 Used £60
MARCONI 893B - No Sinad........ £30
MARCONI 2610 True RMS Voltmeter Autorangin 5Hz-25MHz........ £195
GOULD J3B Sine/Sq Osc. 10Hz-100kHz. Low distortion........ £75-£125
AVO 8 Mk6 in Ever Ready Case, with leads etc........ £80
Others Avos........ from £50
GOODWILL GVT427 Dual Ch AC Millivoltmeter 10mV in 12 Ranges Freq 10Hz-1MHz........ £100-£125
SOLARTRON 7150 DMM $6\frac{1}{2}$ digit True RMS - IEEE........ £95-£150
SOLARTRON 7150 PLUS........ £200

HIGH QUALITY RACAL COUNTERS

9904 Universal Timer Counter, 50MHz........ £50
9916 Counter, 10Hz-520MHz........ £75
9916 Counter, 10Hz-560MHz, 9-digit........ £50
WAYNE KERR B424 Component Bridge........ £125
RACAL/AIM 9343M, LCR Databridge, Digital........ £200
Automeasurements of R.C.L.Q.D.
HUNTRON TRACKER Model 1000........ £125
MARCONI TF2015 AM/FM sig gen, 10-520MHz........ £175
FLUKE 8050A 4.5 Digit, 2A True RMS........ £75
FLUKE 8012A 3.5 Digit, 2A........ £40

SOLARTRON 7045 Bench Multimeter 4.5 Digit Bright LED with Leads *ONLY* **£30**

Portable Appliance Tester Megger Pat 2 *ONLY* **£180**

H.P. 6012B DC PSU 0-60V; 0-50A 1000W........ £1000
FARNELL AP60/50 1KW Autoranging........ £1000
FARNELL H60-/50 0-60V 0-50A........ £750
FARNELL H60/25 0-60V; 0-25A........ £400
Power Supply HPS3010 0-30V; 0-10A........ £140
FARNELL L30-2 0-30V; 0-2A........ £80
FARNELL L30-1 0-30V; 0-1A........ £60
Many other Power Supplies available.
Isolating Transformer 240V In/Out 500VA........ £40

FARNELL DTV 12-14 OSCILLOSCOPE DUAL TRACE 12 MHz TV. COUPLING *ONLY* **£75**

FARNELL LFI 12-14 Sine/Sq OCSILLATOR 10 MHz – 1 MHz *ONLY* **£75**

OSCILLOSCOPES

TEKTRONIX TDS350 Dual Trace 200MHz 1G/S unused........ £1500
TEKTRONIX TDS320 Dual Trace 100MHz 500M/S........ £1200
TEKTRONIX TDS310 Dual Trace 50MHz 200M/S........ £950
LECROY 9400A Dual Trace 175MHz SG/S........ £750
HITACHI VC6523 Dual Trace 20MHz 20M/S etc unused........ £500
PHILIPS PM3092 2+2Ch 200MHz Delay........ £800 As New £950
PHILIPS PM3082 2+2Ch 100MHz Delay etc........ £700 As New £800
TEKTRDNIX TAS465 Dual Trace 100MHz Delay etc........ £750
TEKTRONIX 2465B 4Ch 400MHz Delay Cursors etc £1500
TEKTRONIX 2465 4Ch 300MHz Delay Cursors etc........ £900
TEKTRONIX 468 Dig Storage Dual Trace 100MHz Delay........ £450
TEKTRONIX 466 Analogue Storage Dual Trace 100MHz........ £250
TEKTRONIX 485 Dual Trace 350MHz Delay Sweep........ £550
TEKTRONIX 475 Dual Trace 200MHz Delay Sweep........ £350
TEKTRONIX 465B Dual Trace 100MHz Delay Sweep........ £325
TEKTRONIX 2215 Dual Trace 60MHz Delay Sweep........ £250
PHILIPS PM3217 Dual Trace 50MHz Delay........ £200 - £250
GOULD OS1100 Dual Trace 30MHz Delay........ £125
HAMEG HM303.6 Dual Trace 35MHz Component Tester. As new........ £240
HAMEG HM303 Dual Trace 30MHz Component Tester........ £200
MANY OTHER OSCILLOSCOPES AVAILABLE

MARCONI 2022E Synthesised AM/FM Sig Gen £525 - £750 10KHz - 1.01GHz LCD Display etc
H.P. 8657A Syn 100KHz - 1040MHz Sig Gen........ £2000
H.P. 8656B Syn 100KHz - 890MHz Sig Gen........ £1350
H.P. 8656A Syn 100KHz - 990 MHz Sig Gen........ £995
R&S APN62 Syn 1Hz - 260KHz Sig Gen........ £425
Balanced/Unbalanced Output LCD Display
PHILIPS PM5328 Sig Gen 100KHz - 180MHz with 200MHz........ £550
Freq Counter IEEE
RACAL 9081 Syn AM/FM Sig Gen 5KHz - 1024MHz........ £250
H.P. 3325A Syn Function Gen 21MHz........ £600
MARCONI 6500 Amplitude Analyser........ £1500
H.P. 4192A Impedence Analyser........ £5000
H.P. 4275A LCR Meter 10KHz - 10MHz........ £2750
H.P. 8903A Distortion Analyser........ £1000
WAYNE KERR Inductance Analyser 3245........ £2000
H.P. 8112A Pulse Generator 50MHz........ £1250
MARCONI 2440 Freq Counter 20GHz........ £1000
H.P. 5350B Freq Counter 20GHz........ £2000
H.P. 5342A 10Hz - 18GHz Freq Counter........ £800
H.P. 1650B Logic Analyser 80 Channel........ £1000
MARCONI 2305 Mod Meter 500KHz - 2Ghz........ £750

RADIO COMMUNICATONS TEST SETS

MARCONI 2955/2955A........ from £1500
Rohde & Schwarz CMT 0.1 - 1000MHz........ £2000
Schlumberger 4040........ £900

JUST IN

H.P. 6063B DC Electronic Load 3-240V/0-10A 250W........ P.O.A.
H.P. 66312A PSU 0 - 20V/0-2A........ £400
H.P. 66311B PSU 0 - 15V/0-3A........ £400
H.P. 66309D PSU Dual 0 - 15V 0-3A/0-12V 0-1.5A........ £750
H.P. 6632B PSU 0 - 20V/0-5A........ £500
H.P. 6623A PSU Triple Output ranging from........ £850 0-7V 0-5A to 0-20V 0-4A
H.P./Agilent 34401A DMM $6\frac{1}{2}$ digit........ £400/£450
H.P. 3478A DMM $5\frac{1}{2}$ digit........ £275
FLUKE 45 DMM Dual Display........ £400
KEITHLEY 2010 DMM $7\frac{1}{2}$ digit........ £950
KEITHLEY 617 Programmable Electrometer........ £1250
H.P. 4338B MillIohmmeter........ £1500
RACAL Counter type 1999 2.6 GHz........ £500
H.P. Counter type 53131A 3GHz........ £850
H.P./Agilent 33120A Function Gen/ARB........ £900/£1000 100microHz - 15MHz
SONY/TEKTRONIX AFG320 Arbitary Function Gen........ £1250
H.P. 8904A Syn Function Gen DC - 600KHz £1000/£1250
BLACK STAR JUPITOR 2010 Function Gen 0.2Hz - 2MHz with Frequency Counter........ £140
H.P. 8116A Pulse Generator 1mH-50MHz........ £1950
H.P. 8657B Syn Signal Gen 0.1-2080MHz........ £2500
CO-AXIAL SWITCH 1.5GHz........ £40
IEEE CABLES........ £10

SPECTRUM ANALYSERS

H.P. 8561B 50Hz - 6.5GHz........ £5000
H.P. 8560A 50Hz - 2.9GHz Synthesised........ £5000
H.P. 8594E 9KHz - 2.9GHz........ £4500
H.P. 8591E 1MHz - 1.8GHz 75 ohm........ £2750
H.P. 853A with 8559A 100KHz - 21GHz........ £1750
H.P. 8558B with Main Frame 100KHz - 1500MHz........ £750
H.P. 3585A 20Hz - 40MHz........ £2500
H.P. 3580A 5Hz - 50KHz........ £600
ADVANTEST R4131B 10KHz - 3.5GHz........ £2750
EATON/Ailtech 757 0.001 - 22GHz........ £750
MARCONI 2382 100Hz - 400MHz High Res........ £2000
MARCONI 2370 30Hz - 110MHz........ from £500
H.P. 182 with 8557 10KHz - 350MHz........ £500
H.P. 141T Systems
8553 1KHz - 110MHz........ £500
8554 500KHz - 1250MHz........ £750
8555 10MHz - 18GHz........ £1000
H.P. 8443 Tracking Gen/Counter 110MHz........ £250
H.P. 8444 Opt 059........ £750
B & K 2033R Signal Analyser........ £650
H.P. 8754A Network Analyser 4MHz - 1300MHz........ £1250
H.P. 3577A Network Analyser 5Hz - 200MHz........ £3000
H.P. 53310A Modulation Domain Analyser - Opt 001/003........ £5000
ONO SOKKI Portable FFT Analyser........ £1500
H.P. 8720C Microwave Network Analyser 50MHz-20GHz........ £12500

STEWART OF READING

110 WYKEHAM ROAD, READING, BERKS RG6 1PL

Telephone: (0118) 9268041 Fax: (0118) 9351696

www.stewart-of-reading.co.uk

Callers welcome 9am-5.30pm Monday to Friday (other times by arrangement)

USED EQUIPMENT - GUARANTEED. Manuals supplied.

This is a VERY SMALL SAMPLE OF STOCK. SAE or telephone for lists. Please check availability before ordering. CARRIAGE all units £16. VAT to be added to total of goods and carriage.

Service Link

As an advertiser you can be certain that your sales message is going to be read by decision-making electronics professionals with the power to purchase your products.

The pre-paid rate for semi-display setting is £17 per single column centimetre (maximum 4cm). Box number £22 extra. All prices plus 17½% VAT. All cheques, postal orders etc to be made payable to Highbury Business Communications Ltd. Advertisements together with remittance should be sent to Electronics World Classified, Highbury Business Communications Ltd, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey SM3 8DZ.

Tel: 020 8722 6028. **Fax: 020 8770 2016.**

ARTICLES WANTED

BEST CASH PRICES PAID

For all valves KT88 PX4 and other audio types

Wide range of valves and CRT stocked

Tel: 01403 784961

Billington Export Ltd.
Fax: 01403 783519
Email: sales@bel-tubes.co.uk
Sussex RH14 9EZ
Visitors by appointment

TOP PRICES PAID

For all your valves, tubes, semi conductors and ICs.

Langrex Supplies Limited
1 Mayo Road, Croydon, Surrey CR0 2QP
TEL: 020 8684 1166 FAX: 020 8684 3056

FOR SALE

PRINTED CIRCUIT BOARDS

DESIGNED & MANUFACTURED — agar Circuits

- *Prototype or production quantities*
- *Fast turnround available*
- *PCBs designed from circuit diagrams*
- *Almost all computer files accepted*
- *PCB assembly - mechanical assembly*
- *Full product design-manufacture-test-repair*

Unit 5, East Belfast Enterprise Park
308 Albertbridge Rd, Belfast BT5 4GX
TEL 028 9073 8897 FAX 028 9073 1802
info@agarcircuits.com

RF DESIGN SERVICES

All aspects of RF hardware development considered from concept to production.

WATERBEACH ELECTRONICS

www.rlaver.dial.pipex.com
TEL: 01223 862550
FAX: 01223 440853

Service Link

SERVICES

PCBs Conv/PTH/Multi-Layer/Flexible • UK & Far East production
• CAD Layout • Electronic Design • Assembly (prototype & production)
• SMD m/c assy @ 18,500 cps/hr

Deliveries from 24 Hrs

Prototype PTH PCBs from just £40.00

Approvals: ISO 9002/UL
SEE OUR WEB SITES

Tel: 01635 40347
Newbury Electronics Ltd
Faraday Road Newbury Berks RG14 2AD
Fax: 01635 36143
e-mail: circuits@newbury.tcom.co.uk
http://www.newburyelectronics.co.uk

Visit **www.pcbtrain.com**
The low cost source for prototype PCBs from 1 to 6 layers

P&P ELECTRONICS

Design of Electronic Systems by Degree Qualified Engineer

01924 402931

POWER SUPPLY DESIGN

Switched Mode PSU
Power Factor Correction
designed to your specification
Tel/Fax: 01243 842520
e-mail: eugen_kus@cix.co.uk
Lomond Electronic Services

WANTED

WANTED Surplus or Obsolete Electronic Components

Turn your excess stock into instant cash!

SEND OR FAX YOUR LIST IN STRICTEST CONFIDENCE
Will collect anywhere in the UK

Mushroom COMPONENTS

6a St.Marys St, Bedford, Bedfordshire, MK42 0AS
Tel: 01234 363611 Fax: 01234 326611
E-mail: sales@mushroomcomponents.com
Internet: www.mushroomcomponents.com

SERVICES

From Concept To Production

48 HOUR SERVICE

Electronic design and manufacturing services for the new millennium:

- Embedded monitoring & control
- PSTN telephones and test equipment
- Datacom interfacing, line driving etc.
- Switch Mode & linear PSU and battery management
- Gas detection systems
- Printed Circuit Board design
- Technical documentation, schematic layout & language translation
- Wireless telemetry systems
- Audio & Video processing
- GSM telemetry via. SMS or data (TCP/IP)
- DVD player control systems
- GPS positioning systems
- Specialist cable looms
- Small, medium & large scale manufacturing

Email: sales@designersystems.co.uk
Tel/Fax: +44 (0) 1872 223306

for more information see our web site @ **http://www.designersystems.co.uk**

MICROCHIP Consultant Program Member — Member since 1998

Designer Systems.co.uk
Design & manufacturing in the UK

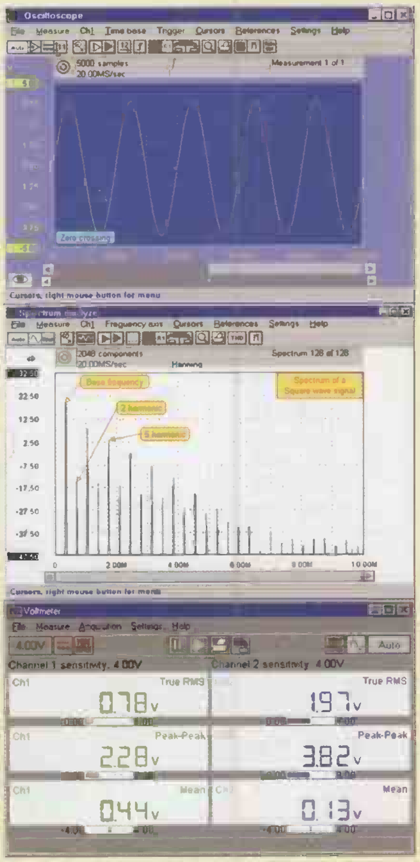
For a FREE consultation on how best to market your products/services to a professional audience contact REUBEN on 020 8722 6028

OSCILLOSCOPE | FFT ANALYSER | VOLTMETER | RECORDER

HANDYSCOPE HS3

The Handyscope 3 is a powerful and versatile two channel measuring instrument with an integrated function generator.

- USB 2.0 connection (USB 1.1 compatible)
- sample speed up to 100 MHz per channel
- 8 to 16 bit resolution (6 µVolt resolution)
- 50 MHz bandwidth
- input sensitivity from 200 mVolt up to 80 Volt
- large memory up to 131060 samples per channel
- four integrated measuring devices
- spectrum analyser with a dynamic range of 95 dB
- fast transient recorder up to 10 kHz
- several trigger features
- auto start/stop triggering
- auto disk function up to 1000 files
- auto setup for amplitude axis and time base
- auto trigger level and hysteresis setting
- cursor measurements with 21 read-outs
- very extensive function generator (AWG) 0-2 MHz , 0-12 Volt



for more information, demo software, software, source code and DLL's visit our internet page: http://www.tiepie.n

TiePie engineering (NL)
Koperslagersstraat 37
8601 WL SNEEK
The Netherlands
Tel: +31 515 415 416
Fax: +31 515 418 819

TiePie engineering (UK)
28, Stephenson Road, St. Ives
Cambridgeshire, PE17 3WJ, UK
Tel: 01480-460028
Fax: 01480-460340