Unique offer – buy a Class-T amp an get a Class-T chip free

ELECTRONICS WORLD

INCORPORATING WIRELESS WORLD

APRIL 2000 £2.65

Austria Asch. 70.00
Denmark DKr. 70.00
Germany DM 18.00
Greece Dra.1400.00
Holland Dfl. 12.95
Italy L. 9400.00
Malta Lm. 1.80
IR £3.30
Spain Pts. 925.00
USA $6.75

ISSN 0959-8332

04>

9 770959 833066

A REED BUSINESS PUBLICATION SOR DISTRIBUTION

Class-T audio power: switching hi-fi at last?

Uses for log amplifiers

Current conveyors made simple

Simple millivoltmeter works to 5MHz

Mega Circuit Ideas section

Life and times of JLH

Room acoustics

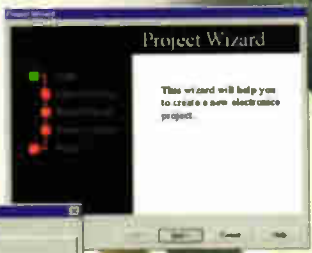
See the famous Williamson valve amp on p. 328

QUICKROUTE SYSTEMS

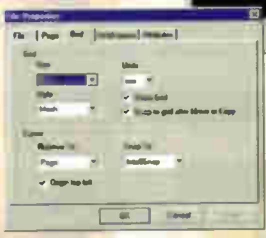
THE NEW FORCE IN EDA

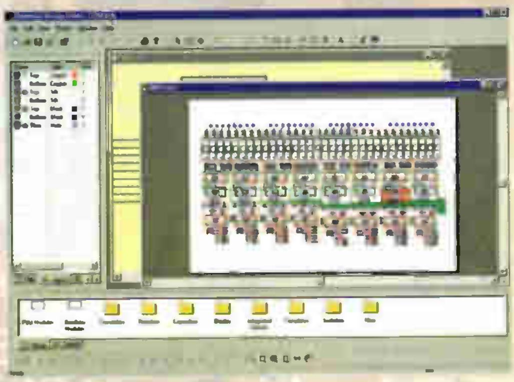
The brief was clear. To create a next generation CAD system for electronic engineers that used state of the art desktop integration and customisability together with unrivaled ease of use.

electronic design STUDIO



From the creators of Quickroute, Electronic Design Studio (EDS) is an entirely new program designed for today's EDA performance needs. Integrating schematic and PCB design into a powerful design studio, EDS lets you view and edit all the files in your projects, and through OLE2, EDS integrates with your desktop letting you drag and drop documents into and from your favorite Office applications.





EDS also includes the new CADObjects engine with tools and flexibility that approaches the power of desktop publishing systems. With its comprehensive drawing and shaping tools, professional support for True Type fonts (even at the PCB stage), high resolution, large design size, polygon fill and shaping tools, EDS represents a genuine advance in EDA price performance. Visit our web site, or call now to find out how EDS can help you.

- State of the art multiple-document user interface offering unrivalled ease of use and customisability.
- OLE 2 support including drag and drop, allows integration with your favorite Office applications.
- Project Wizard and Project Manager make creating and navigating all the documents in your projects easy.
- New heiracial symbol browser, makes creating, editing and managing symbols a breeze!
- High resolution (1um) and large design size (up to 2m x 2m) combined with IntelliSNAP makes metric/imperial design mixing easy!
- Unlimited schematic sheets, with full support for data busses, power rails, etc
- CADCheck automatically syncronises schematic and PCB designs. No more capture worries!
- Unlimited Undo/Redo, print preview and a wide range of import/export options including CAD-CAM.
- Up to 32 layers can be assigned to be copper, silk, gold, mask, drill, mechanical, or annotation layers.
- New CADObjects engine supports a wide range of graphic objects including professional True Type fonts, object shaping and property support, in-situ editing of symbols, high resolution and arbitrary rotation/scaling of objects.
- Unlimited range of pad and track sizes supported.
- Create flood fills and power planes quickly with the new polyfill tool.
- Fast fully customisable poly-algorithmic autorouter

WORK FASTER
WORK BETTER
WORK EASIER

Electronic Design Studio	£199	$319
Electronic Design Studio Cross Grade	£149	$239
Electronic Design Studio LITE	£49	$79

PLUS Your first double-sided Eurosize PCB produced FREE by BETA-LAYOUT

Beta LAYOUT

TRY AND BUY TODAY ONLINE
AT www.quickroute.co.uk

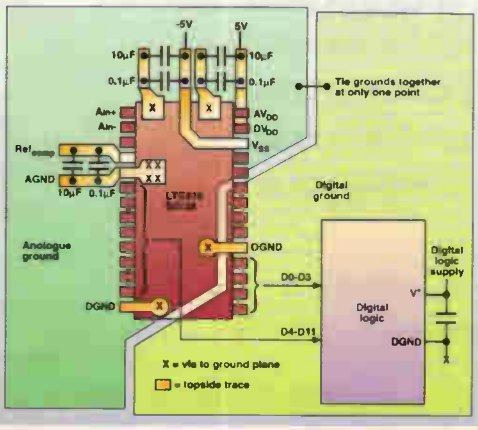
Prices exclude P&P and VAT where applicable.
30 DAY MONEY BACK GUARANTEE

Quickroute Systems Ltd Regent House, Heaton Lane, Stockport, SK4 1BS. UK - Tel 0161 476 0202 - Fax 0161 476 0505
http www.quickroute.co.uk Email info@quicksys.demon.co.uk

 Oversees distributors wanted!

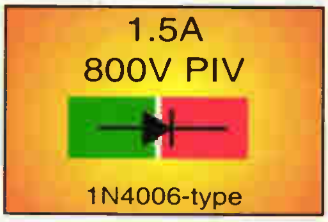
CIRCLE NO. 101 ON REPLY CARD

CONTENTS



Do your a-to-d converter circuits never seem to perform as they should? Steve Bush presents an easy to assimilate analysis of the problems involved on page 304.

Illustration **Hashim Akib**



FREE WITH THIS ISSUE:
Free with this month's issue is a pack of four SS4006 power rectifier diodes. Similar to the 1N4006, but with a 1.5A current handling capability as opposed to 1A, these diodes are excellent general-purpose rectifiers. Turn to page 287 for more details.*
**UK readers only.*

IBM researchers have found a way to project information using the wave nature of electrons to replace wires in tomorrow's ultra-high density chips. See page 272.

Ever tried to measure a few millivolts at 5MHz? Cyril Bateman's meter can, and it does so with a wide dynamic range – turn to page 281.

May issue on sale 6 April

Over 50% Discount

Professional Electronics Design

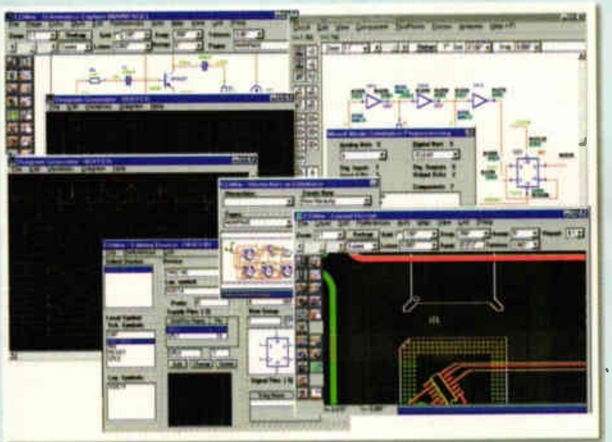
EDWin NC

Over 50% Discount

- Genuine, professional EDA software ***with no limitations! - and YOU can afford it!***
- **EDWin NC** comes from Visionics: one of the *longest established*, *most experienced* producers of *professional* EDA systems, so it's fully proven in professional work.
- Now *you* can have this best-selling non-commercial version of the software at less than ***50% of the normal price***, with no limits in its capabilities.
- *It does just about everything you could want*!

Schematics, simulation, PCB layout, autorouting, manufacturing outputs, EMC and Thermal Analysis. Many more advanced features are available and it runs in Windows 3.x, 95, 98 or NT.

- Where's the catch? It's for non-commercial use, but companies may order for evaluation purposes. Prices start from just £59.00 for the basic system!



New Super Powerful 32 bit version for Windows 95, 98 & NT!

Don't forget - Phone Today for Your 50% Discount!

- **EDWin NC Basic**: Schematics, PCB Layout, Manufacturing Outputs, Max. 100 Component Database, 500 Device Library.
- **EDWin NC De Luxe 1**: Basic + Professional Database and Libraries, Arizona Autorouter.
- **EDWin NC De Luxe 2**: De Luxe 1 + Mix-Mode Simulation, Thermal Analyser.
- **EDWin NC De Luxe 3**: De Luxe 2 + EDSpice Simulation, EDCoMX Spice Model Generator, EMC and Signal Integrity Analysers.

You can't sell it for that!

Plus Postage & Packing UK £5.00; Rest of World £10.00 (only *one* charge per order)

Order hotline: +44 (0)1992 570006 Fax +44 (0)1992 570220 E-mail: swift.eu@dial.pipex.com

Please Visit Our Web Site http://www.swiftdesigns.co.uk

Yes We Can

Swift Eurotech

I enclose: £....................total.

We aim to dispatch as soon as we receive payment, but please allow 28 days for delivery. Subject Unsold.

Cheque/PO/Credit Card:

Visa/Mastercard/Eurocard: No.

Issue Date: Expiry Date:

Date.................. Signature..

Name: ....

Address: ....

....

.... Postcode ....

Tel.: .... Evenings ....

I wish to order:

	16 bit	32 bit	Qty. 16bit/32bit	Total (£)
• EDWin NC BASIC:	**£59.00**	**£119.00**		
• EDWin NC De Luxe 1:	**£119.00**	**£177.00**		
• EDWin NC De Luxe 2:	**£155.00**	**£212.00**		
• EDWin NC De Luxe 3:	**£285.00**	**£340.00**		
Postage & Packing UK	**£5.00**			
Rest of World	**£10.00**			
(only *one* P&P charge per order)	**Total £**			

Swift Eurotech

Swift Eurotech Ltd., Twankhams Alley, 160 High Street, Epping, Essex, CM16 4AQ, UK.

CIRCLE NO. 104 ON REPLY CARD

Matters of perception

Greed and stupidity often go together. And for product and service providers targeting the consumer market this is no bad thing. The painless extraction of money from happy punters is a tricky pursuit, and their insatiable desire for bargains and greater sophistication in technical goodies makes the task of marketing such products a lot easier.

Such a crude and cynical assessment may offend some sensibilities, but it's not far from the truth. It's also demonstrable that as consumers willingly assimilate this heady diet of high technology, their desire is stimulated for even more. This suits the vendors, who clearly wish to do nothing that might obstruct their customers' maturing aspirations.

Unfortunately, although customer aspirations may be agreeably mature, vendors are not always possessed of the ability or the willingness to fulfil them. And this is where problems start to appear. However dumb we imagine Joe Public to be, he's not stupid and doesn't like being sold a pup.

All too often now vendors make promises they clearly cannot fulfil. Take cable modems for example. They've been trumpeted as the bringer of low-cost, high-bandwidth data connectivity to the home.

Here in Britain we've been promised cable modems since autumn 1996 and apart from a few pilot schemes, we're still waiting. Not that they're worth waiting for necessarily; many pundits are convinced that data rates will plummet once everyone starts surfing so perhaps the modems won't be so magical after all.

Digital television is another case in point. For two years or more, cable operators have been promising digital cable to viewers, with stunning interactive services and hundreds of channels. Taking the country as a whole, the reality is just not here yet. So why make empty promises?

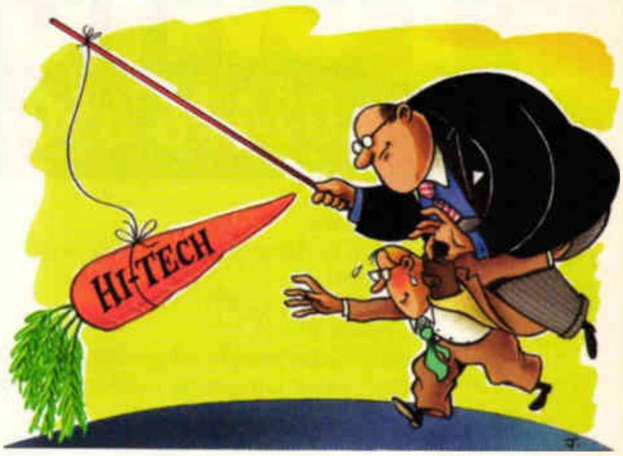
'Always on' Internet access is another holy grail being touted – in the form of ADSL – but it's a mighty long time coming.

Actually there's a good reason why BT is holding back on rolling out this technology; it is neither cheap nor mature and early adopters may find reality different from the dream. BT is already discovering this, with a scenario painfully similar to when KiloStream was installed back in 1983.

Insiders relate that ADSL works fine over freshly installed cabling, but it's a very different story using real-world line plant, with dry joints, damp manholes and aluminium cable. A significant proportion of residential lines will be totally unsuitable for this transmission technology and if you thought the 3km limiting line length of Home Highway was a drawback, just wait till you see the demands that ADSL puts on line plant.

From all this the clear – but apparently unheeded – message is that vendors and service providers who promise much but deliver less, and late, run the risk of alienating customers.

Those of you with long memories may recall the lengthy and relentless run-up before Citizens' Band radio was legalised. The product flopped soon after consumer launch – a classic case of an offering that brought little or no genuine public benefit.



Ionica's telephone service delivered by radio was also high on hype and low – and slow – on delivery; the promised ISDN capability missed two annual deadlines and never materialised, while in areas of high demand the company was unable to provide service to all comers.

One of the factors behind customers' enthusiastic desire for these oversold goodies is the largely ill-informed consumer press that prints any old flannel that equally ill-informed PR types send out.

British Satellite Broadcasting's original mini-Squarial was a case in point. The men in suits insisted their tiny dish was capable of receiving satellite transmissions, even though the technical press pointed out this was scientifically unfeasible.

Eventually the techies were shown to be right and the suits were proved wrong. But until then the public deception continued. The tragedy is that if you print the same drivel often enough, people will eventually believe it.

We're seeing this currently with the Campaign for Unmetered Telecommunications – a remarkable example of commercial self-interest promoted under the guise of benefiting the public at large. Make no mistake: the chief beneficiaries of unmetered, or untimed, local calls will be big business, subsidised by an ignorant public.

Business organisations, which make the bulk of local calls at present and correctly pay for them at expensive daytime rates, will see their bills plummet. Internet service providers too will cash in on a colossal increase in business.

Meanwhile you, me and the rest of the great public will be paying for this, with the cost burden shifted from those with lots of money to those with far less.

Taking the public for a ride is not difficult; these issues all prove it. Truth comes out eventually, however, and bitter memories can influence future purchasing decisions. When it comes to grappling with technology, the public deserves better information from those in the know. ■

Andrew Emmerson

EDITOR
Martin Eccles
020 8652 3614

CONSULTANTS
Ian Hickman
Philip Darrington
Frank Ogden

EDITORIAL ADMINISTRATION
Jackie Lowe
020 8652 3614

EDITORIAL E-MAILS
jackie.lowe@rbi.co.uk

GROUP SALES EXECUTIVE
Pat Bunce
020 8652 8339

ADVERTISEMENT E-MAILS
pat.bunce@rbi.co.uk

ADVERTISING PRODUCTION
020 8652 8339

PUBLISHER
Mick Elliott

EDITORIAL FAX
020 8652 8111

CLASSIFIED FAX
020 8652 8938

NEWSTRADE ENQUIRIES
020 8261 7704

ISSN 0959-8332

For a full listing of RBI magazines: http//www.reedbusiness.com

REED BUSINESS INFORMATION

SUBSCRIPTION HOTLINE
Tel, (0) 1444 475662
Fax, (0) 1444 445447

SUBSCRIPTION QUERIES
rbp.subscriptions@rbi.co.uk
Tel 01444 445566
Fax 01444 445447

Electronics World is published monthly. By post, current issue £2.65, back issues (if available £3.00). Orders, payments and general correspondence to **L333, Electronics World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS**. Tlx:892984 REED BP G. Cheques should be made payable to Reed Business Information Ltd
Newstrade: Distributed by Marketforce (UK) Ltd, 247 Tottenham Court Road London W1P OAU 0171 261-5108.
Subscriptions: Quadrant Subscription Services, Oakfield House Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone 01444 445566. Please notify change of address.
Subscription rates 1 year UK £36.00 2 years £58.00 3 years £72.00. Europe/Eu 1 year £51.00 2 years £82.00 3 years £103.00 ROW 1 year £61.00 2 years £98.00 3 years £123

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. Periodicles Postage Paid at Rahway NJ Postmaster. Send address changes to above.
Printed by Polestar (Colchester) Ltd, **Filmsetting by** JJ Typographics Ltd, Unit 4 Baron Court, Chandlers Way, Southend-on-Sea, Essex SS2 5SE.

Telnet

Tel: 02476 650702

Quality second-user test & measurement equipment

NEW PHONE CODE FOR COVENTRY 02476

Hewlett Packard	
8642A – high performance R/F synthesiser (0·1-1050MHz)	**£5500**
3335A – synthesiser (200Hz-81MHz)	**£2400**
Hewlett Packard	
436A power meter and sensor (various)	**from £750**
437B power meter and sensor (various)	**from £1100**
Hewlett Packard	
8753A network analyser (3GHz)	**from £2500**
8753B network analyser (3GHz)	**from £3250**
'S' parameter test sets 85046A and 85047A available at	**£2000 & £3000**
Wandel & Goltermann	
SPECIAL OFFER	
PCM-4 PCM Channel measurement set (various options available)	**from £6000**
PRA-1 Frame Analyser	**£5250**
Marconi 2305 – modulation meter	**£999**
Marconi 6310 – programmable sweep generator (2 to 20GHz) – new	**£3250**
Hewlett Packard	
5342A – microwave frequency counter (500MHz-18GHz) ops 1 & 3	**£700**
5370B – universal time interval counter	**£1750**

Radio Communications Test Sets

Marconi 2955	£2000
Marconi 2958/2960	£2250
Antritsu MS555A2	£1200
Hewlett Packard 8922B (GSM)	£6950
Schlumberger Stabilock 4031	£3995
Schlumberger Stabilock 4040	£1500
Racal 6111 (GSM)	£1750
Racal 6115 (GSM)	£3995
Rhode & Schwarz CMTA 94 (GSM)	£5950
IFR 1200S	£2995

TELNET

Fax 02476 650 773

OSCILLOSCOPES

Beckman 9020 - 20MHz - Dual channel	£150
Hewlett Packard 54201A - 300MHz Digitizing	£1250
Hewlett Packard 54600A - 100MHz – 2 channel	£750
Hitachi VI52/V212/V222/V302B/V302F/V353F/V550B/V650F	from £125
Hitachi VI I00A - I00MHZ - 4 channel	£900
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 9450A - 300MHz/400 MS/s D.S.O. 2 channel	£2250
Meguro MSO 1270A - 20MHz - D.S.O. (new)	£450
Philips 3055 - 50MHz .Dual channel	£450
Philips PM3094 - 200MHz - 4 channel	£1750
Philips 3295A - 400MHz - Dual channel	£1600
Philips PM3392 – 200MHz-200Ms/s – 4 channel	£1995
Tektronix 465 - I00MHZ - Dual channel	£350
Tektronix 464/466 - I00MHZ - (with AN. storage)	£350
Tektronix 475/475A - 200MHz/250MHz -	from £450
Tektronix 468 - I00MHZ - D.S.O.	£650
Tektronix 2213/2215 - 60MHz - Dual channel	£350
Tektronix 2220 - 60MHZ - Dual channel D.S.O	£1250
Tektronix 2225 - 50MHZ - Dual channel	£395
Tektronix 2235 - I00MHZ - Dual channel	£600
Tektronix 2221 - 60MHz - Dual channel D.S.O	£1250
Tektronix 2245A - 100MHZ - 4 channel	£900
Tektronix 2440 - 300MHz/500 MS/s D.S.O.	£2950
Tektronix 2445A - 150MHz - 4 channel	£1250
Tektronix 2445 - 150MHZ - 4 channel + DMM	£1200
Tektronix TAS 475 - 100MHZ - 4 channel	£995
Tektronix 7000 Series (I00MHZ to 500MHZ)	from £200
Tektronix 7104 – 1GHz Real Time	from £2500
Tektronix 2465/2465A/2465B - 300MHz/350MHz 4 channel	from £1250
Tektronix 2430/2430A – Digital storage - 150MHz	from £1250

SPECTRUM ANALYSERS

Ando AC 8211 - 1.7GHz	£1500
Avcom PSA-65A - 2 to I000MHz	£850
Anritsu MS 2663A - 9KHz - 8.1GHz	£7000
Anritsu MS 62B - 50Hz to 1700MHz	£1450
Anritsu MS 610B 10KHz - 2GHz – as new	£3500
Anritsu MS 710F - 100KHz - 23GHz	£5250
Advantest/TAKEDA RIKEN - 4132 - I00KHz - I000MHz	£1500
Hewlett Packard 3562A Dual channel dynamic signal analyser 64μHz - 100KHz	£5500
Hewlett Packard 8505A - 1.3GHz - Network Analyser	£1995
Hewlett Packard 8756A/8757A Scaler Network Analyser	from £1000
Hewlett Packard 853A Mainframe + 8559A Spec. An. (0.01 to 21GHz)	£2750
Hewlett Packard 182T Mainframe + 8559A Spec. An. (0.01 to 21GHz)	£2250
Hewlett Packard 8568B - 100Hz - 1500MHz	£5250
Hewlett Packard 8569B (0·01 to 22GHz)	£3950
Hewlett Packard 8567A - 100Hz - 1500MHz	£3995
HP 8754A – Network Analyser 4MHz-1300MHz	£1500
IFR A7550 - 10KHz-1GHz - Portable	£1950
Meguro - MSA 4901 - 30MHz - Spec.Analyser	£700
Meguro - MSA 4912 - I MHz - IGHZ Spec.Analyser	£995
Wandel & Goltermann TSA-1 system analyser (100Hz-180MHz)	£2750
Tektronix 495P Spec analyser prog. - 1.8GHz	£3500
Tektronix 469P - 1KHz to 1.8GHz	£3400
Tektron 2712 - 9KHz - 1800MHz	£4500
Wiltron 6409 - 10-2000MHz R/F Analyser	£1750

MISCELLANEOUS

Eaton 2075 – Noise Gain Analyser	at £1500
Farnell AP30250 - Power Supply 30v-250amp	£1500
Fluke 5100A/5100B/5200A – Calibration Units (various available)	from £1000
Fluke 2625 Data Buckets	£POA
Fluke 8842A - Digital Multimeter	£600
GN ELMI EPR31 - PCM Signalling Recorder	£1500
Hewlett Packard 339A Distortion measuring set	£1200
Hewlett Packard 435A + 435B Power meters	from £100
Hewlett Packard 778D Dual-Directional Couplers	£650
Hewlett Packard 3488A - Switch/Control unit	£475
Hewlett Packard 3784A - Digital Transmission Analyser	£4950
Hewlett Packard 3785A - Jitter Generator & Receiver	£1250
Hewlett Packard 5343A - Frequency counter 26.5GHz	£2000
Hewlett Packard 5385A - 1 GHZ Frequency counter	£650
Hewlett Packard 6033A - Autoranging System PSU (20v-30a)	£750
Hewlett Packard 6622A – Dual O/P system p.s.u.	£1250
Hewlett Packard 6623A – Triple o/p system p.s.u.	£1300
Hewlett Packard 6624A – Quad Output Power Supply	£2000
Hewlett Packard 6632A - System Power Supply (20v-5A)	£800
Hewlett Packard 6652A – 20V-25A System PSU	£750
Hewlett Packard 8112A - 50MHz Pulse Generator	£2250
Hewlett Packard 8350B – Sweep Generator Mainframe	£2000
Hewlett Packard 8656A Synthesised signal generator	£650
Hewlett Packard 8656B Synthesised signal generator	£1450
Hewlett Packard 8660D - Synth'd Sig. Gen (10 KHz-2600MHz)	£3250
Hewlett Packard 8901B - Modulation Analyser	£2750
Hewlett Packard 8903A and E - Distortion Analyser	from £1250
Hewlett Packard 16500A + B – Logic Analyser Mainframes	from £1000
Hewlett Packard 16500C - Logic Analyser Mainframe	£3250
Hewlett Packard 16501A/B & C - Logic Analyser System Expander Frame	from £2000
Hewlett Packard 37900D - Signalling test set	£3750
Hewlett Packard 75000 VXI Bus Controllers	£POA
Hewlett Packard 4195A - Vector Impedence Meter	£4750
Hewlett Packard 5350B - 20Hz Frequency Counter	£1950
Hewlett Packard 8657B - 100KHz-2060 MHz Sig Gen	£3995
Hewlett Packard 8657D - XX DQPSK Sig Gen	£4500
Keytek MZ-15/EC Minizap ESD Simulator (15kv - hand held)	£1750
Kikusui TOS 8850 - Auotmatic withstanding Voltage and Insulation Resistance Tester (other models also available)	£950
Marconi 1066B – Demultiplexer & Frame Alignment Monitor (140MBIT to 64KBIT) NEW	£1750
Marconi 2610 True RMS Voltmeter	£550
Marconi 6950/6960/6960B Power Meters & Sensors	from £400
Philips 5515 - TN - Colour TV pattern generator	£1400
Leader 3216 Signal generator 100KHz - 140MHz - AM/FM/CW with built in FM stereo modulator (as new) a snip at	£795
Racal 9087 - 1.3Ghz Synthesised Signal Generator, low noise	£1995
Racal 1992 – 1.3GHz Frequency Counter	£500
Rohde & Schwarz SMY-01 Signal Generator (9KHz-1040MHz)	£2250
Rohde & Schwarz NRV Power Meter & NRV-Z2 Sensor	£1250
Systron Donner 6030 - 26.5GHz Microwave Freq Counter	£1995
Tektronix ASG100 - Audio Signal Generator	£750
Wayne Kerr 3245 – Precision Inductance Analyser	£1995
Wiltron 6747A-20 - 10MHz-20GHz - Swept Frequency Synthesiser	£4950

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.

CIRCLE NO. 105 ON REPLY CARD

Tel: 02476 650 70
Fax: 02476 650 77

Chip firms encourage distributor Web sites

Top semiconductor manufacturers are urging their distributors to put more of their services on the Internet.

Infineon Technologies' managing director Paul Rozier wants to see distributors putting prices, quotes, lead-times, sample ordering and business tracking onto the Web. "We'd also like to know who's accessing that information so we can follow up," said Rozier. Implementing it could be two years away though.

At STMicroelectronics, Ollie Althorpe, said: "Our product range is so broad that the Internet is a very viable methodology for touching our end customers." ST is working towards having distributors Web sites linked to ST's Web sites so ST can publish and update information on distributors' Web sites.

Motorola is developing a web-interface with all its distributors worldwide and hopes to have it up and running by June. When Rosetta-net – the standards for Web-based distribution – is completed, Motorola is one of a number of suppliers intending to adopt it.

National Semiconductor also expects to have its distributors on a Web-based system within six months' time. "When Rosetta-net becomes a reality everyone will use it, but it's maybe a year away. We don't want to wait for it: we'll go ahead without it," said Ray Sinclair, European distribution manager.

"We don't have any set requirements for distributors – it's up to them," said Elaine Burroughs sales boss at ON Semiconductor, "the ones we would be most concerned about being strong on the Internet are the catalogue people."

At Mitsubishi, deputy divisional managing director for semiconductors, Stephen Manley said: "Locally we have put together a task-force to see where we're going."

Samsung Semiconductors remains relaxed. "We don't request much from our distributors in the way of Internet-based services and I'm not sure we're going to request much in the future," said Yves Leonard, senior manager for distribution and e-commerce.

***David Manners** Electronics Weekly*

Electronic ID on your mobile phone

Mobile phones could be used as a means of electronic identification if a pioneering project in Finland proves successful.

Sonera SmartTrust, a division of Finnish telecoms operator Sonera, and the Finnish Population Register Centre (FPRC) are aiming to place all the information normally held on an electronic ID card onto a mobile phone SIMcard.

SmartTrust will be providing the secure wireless technology for the project while FPRC will provide the electronic certificate that contains the cardholder's electronic identity needed for secure identification. Use of the electronic ID is backed up by a personal identification number.

The scheme will allow a user to identify themselves on Internet, WAP and telephone services. The certificate will be read when the phone connects to the service provider and transactions are carried out using the text based short message service, SMS.

"Identification without physical documents will be one of the basic elements of the future information society," said Harri Vatanen, Sonera SmartTrust's CEO. "This solution will be quick and easy to implement as there are over three million card readers, namely mobile phones, in Finland."

The technology is compatible with GSM as well as future mobile standards and it is claimed it could be used anywhere in the world.

Electronic ID cards were introduced to the public in Finland in December 1999.

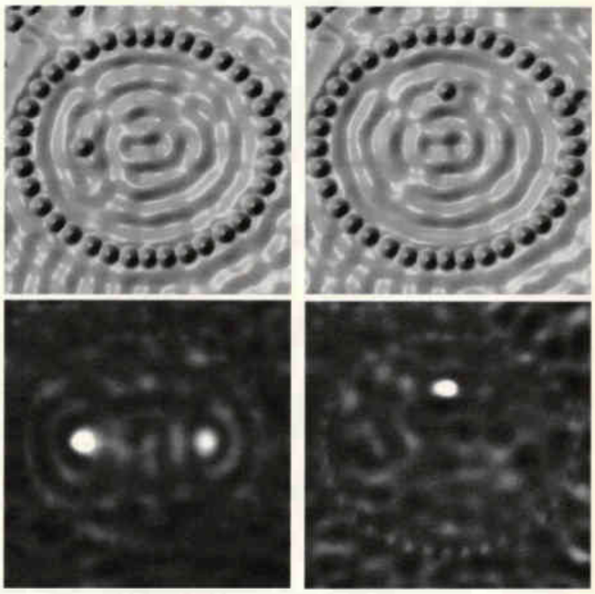
Why not buy two mobile phones?

A frightening prospect was advanced by several people at the GSM World Congress – a world where people have more than one mobile handset.

According to Val Jervis, a prinicipal consultant at Netcom Consultants, this has already happened in Finland in the 18 to 25 year old age group where mobile penetration has reached 150 per cent.

Andy Craigen from Lucent Technologies believes people owning more than one device is going to be the way forward for the industry, maybe one device for work and one for social use. "If they want to continue to grow, what they are going to try and look at doing is build different products for different lifestyles."

Hans Snook, CEO of Orange prediction went even further: "Penetration rates reaching 300 per cent and perhaps beyond."



Wireless ICs... IBM scientists claim to have perfected a technique known as 'quantum mirage' where information is projected using the wave nature of electrons rather than a wire. The upper left picture shows a magnetic cobalt atom placed at a focus point of an elliptical corral, some of its properties also appear at the other focus, lower left, where no atoms exists and appears as a bright spot at each focus. When the cobalt atom is placed elsewhere within the ellipse, but not at a focus point, upper right, the mirage disappears, lower right, and the effect is detected only at the cobalt atom itself. It has the potential to enable data transfer within future nanoscale electronic circuits so small that conventional wires do not work. *See page 272 for more...*

European drive for a black box recorder in your car

Black box data recorders are set to become a standard feature of cars in the next decade.

The benefits of accident data recorders were outlined at a government conference on February 9 by Peter Needham, product and training manager for VDO Kienzle.

"It [the black box] significantly affects driver behaviour," Needham explained.

VDO has fitted recorders in fleets of vehicles across Europe, including police cars and taxis.

"The Berlin police saw a 20 per cent reduction in accident rate," said Needham. A series of spectacular crashes led the police to fit the recorders, which led to a 25 per cent drop in costs.

"Inevitably the private motorist will have one of these black boxes in the future," Needham predicts. "It may require legislation to ensure that all vehicles have one."

There are two forms of black box: journey recorders and accident data recorders. The former is used for fleet management, continually logging times of use and speeds.

"An accident data recorder will store the last 30 seconds before the accident and 15 seconds after," said Needham.

Data can be downloaded to a PC to find out what the vehicle was doing during the accident, and pinpointing who was at fault.

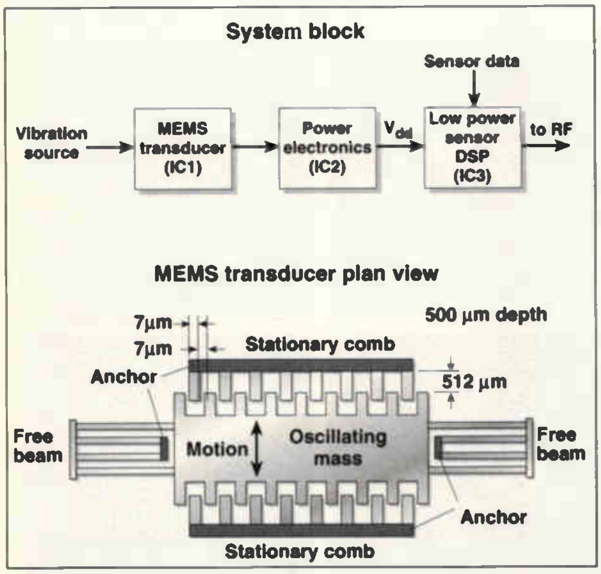
Well rattle my DSP...

A digital signal processor so efficient it can be powered via mechanical vibration.

A digital signal processor so energy efficient that it can be powered by mechanical vibration has been developed at MIT.

"The focus [of the work] is on a picoJoule DSP for a broad spectrum of sensor applications," said Professor Anantha Chandrakasan of MIT's Microsystems Technology Laboratory.

Adding a micro-electromechanical system (MEMS) transducer and a conversion IC, and the DSP can be run using mechanical vibrations as the energy source.



The DSP is aimed at security applications and the processing of heartbeats. Using all three devices makes self-powered machine-mounted sensors and the like become possible.

The MEMS transducer works by converting the external vibrations into a voltage. It has a central mass whose movement, due to a linkage mechanism, is confined to the horizontal. Fingers are etched on the mass and onto two fixed combs such that when they slide past each other, a variable area capacitance results.

Charge is placed on the capacitor when it's at its peak value. As the external vibration prises the fingers apart, the voltage and the energy stored in the capacitor increases. Once the fingers stop, the charge is removed at a higher voltage and returned to the source. The result is a net increase in energy.

"You need to know when the capacitance is at the maximum," Chandrakasan says. The conversion IC evaluates the capacitance to generate the necessary timing. It uses the generated energy to produce a stable voltage for the DSP.

As for the 190 000 transistor DSP, it comprises a distributed arithmetic unit, a non-linear filtering unit and a programmable microcontroller. When processing heartbeat signals from an acoustic sensor, for example, the distributed arithmetic unit (DAU) match-filters the incoming signal.

Since low-bandwidth signals are processed, the input data is clocked into the DSP at 1.2kHz. Processing the data requires a faster 250kHz clock. "Because the circuit doesn't operate fast, the supply voltage can be reduced right down," said Chandrakasan. The result is a 1.5V operating voltage with a power consumption of 560nW.

The DAU is designed such that the input data can be processed with varying bit-length accuracy, starting with the two most significant bits first. Using less bits saves on the overall switching but at a cost of processing accuracy.

The match-filtered output is divided into time segments that contain events to be processed by the classifier. It is the on-chip microcontroller that performs the feature extraction and classification.

MIT has fully tested the DSP and controller IC while the MEMS part has just been fabricated. "The fingers move when you excite it," said Chandrakasan. The full system will be tested in the next few months, he added.

BBC awaits decisions on digital funding

Government ministers and the BBC are close to deciding on how the nation will pay for the development of the Corporation's plans for digital TV. Discussions are nearing completion on which of three options should be adopted.

The BBC, Ten Downing Street, the Treasury, and the Department of Culture Media and Sport have been involved in protracted negotiations over the government's response to the inquiry into the funding of the BBC chaired by economist Gavyn Davies.

While they accept the BBC needs more money, the argument is over how much and how it should be raised.

The three options are:

- To make a one off higher than inflation increase in the basic licence fee for analogue television to find the money.
- To peg the main licence fee to inflation or less and impose a special extra fee on digital sets.
- Increase the main licence fee by a smaller amount and impose a smaller surcharge on digital sets.

The last two options face problems as there is currently no technology to allow TV detector vans to distinguish between analogue and digital equipment while the Data Protection Act prevents the government requiring BSkyB, On-Digital and any other operators to hand over subscriber lists. They would require either technical advances or new legislation to go ahead.

But a major increase in the main licence fee for analogue sets would be politically unpopular with a general election now on the horizon. Any increase by the government would ignore the recommendations of a cross-party Culture, Media and Sport committee which believes there should be no extra money for BBC digital services.

TiePieScope HS801 PORTABLE MOST

ABRITARY WAVEFORM GENERATOR-
STORAGE OSCILLOSCOPE-
SPECTRUM ANALYZER-
MULTIMETER-
TRANSIENT RECORDER-

Reliability

- The HS801: the first 100 Mega samples per second measuring instrument that consists of a MOST (Multimeter, Oscilloscope, Spectrum analyzer and Transient recorder) and an AWG (abritary waveform generator). This new MOST portable and compact measuring instrument can solve almost every measurement problem. With the integrated AWG you can generate every signal you want.

- The versatile software has a user-defined toolbar with which over 50 instrument settings quick and easy can be accessed. An intelligent auto setup allows the inexperienced user to perform measurements immediately. Through the use of a setting file, the user has the possibility to save an instrument setup and recall it at a later moment. The setup time of the instrument is hereby reduced to a minimum.

- When a quick indication of the input signal is required, a simple click on the auto setup button will immediately give a good overview of the signal. The auto setup function ensures a proper setup of the time base, the trigger levels and the input sensitivities.

- The sophisticated cursor read outs have 21 possible read outs. Besides the usual read outs, like voltage and time, also quantities like rise time and frequency are displayed.

- Measured signals and instrument settings can be saved on disk.This enables the creation of a library of measured signals. Text balloons can be added to a signal, for special comments. The (colour) print outs can be supplied with three common text lines (e.g. company info) en three lines with measurement specific information.

- The HS801 has an 8 bit resolution and a maximum sampling speed of 100 MHz. The input range is 0.1 volt full scale to 80 volt full scale. The record length is 32K/64K samples. The AWG has a 10 bit resolution and a sample speed of 25 MHz.The HS801 is connected to the parallel printer port of a computer.

- The minimum system requirement is a PC with a 486 processor and 8 Mbyte RAM available. The software runs in Windows 3.xx / 95 / 98 or Windows NT and DOS 3.3 or higher.

- TiePie engineering (UK), 28 Stephenson Road, Industrial Estate, St. Ives, Cambridgeshire, PE17 4WJ, UK
  Tel: 01480-460028; Fax: 01480-460340

  TiePie engineering (NL),
  Koperslagersstraat 37, 8601 WL SNEEK
  The Netherlands
  Tel: +31 515 415 416; Fax +31 515 418 819

  Web: http://www.tiepie.nl

CIRCLE NO. 106 ON REPLY CARD

Inter-chip data transfer without wires

Quantum corral... This energy plot shows the effect of placing a magnetic cobalt atom at one focus of an elliptical ring of 36 cobalt atoms. Some of the atom's properties suddenly appear at the other focus point of the ellipse, where no atom exists. Thus information is transmitted, without the need for wires or other physical links.

Scientists at IBM have discovered a way of transferring information at the atomic level which could enable data transfer in ICs without using wires.

IBM's researchers in Almaden, California discovered the effect, called 'quantum mirage', when shifting atoms around with a scanning tunneling microscope.

"This is a fundamentally new way of guiding information through a solid," said Donald Eigler, IBM's lead researcher on the project. "We call it a mirage because we project information about one atom to another spot where there is no atom."

At the atomic level, an electron's behaviour changes from the classical physics description to a wave-like, quantum mechanics version.

So shrinking electronic circuits comes up against a law of diminishing returns as speeds reduce. In the long term future new techniques will be needed to transfer data within a chip.

In order to create the quantum mirage, a few tens of cobalt atoms are placed in an ellipse shape on a copper surface. Each ellipse is up to 20nm long and 10nm wide.

When a magnetic cobalt atom is placed at one focus of the ellipse, its quantum wave function is reflected by the 'quantum corral' of cobalt atoms. An image of the atom is seen at the other focus of the ellipse, even though no atom is actually there.

The intensity of the mirage is about one-third of the intensity around the cobalt atom.

"We have become quantum mechanics - engineering and exploring the properties of quantum states," Eigler said. "We're paving the way for the future nanotechnicians."

At last, three-dimensional TV without specs

Philips is shipping prototypes of its 3D television system which does away with those silly plastic glasses, which have been a feature of 3D viewing since the 1950s.

Developed over the last six years at Philips' research centre in Redhill, Surrey, the system uses a set of lenticular lenses in front of liquid crystal displays (LCDs).

This type of autostereoscopic display uses the lenses to create 'segments' of different pixels. Each eye is within a different segment, and so sees a different set of pixels and image.

"We use lenticular lenses over the LCDs. These cylindrical microlenses make specific pixels visible only from specific angles," said Cees van Berkel, from Philips Research Labs. "Our eyes look at the LCD/lenticular under different angles and therefore see different images. The software of course has to provide the right pixel pattern."

By providing not two but as many as nine different views, the image can be viewed from almost any angle or distance, said van Berkel.

A high number of images also makes the image changes smoother as the head is moved through the segments, although it reduces resolution.

Back in 1996 the firm was using VGA screens, but has now increased resolution by using 15in. XGA and 18in. SXGA displays driven by PCs.

The lenticular sheet of lenses is bonded to the front of the LCD, adding just millimetres to the display's thickness.

The main barrier to commercial products is developing software to provide the correct pixel patterns. The firm is shipping prototypes to application developers and academic institutions. ■

***Richard Ball** Electronics Weekly*

Wireless home networking gets a boost

Two new extensions to the HomeRF wireless networking standard will be considered at a working group meeting to be held in Dallas, Texas late in February.

The home networking additions are HomeRF Multimedia and HomeRF Lite. Philips Semiconductors, one of the companies that make up the HomeRF working group, is proposing that the multimedia extension has a data rate of at least 20Mbit/s.

"This is the minimum rate needed for high-definition TV," said Craig Conkling, Philips' marketing manager for wireless connectivity.

HomeRF Lite, meanwhile, is being proposed as a low cost, low data rate – around 128kbit/s – networking scheme for such items as thermostats, home security and PC peripherals.

Extending the data rate of the HomeRF standard is key if it is to keep pace which such standards as HiperLAN 2 and IEEE 802.11a. "IEEE 802.11a is pushing 54Mbit/s as the data rate of choice," said Conkling.

Some relief for small businesses

A new bill introduced by Secretary of State for Trade and Industry Stephen Byers is designed to encourage entrepreneurship and risk taking.

The Insolvency Bill proposes the introduction of Company Voluntary Arrangements, which will give a breathing space to small businesses in difficulty, allowing them a chance to organise a rescue plan.

Byers said: "Promoting entrepreneurship and responsible risk taking in the UK is a key element in fostering a more competitive nation. The new regime proposed in the Insolvency Bill would help to achieve that."

Is Class-T hi-fi?

For some time now, designers have been striving to design hi-fi amplifiers that waste less power. Ingenious solutions have appeared, but the holy grail of low distortion combined with high efficiency has proved elusive. Ian Hickman has been investigating a new approach to the problem – the Class-T. Do we finally have a switching amplifier that can be called hi-fi?

My first real h-fi amplifier, which in the late fifties replaced an earlier puny transistor 'power' amplifier, was that classic design – a Williamson. Its Gilson output transformer had 43% screen grid tappings, and was driven by KT66 output valves.

In the early sixties, in search of something smaller and less like an electric heater, the Williamson was replaced by a well known class B design, due to Tobey and Dinsdale.[1] Like all Class-B audio amplifiers, this was set up with the optimum amount of forward bias to minimise crossover distortion, making it in effect class AB.

Later, I experimented with a Class-D amplifier, which was also published originally in these pages.[2] For readers not familiar with Class-D operation, or who might want to experiment with it, its circuit is reproduced here as **Fig. 1**. Note that the original circuit is reproduced here verbatim – R_7 should have read 1.5kΩ.

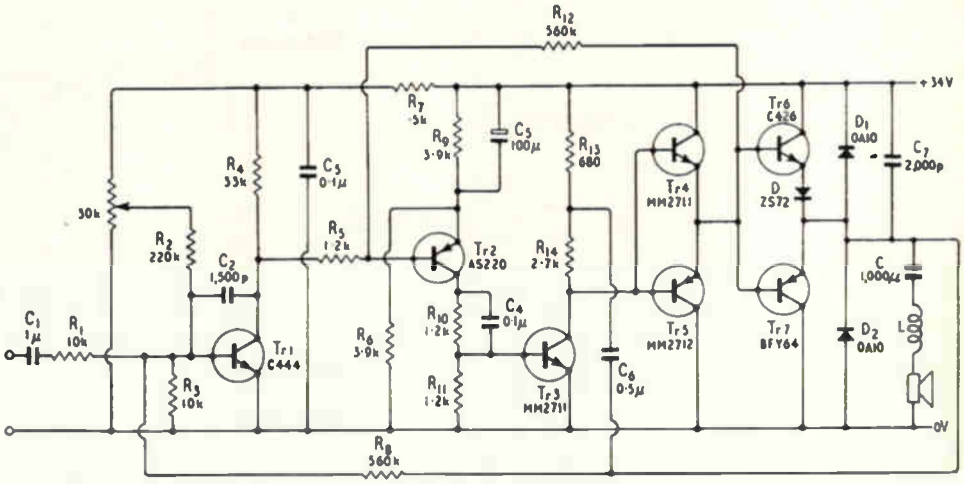


Fig. 1. Class-D amplifier design from 1967. With no signal input, drive to the loudspeaker is a supersonic square wave. An input signal modulates the mark:space ratio of the drive to the speaker. For more on this particular circuit, see ref. 2.

Class-D operation

Briefly, the circuit works as follows. Positive feedback from $Tr_{4,5}$ emitters via R_{12} to the base of Tr_2 causes $Tr_{2\text{-}5}$ to act as a bistable lätch. Consequently, the output connection to the loudspeaker is driven to one or other supply rail.

However, negative feedback is applied from the output, via R_8, to the base of Tr_1. This transistor acts as an integrator due to C_2, and its output rapidly slews until it reaches the point where it sets the bistable latch to the opposite state, whereupon the sequence repeats in the reverse direction.

In the absence of any input signal, the output applied to the loudspeaker is a supersonic square wave, which produces no audible output. An audio signal applied to the input, at C_1, modifies the mark-space ratio, resulting in a corresponding audio component in the output.

The output transistors experience negligible dissipation. Regardless of the presence or absence of any audible signal, they are at all times either bottomed or cut off; only their mark-space

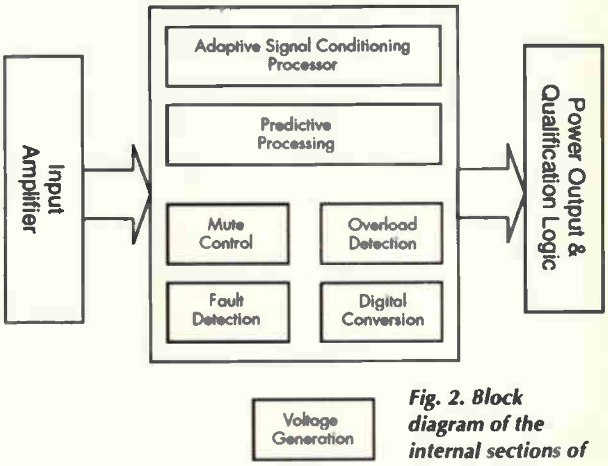
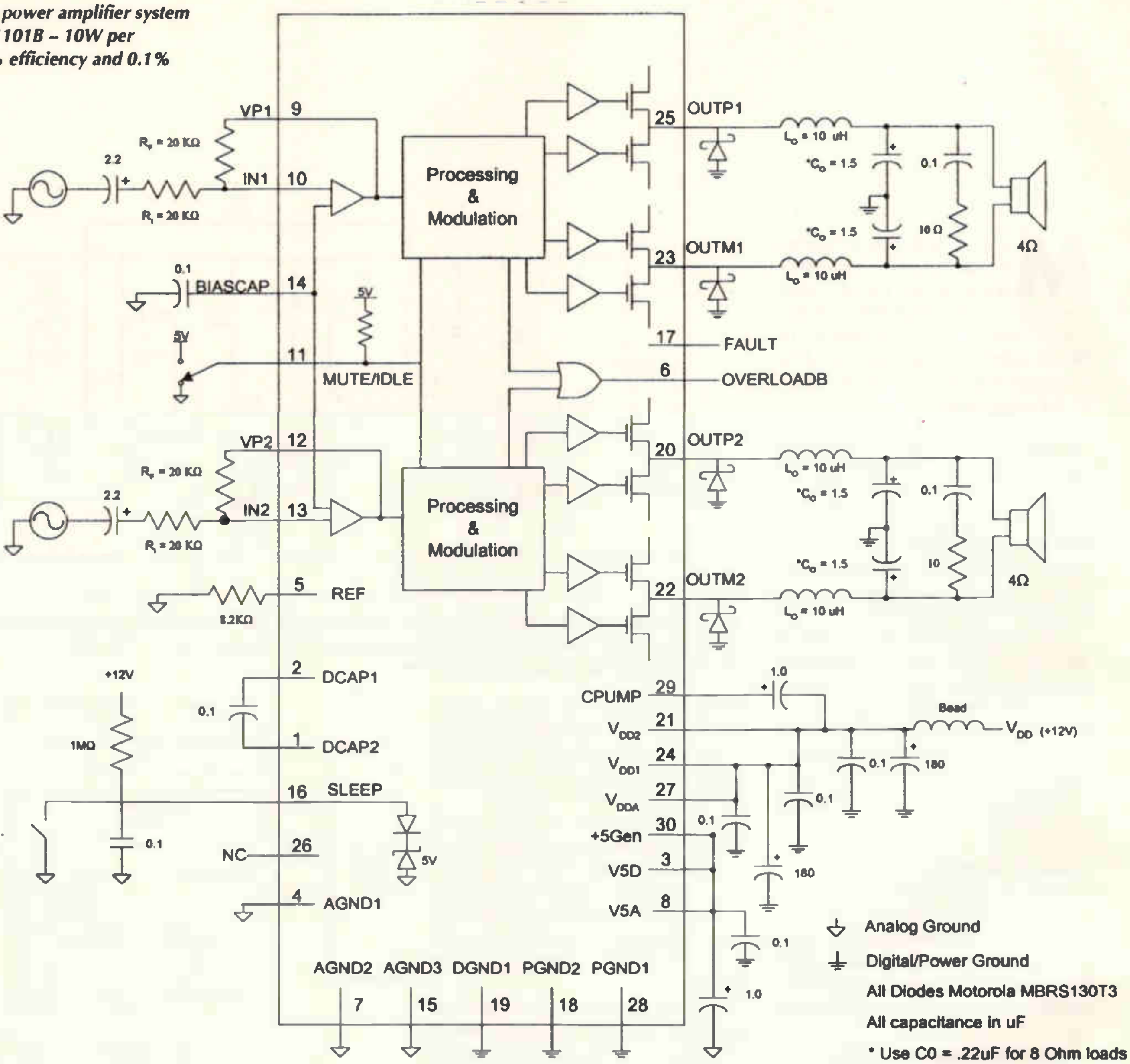


Fig. 2. Block diagram of the internal sections of the new TAxx series 'Class-T' power amplifier building blocks.

Table 1. Characteristics of the TAxx range of Class-T power amplifiers. Note that only the 1101 and 2020 incorporate output power drive devices.

Device	Power/channel (W)	into imp. (Ω)	at thd+n (%)	at supply rail, (V)	efficiency (%)
TA1101B	10	4	0.1	12	78
	9	4	0.04	12	77
	6	8	0.1	12	82
TA2020-020	12	4	0.1	13.5	77
	10	4	0.04	13.5	75
	8	8	0.1	13.5	83
TA0102A	150	4	0.1	±45	78
	80	8	0.1	±45	89
	20	8	0.05	±45	70
TA0103	250	4	0.1	±54	83
	140	8	0.1	±54	83
TA0104	500	4	0.1	±90	82 (@±75V)
	350	8	0.1	±90	90 (@±75V)

Fig. 3. Stereo power amplifier system using the TA1101B – 10W per channel, 78% efficiency and 0.1% thd+n.



ratio varies. A more detailed treatment of Class-D operation can be found in reference 3.

Recent developments

Over the past year or so, there has been renewed interest in high-efficiency audio amplifiers, with some important players coming into the field.

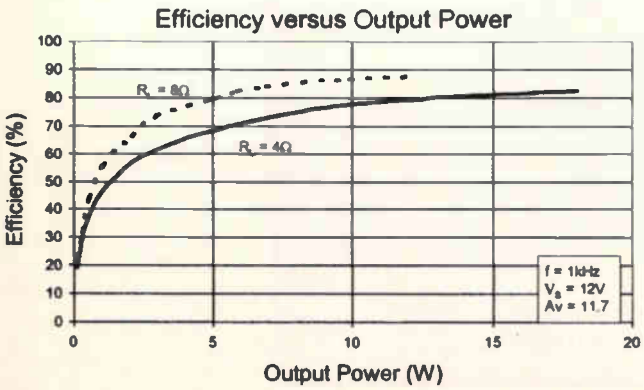
One of the first to catch my eye was Texas Instruments. When this major semiconductor manufacturer enters a field, you may be sure it is seen as an important one.

The company's TPA005D02 is billed as, 'the first-ever stereo Class-D audio power amplifier'. It is aimed at 'portable, battery operated applications, including notebook computers, hand held PCs, PDAs, boom boxes and cellular phones'.

Operating from a single +5V supply, the device will drive 2W continuous into a 4Ω bridge-tied load speaker on each channel of its stereo output – if that is what you want from your PDA or cellular phone. And it does so with a total harmonic distortion plus noise figure of less than 0.5%.

Clearly, the TPA005D02 is a triumph of semiconductor engineering in squeezing 4W at high efficiency out of a 5V supply. But it does illustrate the difficulty of achieving hi-fi levels of thd with a Class-D architecture.

Fig. 4. Efficiency of the TA1101B versus output power, with speaker impedance as parameter.



Hi-fi from a switching amplifier?

Understanding the difficulties of achieving high fidelity using Class-D, I was intrigued to see a range of high-efficiency audio power amplifiers advertised that was claimed to be of 'superior fidelity' and to operate in a mode akin to Class-D.

Made by Tripath,[4] these devices operate in a proprietary mode the manufacturer calls 'Class-T'. Called the TAxx series, the family includes devices covering a wide range of power levels, as indicated in **Table 1**.

I was fortunate in being able to borrow an EB-TA1101B evaluation board, complete with TA1101B and all associated circuitry, from Tripath's UK agent.[5]

I chose the TA1101B device for testing as it contains all the active circuitry needed for a complete power amplifier. The EB-TA1101B evaluation board consists of the device itself, mounted on a high quality PCB, together with all the necessary passive components for gain setting, output filters, decoupling, etc.

Stereo input connections to the board are made via two 'RCA' connectors, better known in this country as phono sockets. There's also six 4mm banana plug sockets. Of these, two pairs are for the bridge-tied load left and right channel speakers, one for a +12V supply and one for 0V ground.

The TA1101B device comes in a special thirty-lead power SOP surface-mount package having a metal area showing on the underside. This metal must be sweated to a suitable area of copper on the PCB, which acts as the heat sink.

Application data supplied gives full details for calculating the required area of copper, depending upon the required output, the speaker impedance and the envisaged top temperature.

Should the maximum temperature limit be exceeded, damage is prevented as the device is shut down by the device's comprehensive protection circuitry. This includes overcurrent/short circuit protection, and turn-on and turn-off 'pop' protection.

The next device up in the power range is the TA2020-020, which comes in a 32 pin SSIP package. Like the TA1101B, this device includes all the necessary active components. It is designed to mount upright at the edge of a PCB though, so that the device's case can be bolted to a finned heat sink.

Higher power devices in the range all come in a 38-pin quad package, but require the addition of separate discrete N-channel mosfets.

Two mosfets are required per channel, as the loudspeakers are driven single ended from positive and negative rails, rather than as bridge-tied loads from a single supply.

These higher power devices also provide a programmable choice of dead time between the turn-off of one device, and the turn-on of the other. This is to avoid 'shoot-through' current due to overlap on the one hand, or excessive dead-space with neither device 'on', on the other.

Inside the TA1101B

Understandably, the manufacturer is reluctant to release all the secrets of the device's operation, but some information is available.

Figure 2 shows a block diagram of the internals of the device. It contains an adaptive signal conditioning pro-

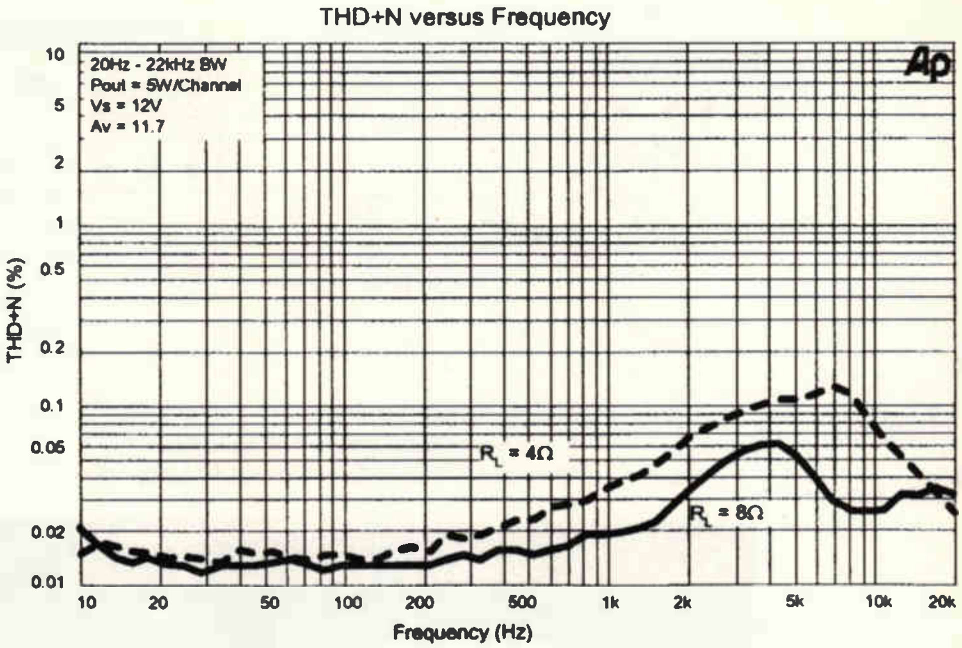


Fig. 5. Distortion – thd+n – at 5W output power per channel versus frequency, with speaker impedance as parameter.

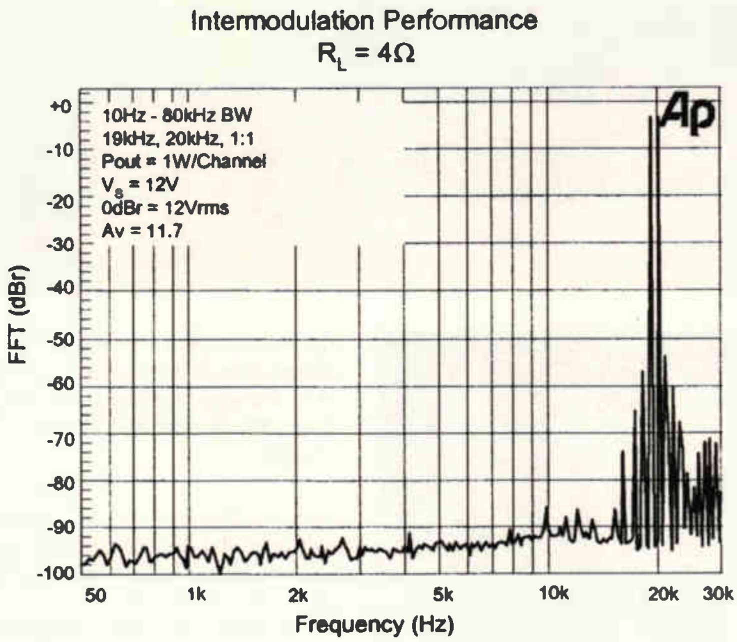


Fig. 6. Intermodulation at high audio frequencies – or IHF IM – at a test level of 1W per channel.

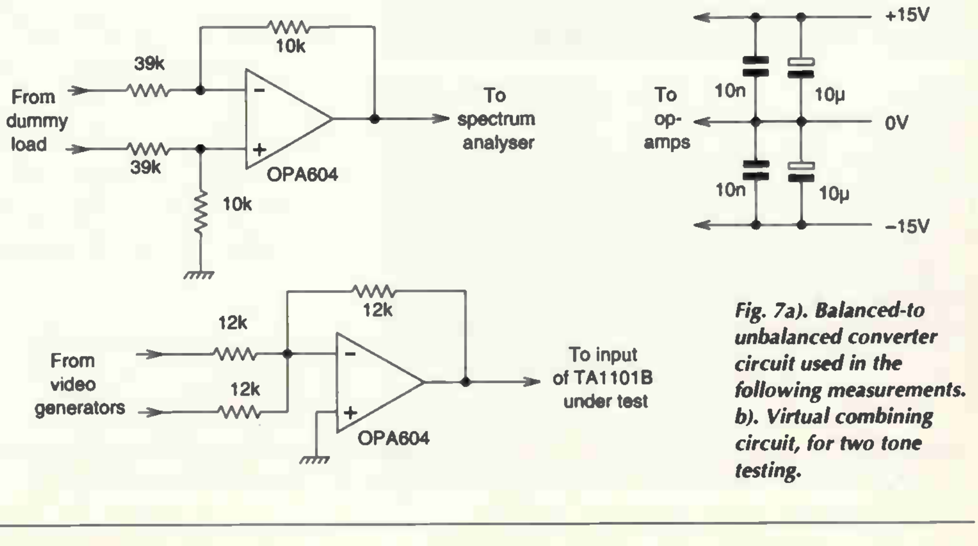


Fig. 7a). Balanced-to unbalanced converter circuit used in the following measurements. b). Virtual combining circuit, for two tone testing.

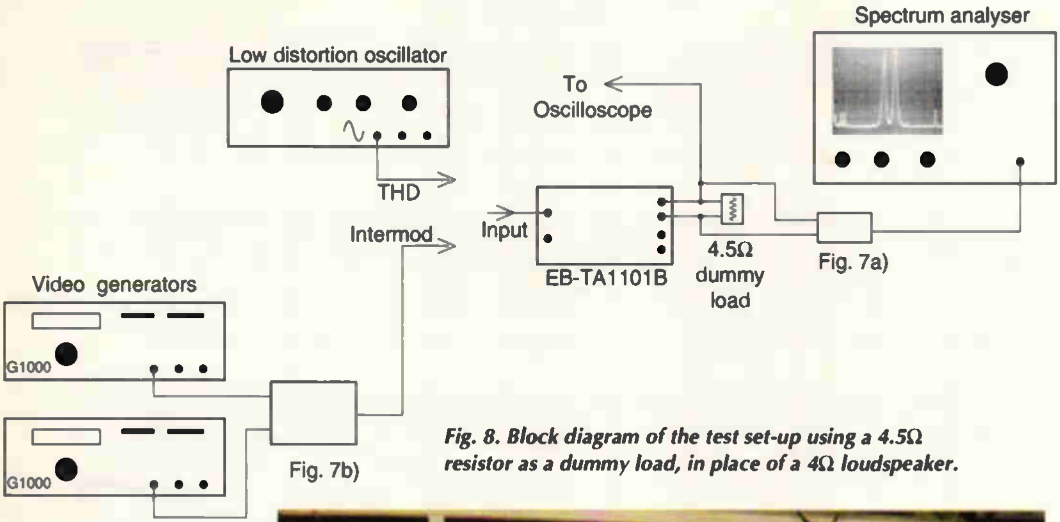


Fig. 8. Block diagram of the test set-up using a 4.5Ω resistor as a dummy load, in place of a 4Ω loudspeaker.

Fig. 9. General view of the test set-up with the EB-TA1101B evaluation board and load resistors in front, and to their right the circuits of Fig. 7.

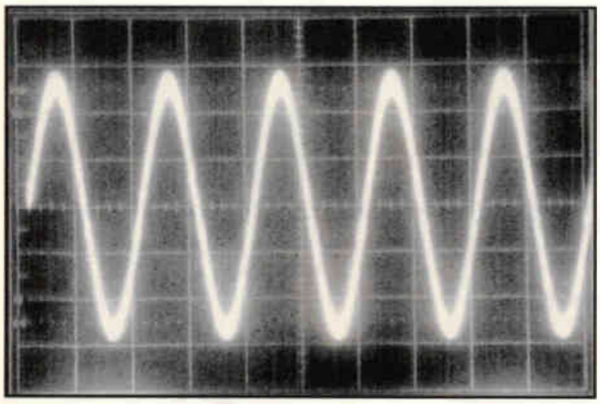


Fig. 10. Waveform at one end of the dummy load, OUTP1 of Fig. 2, with a 1kHz test signal applied. Horizontal: 0.5ms/div. Vertical: 0.5V/div., ac coupled.

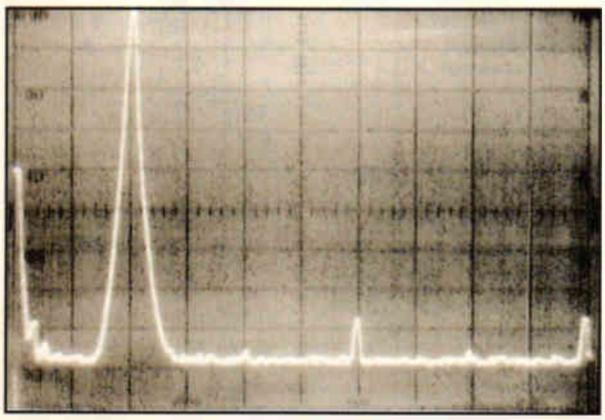


Fig. 11. The output spectrum with a 1kHz test signal. Vertical: 10dB/div. Ref. level (top of screen): –6dBV. Horizontal: 0-5kHz span, 5s/div sweep, 10Hz resolution bandwidth, PDS (post-detector smoothing) off.

cessor, a digital conversion function, mute control, overload handling, fault detection, predictive processing and qualification logic functions.

The result is to produce switching drives to the output devices, which are mark/space modulated like a Class-D amplifier, but differ from the latter in that the switching frequency is not fixed.

In fact, a Class-T amplifier switches its output transistors at a variable rate, up to 1.5MHz, but averaging out at about 600 to 700kHz. Operation is similar in some respects to spread-spectrum working, or to the arrangement used in some direct-digital-synthesiser chips to spread out and thus suppress the energy of discrete line spurs.

Figure 3 shows a TA1101B used to construct a stereo power amplifier. The gain of each channel can be set as required by means of R_I and R_F.

On the EB-TA1101B, with which I was about to experiment, this is all done for you. But first, it was necessary to make up a balanced-to-unbalanced test circuit, so that the balanced output to the bridge-tied load could be applied to the unbalanced input of my various audio frequency test instruments.

I used a Burr-Brown OPA604 op-amp for the test circuit. Its specified distortion of 0.0003% ensured that the instrumentation added a negligible amount of distortion of its own to any measurements.

The TA1101B on test

While I wanted to conduct some tests of my own on the TA1101B, there is a great deal of performance data already available in the data sheet, and there was clearly no point in simply repeating this.

Figure 4 shows the efficiency of the device versus output power, with speaker impedance as parameter. Since the output FET $R_{ds(on)}$ is a lower percentage of the load resistance when using an 8Ω speaker, the efficiency is then of course higher. But with the limited voltage swing available from a 12V supply, the maximum output power is obviously lower.

Figure 5 shows the distortion, i.e. THD+N, at 5W output power per channel versus frequency, again with speaker impedance as parameter.

Figure 6 shows the intermodulation distortion at high audio frequencies. The test level is 1W per channel, i.e. 10dB below full output, and I assume this refers to the average power. The PEP or peak envelope power is of course higher than this, and given the frequency of the two tones, 19kHz and 20kHz, this is quite a severe test of linearity.

As the plot shows, all intermodulation products, including the third order terms, are 50dB or more below either tone, i.e. 56dB or more below PEP.

Next, I wanted to test the linearity of the amplifier, in particular seeing the distribution of the distortion among the various harmonic frequencies – information which is not available from a simple THD+N test.

The balanced-to unbalanced converter circuit mentioned earlier is shown in **Fig. 7**, together with a two-tone combining circuit, also using an OPA604, for intermodulation testing. **Figure 8** shows a block diagram of the test set-up. A 4.5Ω resistor – actually

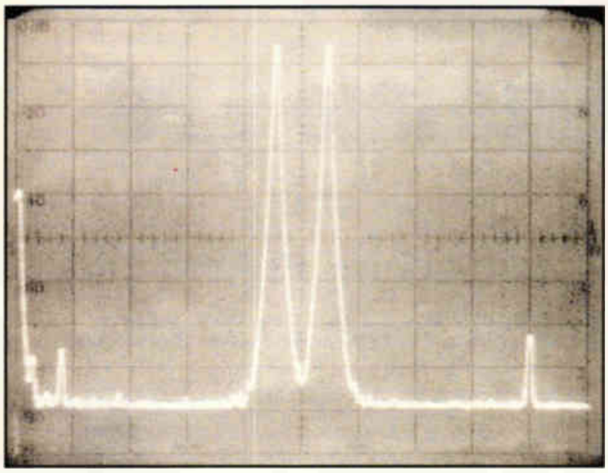


Fig.12. Two-tone test signal, tones combined by circuit of Fig. 6b). Vertical: 10dB/div. ref. level 0dBV, horizontal: span 0-2kHz, 5s/div sweep, 10Hz resolution bandwidth, PDS (post-detector smoothing) off.

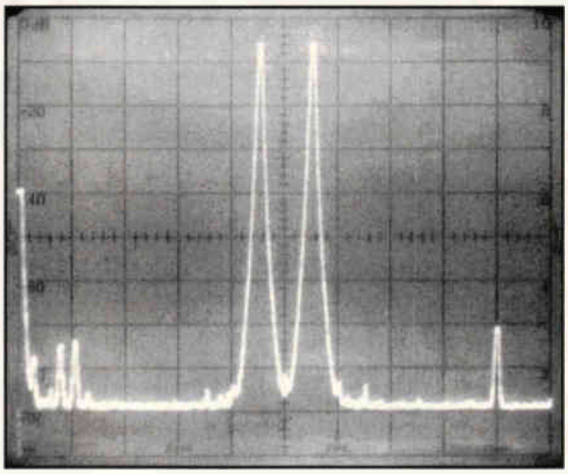


Fig. 13. As above, but measured at the amplifier output, via the circuit of Fig. 6a).

three 1.5Ω wirewound resistors in series – was used as a dummy load, in place of a 4Ω loudspeaker.

Figure 9 is a general view of the unit on test. In the front is the EB-TA1101B evaluation board and load resistors, with to its right the circuits of Fig. 7. Behind them is a low distortion audio frequency generator[6] and to the right of that, an HP3580A audio frequency spectrum analyser. The analyser has had its CRT screen escutcheon and blue filter temporarily removed to allow an oscilloscope camera to be attached.

Figure 10 shows the waveform at OUTP1 of Fig. 3, with a 1kHz test signal applied. It is not blurred or out of focus, the broadening of the trace being due to the residual switching frequency ripple.

Figure 11 shows the spectrum of the voltage across the dummy load, with a 1kHz test signal. A previous check on the test signal itself showed all harmonics below the –88dB noise floor of the analyser.

A modest output power level of some 800mW was chosen, to illustrate how the low level of distortion is maintained as the signal amplitude is reduced. In this respect, the TA1101B resembles a Class-A amplifier, rather than a class AB amplifier, where crossover effects result in an increase in THD at low levels, compared to full output.

Figure 11 demonstrates that the even harmonics, second and fourth, are barely visible above the noise floor, as would be expected with a bridge-tied load drive.[7]

Third and fifth harmonics are both about –78dBc, or 0.013% each. These are the worst harmonics, and this level is probably just not achievable with Class-D operation.

Figures 12 and **13** show a two tone intermodulation test. In contrast to Fig. 6, the test was carried out with tones in the middle of the audible range, where intermodulation products would be most noticeable.

Equal level tones at 900Hz and 1100Hz were provided by two Linstead type G1000 video oscillators, which cover 10Hz to 10MHz. These exhibit a modest THD of around 0.05% at audio frequencies – not exactly hi-fi, but of no consequence for the test in hand.

Figure 12 illustrates the two-tone test signal at the output of the OPA604 combining circuit. Note that as the PEP is 6dB above either tone, the tones have been set at 6dB below the top-of-screen reference level, to avoid overloading the spectrum analyser.

The second harmonic of the lower tone is visible at 1800Hz, while the only other significant responses are a little pick-up at 50, 100 and most noticeably 150Hz at the left hand end of the trace.

I applied the two tone test signal to the EB-TA1101B test bed and adjusted its amplitude to give an amplifier output just below clipping level, as determined by observing the waveform at one end of the dummy load, with the oscilloscope.

Given the 4.5Ω resistance of the dummy load, this corresponded to rather less than 10W. The resultant spectrum is shown in **Fig. 13**. The third-order intermodulation products are visible at 700 and 1300Hz, at about 80dB down on either tone, or 86dB down on PEP. This is a truly excellent performance.

The difference tone of 200Hz is also visible, at a little under 70dB down on either tone. As this is a second-order product, it suggests that the drive signal was pushing one of the four output mosfets a little too close to clipping.

In summary

Published data on the TA1101B, together with my own tests, demonstrate that it is possible to construct an amplifier with comparable efficiency to that of a Class-D circuit, but with substantially lower distortion. In particular, the percentage distortion does not rise as the amplitude is reduced – unlike a class AB amplifier with its inherent crossover distortion.

For those of you wishing to design-in the device, a comprehensive collection of data sheets and application notes is available. These include one giving data on the arrangements for driving a subwoofer in addition to the left and right-channel speakers. Another provides information on FET selection for the higher power alternatives, which need additional discrete output devices.

My thanks to Unique UK – formerly Ambar Components – for the loan of a TA1101B evaluation board, and to Tripath Technology for permission to reproduce Figs 2-6. ■

References

1. R. Tobey & J. Dinsdale, 'Transistor Audio Power Amplifier', *Wireless World*, November 1961, pp. 565-570.
2. G. Turnbull & J. Townsend, 'Efficiency Considerations in a Class-D Amplifier, Part II', *Wireless World* May 1967, pp. 214-217. (Part I appeared in the issue of the previous month)
3. 'Analog Electronics', Ian Hickman, Newnes (Butterworth-Heinemann) 2nd Edition 1999, ISBN 0 7506 4416 8.
4. Tripath Technology Inc., 3900 Freedom Circle, Suite 200, Santa clara, California 95054 408-567-3000.
5. Tripath's UK agent is Unique UK, Rabans Close, Aylesbury, Bucks HP19 3RS, Tel. 01296 397396, fax 01296397439.
6. Ian Hickman, 'Low distortion audio oscillator', *Electronics World and Wireless World*, June 1994, pp. 370-376.
7. Ian Hickman, 'Zero distortion?' *Electronics World*, March 1999, pp. 224-228.

Unique reader offer – Class-T amplifier card that plugs into a PC

Order a TIO Combinant digital amplifier card before 30 April 2000 and receive a TA2020 20W/channel Class-T IC worth £9.22 FREE.

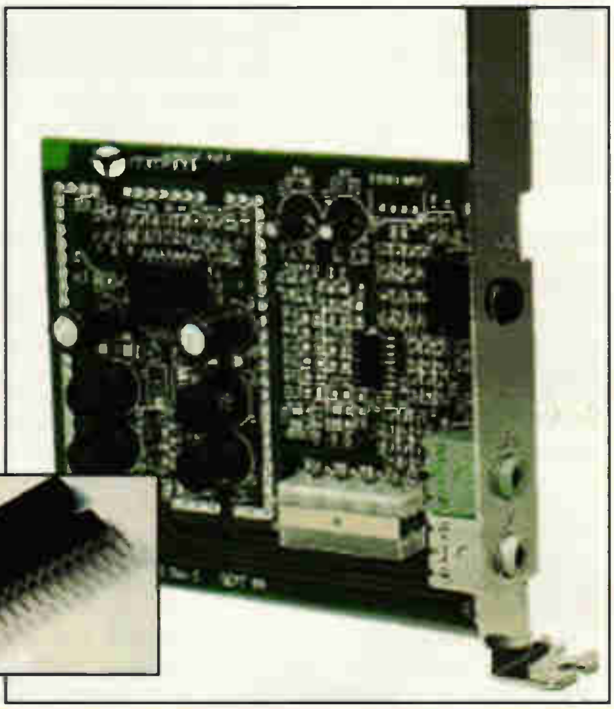
Do you want to listen to music on your PC? Are you unhappy with the audio quality of your PC loudspeakers?

Tripath's new TIO Combinant Digital amplifier card lets you play audio from your PC through a pair of standard passive hi-fi loudspeakers, and the sound quality is amazing.

The TIO, a fully-built TA1101B, is a revolutionary audio amplifier card that straps into a PC expansion slot bay. Using the cables provided, you connect it internally to your PC power supply, and connect the audio input to the audio output of your sound card. Then you plug in the two speaker leads provided and connect them to your speakers. Power on, and that's it! You can listen to whatever your sound card can generate, on the loudspeakers of your choice.

This offer is brought to you by Unique Memec at Rabans Close, Aylesbury, Bucks, HP19 3RS, Tel 01296 397396, fax 01296 397439.

- Hi-fidelity sound (find out why Sony uses this part!)
- Works with nearly all standard passive loudspeakers
- Power output 2x15W cont. (4Ω), 2x 10W cont. (8Ω)
- Revolutionary Class-T architecture
- No software required
- Does not require PCI/ISA motherboard slot
- Draws power from the PC (no mains lead)
- Amplifies *all* PC audio content



Buy this hi-fi audio power amp card for your PC and get a 20W per channel Class-T IC free.

Use this coupon to order your TIO amplifier card/s

Please send me .... TIO(s) with free TA2020 at the special offer price of £42.50 fully inclusive.

Name

Company (if any)

Address

Phone number/fax

Total amount £..........

Make cheques payable to Unique Memec
Or, please debit my Master/Visa card.
Card type (Master/Visa)

Card No
Expiry date

Please mail this coupon to Unique Memec, (Electronics World Offer), Rabans Close, Aylesbury, Bucks, HP19 3RS, Tel 01296 397396, fax 01296 397439.

Measure AC millivolts to 5MHz

General-purpose digital multimeters are fine for DC, but most of them are poor at measuring AC signals much above mains frequency. Cyril Bateman's high-performance millivoltmeter has a wide dynamic range and bandwidth. It even indicates a couple of millivolts reliably at 5MHz, yet it is easy to put together and calibrate. You can add the circuit to your DMM or implement it as a stand-alone meter.

Modern low-cost hand-held digital voltmeters measure DC millivolts with excellent accuracy. With many of them though, measurements of small AC voltages are inaccurate and severely bandwidth limited. I found one otherwise good DVM to be more than –3dB down by just 4kHz when measuring a sinewave of 250mV.

I already have a Hewlett Packard bench AC voltmeter measuring from a few microvolts to 300V. While flat to 1MHz, its response is 3dB down before 5MHz. It also exhibits measurable peaking between 2 and 3MHz.

Recently, I had a job that involved measuring AC from 10mV up to 200mV with reasonable precision up to 5MHz. Readings had to be free from any significant peaking and it had to be possible to make them without switching ranges. In addition, I wanted a portable low cost instrument that could be used with conventional switchable divide-by-10/×1 oscilloscope probes, or within a 50Ω system.

A search of my library files, the Internet and back issues of *Electronics World* revealed a number of published designs. Most designs were intended to measure higher voltages and there was no indication of their accuracy when measuring millivolt levels. Others did not provide an input impedance suited for use with oscilloscope probes.

One which did provide an input for use with conventional oscilloscope probes was designed by Chester Simpson and published in May 1996[1]. Using only three low-cost integrated circuits, he claimed less than 0.2dB error up to 800kHz when measuring a 2V input. This performance equates well with that offered by the well-established, high performance HP3468B and HP34401A bench meters.

However since Chester's design made no performance claims for lesser voltages, I decided to look further. One suggestion I found used the excellent Maxim 435 transconductance amplifier. Having two pairs of matched HP5082-2080 low-voltage Schottky diodes, I breadboarded this circuit[2].

I found its response with 0.5V drive was flat from 1kHz to 1MHz. While it looked initially promising, when I tested it with a 50mV drive, I found it was 0.5dB down by 1MHz, and much worse at higher frequencies. I needed far better small signal performance.

In my Hands-on-Internet article in the March 99 issue, I discussed using

Diode matching

When building the prototype board, I used a number of matched resistors in order to evaluate circuit behaviour. These were simply selected from normal 1% stock using a DMM.

I found that the offset voltages at the +Out and –Out terminals depended more on diode matching than on the MAX457 amplifier's offset voltage.

To facilitate choice of diodes, the printed board has been laid out to accommodate both normal wire-ended diodes and dual surface-mount packaged diodes. Such dual diodes offer good matching and low costs.

Already having several HP5082-2080 diodes, I decided to match these myself. The HP5082-2080 reference indicates they are batch matched HP5082-2835 types.

To select pairs of diodes, I daisy chained ten diodes in series with a 15kΩ current-limiting resistor and applied a voltage in turn such that currents of 10μA, 100μA, and 1mA passed through the diodes.

After stabilising for a few minutes, I measured and noted the voltage dropped across each individual diode. Three well matched pairs were selected from this batch of ten.

To date three circuits have been built using these diode pairs. All provided similar small offset voltages and measurement accuracy with frequency.

the AD630 and the OPA678 'SWOP' amps to rectify fast AC signals. I breadboarded a circuit using an OPA678 amplifier[3] and repeated my tests. At low frequencies the circuit behaved impeccably but even at the 0.5V level its response was 0.25dB down by 1MHz. At the lower input voltage – due to the small but inevitable delays incurred while switching between input channels and switching transients – this error increased.

Time to rethink

Since I already have a very good true RMS meter built in 1992 using the AD637 and AD845 integrated circuits, I returned to an earlier plan to upgrade this design. The high-precision AD637 circuit provides excellent sine-wave performance up to 2MHz, but at this frequency its dynamic range is much reduced. For 1dB accuracy it should only be used to measure signals in the range 0.7 to 7.0V.[4]

Since I needed to measure from a few millivolts up to 200 millivolts, the circuit would require some 30dB of pre-amplifier gain, combined with rescaling of the AD637 output. I explored the various op-amps that were readily available and might be suitable but decided this circuit was now becoming over complicated and too expensive for my present needs.

I then recalled comments from my January Internet article about the improved performance when using a MAX435 transconductance amplifier to drive opto-coupler diodes.

So why were the results I obtained with my breadboarded MAX435 circuit so disappointing? I decided to rebuild this circuit and explore further by examining the diode waveforms using a divide by ten oscilloscope probe.

When driven with the higher input voltage at 1MHz, the circuit rectified cleanly with almost no dead time. As the input voltage was reduced, the diode waveform became visibly more and more distorted, so explaining my earlier results.

After some thought I wondered whether the MAX435 itself was limiting these results. The MAX435 is a wideband transconductance amplifier with a bandwidth of 275MHz and slews at 850V/μs. Its gain is fixed by the value of a resistor connected between its Z+ and Z– pins. Consequently while it was very fast and provided the benefits of a current drive to the diodes, it was not able to go 'open loop' and so reduce the time taken to cross the diodes' threshold voltages.

Was this the answer I was seeking? Did I need a transconductance amplifier which has its gain controlled by an external feedback network, as used with a conventional voltage drive, op-amp precision rectifier?

Less speed, more haste

I recalled the high-gain circuit, also featured in the January Hands on Internet, which used the MAX457 dual op-amp. The MAX457 is a 70MHz transconductance CMOS video amplifier that slews at 150V/μs. It can drive a 1V signal into 75ohms. While much slower than the MAX435, its uses an external feedback loop so could go 'open loop' while crossing the diode threshold voltages. Would this chip provide acceptable performance?

To find out I replaced the MAX435 with the MAX457 dual transconductance amplifier. This being a dual

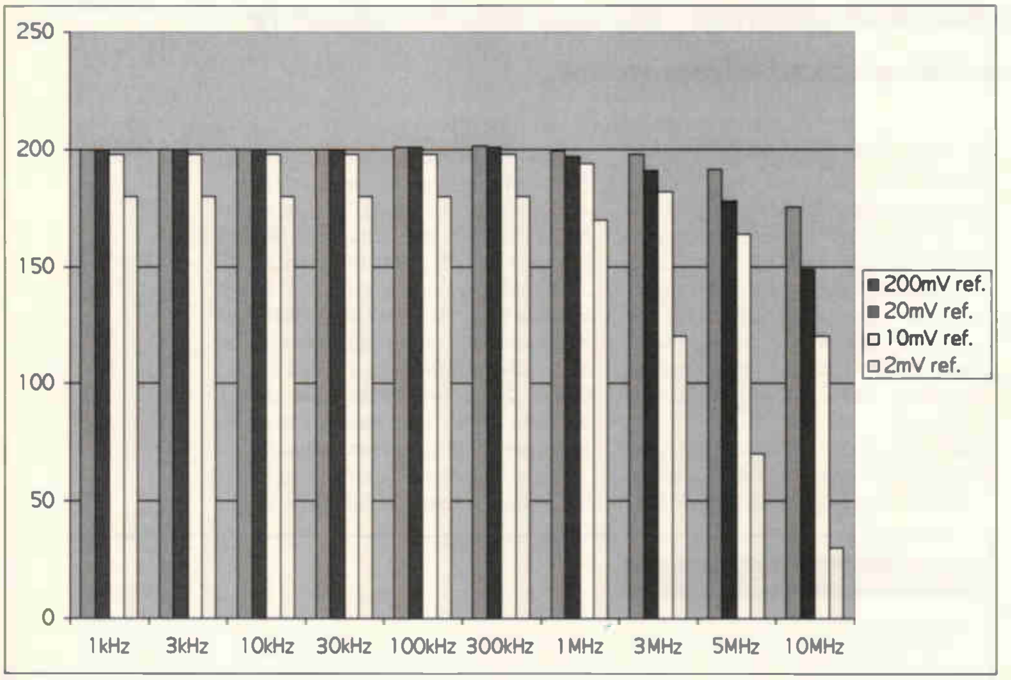
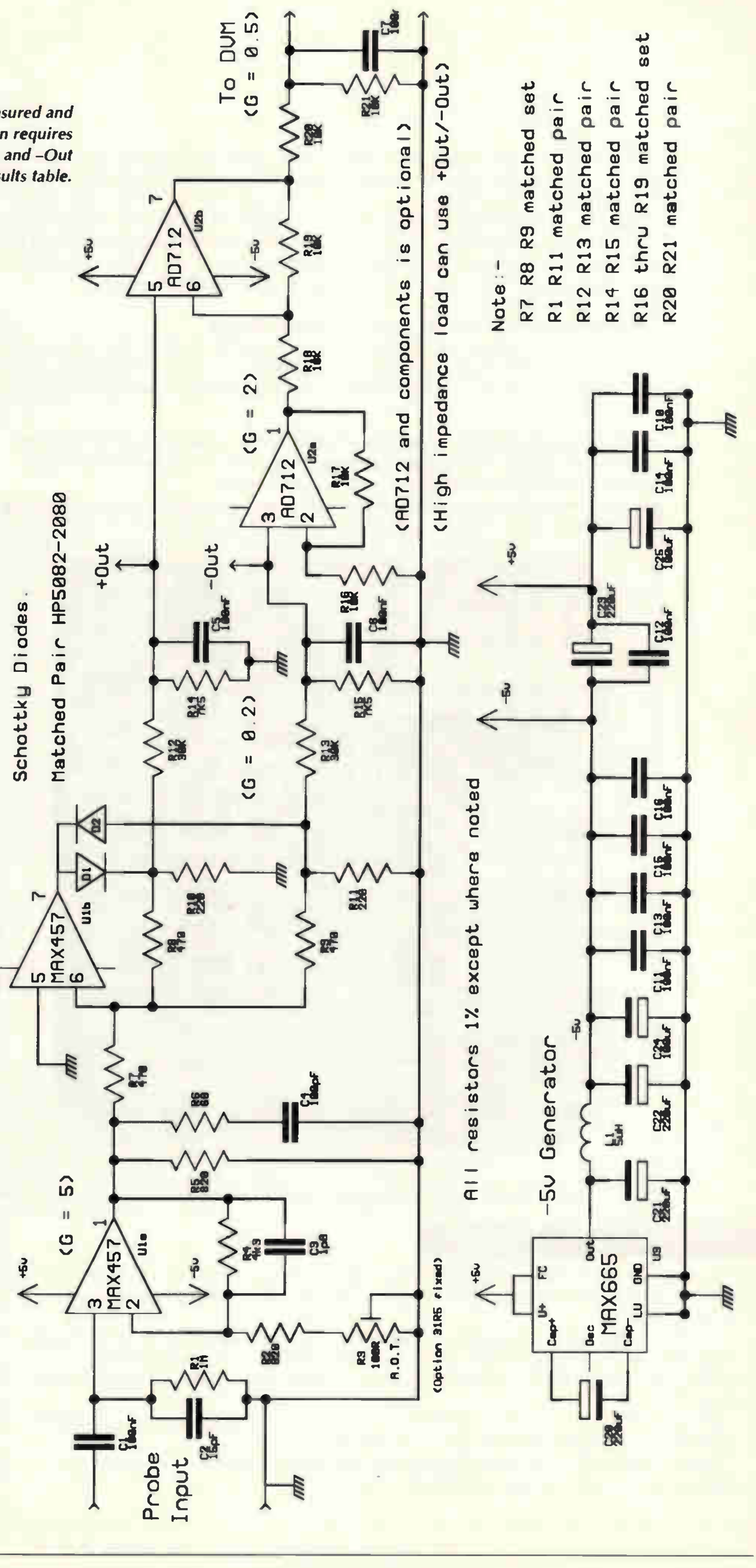


Table 1. Performance of the wide-band AC millivoltmeter. Try making such a table for your DVM! The graph above shows relative roll-off with each reference input voltage.

Frequency (Hz)	Reading 200mV ref.	Error (dB)	Reading 20mV ref.	Error (dB)	Reading 10mV ref.	Error (dB)	Reading 2mV ref.	Error (dB)
1kHz	200.0		20.0		9.9	–0.09	1.8	–0.92
3kHz	200.0		20.0		9.9	–0.09	1.8	–0.92
10kHz	200.0		20.0		9.9	–0.09	1.8	–0.92
30kHz	200.0		20.0		9.9	–0.09	1.8	–0.92
100kHz	200.8	+0.035	20.1	+0.04	9.9	–0.09	1.8	–0.92
300kHz	201.6	+0.07	20.1	+0.04	9.9	–0.09	1.8	–0.92
1MHz	199.5	–0.02	19.7	–0.13	9.7	–0.26	1.7	–1.41
3MHz	198.0	–0.09	19.1	–0.4	9.1	–0.82	1.2	–4.44
5MHz	191.4	–0.38	17.8	–1.0	8.2	–1.72	0.7	–9.1
10MHz	175.4	–1.14	14.9	–2.6	6.0	–4.44	0.3	–16.5

Fig. 1. Final schematic as built, measured and photographed. The minimum cost version requires only those parts to the left of the +Out and –Out terminals, the measurement point for the results table.



amplifier I used the first amplifier simply as a voltage follower, the second amplifier driving a full-wave diode bridge and repeated my measurements.

Driven with the lower test voltage at 1MHz, the diodes' waveform was now visibly much less distorted than for my previous tests.

I swept a 1V signal from 1kHz to 1MHz and found no measurable change in the diodes' output voltage as frequency increased. With the input voltage reset to 100mV, the diode output was equal at both frequencies. A final reduction to 10mV found output down less than 0.8dB at 1MHz.

With this circuit still on a breadboard, I re-configured the first amplifier to provide an input circuit suitable for use with an oscilloscope probe. To improve diode linearity with small signals, I increased its gain so that my desired 200mV AC input signal pro-

Why the MAX457 video amplifier?

The Maxim 457 integrated circuit was part of a family of video amplifiers and buffers featured in Maxim's Design News publication, March 1989. It is a unity-gain-stable dual op-amp with low input bias current and small input capacitance. Standard dual amplifier pinning is used for the device, yet it provides a high isolation between its two amplifiers of 72dB at 5MHz .

Designed specifically as video amplifier it provides good differential gain and differential phase. It can drive ±2.5V into a back-terminated 75Ω cable yet draws only 35mA supply current.

The device's unique features, which suit this meter project, are its transconductance output and a gain bandwidth product that increases with load impedance. This increasing open-loop gain minimises dead-band time when crossing the diodes' threshold voltages.

vided a 1V rectified output from the diodes. Attenuated by five this would drive a 200mV meter to full scale.

With this single op-amp's minimal circuitry, I could perhaps provide a 0-200mV measurement with the probe switched to times one and 0-2V while using the probe set to divide by 10.

One possible drawback of this circuit is that the diodes provide an output of ±100mV around 0V and not a +200mV output referred to ground. This ±100mV output could however be converted to ground referred form using an instrumentation amplifier. The AD712 dual op-amp is arranged as a low cost, simple, times two instrumentation amplifier. Halving its output provided the necessary +200mV ground-referred final output.

Final design

It is possible to build the final circuit design shown in the schematic as a minimum-cost DVM adapter by deleting the AD712 and its components. Using the full schematic as shown, it makes a standalone, ground referenced, millivoltmeter, **Fig. 1**.

Encouraged by the results from my breadboarded circuit, I designed and built a printed circuit board version for my final performance tests. This board also included a low drop-out +5V linear stabiliser and the –5V converter as used in my tanδ meter design, **Fig. 2**.

The board design was sized to easily fit into either of two commercial plastic cases. Using the same style V155 OKW Shell case, as used for my tanδ meter, the board, a PM128 display meter and two PP3 batteries are easily fitted, **Fig. 3**.

Alternatively, the board and batteries can also be fitted into the smaller 80mm by 150mm 'Veronex' case from Vero. If this option is chosen, a different meter display must be used. The low cost PM128 display is too large to fit into this particular Vero case.

To date, I have built three prototypes and all performed equally well. While IC sockets are probably best avoided for these frequencies, my prototypes were built using low profile Augat turned-pin sockets. If different sockets are used, the value of C_3 should be adjusted to compensate for change in socket capacitance, **Fig. 4**.

Performance

I deliberately provided gain reduction above 5MHz in the final circuit for two reasons. One is that the roll-off ensures circuit stability when the MAX457 gain falls off at very high frequencies. The other is that with the test instruments I have available, I would not be able to calibrate the meter with sufficient accuracy at higher frequencies.

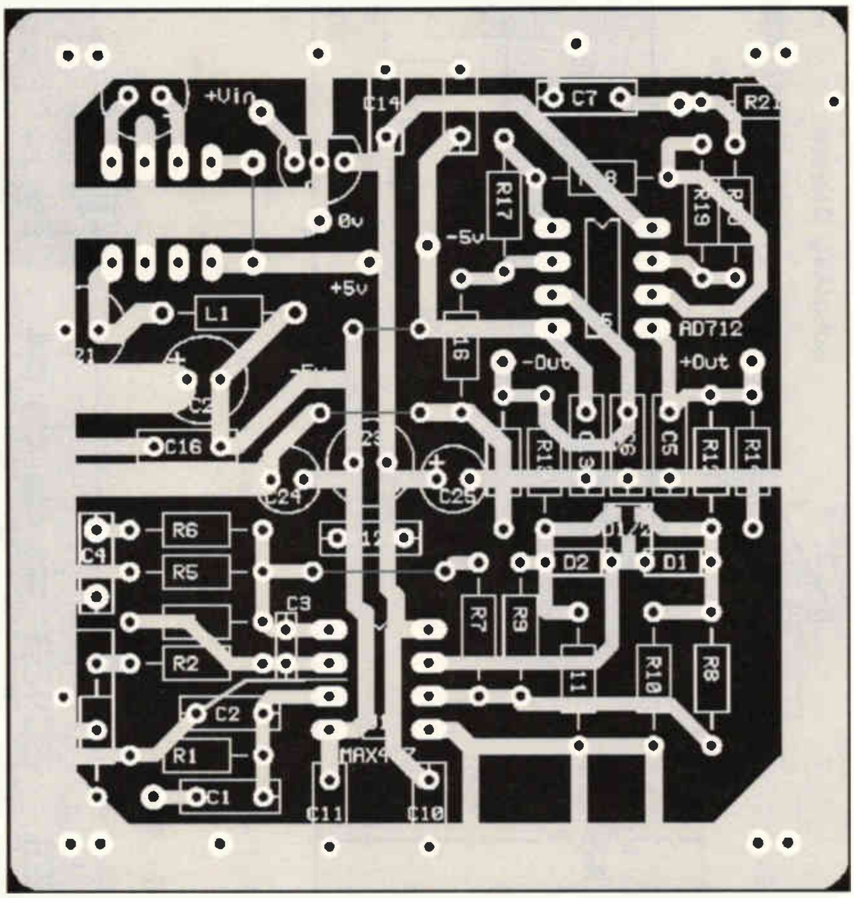
I intend to use this meter with a 50Ω 'through-termination' at its input as well as with my regular M12SW oscilloscope 1MΩ probes. These have a 250MHz bandwidth when set to divide-by-ten, but are –3dB at 10MHz when switched to times one, limiting the highest input frequencies for small signals.

No doubt this circuit is capable of good results to even higher frequencies, but rather than risk any higher frequency gain peaking, I choose to deliberately roll off the gain. The circuit's low cost and its measured results are more than sufficient for my present need. Reading errors are better than ±0.5dB to 5MHz at 200mV and better than ±1dB at 20mV.

Measured results

To eliminate any oscilloscope probe induced errors, I tested the meter using a

Fig. 2. My prototype PCB measures only 65mm by 67mm making it easy to fit into many different box options. The +Out and –Out terminal pins have been spaced to suit the input terminal spacing used for most portable voltammeters.



Instrumentation amplifier

The arrangement used here of dual op-amp as an instrument amplifier, was chosen to provide similar, high input impedances for both inputs, good performance and easy resistor matching.

As with the popular three op-amp configuration, this amplifier's gain can be increased using only one additional resistor, without affecting the common-mode rejection performance of the circuit. This resistor would be connected between pins two and six of the AD712.

Using equal value resistors the circuit has a gain of two. Higher gains are easy, when using the extra resistor, but unity gain is not possible.

Readers interested in more details, together with design equations should refer to application note AN-244 from Analog Devices.

Calibration

As with all my designs I wanted the simplest possible calibration routine. For this design, providing the flattest possible frequency response ensures easy calibration. A flat response allows calibration – if necessary – to be performed at low frequencies only using only a conventional multimeter.

Obviously, when higher frequency comparisons are possible, they should be made. But with my three prototypes, I found acceptable performance could be obtained without using a comparison meter simply by setting the value of R_3 to 31.5Ω.

The calibration routine used for the measured result table was to supply a known test voltage from a 50Ω signal generator to the millivoltmeter, via a 10dB attenuator connected to a 'T' adapter. This was fitted to the millivoltmeter's temporary input BNC connector.

This T adapter was also connected to the high-impedance input terminal of my Hewlett Packard voltmeter, then to my oscilloscope via a 50Ω 'lead-through' termination, thus minimising any line reflections.

For consistent 50Ω system measurements – even at these relatively low frequencies – a 10dB attenuator should be inserted adjacent to the device under test. This attenuator reduces any reflections fed back to the generator by 20dB, optimising the signal generator's output stability with change in frequency.

Allow the circuits to warm up, then with no signal input, connect a DMM across +Out and –Out terminals and check the offset voltage. If this is satisfactory, apply a signal at as near 200mV as possible from the signal generator.

At this point, I adjusted R_3 until both the HP voltmeter and the DMM read the same voltage. If you don't have a suitable high-frequency voltmeter available for comparison, apply a suitable low test frequency. Measure the input voltage on the BNC inner contact using an appropriate AC multimeter. Reconnect the multimeter across the +Out and –Out terminals, read the DC voltage and adjust R_3 as before.

correctly-terminated 50Ω system. Signal input to the millivoltmeter was from a –10 dB coaxial attenuator. This connected to the signal generator via a Hatfield 50Ω attenuator and a short 50Ω coaxial cable.

Initially, the switchable attenuator was set to 0dB, then –20dB, –26dB and –40dB in turn. With the attenuator switched to 0dB, the signal generator output was set to provide 200mV at the input to the millivoltmeter

I monitored the actual voltage input at the millivoltmeter circuit up to 1MHz using my Hewlett Packard voltmeter, with the attenuator switched to 0dB. At 1MHz and above, I used my HP8405 vector voltmeter.

As an additional check, I also cross-checked the peak-to-peak amplitude at all frequencies using my 100MHz oscilloscope, which completed the system. Measurement frequencies were checked using a Racal 9918 frequency counter. Results are shown in **Table 1**.

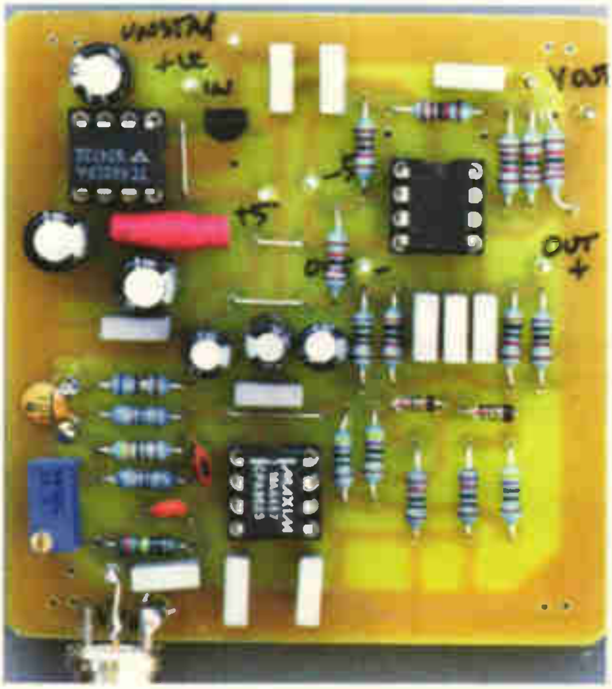
All the output voltages shown in the Table were measured using a 3 3/4 digit DMM across the +Out and –Out terminals marked on the schematic drawing. With no input signal, the offset at these terminals measured 0.1mV while that at the AD712 output measured –0.1mV. The AD712 output voltage closely followed the above readings after correcting for these measured offsets. ■

References

1. Simpson, Chester, 'Fast amplifiers simplify ac measurement', *EDN Design Ideas* May 9 1996
2. May, Peter, 'Fast full-wave rectifier', *Electronics World*, p. 413 May 1993.
3. Wideband Switched-input Operational Amplifier, http://www.burr-brown.com
4. Special Linear Reference Manual, Analog Devices, Norwood MA, USA.

Fig. 3. This photograph illustrates one possible packaging option, in an OKW 'Shell' case, resulting in a battery powered, self contained, portable AC millivoltmeter. This case provides a removable aluminium front panel able to support a panel mounting BNC socket and on/off switch.

Fig. 4. The prototype hand-etched board, complete with the temporary BNC socket exactly as used for the measured results table. The value of C_3, which is visible adjacent to pins 1 and 2 of the MAX457, should be adjusted to compensate for capacitance change if using a different IC socket.



Unique 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 Reed Business Information

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, Electronics World Editorial, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

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

Free with this issue of

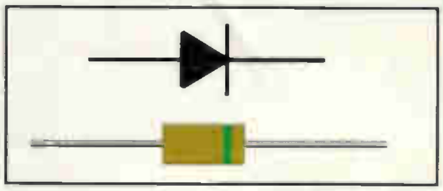
Electronics World, four 1.5A 1N4006 type diodes

Free with this month's issue* is a pack of four SS4006 power rectifier diodes. Similar to the 1N4006, but with a 1.5A current handling capability as opposed to 1A, these diodes are excellent general-purpose rectifiers.

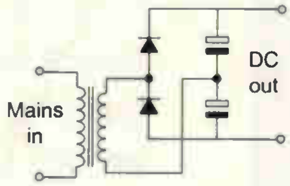
*UK readers only

SS4006 specifications

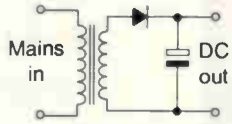
Forward current I_o	1.5A	
Peak inverse voltage	PIV	800V
Forward voltage @1A	1.6V	



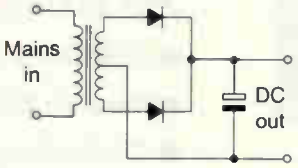
Simple power supplies



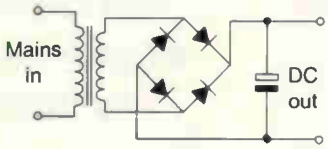
Voltage doubler. High ripple and poor regulation but useful for low-current applications where a suitable transformer isn't available.



Half-wave rectifier – use where simplicity is paramount and high 50Hz ripple isn't a problem.



Full-wave rectifier needs a centre-tapped transformer but produces an output with much less ripple than the half-wave rectifier. Ripple is 100Hz, assuming 50Hz mains, hence easier to smooth.



Bridge rectifier doesn't need a centre-tapped transformer to produce a clean output and although it uses four diodes, these only need to have a voltage rating of half those needed for an equivalent full-wave rectifier.

Outline rectifier circuit characteristics.

Circuit	Input voltage (rms)	Output voltage no load	Approx. output voltage full load	Rectifier peak inverse voltage	Rectifier current
Half wave	E	$\sqrt{2}\times E$	E	$2\sqrt{2}\times E$	I
Full wave	E+E	$\sqrt{2}\times E$	1.2E	$2\sqrt{2}\times E$	0.5I
Bridge	E	$\sqrt{2}\times E$	1.2E	$\sqrt{2}\times E$	0.5I
Doubler	E	$2(\sqrt{2}\times E)$	2E	$2\sqrt{2}\times E$	I

Your SI4006 diodes are sponsored by Semiconductor Supplies International – the distributor with 20 000 hard-to-find items from stock. Web address: http://www.ssi-uk.com, e-mail: sales@ssi-uk.com, fax 020 8643 3937.

£9.99

+ postage & packaging

Please send me _____ copies of The LP is Back!

Name ______________________________

Address ______________________________

____

______________________ Post code ___ ___

Daytime phone number ______________________

I enclose a cheque for £_______

Or debit my Visa ____ Master Card ____ (tick one)

Card number _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Expiry date _ _ / _ _

Card-holder's signature:

____

Love vinyl?

If you treasure your vinyl collection, this book is for you. Featuring articles from the pages of the US magazine *Audio Amateur* and other sources, it contains absolutely everything the serious LP music collector needs to get the most out of both vintage records and the highest quality new pressings.

Articles feature:

- **Cleaning discs**
- **How to build a cleaning machine**
- **Calibrating and maintaining your tonearm and cartridge**
- **Equipment that will improve the quality of long-play record listening**

Collected from the high point of this old-new again technology, 'The LP is Back!' brings a wealth of information to help you keep your existing equipment in top form and help you understand and appreciate the best in new products available from cartridges to turntables. Published 1999, 160 pp., 8in by $10^1/_2$in, softbound.

Fully inclusive prices:

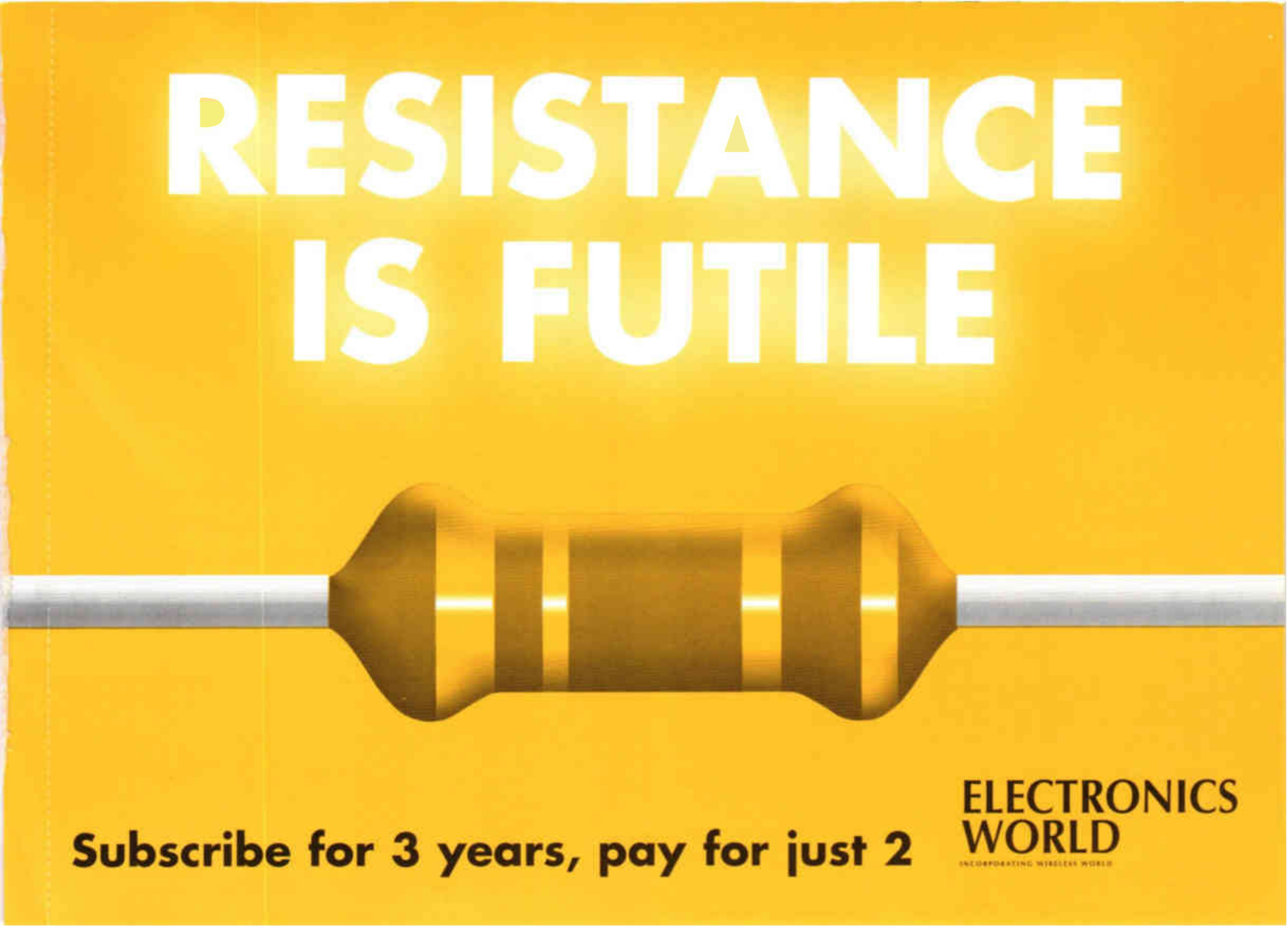
UK	£11.49
Europe	£11.99
ROW	£13.98

How to order:

Post the coupon to:
The LP is back, Electronics World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS, or fax 0208 652 8111,

or e-mail jackie.lowe@rbi.co.uk

Please make cheques payable to **Reed Business Information**


RESISTANCE
IS FUTILE
Subscribe for 3 years, pay for just 2
ELECTRONICS
WORLD

SMALL SELECTION ONLY LISTED - EXPORT TRADE AND QUANTITY DISCOUNTS - RING US FOR YOUR REQUIREMENTS WHICH MAY BE IN STOCK

HP New Colour Spectrum Analysers LAST FEW ONLY
HP141T+ 8552B IF + 8553B RF -1KHZ -110Mc/s - £500.
HP141T+ 8552B IF + 8554B RF -100KHz -1250M - £600.
HP141T+ 8552B IF + 8556A RF - 20Hz-300KHz - £400.
HP141T+ 8552B IF + 8555A 10 MC/S-18GHzS - £1000.
HP8443A Tracking Gen Counter 100KHz-110Mc/s - £200
HP8445B Tracking Preselector DC to 18GHz - £250.
HP8444A Tracking Generator • 5-1300Mc/s - £450.
HP8444A OPT 059 Tracking Gen • 5-1500Mc/s - £650.
HP35601A Spectrum Anz Interface - £300.
HP4953A Protocol Anz - £400.
HP8970A Noise Figure Meter + 346B Noise Head - £3k.
HP8755A+B+C Scalar Network Anz PI - £250 + MF 180C - Heads 11664 Extra - £150 each.
HP3709B Constellation ANZ £1,000.
HP11715A AM-FM Test Source - £350.
FARNELL TVS70MKII PU 0-70V 10 amps - £150.
MARCONI 6500 Network Scaler Anz - £500. Heads available to 40GHz many types in stock.
Mixers are available forANZs to 60GHz.
HP6131C Digital Voltage Source + -100V½ Amp.
HP5316A Universal Counter A+B.
Marconi TF2374 Zero Loss Probe - £200.
Racal/Dana 2101 Microwave Counter - 10Hz-20GHz - with book as new £2k.
Racal/Dana 1250-1261 Universal Switch Controller + 200Mc/s PI Cards and other types.
Racal/Dana 9303 True RMS Levelmeter + Head - £450.
TEKA6902A also A6902B Isolator - £300-£400.
TEK CT-5 High Current Transformer Probe - £250.
HP Frequency comb generator type 8406 - £400.
HP Sweep Oscillators type 8690 A+B + plug-ins from 20Mc/s to 18GHz also 18-40GHz.
HP Network Analyser type 8407A + 8412A + 8601A - 100Kc/s - 110Mc/s - £500 - £1000.
HP 8410-A-B-C Network Analyser 110Mc/s to 12 GHz or 18 GHz - plus most other units and displays used in this set-up - 8411a-8412-8413-8414-8418-8740-8741-8742-8743-8746-8650. From £1k.
Racal/Dana 9301A-9302 RF millivoltmeter - 1.5-2GHz - qty in stock £250-£400.
Racal/Dana Modulation Meter Type 9009-9008 - 8Mc/s - 1.5GHz - £150/£250 – 9009A £350.
Marconi RCL Bridge type TF2700 - £150.
Marconi Microwave 6600A 1 sweep osc., mainframe with 6650PI - 18-26.5 GHz or 6651 PI - 26.5-40GHz-£750 or PI only £600. MF only £250.
Gould J3B test oscillator + manual - £150.
Marconi 6155A Signal Source-1 to 2GHz - LED - £400.
Barr & Stroud Variable filter EF3 0.1Hz-100Kc/s + high pass + low pass - £150, other makes in stock.
Racal/Dana 9300 RMS voltmeter - £250.
HP 8750A storage normalizer - £400 with lead + S.A. or N, A
Marconi mod meters type TF2304 - £250 – TF2305 - £1,000.
Racal/Dana counters-99904-9905-9906-9915-9916-9917-9921-50Mc/s-3GHz - £100 - £400 - all fitted with FX standards.
HP180TR. HP181T, HP182T mainframes £300 - £500.
HP432A-435A or B-436A-power meters + powerheads to 60GHz - £150 - £1750 - spare heads available.
HP3586A or C selective level meter - £500.
HP86222A+B Sweep PI -01-2.4GHz + ATT £1000-£1250.
HP86290A+B Sweep PI-2 - 18GHz - £1000 - £1250.
HP8620C Mainframe - £250. IEEE £350.
HP8165A Programmable signal source - 1MHZ - 50Mc/s - £1k.
HP3455/3456A Digital voltmeter - £400.
HP5370A Universal time interval counter - £1k.
HP5335A Universal counter - 200Mc/s-£1000.
HP3552A Transmission test set - £350.
TEKTRONIX 577 Curve tracer + adaptors - £900.
TEKTRONIX 1502/1503 TDR cable test set - £400.
HP8699B Sweep PI YIG oscillator .01 - 4GHz - £300. 8690B MF-£250. Both £500.
Dummy Loads & Power att up to 2.5 kilowatts FX up to 18GHz - microwave parts new and ex equipt - relays - attenuators - switches - waveguides - Yigs - SMA - APC7 plugs - adaptors etc. qty. in stock.
B&K Items in stock - ask for list.
Power Supplies Heavy duty + bench in stock - Farnell - HP - Weir - Thurlby - Racal etc. Ask for list. Large quantity in stock, all types to 400 amp - 100Kv.
HP8405A Vector voltmeter - late colour - £400.
HP8508A Vector voltmeter - £2500.
HP8505A Network Anz 500KHz-1.3GHz - £1000.
HP8505A + 8502A or 8503A test sets- £1200 - £1500.
HP8505A + 8502A or 8503A + 8501A normalizer - £1750-£2000.
Phillips 3217 50Mc/s oscilloscopes - £150-£250.
Wavetek-Schlumberger 4031 Radio communication test set

LIGHT AND OPTICAL EQUIPMENT

Anritsu ML93A & Optical Lead Power Meter - £250.
Anritsu ML93B & Optical Lead Power Meter - £350.
Power Sensors for above MA96A - MA98A - MA913A - Battery Pack MZ95A.
Anritsu MW97A Pulse Echo Tester.
PI available - MH914C 1.3 - MH915B 1.3 - MH913B 0.85 - MH925A 1.3 - MH929A 1.55 - MH925A 1.3GI - MH914C 1.3SM - £500 + one P.I.
Anritsu MW98A Time Domain Reflector.
PI available - MH914C 1.3 - MH915B 1.3 - MH913B 0.85 - MH925A 1.3 - MH929A 1.55 - MH925A 1.3GI - MH914C 1.3SM - £500 + one P.I.
Anritsu MZ100A E/O Converter.
+ MG912B (LD 1.35) Light Source + MG92B (LD 0.85) Light Source £350.
Anritsu MZ118A O/E Converter.
+MH922A 0.8 O/E unit + MH923 A1.3 O/E unit £350.
Anritsu ML96B Power Meter & Charger £450.
Anritsu MN95B Variable Att. 1300 £100.
Photo Dyne 1950 XR Continuous Att. 1300 - 1500 £100.
Photo Dyne 1800 FA. Att £100.
Cossor-Raytheon 108L Optical Cable Fault Locator 0-1000M 0-10kM £200.
TEK P6701 Optical Converter 700 MC/S-850 £250.
TEK OF150 Fibre Optic TDR – £750.
HP81512A Head 150MC/S 950-1700 £250.
HP84801A Fibre Power Sensor 600-1200 £250.
HP8158B ATT OPT 002+011 1300-1550 £300.
HP81519A RX DC-400MC/S 550-950 £250.
STC OFR10 Reflectometer – £250.
STC OFSK15 Machine jointing + eye magnifier – £250.

COMMUNICATION EQUIPMENT

Anritsu ME453L RX Microwave ANZ – £350.
Anritsu ME453L TX Microwave ANZ – £350.
Anritsu MH370A Jitter Mod Oscillator – £350.
Anritsu MG642A Pulse Patt Gen. £350.
System MS02A Timer & Digital Printer – £500.
Complete MS65A Error Detector.
Anritsu ML612A Sel Level Meter – £400.
Anritsu ML244A Sel Level Meter – £300.
W&G PCM3 Auto Measuring Set – £300.
W&G SPM14 Sel Level Meter – £300.
W&G SPM15 Sel Level Meter – £350.
W&G PS19 Level Gen – £500.
W&G DA20+DA1 Data ANZ £400.
W&G PMG3 Transmission Measuring Set – £300.
W&G PSS16 Generator – £300.
W&G PS14 Level Generator – £350.
W&G EPM-1 Plus Head Milliwatt Power Meter – £450.
W&G DLM3 Phase Jitter & Noise – £350
W&G DLM4 Data Line Test Set – £400.
W&G PS10 & PM10 Level Gen. – £250.

MISCELLANEOUS ITEMS

HP 3852A Data Acquisition Control Unit + 44721A 16ch input £1,000.
HP 4261 LCR meter – £650.
HP 4274 FX LCR meter – £1,500.
HP 4951A Protocol ANZ – £500.
HP 3488 Switch Control Unit + PI Boards – £500.
HP 75000 VXI Bus Controllers + E1326B-DVM-quantity.
HP 83220A GSM DCS/PCS 1805-1990MC/S convertor for use with 8922A – £2,000.
HP 1630-1631-1650 Logic ANZ's in stock.
HP 8754A Network ANZ 4-1300MC/S + 8502A + cables – £1,500.
HP 8754A Network ANZ H26 4-2600MC/S + 8502A + Cables – £2,000.
HP 8350A Sweeper MF + 83540A PI 2-8.4GHZ + 83545A PI 5.9-12.4GHZ all 3 – £3,500.
HP MICROWAVE TWT AMPLIFIER 489A 1-2GHZ-30DB – £400.
HP PREAMPLIFIER 8447A 0.1-400MC/S – £200. Dual – £300.
HP PREAMPLIFIER 8447D 0.01-1.3GHZ – £400.
HP POWER AMPLIFIER 8447E 0.01-1.3GHZ – £400.
HP PRE + POWER AMPLIFIER 8447F 0.01-1.3GHZ – £500.
HP 3574 Gain-Phase Meter 1HZ-13MC/S OPT 001 Dual – £400.
MARCONI 2305 Modulation Meter-50KHZ-2.3 GHZ – £1,000.
MARCONI 2610 True RMS Meter – £450.
MARCONI 893B AF Power Meter (opt Sinad filter) – £250-£350.
MARCONI 6950-6960B Power Meters + Heads – £400-£900.
MARCONI SIGNAL SOURCE-6055-6056-6057-6058-6059 – FX Range 4-18GHZ– £250-£400.
RACAL 1792 COMMUNICATION RX – £500 early – £1,000 – late model with back lighting and byte test.
RACAL 1772 COMMUNICATION RX – £400-£500.
PLESSEY PR2250 A-G-H COMMUNICATION RX – £500-£900.
TEK MODULE MAINFRAMES – TM501-502-503-504-506-TM5003-5006.
TEK PI 5010-M1 – Prog Multi Interface – £250. FG Prog 20MC/S Function Gen – £400 – S1 Prog Scanner – £250 – DM Prog DMM – £400.
TEK 7000 OSCILLOSCOPE MAINFRAMES – 7603-7623-7633-7834-7854-7904-7904A-7104 – £150-£1,000.
TEK 7000 PI's – 7A11-7A12-7A13-7A18-7A19-7A22-7A24-7A26-7A29-7A42-7B10-7B15-7B53A-7B80-7B85-7B92A-7D15-7D20.
TEK 7000 – 7S11-7S12-7S14-7M11-S1-S2-S3A-S4-S5-S6-S51-S53-S54.
HP POWER SUPPLIES – 6621A-6623A-6624A-6632A-6652A. Qtys available. Also 6000 types £POA.

RADIO COMMUNICATION TEST SETS
BULK PURCHASE ONLY FROM JOHNS RADIO

HP 8920A RF Communication Test Sets – Opts available 001-3-4-5-7-11-12-14-H13-K13. £1,500-£1,750.
HP8920A with opt 002 Spectrum anz plus tracking generator plus opts. 001-3-4-5-11-12-014 available in part includes syn sig generator - digital oscilliscope distortion meter - mod meter - RF power meter etc. £2,500.

SPECIAL OFFERS

MOTOROLA R2600A plus RLN4260A RF Test Set – £1,800.
MARCONI 2955 RF Test Sets-1000MC/S – £1,000 each.
MARCONI 2958 RF Test Sets-1000MC/S – £1,000 each.
MARCONI 2960 RF Test Sets-1000MC/S – £1,250 each.
MARCONI 2955A RF Test Sets-1000MC/S – £1,500 each.
MARCONI 2960A RF Test Sets-1000MC/S – £1,500 each.
ANRITSU MS555A2 Radio Comm Anz-1000MC/S – £750 each.
MARCONI 2019A SYNTHESIZED SIGNAL GENERATORS – 80KC/S-1040MC/S – AM-FM – £400 inc. instruction book – tested.
MARCONI 2022E SYNTHESIZED SIGNAL GENERATOR – 10KC/S-1.01GHZ AM-FM – £500 inc. instruction book – tested.
R&S APN 62 LF Sig Gen 0.1Hz – 260KHz c/w book – £250.

WE KEEP IN STOCK HP and other makes of RF Frequency doublers which when fitted to the RF output socket of a S/Generator doubles the output frequency EG.50-1300MC/S to 50-2600MC/S price from £250 – £450 each.

SPECTRUM ANALYZERS

HP 3580A 5HZ-50KHZ – £750.
HP 3582A Dual 0.2HZ-25.5KHZ – £1,500.
HP 3585A 20HZ-40MC/S – £3,500.
HP 3588A 10HZ-150MC/S – £7,500.
HP 8568A 100HZ-1.5GHZ – £3,500.
HP 8568B 100HZ-1.5GHZ – £4,500.
HP 8590B 9KC/S-1.8GHZ – £4,500.
HP 8569B 10MC/S (0.01-22GHZ) – £3,500.
HP 3581A Signal Analyzer 15HZ-50KHZ – £400.
TEK491 10MC/S-12.4GHZ + 12.4-40GHZ – £500.
TEK492 50KHZ-21GHZ OPT 2 – £2,500.
TEK492P 50KHZ-21GHZ OPT 1-2-3 – £3,500.
TEK492AP 50KHZ-21GHZ OPT 1-2-3 – £4,000.
TEK492BP 50KHZ-21GHZ – £3,000-£4,000.
TEK495 100KHZ-1.8GHZ – £2,000.
HP 8557A 0.01MC/S-350MC/S – £500 + MF180T or 180C – £150 – 182T – £500.
HP 8558B 0.01-1500MC/S – £750 – MF180T or 180C – £150 – 182T – £500.
HP 8559A 0.01-21GHZ – £1,000 – MF180T or 180C – £150 – 182T – £500.
HP 8901A AM FM Modulation ANZ Meter – £800.
HP 8901B AM FM Modulation ANZ Meter – £1,750.
HP 8903A Audio Analyzer – £1,000.
HP 8903B Audio Analyzer – £1,500.
MARCONI 2370 SPECTRUM ANALYZERS – HIGH QUALITY – DIGITAL STORAGE – 30HZ-110MC/S Large qty to clear as received from Gov – all sold as is from pile complete or add £100 for basic testing and adjustment – callers preferred – pick your own from over sixty units – discount on qtys of five.
A EARLY MODEL GREY – horizontal alloy cooling fins – £200.
B LATE MODEL GREY – vertical alloy cooling fins – £300.
C LATE MODEL BROWN – as above (few only) – £500.

OSCILLOSCOPES

TEK 465-465B 100MC/S + 2 probes – £250-£300.
TEK 466 100MC/S storage + 2 probes – £200.
TEK 475-475A 200MC/S-250MC/S + 2 probes – £300-£350.
TEK 2213-2213A-2215-2215A-2224-2225-2235-2236-2245 60-100MC/S – £250-£400.
TEK 2445 4ch 150MC/S + 2 probes – £450.
TEK 2445A 4ch 150MC/S + 2 probes – £600.
TEK 2445B 4ch 150MC/S + 2 probes – £750.
TEK 468 D.S.O. 100MC/S + 2 probes – £500.
TEK 485 350MC/S + 2 probes – £550.
TEK 2465 4ch-300MC/S – £1,150.
TEK 2465A 4ch-350MC/S – £1,550.
TEK 2465ACT 4ch-350MC/S – £1,750.
TEK D.S.O. 2230 -100MC/S + 2 probes – £1,000.
TEK D.S.O. 2430 -150MC/S + 2 probes – £1,250.
TEK D.S.O. 2430A -150MC/S + 2 probes – £1,750.
TEK D.S.O. 2440 -300MC/S + 2 probes – £2,000.
TEK TAS 475-485 -100MC/S-20MC/S-4 ch + 2 probes – £900-£1.1K.
HP1740A – 100MC/S + 2 probes – £250.
HP1741A – 100MC/S storage + 2 probes – £200.
HP1720A – 1722A - 1725A - 275MC/S + 2 probes – £300-£400.
HP1744A – 100MC/S storage - large screen – £250.
HP1745A – 1746A - 100MC/S - large screen – £350.
HP54100A – 1GHz digitizing – £500.
HP54200A – 50MC/S digitizing – £500.
HP54501A – 100MC/S digitizing – £500.
HP54100D – 1GHZ digitizing – £1,000.

MICROWAVE COUNTERS – ALL LED READOUT

EIP 351D Autohet 20Hz-18GHz – £750.
EIP 371 Micro Source Locking – 20Hz-18GHz – £850.
EIP 451 Micro Pulse Counter – 300MC/S-18GHz – £700.
EIP 545 Microwave Frequency Counter – 10Hz-18GHz – £1K.
EIP 548A Microwave Frequency Counter – 10HZ-26.5GHz – £1.5k.
EIP 575 Microwave Source Locking – 10Hz-18GHz – £1.2K.
EIP 588 Microwave Pulse Counter – 300MC/S-26.5GHz – £1.4K.
SD 6054B Micro Counter 20HZ-24GHZ – SMA Socket – £800.
SD 6054B Micro Counter 20HZ-18GHZ – N Socket – £700.
SD 6054D Micro Counter 800MC/S-18GHz – £600.
SD 6246A Micro Counter 20Hz-26GHz – £1.2K.
SD 6244A Micro Counter 20Hz-4.5GHz – £400.
HP5352B Micro Counter OPT 010-005-46GHz – new in box – £5k.
HP5340A Micro Counter 10HZ-18GHz – Nixey – £500.
HP5342A Micro Counter 10HZ-18-24GHz – £800-£1K – OPTS 001-002-003-005-011 available.
HP5342A + 5344S Source Synchronizer – £1.5K.
HP5345A 500MC/S 11 Digit LED Readout – £400.
HP5345A + 5354A Plugin – 4GHz – £700.
HP5345A + 5355A Plugin with 5356A 18GHz Head – £1K.
HP5385A 1GHz 5386A-5386A 3GHz Counter – £1K-£2K.
Racal/Dana Counter 1991-160MC/S – £200.
Racal/Dana Counter 1992-1.3GHz – £600.
Racal/Dana Counter 9921-3GHz – £350.

SIGNAL GENERATORS

HP8640A – AM-FM 0.5-512-1024MC/S – £200-£400.
HP8640B – Phase locked – AM-FM-0.5-512-1024MC/S – £500-£1.2K. Opts 1-2-3 available.
HP8654A – B AM-FM 10MC/S-520MC/S – £300.
HP8656A SYN AM-FM 0.1-990MC/S – £900.
HP8656B SYN AM-FM 0.1-990MC/S – £1.5K.
HP8657A SYN AM-FM 0.1-1040MC/S – £2K.
HP8657B SYN AM-FM 0.1-2060MC/S – £3K.
HP8660C SYN AM-FM-PM-0.01-1300MC/S-2600MC/S – £2K.
HP8660D SYN AM-FM-PM-0.01-1300MC/S-2600MC/S – £3K.
HP8673D SYN AM-FM-PM-0.01-26.5 GHz – £12K.
HP3312A Function Generator AM-FM 13MC/S-Dual – £300.
HP3314A Function Generator AM-FM-VCO-20MC/S – £600.
HP3325A SYN Function Generator 21MC/S – £800.
HP3325B SYN Function Generator 21MC/S – £2K.
HP8673-B SYN AM-FM-PH 2-26.5 GHz – £6.5K.
HP3326A SYN 2CH Function Generator 13MC/S-IEEE – £1.4K.
HP3336A-B-C SYN Func/Level Gen 21MC/S – £400-£300-£500.
Racal/Dana 9081 SYN S/G AM-FM-PH-5-520MC/S – £300.
Racal/Dana 9082 SYN S/G AM-FM-PH-1.5-520MC/S – £400.
Racal/Dana 9084 SYN S/G AM-FM-PH-.001-104MC/S – £300.
Racal/Dana 9087 SYN S/G AM-FM-PH-.001-1300MC/S – £1K.
Marconi TF2008 AM-FM-Sweep 10KC/S-510MC/S – £200 Fully Tested to £300, as new + book + probe kit in wooden box.
Marconi TF2015 AM-FM-10-520MC/S – £100.
Marconi TF2016A AM-FM 10KC/S-120MC/S – £100.
Marconi TF2171/3 Digital Synchronizer for 2015/2016A – £50.
Marconi TF2018A AM-FM SYN 80KC/S-520MC/S – £500.
Marconi TF2019A AM-FM SYN 80KC/S-1040MC/S – £650-£1K.
Marconi TF2022E AM-FM SYN 10KC/S-1.01GHz – £1K-£1.2K.
R & S SMPD AM-FM-PH 5KHz-2720MC/S – £3K.
Anritsu MG3601A SYN AM-FM 0.1-1040MC/S – £1.2K.

ITEMS BOUGHT FROM HM GOVERNMENT BEING SURPLUS. PRICE IS EX WORKS. SAE FOR ENQUIRIES. PHONE FOR APPOINTMENT OR FOR DEMONSTRATION OF ANY ITEMS, AVAILABILITY OR PRICE CHANGE. VAT AND CARRIAGE EXTRA. ITEMS MARKED TESTED HAVE 30 DAY WARRANTY. WANTED: TEST EQUIPMENT-VALVES-PLUGS AND SOCKETS-SYNCROS-TRANSMITTING AND RECEIVING EQUIPMENT ETC.

Johns Radio, Whitehall Works, 84 Whitehall Road East, Birkenshaw, Bradford BD11 2ER. Tel: (01274) 684007. Fax: 651160

CIRCLE NO. 108 ON REPLY CARD

CIRCUIT IDEAS

Winner of the second National Instruments digital multimeter worth over £500

'A' scope target tracking

In radar and sonar applications, the A scope display – received signal vertically versus range horizontally – is popular.

Range *R* is given by $R=c\times\Delta t/2$, where Δt is the time from the transmitted pulse to the reception of the echo, and c is the speed of light. **Fig. 1**. A target tracking system can follow a given target, providing range information continuously. **Figure 2** shows a circuit to perform this function.

Two monostable multivibrators M_2 and M_3 of Fig. 2 produce adjacent time slots, the early gate and late gate. **Fig. 3.** The target echo blip on the CRT display is sampled by these gates, each of width $\tau/2$.

If the areas of the portions of the echo in each gate are equal, then the position of the gates – i.e. the delay Δt relative to the 'tr' pulse, **Fig. 4** – indicates the range.

Monostable device M_1 is triggered by the tr pulse, its delay being determined by its timing components. These include an FET, controlled by feedback from the SUM amplifier.

Analogue switch SG_1 gates the received echo to SG_2 and SG_3. The area of the echo under the early and late gates is thus integrated by I_1 and I_2 respectively.

The inverted early gate output is summed with the late gate output, the result controlling the period of M_1, waveform b) of Figure 4.

Integrators I_1 and I_2 are reset by the transmit pulse tr each sweep, so that the SUM output is always updated to correspond to the current position.

Tracking is initiated by setting switch SW to A, applying a fixed voltage V_1 to the gate of the FET. Potentiometer PR is adjusted to centre the bright-up cursor, g) of Fig. 4, on the selected target, and SW returned to position B. The output of OR_2, f), gives the range in PWM form, and the negative edge detect NED output, g), in PPM form.

K. Balasubramanian
European University of Lefke, Turkish Republic of Northern Cyprus
D96

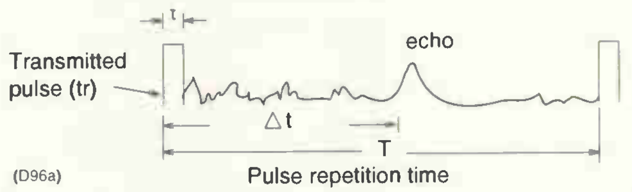


Fig. 1. Echo delay Δt gives the target range.

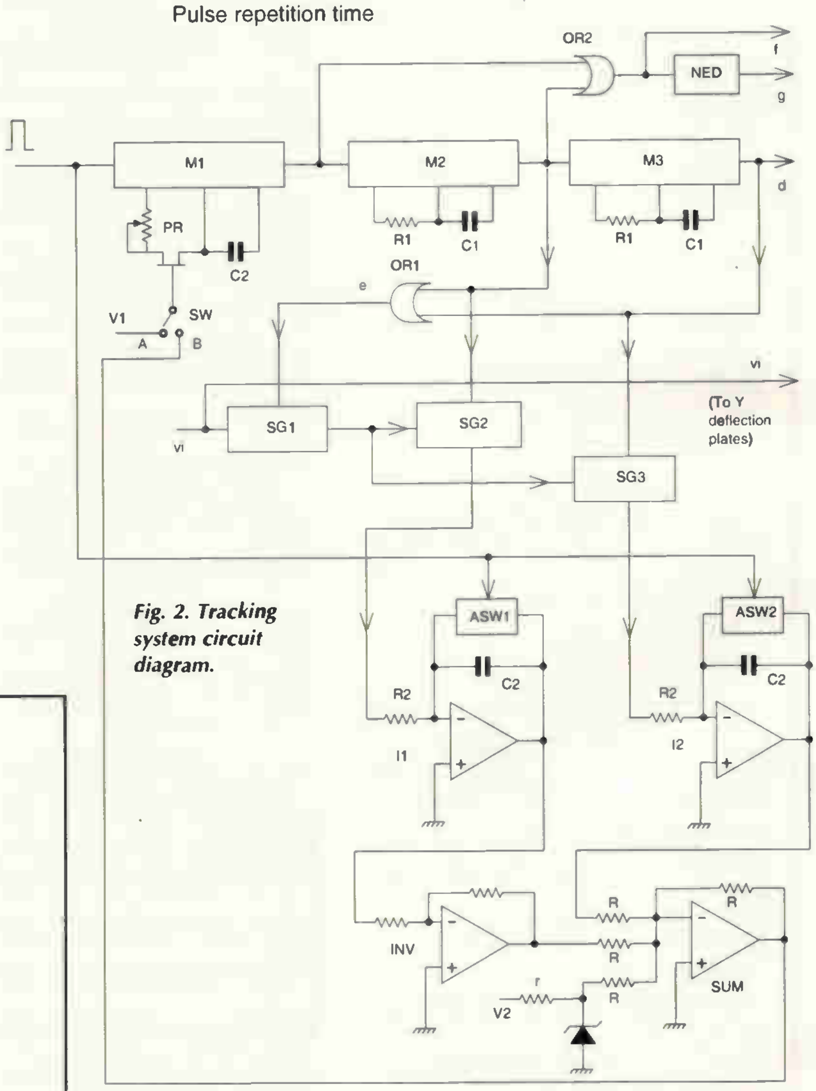


Fig. 2. Tracking system circuit diagram.

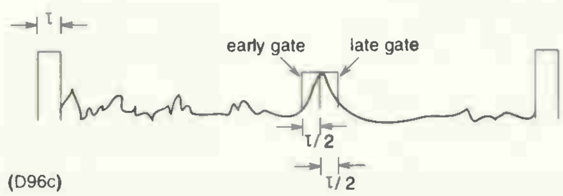


Fig. 3. Showing gates centred on target return.

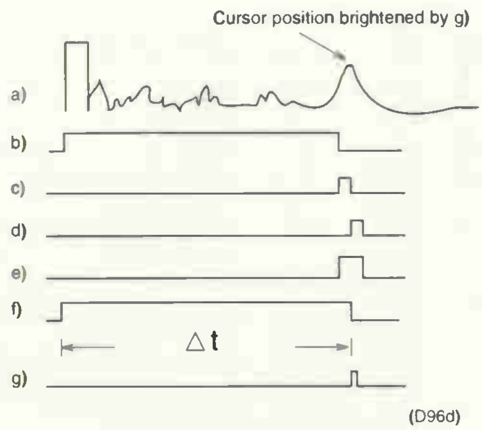


Fig. 4
a). 'A' scope trace
b) M_1 output
c) M_2 (early gate)
d) M_3 (late gate)
e) OR_1 output
f) OR_2 output (PWM range)
g) NED output (PPM range)

National Instruments sponsors Circuit Ideas

Over the next 12 months, National Instruments is awarding over £3500 worth of equipment for the best circuit ideas.

Once every two months for the next year, National Instruments is awarding an NI4050 digital multimeter worth over £500 each for the best circuit idea published over each two-month period. At the end of the 12 months, National is awarding a LabVIEW package worth over £700 to the best circuit idea of the year.* The first winner, selected from this issue or the following one, will be announced next month.

NI4050

The NI 4050 is a full-feature digital multimeter (DMM) for hand-held and notebook computers with a Type II PC Card (PCMCIA) slot. The NI 4050 features accurate $5^1/_2$ digit DC voltage, true-rms AC voltage, and resistance (ohms) measurements. Its size, weight, and low power consumption make it ideal for portable measurements and data logging with hand-held and notebook computers.

- DC Measurements: 20mV to 250V DC; 20mA to 10A
- AC Measurements: 20mV rms to 250V rms; 20mA rms to 10A rms;
- True rms, 20Hz to 25kHz
- Up to 60 readings/s
- UL Listed
- $5^1/_2$ Digit Multimeter for PCMCIA

About National Instruments

National Instruments offers hundreds of software and hardware products for data acquisition and control, data analysis, and presentation. By utilising industry-standard computers, our virtual instrument products empower users in a wide variety of industries to easily automate their test, measurement, and industrial processes at a fraction of the cost of traditional approaches.

Software

Our company is best known for our innovative software products. The National Instruments charter is to offer a software solution for every application, ranging from very simple to very sophisticated. We also span the needs of users, from advanced research to development, production, and service. Our flagship LabVIEW product, with its revolutionary, patented graphical programming technology, continues to be an industry leader. Additional software products, such as LabWindows/CVI, ComponentWorks, Measure and VirtualBench, are chosen by users who prefer C programming, Visual Basic, Excel spreadsheets, and no programming at all, respectively.

Hardware

Our software products are complemented by our broad selection of hardware to connect computers to real-world signals and devices. We manufacture data acquisition hardware for portable, notebook, desktop, and industrial computers. These products, when combined with our software, can directly replace a wide variety of traditional instruments at a fraction of the cost. In 1996 we expanded our high-performance E Series product line in PCI, ISA and PCMCIA form factors, shipped our first VXI data acquisition products, and added remote (long-distance) capabilities to our SCXI signal conditioning and data acquisition product line.

Our virtual instrumentation vision keeps us at the forefront of computer and instrumentation technology. National Instruments staff works actively with industry to promote international technological standards such as IEEE 488, PCMCIA, PCI, VXI plug&play, Windows 95/NT, and the Internet. More importantly, we integrate these technologies into innovative new products for our users.

*All published circuit ideas that are not eligible for the prizes detailed here will earn their authors a minimum of £35 and up to £100. The first NI4050 will be awarded next month for the best idea from the December or January issue.

LabVIEW

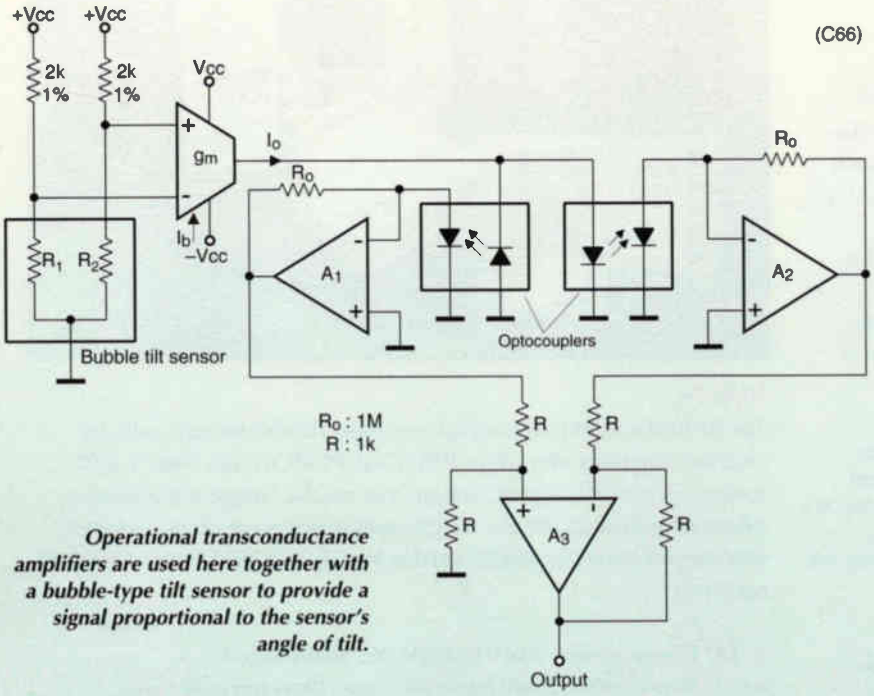
LabVIEW is a highly productive graphical programming environment that combines easy-to-use graphical development with the flexibility of a powerful programming language. It offers an intuitive environment, tightly integrated with measurement hardware, for engineers and scientists to quickly produce solutions for data acquisition, data analysis, and data presentation.

- Graphical programming development environment
- Rapid application development
- Seamless integration with DAQ, GPIB, RS-232, and VXI
- Full, open network connectivity
- Built-in display and file I/O

National Instruments – computer-based measurement and automation

National Instruments, 21 Kingfisher Court, Hambridge Road, Newbury, Berkshire, RG14 5SJ. Tel (01635 523545), Fax (01635) 524395 info.uk@ni.com www.ni.com.

Photoelectric tilt sensor



Operational transconductance amplifiers are used here together with a bubble-type tilt sensor to provide a signal proportional to the sensor's angle of tilt.

Angle of tilt information is extracted from an electrolytic tilt sensor in this circuit. The sensor is connected in a Wheatstone bridge arrangement so that the tilt angle and direction is sensed due to the varying resistances R_1 and R_2.

Differential output of the bridge connects to an operational transconductance amplifier. The magnitude of the transconductance amplifier's output current is determined by the transconductance $g_m=I_b/2V_T$, where I_b is the auxiliary bias current and V_T is the thermal voltage.

Magnitude and direction of the output current depends on R_1 and R_2 and thus flows in the LED of one or other optocoupler. Transconductance of A_1 or A_2, and hence resultant output voltage, is determined by the value of R_0, typically 1MΩ or more.

Outputs of A_1 and A_2 are applied to A_3, connected as a differential amplifier, thus rejecting any common mode errors due to temperature effects on the photodiodes or other causes. The output of A_3 represents the wanted direction and angle of tilt.

Current I_b can be manipulated to alter the angle-to-voltage scaling factor.

M Abuelma'atti
Dahran
Saudi Arabia
C66

Telephone light switch

This circuit switches on an electric light in the vicinity of a telephone when it rings, if natural light is insufficient. It is built around two monostables, $IC_{1a,b}$, R_1, C_1; $IC_{1c,d}$, R_2 and C_2.

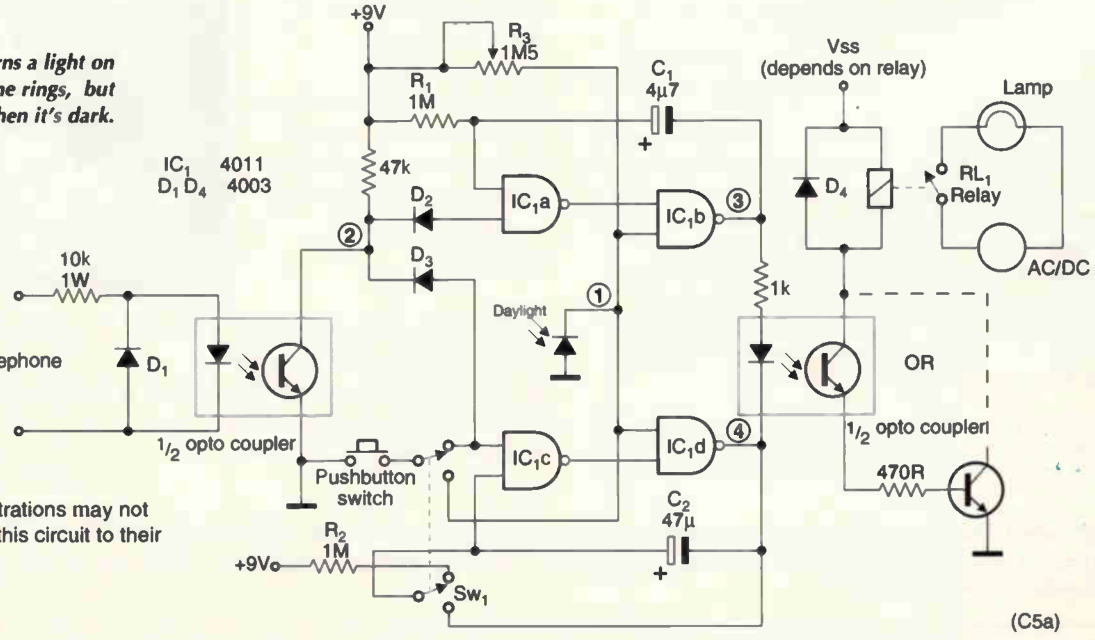
When the telephone rings, voltage at point 2 falls, triggering both monostables, assuming the photodiode has not pulled point 1 low. The period of monostable 2, waveform 4, is longer than that of monostable 1, waveform 3.

During the period when waveform 4 is low but waveform 3 has returned high, the second optocoupler is activated and the lamp is on.

The period for which the lamp is lit can be extended via the push-button switch. Assuming Sw_1 is in its 'up' position, setting Sw_1 to 'down' lights the light continuously, but it can be extinguished by pressing the push-button.

Vasiliy Borodai
Zaporozhje
Ukraine
C5a

This circuit turns a light on when the phone rings, but only when it's dark.



Some telephone administrations may not permit the connection of this circuit to their lines. Ed.

Low noise solid-state relay

In most commercial solid-state relays, zero crossing detection is by a standard opto-coupled triac. The 'zero point' thus sensed is somewhere between 20 and 35 volts, and the load waveform is therefore distorted, resulting in harmonics.

These harmonics can cause EMC problems of about 120dB at 100kHz, requiring filtering. This is bulky, and not always effective in reaching the required specification.

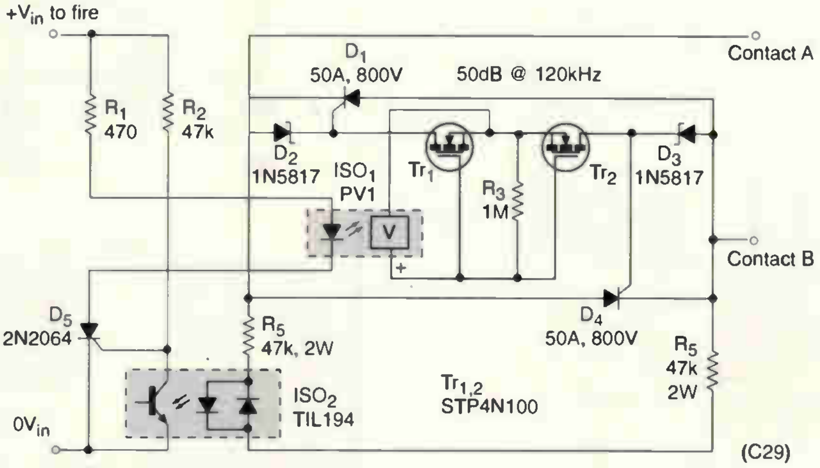
Shown is an improved solid-state relay. A thyristor requires about 0.8V cathode to gate bias before latching on, and here, this is bypassed by a low forward conduction Schottky diode.

Zero crossing detection is by an optocoupler and a pilot thyristor. When the voltage across ISO_2 falls to too low a level to maintain current in the LED, the opto transistor turns off. Thus, assuming $+V_{in}$ has been asserted to turn on the relay, pilot triac D_5 turns on, and current flows in the photovoltaic coupler ISO_1. This produces a high enough voltage to turn on the source coupled FETs Tr_1 and Tr_2.

In this configuration, both FETs are conducting, one in the forward direction and the other in the reverse, not as might be supposed via the body diode. The total $R_{ds(on)}$ is about 7Ω, and the thyristor turns on at some 30mA gate current. Up to this point, current flows in parallel with the thyristor, via the FETs and the Schottky diode, reducing harmonic distortion and the consequent RFI/EMC to the 50dB level.

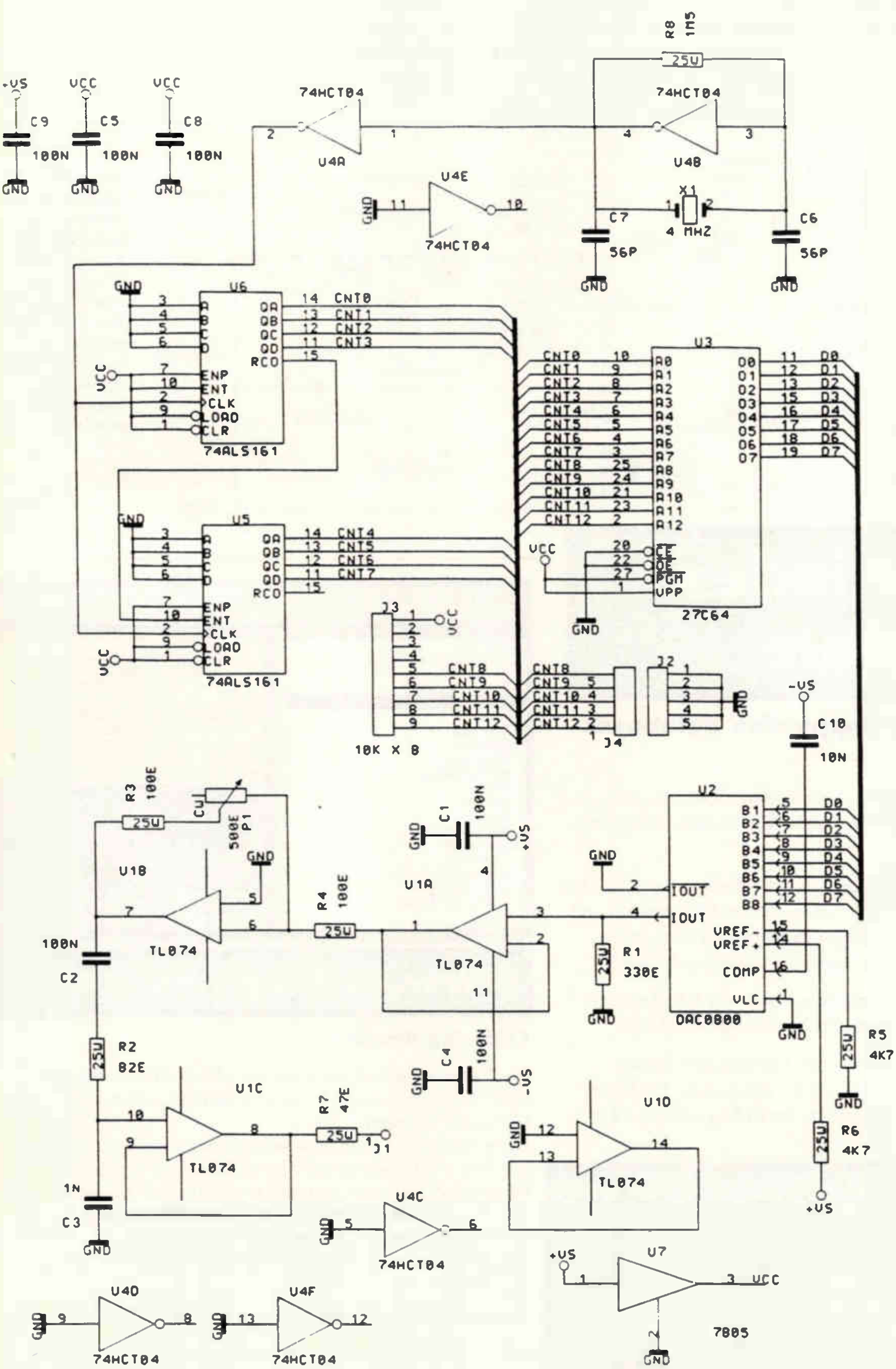
Removing the control signal $+V_{in}$ causes the FETs, and hence the thyristors, to turn off. Due to the storage time in the FETs, this in fact takes about one to one and a half cycles.

Colin Wonfor
Dumfermline
Scotland
C29



Relays that incorporate zero-crossing switching don't actually switch at zero volts, resulting in EMI. This alternative switches at much nearer 0V, significantly reducing EMC problems.

A low-cost function generator



A simple flexible function generator can be built using a single EPROM, a standard d-to-a converter and a counter. The principle is based on direct digital synthesis, or DDS, where the digital samples of the required function are stored in a memory, an EPROM for example, and read out in a cyclic manner.

The digital samples are spaced in time by the memory clock frequency period *T*. The digitised signal is converted to the analogue domain by the d-to-a converter and a low-pass filter selects the base-band signal (the first Nyquist window, from 0 to *Fs*/2, where *Fs*=*T*/2).

Most commercially available DDS chips have a sinewave output, the output frequency being set by the user clock. By using an EPROM, you can build whatever signal you want, as long as the signal is cyclic. To avoid distortion, the first sample and the last sample should be the same, so that as the sequence repeats, there is no discontinuity in the output.

The setup as shown on the schematic will generate the required sequence, between frequency limits of 16kHz and 500kHz. Four-bit counters U_5 and U_6 form the 8-bit count word, which generates addresses for the memory EPROM, U_3, together with the 8-bit d-to-a converter for the analogue conversion.

An inverter generates the 4MHz clock for the counter. The address range of the 8-bit wide EPROM is 256 samples per stored waveform. The sample frequency of the signal is the frequency of the CNT0 signal, being 2MHz (LSB of the counter).

There are five jumpers allowing selection of 32 different sequences of 256 samples in the EPROM. To select the first bank, bank0, all five jumpers should be present, as each address pin from CNT8 to CNT12 is pulled-up with a 10k resistor.

The d-to-a converter is a standard DAC0800, where the reference resistor R_6 sets the reference current to 2.55mA. Full-scale output-current of the converter is therefore (255/256)×I_{ref}. Resistor R_1 sets the full-scale voltage at 840mV and P_1 allows the gain to be adjusted between 1 and 6.

Components R_2 and C_3 set the low-pass filter cut-off frequency at 2MHz. Output impedance of U_1 is 50Ω, suitable to drive coaxial lines. Voltage V_s is 12V and V_{CC} is +5V.

Contents of the EPROM are generated with a simple C program, as per the listing. As shown, this generates 32 sequences. The source code, executables and EPROM content are freely available at apollonia@skynet.be.

Further extensions are possible. Two EPROMs and further address counters can be added to provide 16-bit resolution. The EPROM may be replaced by a RAM, loaded via buffering from a PC parallel or serial port. Higher clock frequencies can then be used, and a programmable function generator implemented.

By using a larger counter and addressing more address lines of the EPROM, longer sequences can be generated. For these extensions, the C code for the mapping of the sequence samples in the EPROM needs to be changed accordingly.

Martin Van De Weghe
9620 Zottegem
Belgium
E3

Listing in C for the PC-controlled function generator.

```
*/ An array of 256 samples is used to generate the
sequence. In total, 32 sequences can be defined to be
stored in the EPROM. The format of the EPROM is absolute
binary and the first samples should start on address 0.
Two functions are shown to make ramps (make_ramp) and to
make sines (make_sine)
*/
#include <math.h>
#include <stdio.h>
#include <conio.h>
#define samples 255
#define pi 3.1415
void output_to_new_file (unsigned char *signal, char
*Filename)
{
    FILE *outstream;
    int i;
    if ((outstream = fopen(FileName,"wb")) == NULL)
    {
        printf("\nThe outputfile could not be opened");
    {
    else
    {
        printf("\n");
        for (i=0;i<=samples;i++)
        {
            if ((signal[i]>=0) & (signal[i]<=255))
            {
                fputc(signal[i], outstream);
            }
            else
            {
                printf("Data exceeds range [O..255] !!");
                fputc(255,outstream);
            };
        };
        fclose (outstream);
    };
};
void append_to_file ( unsigned char *signal, char
*FileName)
{
    FILE *outstream;
    int i;
    if ((outstream = fopen(FileName,"ab")) == NULL)
    {
        printf("\nThe outputfile could not be opened");
    }
    else
    {
        printf("\n");
        for (i=0;i<=samples;i++)
        {
            if ((signal[i]>=0) & (signal[i]<=255))
            {
                fputc(signal[i], outstream);
            }
            else
            {
                printf("Data exceeds range [0..255] !!");
                fputc(255, outstream);
            };
        };
        fclose (outstream);
    };
};
void make_ramp ( unsigned char *signal, unsigned char
factor)
/* Variable factor determines No of ramps per sequence:
the more 'ramps', the steeper they are.
*/
{
    int i,j;
    for (i=1;I<=factor;i++)
    {
        for (j=(i-1)*(256/factor);j<=(i*(256/factor))-1;j++
        {
            signal [j]=j*factor;
        };
    };
};
void make_sine ( unsigned char *signal, unsigned char
factor)
/* Here the variable factor determines the sine frequency
= (4MHz*factor)/256.
*/
{
    int i,j;
    double x;

    for (i=1;i<=factor;i++)
    {
        for (j=(i-1)*(256/factor);j<=(i*(256/factor))-1;j++)
        {
            x = 127*sin(2*pi*j*factor256);
            signal[j]=(unsigned char)(x+128);
        };
    };
};
void main()
{
    unsigned char signal [samples];
    /* Four ramps */
    make_ramp(signal,1);
    output_to_new_file(signal, "test.abs"
    make_ramp(signal,2);
    append_to_file(signal, "test.abs");
    make_ramp(signal,3);
    append_to_file(signal, "test.abs);
    make_ramp(signal,4);
    append_to_file(signal, "test.abs");
    /* Four sines */
    make_sine(signal,1);
    append_to_file(signal, "test.abs");
    make_sine(signal,2);
    append_to_file(signal, "test.abs");
    make_sine(signal,3);
    append_to_file(signal, "test.abs");
    make_sine(signal,4);
    append_to_file(signal, "test.abs");
    make_sine(signal,5);
    append_to_file(signal, "test.abs");
    make_sine(signal,6);
    append_to_file(signal, "test.abs");
    make_sine(signal,7);
    append_to_file(signal, "test.abs");
    make_sine(signal,8)
    append_to_file(signal, "test.abs");
```

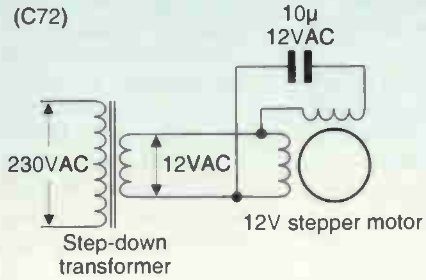
Simple fixed-speed stepper motor driver

In some applications where position control is not required, this inexpensive stepper motor drive arrangement may be used. The micro-stepper drive motor is driven by sine and cosine waveforms, using a step-down transformer and a capacitor. The capacitor generates the phase-shifted cosine wave.

The limitation is that the motor speed is fixed at synchronous speed, given by 120f/p , where *p* is the number of poles and *f* the mains (line) frequency.

Vikas Meshram
Indore
India
C72

(C72)



Note: stepper motor should be of permanent magnet type

If you need a fixed rotational speed but have only a stepping motor, this simple sine/cosine drive may be the answer.

h_{FE} tester uses no meter

This is a test set for measuring the h_{FE} of transistors, either n-p-n or p-n-p. It is completely self contained and very low cost, as it does not use a meter. The arrangement is an improved version of a scheme published some years ago.[1]

Base current bias for the transistor is supplied from its own collector circuit. The base current therefore flows through the collector resistor R_c, and thence via base resistor R_b (RV_1) and another resistor of value equal to R_c.

Op-amp IC_{1a} produces a buffered reference voltage equal to the transistor's base voltage. Thus the non-inverting input of IC_{1b} is held at a potential midway between base voltage of the transistor under test and the supply rail.

Potentiometer RV_1 is adjusted so that the voltage across its collector resistor R_c is equal to its collector-base voltage. This condition is indicated by one LED just extinguishing and the other lighting. The change-over point is clearly marked, as IC_{1b} is operated open loop, without any negative feedback.

When this condition applies, the collector current I_c and the base current I_b are related as follows.

$$V_{load}=V_{cb}$$

so,

$$R_c(I_b+I_c)=(R_b+R_c)I_b$$

The term R_cI_b appears on both sides of the equation and therefore cancels out, leaving the relationship,

$$R_cI_c=R_bI_b$$

from which,

$$h_{FE}=I_c/I_b=R_b/R_c.$$

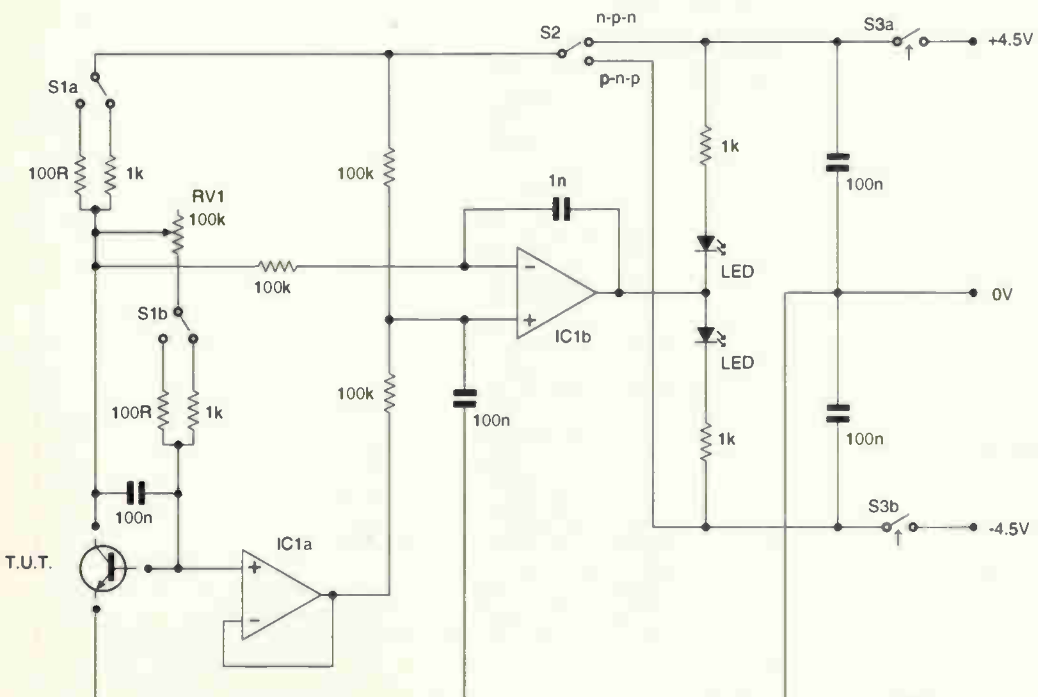
A pointer knob on the 100kΩ potentiometer RV_1 is used to indicate the resistance setting, which is marked directly on the panel of the instrument. Two h_{FE} ranges are provided. If S_1 is used to select R_c=100Ω, then RV_1 provides a range of h_{FE} readings up to 1000, while with the 1kΩ collector load selected, values up to h_{FE}=100 are indicated.

For IC_1, a BicMOS or CMOS type should be used, with negligible bias current I_{bo}. A TL082 proved satisfactory, although a more modern type designed for ±5V supplies would be even better.

Switch S_2 permits either n-p-n or p-n-p devices to be tested. Note that when testing an n-p-n transistor, as in the diagram, if the setting of RV_1 is too *high* the *upper* LED will be lit, or the lower LED if the setting is too low. When testing a p-n-p device, the situation is reversed.

The tester is designed to be powered from two 4.5V flashlamp batteries, type 703 or 1289, IEC designation 3R12. Assuming a biased toggle is used as indicated at S_3, to prevent the instrument being accidentally left switched on, the batteries should last almost indefinitely.

Ian March
Waterlooville
Hampshire
E2



(E2)

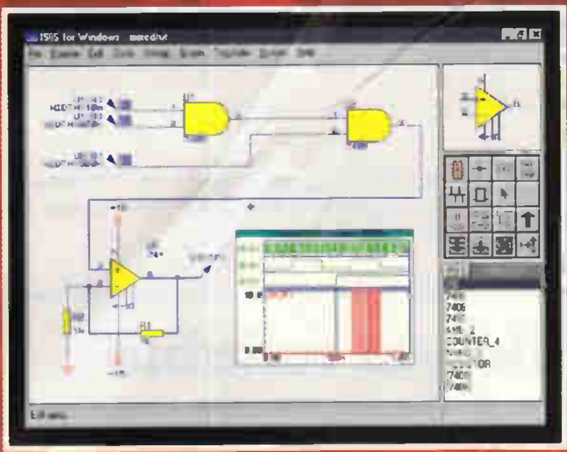
Ref. 1. 'Novel direct reading h_{FE} Tester,' *Electronic Engineering*, April 1988, page 28.

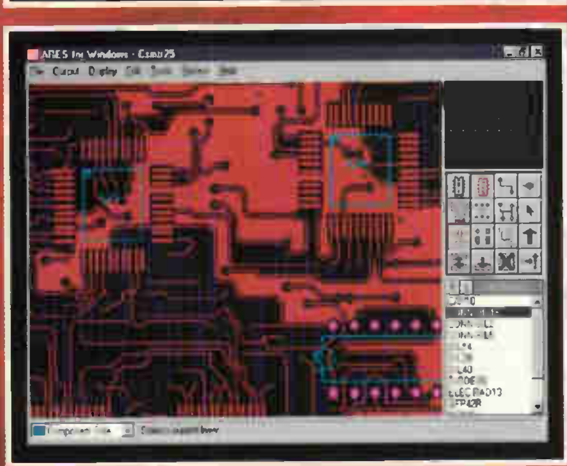
PROTEUS

including NEW SIMULATOR

PRO SPICE 3F5

NEW
NOW WITH
Interactive Circuit
Animation





Simulation

- Berkeley SPICE3F5 analogue simulation kernel.
- True mixed mode simulation.
- New analysis types include multi-plot sweeps, transfer curves, distortion and impedance plots.
- Active Components: Switches, Pots etc.
- Over 1000 new library parts with SPICE models.
- Greater ease of use.

"a constant high level of capability throughout"
EWW CAD Review Round Up September 1998

Schematic Capture

- Produces attractive schematics like in the magazines.
- Netlist, Parts List & ERC reports.
- Hierarchical Design.
- Full support for buses including bus pins.
- Extensive component/model libraries.
- Advanced Property Management.
- Seamless integration with simulation and PCB design.

PCB Design

- Automatic Component Placement.
- Rip-Up & Retry Autorouter with tidy pass.
- Pinswap/Gateswap Optimizer & Back-Annotation.
- 32 bit high resolution database.
- Full DRC and Connectivity Checking.
- Shape based gridless power planes.
- Gerber and DXF Import capability.

SHAREWARE VERSIONS
NOW WITH INTERACTIVE CIRCUIT ANIMATION
DOWNLOAD YOUR COPY NOW
http://www.labcenter.co.uk

"the BEST all-round PROGRAM"
EWW CAD Review Round Up September 1998

Available in 5 levels - prices from £295 to £1625 + VAT.
Call now for further information & upgrade prices.

labcenter
Electronics

Write, phone or fax for your free demo disk, or ask about our full evaluation kit.
Tel: 01756 753440. Fax: 01756 752857. EMAIL: info@labcenter.co.uk
53-55 Main St, Grassington. BD23 5AA. WWW: http://www.labcenter.co.uk

Fully interactive demo versions available for download from our WWW site.
Call for educational, multi-user and dealer pricing - new dealers always wanted.
Prices exclude VAT and delivery. All manufacturer's trademarks acknowledged.

Isolated power-on switch

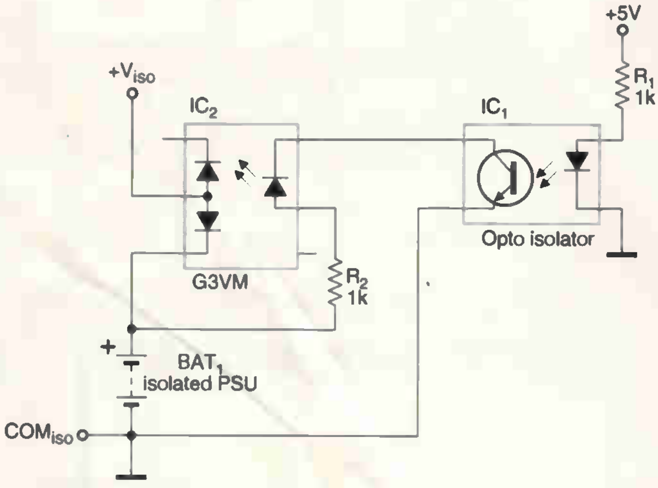
This circuit was developed to switch on an isolation amplifier when the unit's serial interface supply was turned on.

Due to mounting problems associated with the unit's enclosure, the use of two separated switches was ruled out. The solution was to use a photo-relay connected in series with the isolation amplifier's battery.

Current for the photo-relay's LED is formed by the I_{ce} current of an optoisolator transistor. The optoisolator's LED is supplied from the serial interface power supply. Thus when the serial interface supply is turned on, the isolation amplifier is powered up.

In the power-off state, the optoisolator current drawn from the isolation battery power supply is very small, and only a few milliamps in the powered state.

W. Maggs
Bedminster Down
Bristol, U.K.
C73



Designed to power up an isolation amplifier when the +5V supply powering a serial interface is sensed, this circuit consumes very little battery power when in the 'off' state.

Capacitive keypad is simple yet reliable

A simple and reliable keypad – or switch – sensor can be made using the propagation delay and high input impedance of the CMOS digital family.

This circuit uses four 4011 NAND gates and an octal D-type flip-flop designated 74HC374. Two of the gates operate as a clock oscillator, while the other two provide a clock to the octal D-type flip-flop, delayed by the time T, see the timing diagram.

When a finger is placed on a touch plate, the increase in its effective capacitance is sufficient to delay the rising edge at the corresponding D input, so that a logic 'one' is latched, instead of a logic 'zero'.

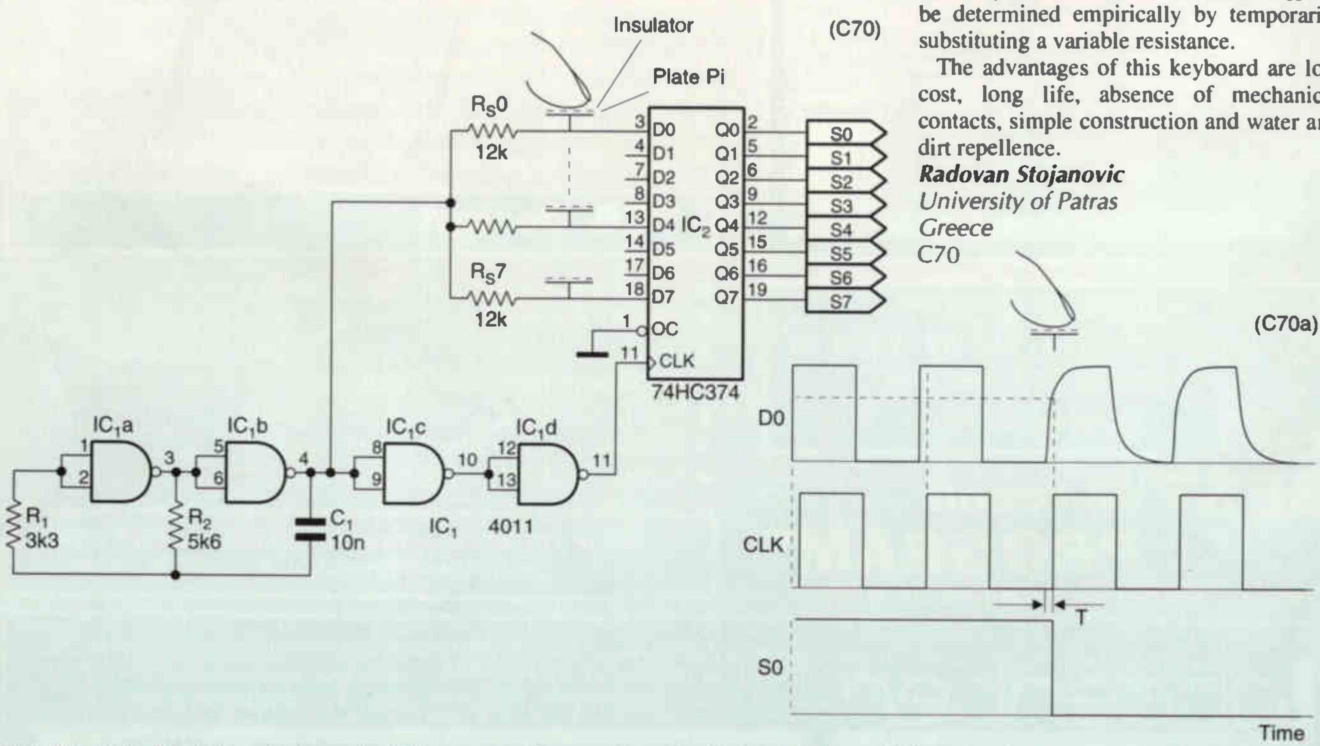
Value of resistors $R_{s0\text{-}7}$ are given by the inequality,

$$R_{s0} \times C \ln \frac{V_{cc}}{V_{cc} - V_{IL(\max)}} \geq T_{\max}$$

where C is the total capacitance associated with each D input with finger present, $V_{IL(\max)}$ the maximum input low voltage and $T_{\max}$ the maximum delay between the D and clock signals. The minimum value of R_{s0} can be determined empirically by temporarily substituting a variable resistance.

The advantages of this keyboard are low cost, long life, absence of mechanical contacts, simple construction and water and dirt repellence.

Radovan Stojanovic
University of Patras
Greece
C70



Touch keypad with eight contacts works off finger capacitance and needs only two ICs to provide logic-level output.

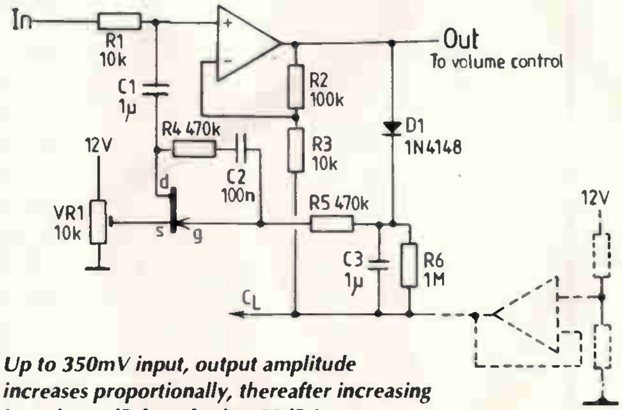
Automatic gain control for audio

This audio AGC circuit is an improved version requiring only one op-amp. With inputs increasing up to 350mV, the output rises pro rata, increasing up to 1.5V. With larger inputs, increasing by up to a further 30dB, the output increases by less than 0.5dB.

Sensitivity may be increased by reducing R_3. When R_3 equals 5.6kΩ, limiting commences at 125mV. Components R_4 and C_2 prevent audio distortion when in limiting.

The prototype used an MEF103 FET, adjust preset VR_1 allowing for device selection tolerance. For single-rail applications, the centre-rail generator, shown dotted, may be used. R_2/R_3 sets the small signal gain.

John Hey G3TDZ
Leeds
E1



Up to 350mV input, output amplitude increases proportionally, thereafter increasing by only 0.5dB for a further 30dB input.

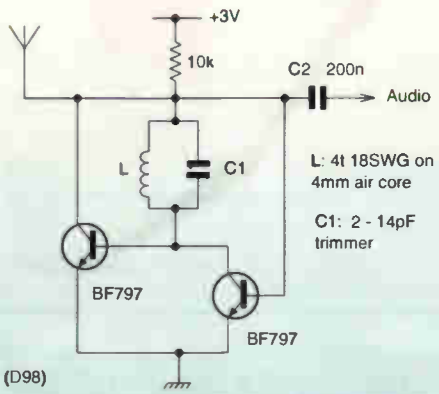
Simple FM broadcast receiver

This simple FM radio receiver uses only two transistors. They function as a low power oscillator, the frequency being determined by L and C_1.

When the frequency of oscillation is the same as that of the wanted signal, the recovered audio is available at the output. The audio signal is dc blocked by C_2 and fed to an audio amplifier.

Rajik Gorland
(address not supplied)
D98

This synchronised oscillator recovers the audio from a broadcast FM station.



(D98)

Simple glass-fibre receiver monitors laser pulses

The circuit shown uses a low-cost multimode glass fibre and receiver to monitor the shape of pulses from a copper vapour laser. The laser gives optical pulses of approximately 45ns FWHM and at 510nm and 578nm wavelength.

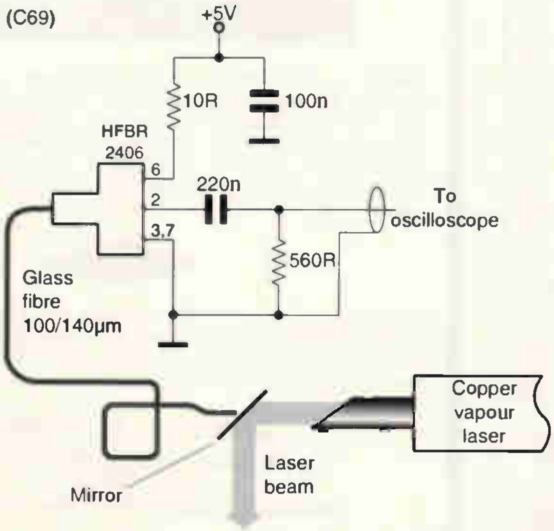
The set-up uses an HP HFBR2406 receiver, mounted near an oscilloscope and coupled to a 100/140µm multimode glass fibre. Both the HFBR2406 and the fibre are low-cost components.

The other end of the fibre intercepts part of the beam, or, such is the sensitivity of the receiver, can even work on stray reflected laser light. Working on a single 5V supply, the circuit is much cheaper and less cumbersome than the standard set-up, which requires a biplanar diode and associated high-voltage power supply.

In the second diagram, pulses from the laser are shown, monitored on a Tektronix TDS540 oscilloscope. The set-up can be used to monitor pulses from other lasers – particularly in the visible band.

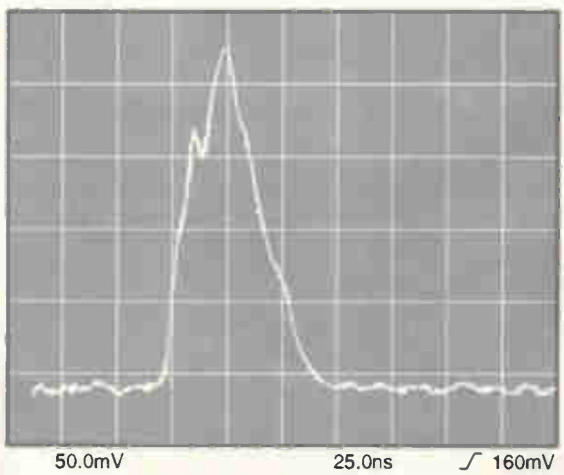
S. V. Nahke
Indore 452013
India, C69

(C69)



Monitoring pulses from a copper vapour laser normally needs a biplanar diode and high-voltage power supply. This alternative is cheaper and simpler.

(C69a)

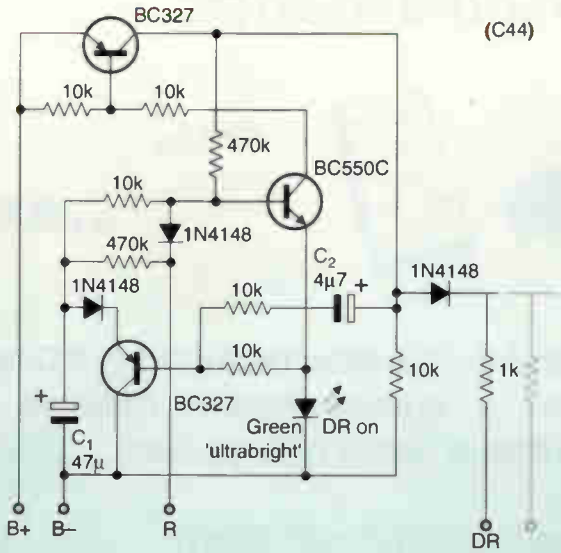


Car stereo protection unit

With customised in-car entertainment component systems, it is essential that loudspeaker thumping at switch-on is prevented by activating the power amplifiers after all other equipment has stabilised. This circuit provides:

- a latching delayed DR output five seconds after the normal R line goes high (for a 2.5 second delay, change C_1 to 22μF);
- an R 'off' causes an immediate DR 'off';
- with R 'on' but a sudden B+ drop that exceeds 2V (engine starting or overloaded battery cell), C_1 is immediately discharged via the C_2 circuit, and DR resets cutting the audio for five seconds.

Graham Maynard,
Newtownabbey
N. Ireland
C44



This gating provides two signals, D and DR, which make sure that in-car power amplifiers don't suffer from power surges.

PC control of a DC motor

This circuit, in conjunction with a PC, controls the speed and direction of rotation of a DC electric motor, via the PC's parallel port LPT1. It uses bridge connected complementary transistors with freewheeling diodes. Controlling the bridge are two 2SC1483 transistors, which interface with the parallel port of the PC at address 378_{16}.

Data bits D_0 and D_1, on pins 2 and 3 of the parallel port are used to drive the bridge circuit. Pin 25 of the parallel port is connected to the 0V ground of the bridge power supply. The simple QuickBasic program runs the DC motor at any speed in either direction.

A data 0 on bit D_0 and a 1 on D_1 switch transistors Tr_1 and Tr_3 'on', resulting in current flow through the motor in one direction. A data 1 on bit D_0 and a 0 on D_1 switch transistors Tr_2 and Tr_4 'on', resulting in current flow through the motor in the other direction, reversing the direction of rotation.

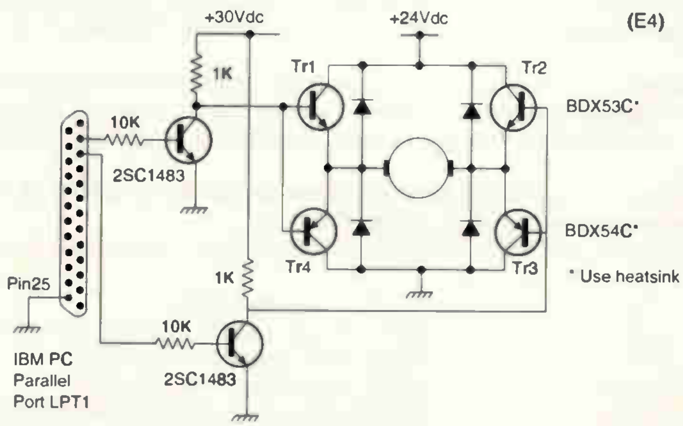
The software controls the motor speed by pulse width modulation. If, for example, D_0 is at logic 0 and hence Tr_1 is 'on', current flow through the motor is controlled by switching on Tr_2 and Tr_3 alternately. Setting the length of one FOR/NEXT loop, while adjusting the other to keep the sum constant, results in pulse width modulation of the motor current.

With the QuickBasic program running on a P-1 166MHz PC, a pulse-width modulation frequency of about 7kHz resulted. Speed and direction of rotation are controlled by the keys F1 and F2.

M T Iqbal
Rawalpindi
Pakistan
E4

Listing for PC control

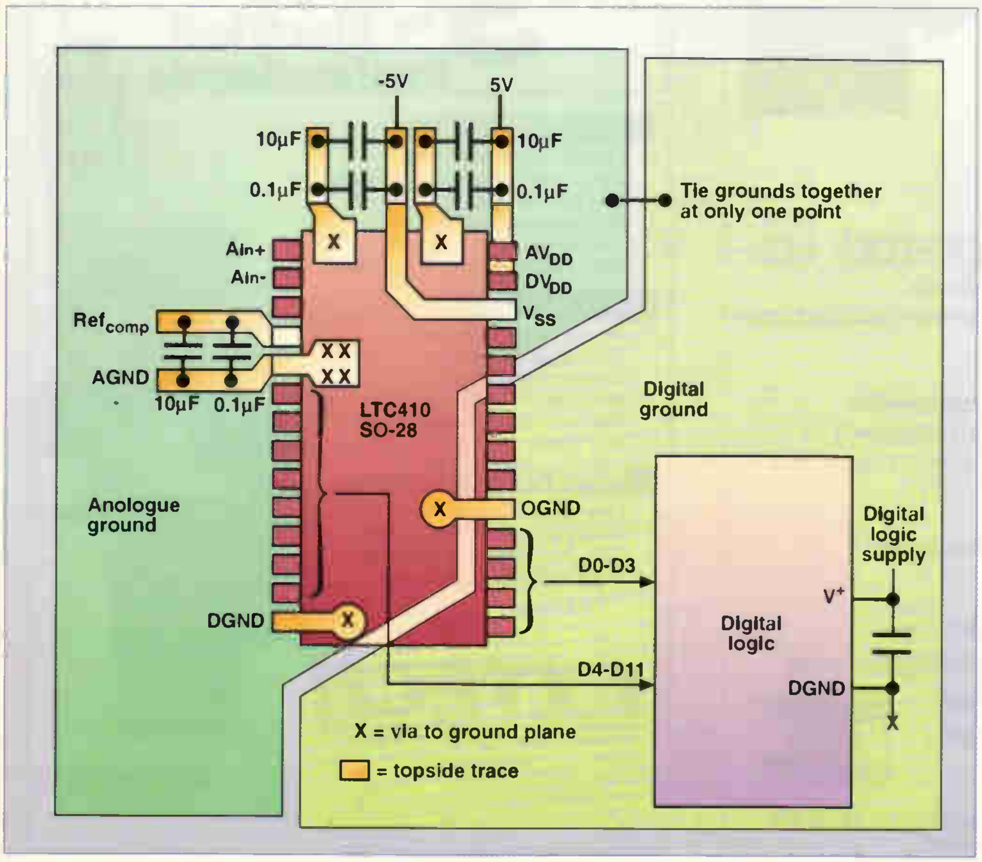
```
ON KEY (1) GOSUB Speed
KEY(1) ON
ON KEY (2) GOSUB Direction
KEY(2) ON
d = 1: h = 500: 1 = 0

INPUT "Speed 0 - 500 = "; s
20 FOR i% = 0 TO h - s: NEXT i%
OUT &H378, d
FOR j% = 0 TO 1 + s: NEXT j%
OUT &H378, 0
GOTO 20

Speed:
INPUT "Speed 0 - 500 = " ; s
RETURN

Direction:
INPUT "Direction 1=>CW; 2=>CCW " ; d
RETURN
```



Perfect conversions

What are the most common mistakes made when engineers design with analogue-to-digital converters? Steve Bush asked five application engineers from the companies that make the chips

Suggested layout diagrams, which can be lifted directly into your application, are effort-saving gems that can be dug up in data sheets.



Analogue-to-digital converters are deceptive little beasts. On the face of it, they are simply building blocks, to be dropped into a circuit at will. In reality they are a can of worms and the surrounding circuitry has to be very carefully considered if all the performance you pay for in the chip is to be realised in the final circuit.

Fast or high-resolution analogue-to-digital, or a-to-d, converters, are the most difficult to apply, but there is still plenty of scope for the uninitiated to make cock-ups in the simplest of low-performance designs. Only the foolhardy set forth without a thorough understanding the principles involved.

Grounding and power

Grounding seems to be the issue that most frequently confuses the uninitiated. Except for the simplest, most a-to-d converters have more than one ground connection. These are provided to allow digitally sourced switching currents to be routed away from the inductance and resistance of bond wires and tracks carrying the input signal.

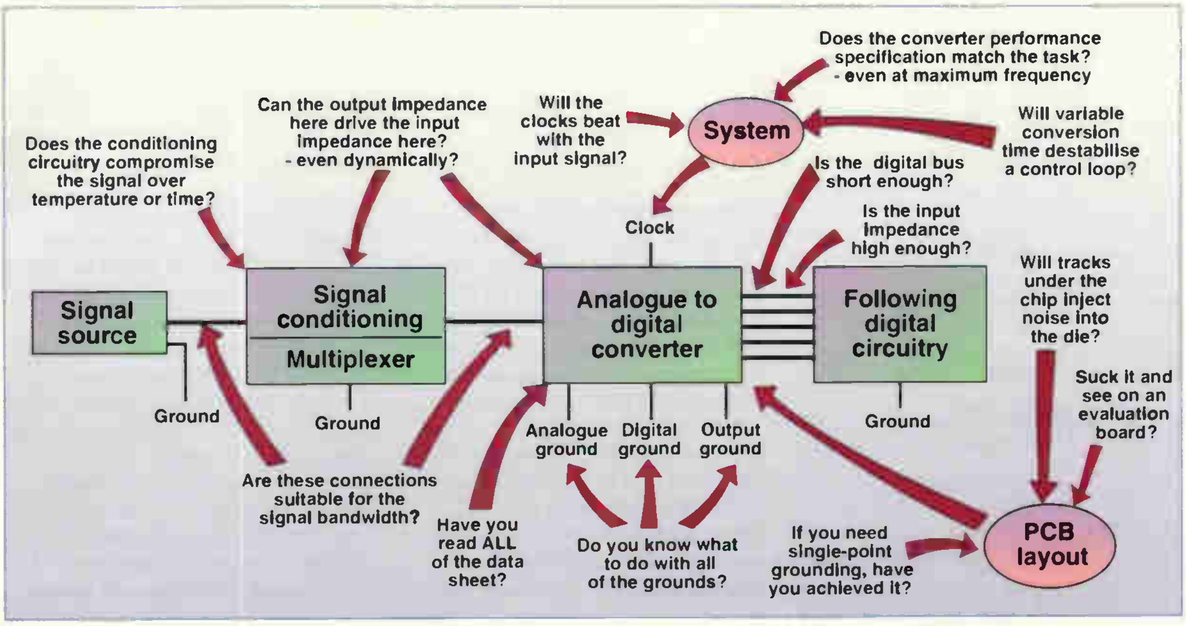
The most extreme grounding problems are to be found in instrumentation a-to-d converters.

"A single point ground is absolutely critical for instrumentation," says Adolpho Garcia, applications manager at Linear Technology. "We produce sigma-delta a-to-d converters with more than 20-bit resolution. One LSB (least-significant bit) for these converters is in the order of 1µV."

A milliamp of current through 1mΩ of track can produce this on its own, without invoking inductance and 100mA bus driver pulses.

The idea of single-point grounding is to separate all the converter system current paths until they meet at one point. This point acts as a local reference ground, even though circuit currents will impose voltage variations on it with respect to the PCB power ground connection.

Working to maintain a single-



Take heed... The distilled wisdom of five top analogue-to-digital converter application specialists. It may not say everything, but ignore it at your peril.

point ground in a design, in the face of grounding due to chassis-mounted connectors and the like, can be a major system-level exercise.

The next step down from single point grounding is to isolate part of the PCB ground plane, assuming it is an equi-potential surface and declaring it the 'analogue ground'. This can be a good alternative to strict single-point grounding and is probably the most common way to implement high-performance a-to-d converter circuits.

As before, this has to be done with extreme care as the equi-potential assumption has to be valid for the signals you are designing for.

Some, with good justification, advocate a single ground plane. But "One big ground plane is certainly not always the best strategy," warns Marcel Pelgrom of Philips' mixed-signal research group.

At the low-performance end, a-to-d converters are mostly integrated on-chip with microcontrollers. There is little scope for finesse here, but an understanding of basic principles can still pay dividends.

Proper supply-rail decoupling is vital if the a-to-d converter power pins are not to become alternative converter inputs.

Some say you cannot go too far. "You want short loops and no inductance. Try to glue the decoupling caps under the die," says Pelgrom. "With a 12-bit 50MHz converter there is 120 to 140dB more energy switched in the output latch than in the input signal." This puts into perspective the importance of proper output latch grounding and decoupling.

The aspect of circuit design that is frequently left until late and then palmed off onto some unsuspecting PCB designer is the layout of conductors under and around the a-to-d converter chip. This sweep-it-under-the-carpet approach is likely to decrease resolution or increase system noise. Both, if it is not your day.

Makers of a-to-d converter chips are now used to circuit designers compromising the performance of their babies and now – for it was not always so – mostly include plenty of layout information in their device data sheets. The gems among these are suggested layout diagrams which can be lifted directly into your application.

Evaluation boards are another wonder that chip makers have woken up to supplying. Unless your Spice skills are particularly well honed, or lucky is your middle name, use them to breadboard that tricky a-to-d converter section before you go for a first PCB.

National Semiconductor does a PC interface board and software suite to go along with some of its a-to-d converters, to enable statistical performance data to be gathered at an early stage.

The importance of timing

Most converters require some form of clock signal. In a low-speed application, this could come straight from the system clock, but as speed increases, jitter in the clock becomes an issue.

"It is no use looking at dynamic performance of a 20MHz 12-bit system if the clock jitter is worse than 10ps. It is easy to show that a few picoseconds of jitter introduces more than 1 LSB in error," says Philip's Pelgrom. "Feeding a 20MHz converter through a standard logic gate with a clock derived from some lousy CMOS oscillator is unreasonable."

Constant-impedance inputs?

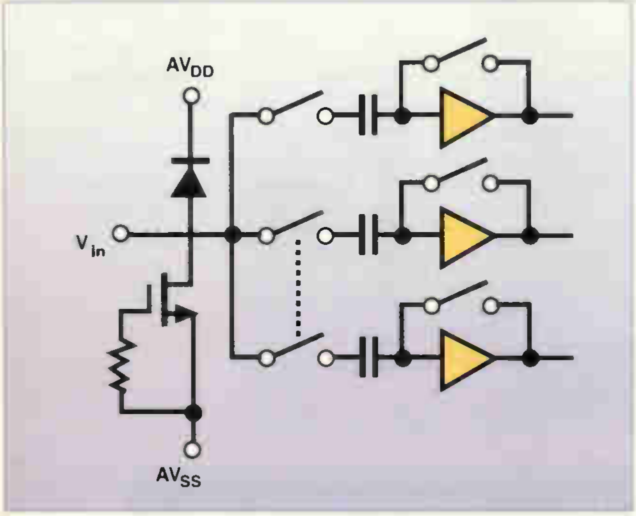
For various good reasons, converter makers seldom add on-chip buffers to the inputs of their high-performance a-to-d converters. This means that their input impedance is unlikely to look like a well behaved resistor to ground – however handy that would be.

The input impedance of a sampling a-to-d converter – particularly if the part uses a capacitor front end – is likely to be dynamic and change during the conversion cycle.

"CMOS charge transfer a-to-d converters squirt current out of their inputs," said Tony Allen, application engineer of Maxim. "If it is fed from an inductive source this can be a nightmare."

The most important thing

Ask a bunch of analogue to digital converter application engineers for one good tip they will cry in unison: "READ THE DATA SHEET." And they mean all of it, not just the first page. Beyond this, there are many general texts. As a start, take a look at Linear Technology's Application Note 71, the excellently named: 'The care and feeding of high performance a-to-d converters: Get all the bits you paid for'. www.linear-tech.com



The input of an unbuffered analogue-to-digital converter is most unlikely to look like a well-behaved resistance to ground.

There is one simple solution, so long as the input signal is relatively slow. "Put a low inductance capacitor to ground right next to the input. Any value that will fit will be fine as the LSB sampling capacitor will be small, under 1pF," said Allen.

If the input signal bandwidth is high, this solution is less viable as anything driving the capacitor at high frequency will have to work hard. An op-amp is the obvious solution. But Allen warns: "An op-amp's output impedance rises with frequency and starts to look inductive. A very high bandwidth op-amp – a video amplifier – can be used as a buffer. I would go for a 100MHz device on the input of a 1Msample/s converter." As always, the solution is to understand the problem and work out the answer.

Any input buffer has to maintain the accuracy and bandwidth of the system. If you think about what 1LSB of a high speed 14-bit converter represents, it is a very small part of the input signal. Maintaining accuracy and timing through the input buffer is anything but trivial.

It is frequently necessary to multiplex more than one signal into an a-to-d converter. This multiplexer can either be a separate device, or on the same chip as the converter. But, "adding a separate multiplexer is a gotcha waiting to happen", says Allen.

Charge injection is the problem. When a multiplexer changes state, unwanted charge is added to its signal path.

The bigger the signal switching transistors in the multiplexer are, the worse the problem. Off-a-to-d converter multiplexers have to drive PCB tracks so they need large transistors. "If you go fast with a separate multiplexer you get significant charge injection and have to wait for the signal to settle," said Allen, "On-chip multiplexers can have low charge injection transistors because they only have to drive on-chip connections."

Allen makes similar arguments for pre-converter sample-and-holds and track-and-holds.

Multiplexers can have another unwanted effect as Allen's co-worker, Maxim applications engineer Kevin Bilk explains. "A sigma-delta converter will quickly follow a continuously varying input signal, but will take longer to settle if a multiplexer is switching step changes into it."

One final thing to think about on the route to the a-to-d converter input is the PCB tracks themselves. Keep an eye on resistance in high-accuracy systems and inductance in high-speed systems. Stripline techniques are an option as frequencies rise and track length matching is something to watch to avoid phase errors when sensing signals in quadrature.

The digital output

The more current the a-to-d converter digital output drivers have to deliver, the more spurious signals are injected into the a-to-d converter chip and the higher the risk of errors creeping into the conversion process. Buffering the digital data stream with a high impedance buffer, as physically close to the a-to-d converter chip as possible, will reduce the capacitive load on the converter chip drivers as much as possible.

Be careful with the buffer power connections. You don't want to inject noise straight into the a-to-d converter grounding system. "It is preferable to have low-swing slow buffers to prevent injection," said Philips' Marcel Pelgrom. "Consider a buffer from the previous logic generation."

Serial interfaces are better standardised than parallel ones and involve switching less current, but have to switch faster to achieve a given data rate.

The moral of this design story is: If you understand your pet a-to-d converter, and treat it with respect, it won't bite your hand off. ■

Which converter?

The appropriate number of bits and sampling rate are only the very tip of the a-to-d converter specification iceberg. Most *n*-bit converters only have *n*-bit resolution with a slowly changing input. Converter designers have invented the term ENOB (effective number of bits) to describe how a converter operates at high speed. "The 1175 is an industry standard 8-bit 20Msample/s a-to-d converter," says Mark Holdaway, data-converter marketing manager at National Semiconductor, "Our version of it has an effective resolution of 7.5 bits at 20MHz. Some others only achieve 6.8."

ENOB is not the only useful dynamic parameter. Spurious-free dynamic range (SFDR) and differential non-linearity (DNL) are another couple. "For radio applications, SFDR may be more important than DNL. Then DNL is more relevant for baseband video than jitter specs," says Marcel Pelgrom of Philips' mixed signal research group. National Semiconductor's ADC1175 data sheet, page 8 (www.national.com) has a handy explanation of dynamic specifications.

One extra thing to think about if the converter is part of a control loop is conversion time. Long conversion times are bad enough – particularly within fast control loops like those found in mobile phone base stations. Add in the fluctuations in conversion times that sigma-delta and pipeline converters can produce and almost anything can happen.

Room for improvement

The listening room has a surprisingly significant effect on the loudspeaker. In this first article on the topic, John Watkinson examines how the listening room affects sound at low frequencies.

SPEAKERS' CORNER

It's not widely appreciated that no-one has ever heard what a loudspeaker sounds like. Even if it was possible, people wouldn't like it. It is impossible to hear anything but the result of exciting the acoustic environment with a loudspeaker.

Often, the acoustic environment will be a room of some sort, perhaps because we like to be out of the cold, or because we want to listen to reproduced sound to the exclusion of extraneous sounds.

The closest we can get to hearing a speaker alone is perhaps to suspend it and ourselves a hundred feet off the ground by thin wires. In the absence of a suitably quiet location and means of support, we might try an anechoic room. Such a room absorbs almost every sound so that only the direct sound from the speaker can be heard.

In both environments, the results are disappointing. Even with a very high quality speaker, the sound appears dry and lacking in bass. Consequently anechoic room testing can only be used for making objective measurements on a loudspeaker.

We should not listen to the speaker in an anechoic room to assess its subjective quality. Instead we should use the results of measurements made in the room to determine what the speaker will sound like in more representative environments. The absence of any reflections allows anechoic testing to give very good measurements of speaker directivity and phase linearity.

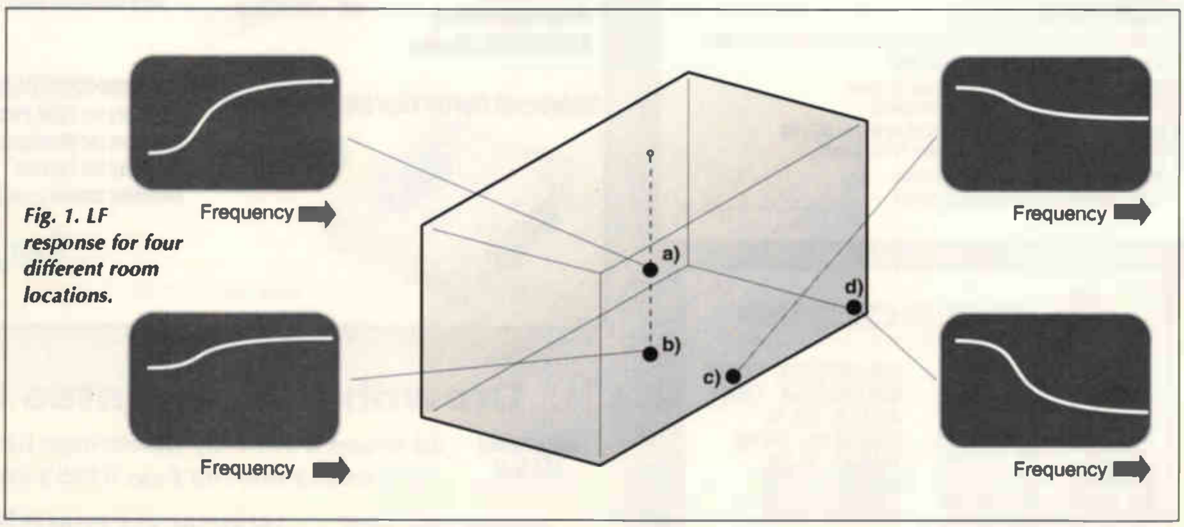


Fig. 1. LF response for four different room locations.

Is a metre enough?

For some reason, anechoic tests are usually performed with the microphone a metre from the speaker under test. This is suspect in many cases because most speakers are designed to be heard from at least 2m away. Also, in the case of large speakers or phased arrays the wavefronts may take more than a metre to coalesce.

In a listening room, the effects of the room vary with frequency. At low frequencies the wavelengths may be long compared to the distances to the floor and walls. Thus these obstacles are acoustically close and their presence will raise the acoustic impedance allowing a greater sound-pressure level to be created for a given volume velocity. This can easily be demonstrated by equipping a moderate-sized speaker with long leads so it can be moved while playing.

Figure 1 shows the results of placing the speaker in various locations. In the centre of the floor, but elevated half way to the ceiling, the bass response, **1a)**, is least because the speaker is radiating into a whole sphere.

Placing the speaker centrally on the floor or on a wall, **1b)**, will raise low-frequency output by 6dB because radiation is now into a half sphere. Placing the speaker in the angle between the floor and the wall, as in **1c)**, gives a further boost as radiation is now into a quarter sphere. Finally, placing the speaker in a corner, **1d)**, gives the most boost of all.

Generally, the speaker designer doesn't know where the speaker is going to be positioned, and so has to provide a good tonal balance somewhere in the middle of the possibilities of Fig. 1. In the case of a cheap speaker with a fixed response, it will only sound tonally balanced when placed in the correct location.

Note that the bass lift effect only occurs at frequencies up to a few hundred hertz. The frequency at which it ceases is often very close to the low-frequency crossover point. Because of this, it is desirable to have a means of adjusting the relative output of the woofer with respect to the remaining drivers. All serious speaker designs will have such adjustment capability.

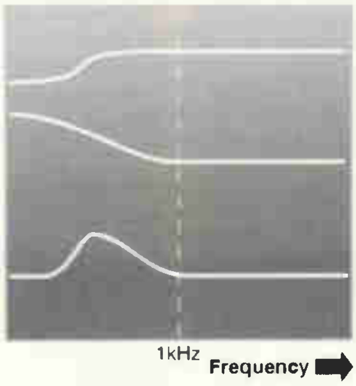


Fig. 2. 'Tone' controls can't fix poorly positioned or equalised speakers.

A stand for better performance

Another possibility is to limit the number of mounting possibilities by making the speaker integral with a suitable stand. The amount of equalisation needed on installation will be less and this can be a great advantage in location recording where the monitoring is frequently moved.

The conventional tone controls of an audio system are quite unable to compensate as the bass lift generally begins below 1kHz. **Figure 2** shows the result of trying to compensate for a wrongly positioned or incorrectly equalised speaker using a tone control. Doing so simply results in a response peak, resulting in colouration and listening fatigue. In fact this is how most of the general public listen.

Two speakers change tonal balance

In stereo systems naturally there are two speakers. These are often spaced apart by two to three metres. At this distance the woofers are acoustically close and will augment one another's output by mutually raising the acoustic impedance seen when reproducing signals that are correlated at low frequencies – which is usually the case.

The effect of using two speakers instead of one is therefore not simply to increase the level, but also to change tonal balance.

It follows that when adjusting the equalisation of stereo speakers in a room, both speakers must be operating and both must be adjusted simultaneously or a correct balance will not be achieved.

At low frequencies, rooms may not be acoustically what they appear to be. Actual results depend heavily on the constructional techniques and materials.

Lightweight construction, such as plasterboard on thin wooden uprights is from an acoustic standpoint very nearly absent at low frequencies. In other words, low-frequency signals can almost pass straight through because the panelling simply flexes.

The result is twofold. Firstly the listening room is not isolated so sound can escape or enter, possibly causing a disturbance within or outside the room. Secondly, the acoustic impedance seen by a speaker in such a room will be lower and it will appear bass light. Low-powered speakers in flimsy buildings may run out of power when, from an acoustic standpoint, they are trying to provide adequate sound-pressure level in the car park.

The only solution here is mass. There is no substitute for masonry, but there is little point in providing heavy walls if the ceiling is flimsy. ■

NEW PRODUCTS

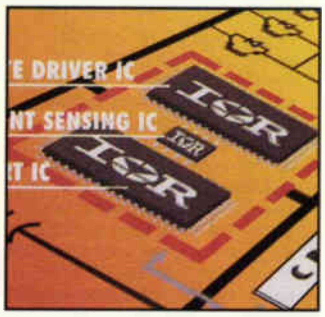
Please quote *Electronics World* when seeking further information

Bus transceiver

Fairchild has introduced the GTLP17T616 17-bit registered bus transceiver that provides LVTTL to GTLP signal level translation. The device allows for transparent, latched and clocked modes of data flow and provides buffered GTLP (CLKout) clock output from the LVTTL CLKAB. For backplane and bus applications, the transceiver can be used in datacomms, telecoms and server systems. It suits source synchronous clocking architectures. There is a balanced timing relationship between clock and data to improve its operating frequency. It supports multi-drop backplane designs up to the 100MHz range and operates at 3.3V. The product has internal edge-rate control and is process, voltage and temperature compensated. There is a bidirectional interface between cards operating at LVTTL voltage levels and a backplane operating at GTLP voltage levels.
Fairchild Semiconductor
Tel: 01793 856856
Enquiry No 501

Motor drive ICs

International Rectifier has announced ICs supporting its power conversion processor architecture for 600 and 1200V AC or brushless DC motor drives. The architecture uses monolithic integration of high voltage circuits for gate drive, protection, current sense, soft start and power supply functions. The range includes gate drivers with IGBT protection, motor phase current sensing ICs with



direct PWM interface to a microcontroller, and a soft start controller for the input converter.
International Rectifier
Tel: 01883 732020
Enquiry No 503

16A relay

The 16A LE relay from Matsushita comes in PCB and top mounted terminal variants. It can switch 16A at 250V AC. The top mounted terminal version switches the load via a crimped terminal connector instead of a conventional PCB pin. Creepage and clearance distances are 8mm.

Power consumption is 400mW and heat resistance characteristics are to class B standard (130°C). This relay is suitable for switching the magnetron and heater loads in microwave ovens. Other applications include refrigerators, domestic heating, and office and industrial catering equipment.
Matsushita
Tel: 01908 231555
Enquiry No 504

Electrolytic capacitors

BC Components has announced electrolytic capacitors, the 198 PHR-SI series. There are nearly 50 capacitors in the range with case sizes from 22 x 25mm to 35 x 60mm. There are snap-in products with 4mm pins, which do not have to be cut after mounting. They are rated from 56 to 820μF at 400 and 450V.
BC Components
Tel: 00 31 40 259 0724
Enquiry No 505

Four-resistor arrays

Philips Components has introduced resistor arrays integrating four size 0402 resistors in a 0804 surface-mount package. The 0.5mm thick eight-pin package contains four electrically isolated resistor chips. The package is available with convex or concave terminations and has a 0.5mm termination pitch. It can be used as a pull-up, pull-down circuit, damping circuit or bridge. Power dissipation is up to 0.0625W at 50V. Applications include on motherboards and hard-disk drive circuits for notebook, desktop and hand-held computers, mobile phones and digital consumer equipment such as DVD players, camcorders and pagers. The arrays are available in resistances from 10Ω to 1MΩ with five per cent tolerance and a maximum operating voltage of 50V.
Philips Components
Tel: 00 31 40 272 2091
Enquiry No 506

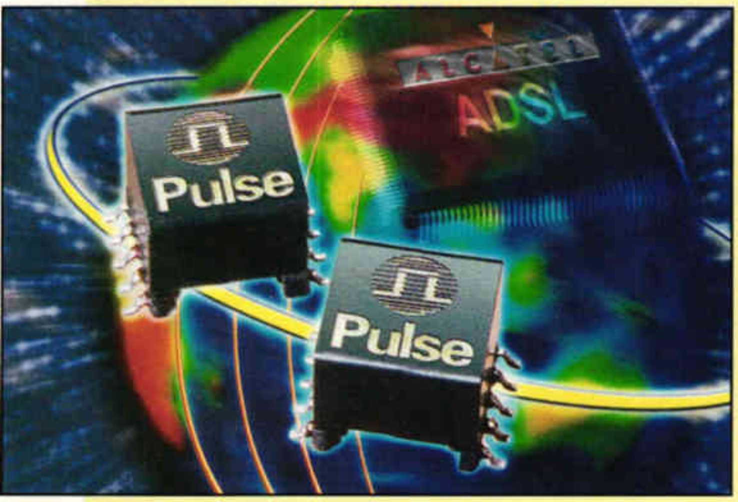
Coprocessor for digital cameras

STMicroelectronics has introduced an integrated coprocessor for use with CMOS image sensors in digital still cameras. The STV0680 interfaces to the firm's CIF (352 x 288) or VGA (640 x 480) resolution sensors. The coprocessor supports 16 or 64Mbyte of external memory. The 64Mbyte version supports up to 24 VGA images, 80 CIF images or 300 QCIF images. Power consumption is

typically 70mA from four 1.5 batteries and 350μA, depending on SDRAM, in sleep mode while retaining pictures in memory. It has a USB interface, tethered video modes, serial interface and an untethered video mode that lets small video clips be made remotely. The video clip size depends on the available memory and image resolution selected. It is supplied with USB drivers and Twain support, allowing plug and play operation.
STMicroelectronics
Tel: 01628 890800
Enquiry No 507

22.5 and 30mm pushbuttons

IMO has launched 22.5 and 30mm pushbuttons. The B5 is a flush mounted IP65 30mm push-button with indicator lens to protect against extreme environments. It is vandal proof and shock resistant. The



Transformers for ADSL chip sets

Pulse's B2064 and B2068 ADSL line transformers are UL approved for use with Alcatel's Dynamite MTK-20140 ADSL chip set. The transformers are for central office applications and customer premises equipment such as external modems, set-top boxes and PC adapter cards. The surface mount B2064 has a footprint of 13.1 by 13.5mm and a height of 12.3mm. The through-hole B2068 measures 14.0 by 13.9 by 12.7mm. Both come in ten-pin configurations with a minimum linearity less than 72dB at 20kHz for the through-hole part and 10kHz for the surface mount device.
Pulse
Tel: 01483 401700
Enquiry No 502

Please quote *Electronics World* when seeking further information

22.5mm IP65 B3 range includes momentary and maintained mushroom head actuators, push-buttons and selector switches that are opaque or illuminated, key switches and indicator lenses in various colours. Both come with either black plastic or metal bezels. The B3 has a single handed mounting operation, where the actuator is positioned from the front of the panel. A locking nut mounted from the rear first grabs, then tightens the actuator tightly into position. An anti-rotational peg ensures the actuators are held in the correct orientation, but this peg can be removed to update products already in the field. The range also includes assembled push-button stations and accessories such as single snap on contact blocks that are colour coded for normally open and closed contacts.
IMO
Tel: 0208 2084006
Enquiry No 508

Right-angled male connector

A male-side right-angle version of the HDRA series of PCB mounted I/O connectors available from Honda Connections. Applications include notebook computers, ultra SCSI devices and Raid controllers. Height is 6mm and it conforms with ANSI SFF-8441 requirements for VHDCI. The 68-way connector is based on 0.8mm pitch and has a metal shell with grounding fingers that protect signal circuits by engaging first when connectors are mated. Honda claims more than 5000 mating cycles.
Honda Connections
Tel: 01793 523388
Enquiry No 510

RF design tools

An RF design kit including design tools and components is an option in the latest version of Electronics Workbench Multisim (EWM) from Adept Scientific. EWM is a circuit design and simulation tool that can perform at frequencies above 100MHz, making it a suitable software simulator for radio frequency design. The design kit is included as standard with Power Professional editions or available separately as an add-on to the Professional edition. It includes an on-screen spectrum analyser. Circuit characterisation analysis identifies the properties of RF circuits by automatically calculating voltage and power gain. It also determines a noise figure. There's a network analyser from which EWM can automatically calculate S, Y, Z and H parameters. Network properties can be plotted onto Smith charts, and stability and gain circles generated. An RF parts library is supplied, including models of RF BJTs, MOSFETs and various diodes, striplines, microstrips and waveguides. Model-making tools can generate custom Spice models from databook values.
Adept Scientific
Tel: 01462 480055
Enquiry No 511

Universal battery charger

Datek is launching the UP-01 universal 5A battery charger for NiCd, NiMH and lead-acid batteries. The charger uses an electrode specific

charging system to provide the exact and maximum charging current needed. It can revitalise batteries, extending accumulator regeneration and capacity, and provides automatic battery detection and exact signalling at the end of charging. Using a computer controlled charger, it monitors the electrochemical, thermodynamic and crystal structural state of each cell within the battery.
Datek
Tel: 01844 273800
Enquiry No 512

Expansion chassis

APW Electronics has introduced a Smartslot interface for its intelligent UPS, letting an extra three modular accessories be plugged directly into the units. The triple chassis is available as a free-standing or 19in. rack mounted unit. It can be powered from the host UPS, giving a maximum of 200mA for driving the accessories. A separate 24V DC power supply, giving an additional 400mA, is also available.
APW Electronics
Tel: 01703 266300
Enquiry No 513

CAD converter

The latest version of Mydata Automation's CAD conversion program has been released with features claimed to make CAD file conversion simpler. A wizard leads the user through a step-by-step process to create control files when new CAD file types are encountered. When a PCB or component file is created, it can be transferred through the network and imported to the directory on the machine or server. A graphical viewer shows a representation of the converted PCB including reference points or fiducials. This helps ensure accurate CAD data matching with the control file and assures the PCB was correctly created. Simplified drawings of all the components including their angles are also reproduced.
Mydata
Tel: 01202 723585
Enquiry No 514

Multiport test system for RF

Agilent Technologies has introduced the 87050E multiport test set for evaluating 50Ω RF components on production lines. The set works with the firm's 8712E network analysers for use up to 3GHz for measuring devices with up to 12 ports. The system lets all transmission paths and port reflection characteristics of a multiport device be characterised with one set of connections to a device's ports. It has specified performance at the test ports, whether the device is measured in a fixture or at the ends of test cables. The system's two calibration routines can reduce downtime typically needed to calibrate multiport test sets. The calibration routine requires users to connect short, open and load standards only once to each measurement port, and reduces the number of through connections required to calibrate all possible measurement paths. The self cal routine performs automatic, periodic calibrations using the set's internal calibration standards to correct system drift. The routine takes a few seconds to run, and the user can program the interval between self cal operations.
Agilent Technologies
Tel: 01344 366666
Enquiry No 509

Digital meters and controllers

Carlo Gavazzi has introduced digital meters and controllers, with setpoint and relay output, that cover applications for volts, amps, frequency, temperature and, via sensors, rate measurement. Available are 3, 3.5 and 4-digit models, with either Din rail or panel mount options. The meters provide scalable inputs and scalable outputs (analogue output only) with an RS485 serial comms option on some models. Other options include the EDM35, which can be field configured to suit an application via plug-in modules, and the LDI3 and LDI35 that handle voltage and current inputs in the same unit.
Carlo Gavazzi
Tel: 01252 339600
Enquiry No 515

Power supplies

Thurlby Thandar has introduced two single-output laboratory bench power supplies – the EL183 18V 3.3A and the EL561 56V 1.1A. The linear-regulated PSUs have digital voltage and current meters on the output. The meters use 14mm LED displays, and have an update rate of $4s^{-1}$. They simultaneously meter voltage and current.
Thurlby Thandar Instruments
Tel: 01480 412451
Enquiry No 516

Please quote *Electronics World* when seeking further information

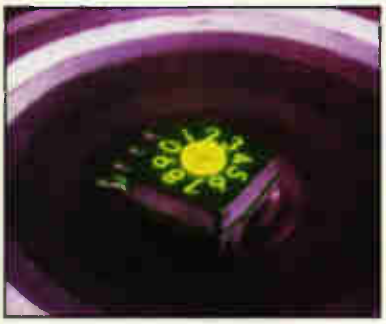
8-bit micro with 2K x 14-bits flash

Microchip's latest 8-bit flash microcontroller extends its range with the 28-pin PIC16F872 device providing 2k x 14-bits of flash memory, 64 bytes of EEPROM data memory, and an extended operating

voltage of 2.0 to 5.5V. It also has a 5-channel 10-bit (±1LSB) A/D converter, brownout detection, up to 5MIPS performance at 20MHz, I^2C or SPI communications capability for peripheral expansion, two 8-bit timers and one 16-bit timer. As with all Microchip's PICmicro flash and OTP microcontrollers it features in-circuit serial programming. The PIC16F87X family also supports self-programming, allowing the device to be reprogrammed in-circuit at a remote location. In addition, an in-circuit debugging feature allows designer to 'emulate' the microcontroller without the need of an in-circuit emulator.
Microchip
Tel: 0118 921 5858
Enquiry No 517

Rotary-coded switches

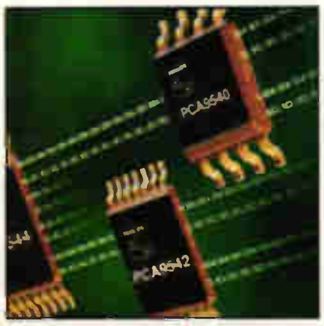
Devlin Electronics has introduced a range of Fujisoku rotary coded switches, with fluorescent ink markings, for improved visibility in applications with low light levels. The



supplier describes the rotary switches is 'digital' i.e. the rotary movement is divided into a series of positive 'clicks', and a clearly calibrated rotary scale shows the rotational position. There are four ranges of switches: 10x10mm switches with a recessed slotted spindle (through-hole or SM); 10x
10mm switches with a raised, slotted spindle (through-hole); 10x10mm switches with a turning knob and fluorescent markings (through-hole); and 7.5x7.5mm switches with a raised, slotted spindle (through-hole or SM).
Devlin Electronics
Tel: 01256 467367
Enquiry No 519

I^2C multiplexers

Philips Semiconductors has announced a family of I^2C multiplexers. Designated the PCA954x family, it is designed for multiple system management buses or multiple I^2C devices with the same address, different voltage levels, or loads too large for the I^2C master to handle. The devices provide multiplexing and interrupt controlling to eliminate the need for glue logic and general purpose I/Os. In addition, they include diodes to enable shifting between 5.0V and 3.3V buses and bus isolation to prevent system hang-ups. The PCA9540 is a two-channel I^2C multiplexer without interrupts that switches between two I^2C devices or buses. The PCA9542 is a two-



channel multiplexer that contains three address pins, allowing a bus to use eight PCA9542s to switch up to 16 I^2C devices or buses. The PCA9544 is a four-channel multiplexer that can be used for switching up to 32 I^2C devices or buses. Both devices include an interrupt controller to prevent system hang-ups if a bus generates interrupts.
Philips Semiconductors
Tel: 00 31 40 272 20 91
Enquiry No 520

3U CompactPC card

MEN makes its first move into 3U CompactPCI with the F2 CPU card. It is a Pentium III-class system master with scalable performance enabled by the 'Super Socket 7' support. It provides typical PC functions such as main memory (SO-DIMM), different interfaces such as 4 fast UARTs, 10/100Mbit Ethernet, EIDE, LPT, USB and GPIO, plus support for Microsoft's ACPI specification. In addition, the F2 provides 32Mbyte shock-resistant on-board DRAM, watchdogs to monitor temperature, voltage, fan and time-out, PXI trigger lines for data acquisition and analysis, and industrial BIOS, allowing the CU to operate without graphics. A PC-MIP mezzanine slot

SiGe power amp for 2-way pagers

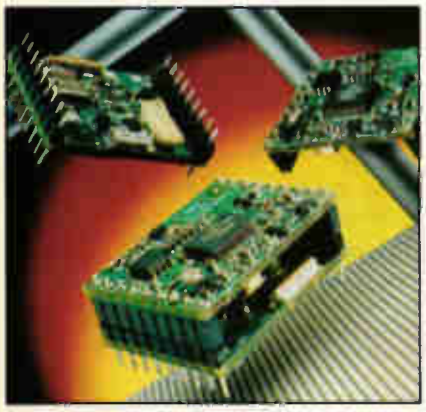
Temic Semiconductors has introduced a silicon germanium (SiGe) power amplifier (PA) designed for use in 900MHz 2-way pagers, PDAs, meter reader transceivers, driver amplifiers and ISM phones. The T0930 is intended to replace the usual GaAs power amplifier devices normally used in two-way pagers by a SiGe integrated solution. In addition to the power amplifier, the device includes an RF power-control and a standby circuit. Thanks to SiGe, the current consumption in power-down mode is only 10pA, eliminating the need for a high-side switch. The T0930 permits real continuous wave (CW) operation as necessary in systems with high duty cycles or long time slots. The output power in CW mode is up to 33dBm.
Temic Semiconductors
Tel: 01753 763120
Enquiry No 518

Please quote *Electronics World* when seeking further information

expands the F2's I/O capabilities to cover industrial graphics, serial interfaces and field busses, etc. All the F2's functions are supported by board support packages for Windows NT/NTE and VxWorks. Whilst the F2 is a two-board solution – CPU and 110 – it occupies only one slot on the CPCI backplane.
MEN
Tel: 01276 677676
Enquiry No 522

Long range transceiver

Low Power Radio Solutions is offering the RDT868 transceiver which is designed for sending high volumes of data over long distances. Operating at 868.3MHz in the newly harmonised pan-European band, the transceiver combines a high-stability 25mW transmit section with a selective dual SAW filter receiver. This is combined with a 1ms turnaround between transmit and receive sections to provide a 50kbit/s data rate at typical ranges up to 700m line-of-sight or 100m in buildings. The system's construction means that the transmit and receive halves can be pulled apart to provide a separate transmitter and receiver. With a dual-in-line construction occupying only 23 x 33mm of PCB space, the RDT868 is both compact and frugal, drawing 135mA in transmit mode and 70mA in receive mode, both from a single 5V supply.
Low Power Radio Solutions
Tel: 01993 709418
Enquiry No 523



200kHz switching regulator

Linear Technology's latest 200kHz monolithic buck mode switching regulator is designed for dc-to-dc conversion at 5V to 3.3V or lower conversions. Lower output voltages can be delivered since the output can be adjusted down to the 1.2V reference voltage. The LT1 578 includes a 1.5A low-loss switch and a BIAS pin that is designed to improve efficiency and lower thermal dissipation. The device requires 1.35mA of supply current that drops to 20μA in shutdown mode. While the efficient high power internal switch with 200mΩ on-resistance eliminates the need for an external MOSFET and $R_{(sense)}$ resistor, the constant 200kHz switching frequency keeps noise away from sensitive IF frequencies and reduces inductor size to as low as 15μH. The device incorporates all oscillator, control and protection circuitry for a complete switching regulator and is available in 8-pin SO in both commercial and industrial temperature ranges.
Linear Technology
Tel: 01276 677676
Enquiry No 524

Jack plugs with fibre lightpipes

Inverted right-angle modular jacks (modjacks) with lightpipes from Molex direct light from PCB-mounted LEDs to the front of the modjack to indicate system activity. The design uses lightpipes and customer supplied surface-mount LEDs, which in combination reduce EMI/RFI (antenna effect) noise by 50 per cent as compared to a modular jack with integral LEDs, claimed the supplier. Applications are expected to be in networking systems, set-top boxes, security systems and mini-PCI applications. The modjacks feature a plug latch on top for easy unmating.

They are available in shielded and unshielded versions for both RJ11 and RJ45 configurations. The RJ45-configured modjack is specified to deliver CAT 5 performance for Fast
Molex
Tel: 01420 488488
Enquiry No 525

SiGe LNA GSM dual-band phones

Maxim's silicon germanium (SiGe) low-noise amplifier (LNA) is designed for use in the GSM900, DCS1800, and PCS1900 mobile phone frequency bands. The MAX2652 includes a 20dB attenuation step control to further improve receiver sensitivity and dynamic range performance in GSM dual-band and triple-band cellular phones. The device consists of two LNAs. One LNA is optimised for the GSM900 band and provides a low 1.3dB noise figure and a 1.8dB gain; the other LNA is optimised for the DCS1800 band and provides 1.8dB noise figure and also an 18dB gain. A band select pin allows either of the two LNAs to be active at one time, helping to reduce supply current.
Maxim Integrated Products
Tel: 0188 930 3388
Enquiry No 526

Low cost set-top box decoder

STMicroelectronics has announced an addition to its Omega family of set-top box decoders. The STi5512 device is pin-to-pin and software compatible with the existing STi5510 launched last year but has been introduced to deliver increased system performance. The STi5512 integrates, in a single chip, a programmable MPEG transport stream demultiplexer block, an ST20 32-bit system CPU, an audio/video MPEG-2 decoder, advanced display and graphics features, a digital video encoder and system peripheral functions, including interfaces for external memory, IEEE1394, I^2C, teletext and smartcards. It is designed to increase the performance in real STB applications through a 20 per cent increase in processor speed coupled with peripheral optimisations that reduce CPU loading. At the same time, 16 and 64Mbit SDRAM support is added.
STMicroelectronics
Tel: 01628 890800
Enquiry No 527

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!

THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!

TV SOUND & VIDEO TUNER
*CABLE COMPATIBLE**

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 £49.95* *code (B)*
See www.distel.co.uk/data_my00.htm for picture + full details

FLOPPY DISK DRIVES 2½" - 8"

All units (unless stated) are *BRAND NEW* or removed from often brand new equipment and are fully tested, aligned and shipped to you with a full 90 day guarantee. Call or see our web site ***www.distel.co.uk*** for over 2000 unlisted drives for spares or repair.

3½" **Mitsubishi** MF355C-L. 1.4 Meg. Laptops only	£25.95(B)
3½" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" **Teac** FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" **Teac** FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" **BRAND NEW Mitsubishi** MF501B 360K	£22.95(B)
Table top case with integral PSU for HH 5¼" Floppy / HD	£29.95(B)
8" **Shugart** 800/801 8" SS refurbished & tested	£210.00(E)
8" **Shugart** 810 8" SS HH *Brand New*	£195.00(E)
8" **Shugart** 851 8" double sided refurbished & tested	£260.00(E)
8" **Mitsubishi** M2894-63 double sided *NEW*	£295.00(E)
8" **Mitsubishi** M2896-63-02U DS slimline *NEW*	£295.00(E)
Dual 8" cased drives with integral power supply 2 Mb	£499.00(E)

HARD DISK DRIVES 2½" - 14"

2½" **TOSHIBA** MK1002MAV 1.1Gb laptop(12.5 mm H) *New*	£79.95
2½" **TOSHIBA** MK2101MAN 2.16 Gb laptop (19 mm H) *New*	£89.50
2½" **TOSHIBA** MK4309MAT 4.3Gb laptop (8.2 mm H) *New*	£105.00
2½" **TOSHIBA**MK6409MAV 6.1Gb laptop (12.7 mm H) *New*	£190.00
2½" to 3½" conversion kit for Pc's, complete with connectors	£14.95
3½" **FUJI** FK-309-26 20mb MFM I/F RFE	£59.95
3½" **CONNER** CP3024 20 mb IDE I/F (or equiv.) RFE	£59.95
3½" **CONNER** CP3044 40 mb IDE I/F (or equiv.) RFE	£69.00
3½" **QUANTUM 40S Prodri ve** 42mb SCSI I/F, New RFE	£49.00
5¼" **MINISCRIBE** 3425 20mb MFM I/F (or equiv.) RFE	£49.95
5¼" **SEAGATE** ST-238R 30 mb RLL I/F Refurb	£69.95
5¼" **CDC** 94205-51 40mb HH MFM I/F RFE tested	£69.95
5¼" **HP** 97548 850 Mb SCSI RFE tested	£99.00
5¼" **HP** C3010 2 Gbyte SCSI *differential* RFE tested	£195.00
8" **NEC** D2246 85 Mb SMD interface. *New*	£199.00
8" **FUJITSU** M2322K 160Mb SMD I/F RFE tested	£195.00
8" **FUJITSU** M2392K 2 Gb SMD I/F RFE tested	£345.00

Many other drives in stock - Shipping on all drives is code (C1)

IC's -TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK
10,000,000 items EX STOCK
For *MAJOR* SAVINGS
CALL OR SEE OUR WEB SITE www.distel.co.uk

VIDEO MONITOR SPECIALS

One of the highest specification monitors you will *ever* see - At this price - Don't miss it!!

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 £119 (E) Order as **MITS-SVGA**
External cables for other types of computers available - CALL

Ex demo 17" 0.28 SVGA Mitsubishi Diamond Pro monitors, Full multisync etc.
Full 90 day guarantee. Only £199.00 (E)

Just In - Microvitec 20" VGA (800 x 600 res.) colour monitors.
Good SH condition - from £299 - **CALL for info**

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with <u>both</u> **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
Dimensions: W14" x H12¾" x 15½" D. **Only £99.00** (E)

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 13½" D. 240 V AC mains powered. **Only £79.00** (D)

KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13½" x 12" x 11". Good used condition. **Only £125** (E)

20" 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & *optional* sound input. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs, etc.In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

We probably have the largest range of video monitors in Europe. All sizes and types from 4" to 42" call for info.

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.

19" RACK CABINETS

Superb quality 6 foot 40U Virtually New, Ultra Smart
Less than Half Price!

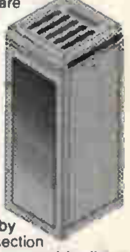
Top quality 19" rack cabinets made in UK by **Optima Enclosures Ltd. Units feature** designer, smoked acrylic lockable front door, full height lockable half louvered back door and louvered removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting ,plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the ***most versatile we have ever sold.*** Racks may be stacked side by side and therefore require only two side panels to stand singly or in multiple bays. Overall dimensions are: 77½" H x 32½" D x 22" W. **Order as:**

OPT Rack 1 Complete with removable side panels.	**£345.00 (G)**
OPT Rack 2 Rack, Less side panels	**£245.00 (G)**

Over 1000 racks, shelves, accessories
19" 22" & 24" wide 3 to 46 U high.
Available from stock !!

32U - High Quality - All steel RakCab

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 are 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. External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)



Sold at LESS than a third of makers price !!

A superb buy at only £245.00 (G)

42U version of the above only £345 - CALL

12V BATTERY SCOOP - 60% off !!

A special bulk purchase from a cancelled export order brings you the most **amazing savings** on these ultra high spec 12v DC 14 Ah rechargeable batteries. Made by **Hawker Energy Ltd. type SBS15** featuring pure lead plates which offer a far superior shelf & guaranteed 15 year service life. **Fully BT & BS6290 approved.** Supplied **BRAND NEW** and boxed. Dimensions 200 wide, 137 high, 77 deep. M6 bolt terminals. Fully guaranteed. Current makers price over £70 each ***Our Price £35 each*** (C) ***or 4 for £99*** (E)

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*

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.

Web ref = LK33 ***ONLY £99.00 or 2 for £180.00*** (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 3½" disks with concise books c/w QBasic .	£14.95
Windows for Workgroups 3.11+ Dos 6.22 on 3.5" disks	£55.00
Wordperfect 6 for DOS supplied on 3½" disks with manual	£24.95

shipping charges for software is code B

TEST EQUIPMENT & SPECIAL INTEREST ITEMS

MITS. **FA3445ETKL** 14" Industrial spec SVGA monitors	£245
FARNELL 0-60V DC @ 50 Amps, bench Power Supplies	£995
FARNELL AP3080 0-30V DC @ 80 Amps, bench Suppy	£1850
1kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
IBM 8230 Type 1, Token ring base unit driver	£760
Wayne Kerr RA200 Audio frequency response analyser	£2500
IBM 53F5501 Token Ring ICS 20 port lobe modules	£750
IBM MAU Token ring distribution panel 8228-23-5050N	£95
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE	£550
ALLGON 8360.11805-1880 MHz hybrid power combiners	£250
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
Marconi 2022C 10KHz-1GHz RF signal generator	£1550
Marconi 2030 opt 03 10KHz-1.3 GHz signal generator,New	£4995
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & **HP3782A** Error Detector	£POA
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£675
HP54121A DC to 22 GHz four channel test set	£POA
HP8130A opt 020 300 MHz pulse generator, GPIB etc	£7900
HP 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
View Eng. Mod 1200 computerised inspection system	£POA
Sony DXC-3000A High quality CCD colour TV camera	£995
Keithley 590 CV capacitor / voltage analyser	£POA
Racal ICR40 dual 40 channel voice recorder system	£3750
Fiskers 45KVA 3 ph **On Line UPS** - New batteries	£9500
Emerson AP130 2.5KVA industrial spec.UPS	£2100
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£945
Siemens K4400 64Kb to 140Mb demux analyser	£2950
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
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 MS9001B1 0.6-1.7 uM optical spectrum analyser	£POA
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
CLAUDE LYONS 12A 240V single phase auto. volt. regs	£325
CLAUDE LYONS 100A 240/415V 3 phase auto. volt. regs	£2900

DISTEL on the web !! - Over 16,000,000 items from stock - www.distel.co.uk

DISPLAY -ELECTRONICS-

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

LONDON SHOP
Open Mon - Sat 9:00 - 5:30
215 Whitehorse Lane
South Norwood
On 68A Bus Route
Nr.Thornton Heath &
Selhurst Park SR Rail Stations

NEW **DISTEL©**
Visit our web site
www.distel.co.uk
email = admin@distel.co.uk

ALL ☎ ENQUIRIES
0208 653 3333
FAX 0208 653 8888

All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. Bona Fide account orders accepted from Government, Schools, Universities and Local Authorities - minimum account order £50. Cheques over £100 are subject to 10 working days clearance. Carriage charges (A)=£3.00, (A1)=£4.00, (B)=£5.50, (C)=£8.50, (C1)£12.50, (D)=£15.00, (E)=£18.00, (F)=£20.00, (G)=CALL. Allow approx 6 days for shipping - faster CALL. All goods supplied to our Standard Conditions of Sale and unless stated guaranteed for 90 days. All guarantees on a return to base basis. All rights reserved to change prices / specifications without prior notice. Orders subject to stock. Discounts for volume. Top CASH prices paid for surplus goods. All trademarks, tradenames etc acknowledged. © Display Electronics 1999. E & O E. 07/99.

SWITCH VISA EST 26 YEARS

CIRCLE NO. 126 ON REPLY CARD

Low power 8-bit microcontrollers

Hitachi has announced the H8/3887 series of low power 8-bit microcontrollers, based on the H8/300L CPU core. The micro's 1.8V operation makes it suitable for applications where low power consumption is critical. The device also incorporates an LCD controller with on-board LCD power supply generation, suitable for many simple display applications. The H8/3887 has the ability to start its main oscillator in 20μs, which according to the supplier is unlike most other devices which typically take a few milli-seconds to start. This means the device can power up, handle an external event or internal process and return to standby before a typical microcontroller has

responded. The H8/3887 also features a peripheral set of up to 2kbytes of SRAM and 60 kbytes of ROM, three 8-bit timers, a 16-bit timer and a watchdog timer, 8 channels of 10-bit a-to-d converter, dual USARTS, a synchronous serial interface and 84 I/O pins. The device is supported by an emulator, the E6-3880, and a more comprehensive development kit, the S6-3880. This includes Hitachi WorkBench, an integrated development environment complete with C compiler, assembler and debugger.

Hitachi
Tel: 01628 585163
Enquiry No 528

CAN micro with flash

The latest CAN microcontroller from Toshiba is a 16-bit device featuring 128kbytes of on-board flash memory. Based on the TLCS-900/H core, the TMP95FW54AF integrates full CAN functions, a 16-bit controller, memory and a number of on-board peripherals including eight 8-bit timers, two 16-bit timers, a watchdog timer and an 8 by 10-bit a-to-d converter. As well as the single-channel CAN interface, on-board connectivity options include two serial I/O channels and an SPI-compatible TSEI interface. It incorporates 4kbytes of built-in RAM, 128kbytes of on-board flash EEPROM and 2kbytes of mask ROM for booting. The core delivers a number of features suited to real-time applications including a general-purpose register bank for fast context switching, high-speed, four channel micro DMA and 16bit multiplication and division instructions. Full

CAN2.0B bus ensures compatibility with both standard frame (11-bit) and extended frame (29-bit) identifiers. The TMP95FW54AF is supplied in a 100-pin QFP package and operates from a nominal 5V supply.

Toshiba Electronics
Tel: 00 49 211 52960
Enquiry No 529

Optical-fibre interconnect

An optical fibre interconnect system from AMP offers a complete end-to-end design for Gigabit Ethernet, Fibre Channel and ATM OC-12. Based on the MT-RJ small form connector, the new system offers twice the port density of traditional systems. The family of products features a range of multimode and singlemode preterminated cable assemblies, transceivers, work-station field

installable jacks, patch panel field installable jacks, patch panels, adapters and snap-in adapter plates and a jack termination tool kit.

AMP
Tel: 0800 267777
Enquiry No 530

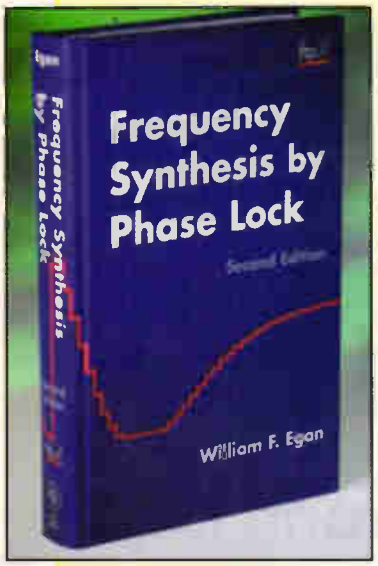
JTAG debugger for Pentiums

Embedded Power Corporation has launched a JTAG debugger for the Pentium family. The system supports the entire Intel embedded Pentium family: Pentium I/II/III, mobile Celeron and Xeon, including 5V and 3V Pentium processors. Also the QED debugger's reconfigurable design simplifies the changing from one configuration to another. If no JTAG

BOOK TO BUY

Frequency Synthesis by Phase Lock

Frequency synthesis is an important element in the design of all communications equipment, but has taken on new life recently with the advent of new hand-held wireless devices. This technology not only allows wireless transmitters to change frequencies quickly, but also gives high reliability and security in transmissions. Mobile devices such as cell phones can utilise this technology to change frequencies until a suitable one is found for the location in which it is being used.



- Emphasises the fundamentals of frequency synthesis
- Based on a course that Dr. Egan has been teaching for over 20 years at Santa Clara University
- Provides a link to the Wiley ftp site for the use of associated MATLAB exercises
- Taken together with Phase Lock Basics by the same author, the two books provide readers with complete coverage of the field.

CONTENTS

Introduction; The Elementary Phase-Locked Synthesiser; Modulation, Sidebands and Noise Spectrums; Frequency Dividers; Phase Detectors; Higher Order Loops; Sampling Effects; Architectures; Large-Signal Performance, Natural Acquisition; Acquisition Aids; Spectral Purity; Computer Aided Engineering.

UK Price: £64.00 Europe £66.50 ROW £69.00

** Price includes delivery **

Return to Jackie Lowe, Room L333, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Please supply the following title:
Frequency Synthesis by Phase Lock

I enclose Total__________

Name ____

Address ____

____

Postcode ___________________________________

Telephone ______________________

Method of payment *(please circle)*

Access/Mastercard/Visa/Cheque/PO

Cheques should be made payable to Reed Business Information

Credit card no________________________________

Card expiry date ________________

Signed ________________________

connection interface is available on the target hardware, optional socket breakout adapters are offered, which add minimal loading to the design and support all popular Pentium socket configurations. Five different connector interfaces are offered: 20-pin JTAG; PGA 320 Socket 5; 30-pin

JTAG; PGA 370 Socket 7; and Slot 1 The debugger comprises the VisualProbe debug interface and a MicroChassis, which incorporates a full implementation of the JTAG port, providing all the standard debug features, and access to special "hidden" internal Pentium registers.
AMP
Tel: 01256 474448
Enquiry No 531

High bandwidth FIFOs

IDT's 3.3V x72 SuperSync II FIFOs operate at 100MHz and are available in versions ranging from 32kbit to 4Mbit densities. The FIFOs are designed to provide double the system bandwidth of existing x36 FIFOs in a single fine-pitch BGA package. Developed for terabit switches and routers, the devices also include JTAG which allows board designers to debug and test the FIFOs and other components on the board. All members of the extended-bus (x72) family are pin-compatible with each other and have a common feature set and timing characteristics with existing narrow-bus (x9/x18) and mid-bus (x36) SuperSync II FIFOs. The x72 FIFOs provide a separate serial clock a synchronous output enable feature and bus matching capabilities.
IDT
Tel: 01372 378851
Enquiry No 533

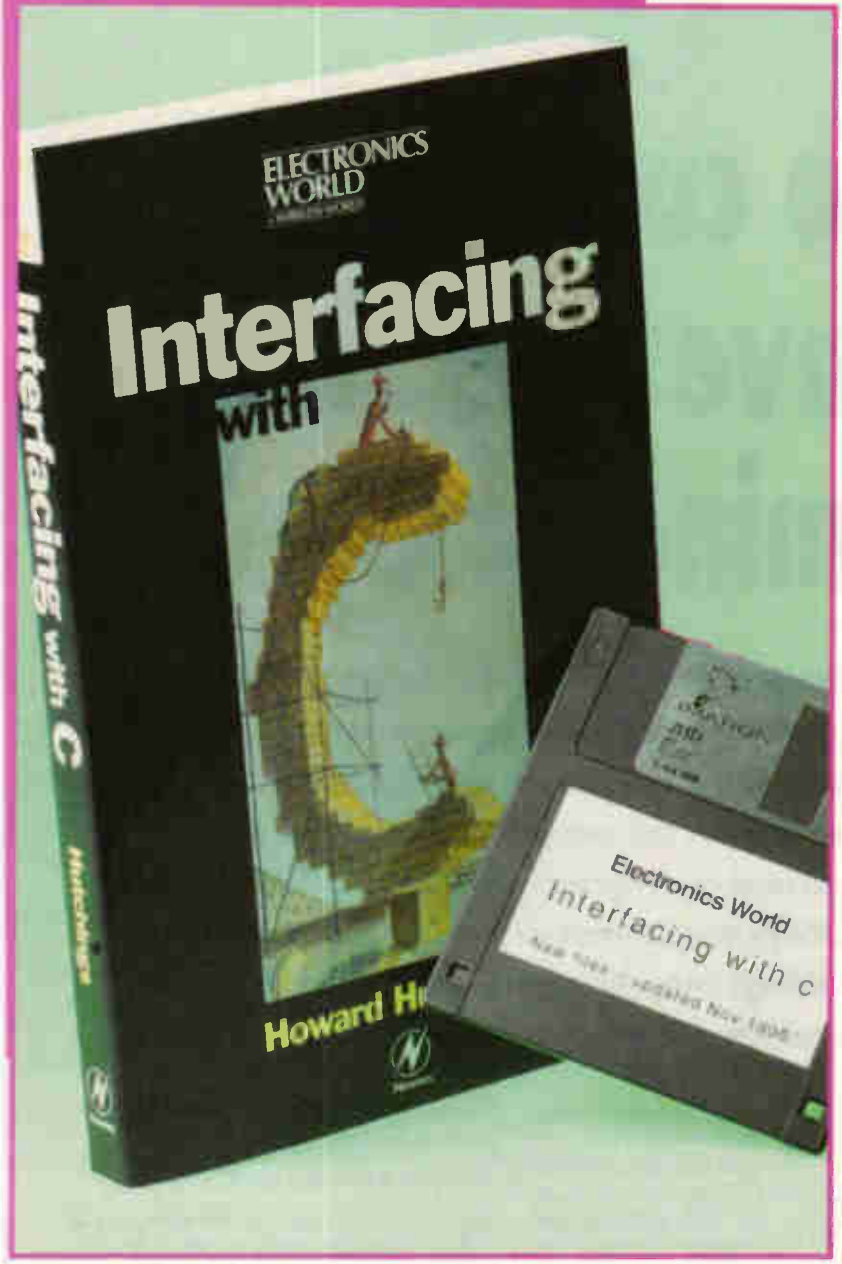
High-speed op-amp

The LT1886 contains two high-speed op amps, which are capable of providing a minimum of 8.6V peak-to-peak output at 200mA on a ±6V or single 12V supply with low total signal distortion. They are suitable for upstream line driver application in G.dmt and G.Lite ADSL modems.
Linear Technology
Tel: 01276 677676
Enquiry No 534 ■

Instruments get optical interface

The new Yokogawa WE7000 Series is a PC-based range of instrumentation modules, which combine together to produce a measurement workstation, incorporates an optical communications interface that operates up to 250Mbit/s, is also immune to noise and interference. The system also allows each module to be calibrated individually to maintain stand-alone traceability. Instrument modules available include a digital oscilloscope, function generator, counter/timer, multichannel digital thermometer, and a data-acquisition system with fully isolated inputs. Each instrument module contains its own in-built software, which automatically opens up on the PC as soon as it is connected. This software provides full front-panel emulation for instrument control and setting, along with a wide range of signal viewing and analysis capabilities. Diagrammatic set-up screens are available to allow complex trigger arrangements to be created between modules.
Yokogawa Martron
Tel: 01494 459200
Enquiry No 532

BOOK TO BUY



Without an engineering degree, a pile of money, or an infinite amount of time, the revised 289-page Interfacing with C is worth serious consideration by anyone interested in controlling equipment via the PC. Featuring extra chapters on Z transforms, audio processing and standard programming structures, the new Interfacing with C will be especialy useful to students and engineers interested in ports, transducer interfacing, analogue-to-digital conversion, convolution, digital filters, Fourier transforms and Kalman filtering. Full of tried and tested interfacing routines.
Price £14.99.

Listings on disk – over 50k of C source code dedicated to interfacing. This 3.5in PC format disk includes all the listings mentioned in the book Interfacing with C. Note that this is an upgraded disk containing the original Interfacing with C routines rewritten for Turbo C++ Ver.3
Price £15, or £7.50 when purchased with the above book.

Especialy useful for students, the original Interfacing with C, written for Microsoft C Version 5.1, is still available at the price of £7.50. Phone 0181 652 3614 for bulk purchase price.

Post your completed order form to:-
Jackie Lowe, Electronics World, Room L333,
Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

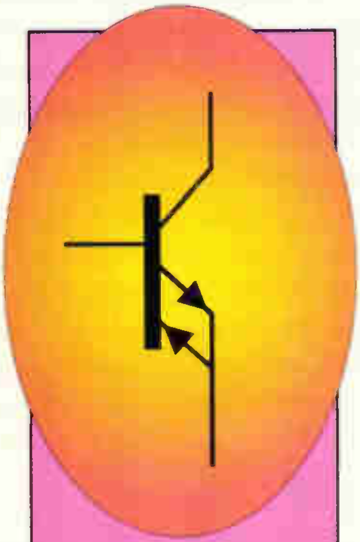
Please send me	Price	Qty	Total
Enhanced Interfacing with C book @	£14.99	....	£.......
Enh. Interfacing with C book @ + disk	£22.49	....	£.......
Interfacing with C disk @	£15.00	....	£.......
Original Interfacing with C book @	£7.50	....	£.......
Postage + Packing per order UK	£3.50	....	£.......
Postage + Packing per order Eur	£7.00	....	£.......
Postage + Packing per order UK	£12.00	....	£.......
		Total	£.......

How to pay

❑ I enclose a cheque/bank draft for £__________
(payable to Reed Business Information)
Please charge my credit/charge card
❑ Mastercard ❑ American Express ❑ Visa ❑ Diners Club
Credit Card No: Expiry Date:

Signature of Cardholder__________
Send my order to: (please use capitals)
Name__________
Address__________

Post Code__________ Tel:__________
Fax:__________ Date__________
Please allow up to 28 days for delivery



Not an ideal symbol for the current conveyor, but nevertheless a useful tool for envisaging what it does.

Are current conveyors finally coming of age?

Circuit designers avoid current conveyors, invariably resorting to the traditional op-amp regardless of how much better the conveyor might be at solving their problem. In the past, they have had an excuse in that current conveyors have been difficult to get hold of. With the advent of the 'perfect transistor' though, things may be starting to change, as John Lidgey and Khaled Hayatleh explain.

In our last article, we discussed the second-generation current-conveyor, or CCII, as a building block. Here, we look at implementing the CCII at transistor level.

As a reminder, the sign suffixing the abbreviation 'CCII' indicates whether the polarity of device's output current is inverted or not relative to input current. For a CCII+, the current/voltage transfer relationship it is given by,

$$V_X=V_Y,\ I_Y=0,\ \text{and}\ I_Z=I_X.$$

These equations show that there is a simple voltage-following action between input Y and X nodes, and that there is a simple current-following action between node-*X* and output node-*Z*.

In addition, these equations tell us that the ideal impedance relationship for the current-conveyor are,

$$Z_{IN(Y)}=\infty,\ Z_X=0\ \text{and}\ Z_{Z(OUT)}=\infty.$$

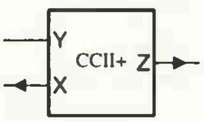
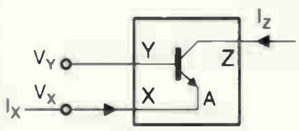


Fig. 1. Current-conveyor symbol, the '+' denoting 'non-inverting' current gain. Loosely speaking, there's a voltage follower action between X and Y nodes and a current-follower action between X and Z.



$$V_X \approx \frac{V_Y}{\left[1+\left(\frac{1}{g_m R_X}\right)\right]},\ \text{since } g_m R_X >> 1,\ \therefore\ V_X \approx V_Y$$

$$I_Z = -\frac{\beta}{[\beta+1]} I_X,\ \text{since } \beta >> 1,\ \therefore\ I_Z \approx -I_X$$

Fig. 2. In principle, an n-p-n bipolar transistor is a unipolar CCII–, so a current-conveyor can be regarded as an ideal transistor with infinite gain and transconductance.

Comparison with a transistor

Figure 2 shows a single bipolar-junction transistor. In principle, this is a unipolar CCII–, so a current-conveyor can be regarded as an ideal transistor with infinite gain, represented by β, and transconductance, or g_m.

Driving into the base of a bipolar transistor gives close to unity voltage gain from input base to output emitter. There's a relatively high input impedance at the input and a low impedance at the output.

On the other hand, driving into the emitter of a bipolar transistor gives almost unity current gain from emitter input to collector output, with low input impedance and high output impedance.

Drawing the comparison further, the high input impedance *Y* node corresponds to the base (or gate) of a transistor while the low input impedance *X* node corresponds to the emitter (or source) of a transistor. Similarly, the high output impedance *Z* node corresponds to the collector (or drain) of a transistor.

Clearly one transistor cannot function alone as a complete current-conveyor. An unbiased single transistor can only handle unipolar signals. The high accuracy unity voltage and unity current gain required for a high performance current-conveyor cannot be obtained.

However, the generic relationship between the transistor and the current-conveyor is valid and it does provide valuable insight into the development and operation of monolithic current-conveyors.

First monolithic current-conveyor

The first commercially available current-conveyor based on the current-feedback op-amp was the CCII01. Shown in **Fig. 3**, this monolithic device was designed and marketed by LTP Electronics and manufactured by Elantec Inc.

This circuit was fully symmetrical. Transistors Tr_1 to Tr_4 made up the input stage. The *Y*-node input was high impedance while the low impedance *X* node could be used as an input or output.

A voltage applied to the *Y* input was followed at the *X* node. The collector currents of Tr_2 and Tr_3 were reflected and recombined through current mirrors CM_1 and CM_2 to the high output impedance *Z* node. Hence any input into the *X* node was conveyed with unity current gain through to the output *Z* node.

Supplied as a dual device in an 8-pin DIL package, the CCII01 was built on a high-speed dielectric isolation fully complementary bipolar process. The device featured an equivalent slew rate of 2000V/μs and 100MHz bandwidth. Its equivalent open-loop gain was 80dB and its CMRR performance better than 53dB at 1MHz. Maximum output current from the device was ±10mA and it operated from ±5V to ±15V supplies.

The CCII01 first appeared in 1993.

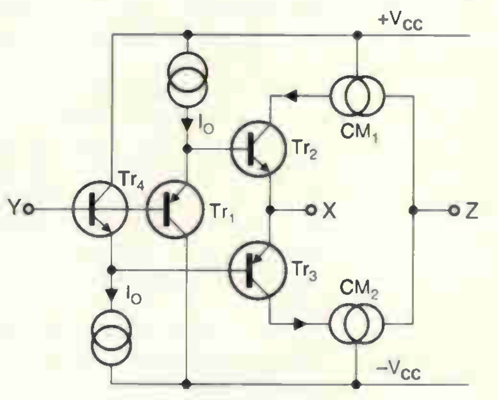


Fig. 3. Internal schematic of the first monolithic current-conveyor.

Unfortunately, the electronics industry looked somewhat sceptically at this new analogue building-block. Despite many passionate enthusiasts around the world who realised the value of the CCII01, its manufacturer stopped producing it due to poor sales volumes.

What is the 'perfect transistor'?

On pages 1049-53 of December 1999's issue of *Electronics World*, Cyril

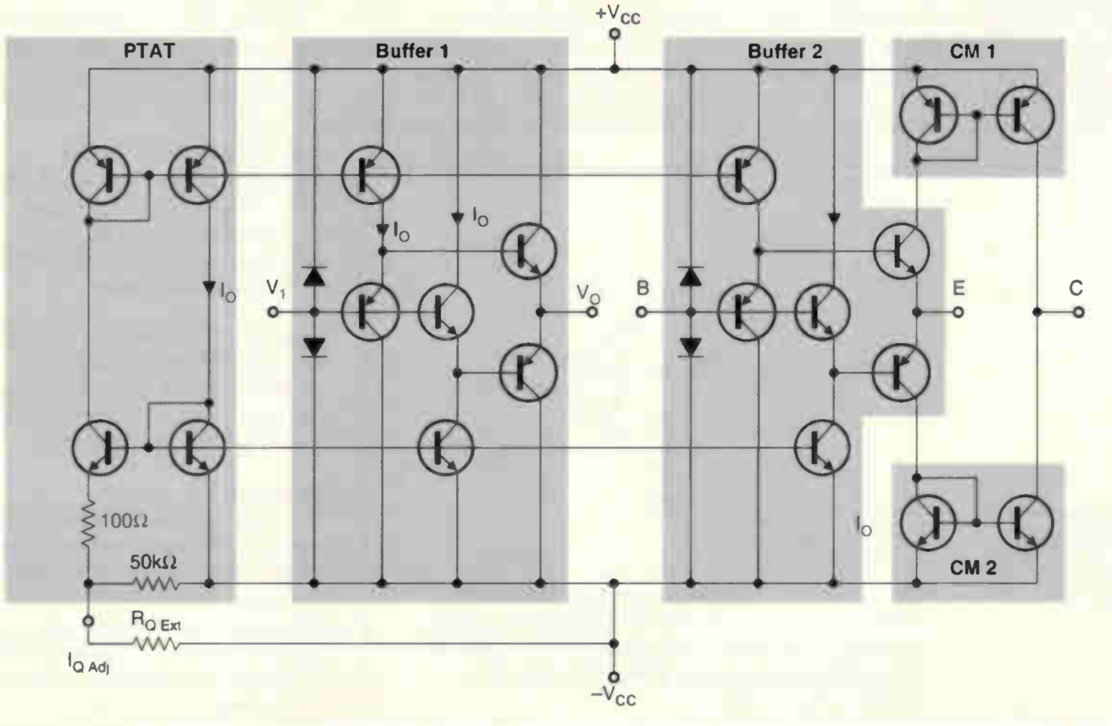


Fig. 4. Schematic of the OPA660 'perfect transistor' reveals three main building blocks – a temperature-controlled current source, PTAT, a voltage buffer and a CCII+ type current conveyor (buffer 2 plus CM1 + CM2.)

Bateman outlined a 'new' analogue integrated circuit. Described as 'the perfect transistor', this was a relatively new device from Burr Brown known as the OPA660.

Within the OPA660, whose schematic is shown in **Fig. 4**, there are three main building blocks. These are a current source proportional to absolute temperature (PTAT), an independent high-speed complementary common-collector emitter-follower (voltage buffer) and a current-conveyor type CCII+.

Buffer 1 to the right of the PTAT current source in Fig. 4 is a two-stage, cascaded complementary common-collector emitter-follower. Similar circuit configurations to this have been available in integrated circuit form from several semiconductor manufacturers, one of the first being National Semiconductor's so-called fast buffer the *LH0002*. This topology offers high speed, push-pull operation. It has good unity gain conformance and excellent current gain, which is exactly what is wanted for a fast voltage buffer.

The second buffer combined with the complementary current-mirror output stage shown in Fig. 4 is referred to in the Burr Brown data sheet as a 'Diamond transistor', or operational transconductance amplifier, OTA.

By comparing this stage with the CCII01 schematic of Fig. 3 you can see that the two circuits are virtually identical. This leads to the conclusion that the OPA660 is actually a CCII+ type current-conveyor, with an additional on-chip voltage buffer.

Burr Brown has clearly decided to describe the CCII+ part of the OPA660 as a 'diamond transistor'. The company uses the bi-directional transistor symbol shown in **Fig. 5** as a schematic representation.

Unfortunately this symbol is potentially confusing. Any current flowing out of the E (emitter equivalent) terminal results in the same level of current flowing out of the C (collector equivalent) terminal, and *vice-versa*. This is counter intuitive to Kirchhoff's current law.

Also, the symbol is rather too close to that of a single BJT and it is difficult not to be concerned with bias voltages for V_{BE} and V_{CE}, which are actually of no relevance to the operation of a fully integrated CCII+.

Current-conveyors and current-feedback op-amps

Monolithic current-feedback op-amps became commercially available as high-speed alternatives to voltage op-amps over a decade ago. Examination of the internal structure of the current-feedback op-amp is revealing as this device is essentially a CCII+ with the internal high impedance *Z* node connected to an output voltage-follower, as in **Fig. 6**.

Any current flowing at the low-impedance inverting input is conveyed to the gain node, *Z*. Resulting voltage at the Z node is buffered to the output.

The impedance at node *Z* is thus the open-loop transimpedance gain (CCVS) of the current-feedback op-amp. In practice, node Z's impedance is equal to the parallel combination of the CCII+ output impedance, the voltage buffer input impedance and any compensation capacitance at the gain or *Z* node.

Generally the gain node is not connected to an external pin and so the Z node of the CCII+ in a current-feedback op-amp cannot be accessed. However, simply removing the output buffer from a current-feedback op-amp is all that is required to obtain a high performance CCII+, and this is effectively what is inside the OPA660.

Future of the current-conveyor

Although the concept of the current-conveyor is over 30 years old, it is an analogue building block of considerable value. Now that it is available in monolithic form it is a very welcome device for the analogue circuit designer's tool-kit.

There is no doubt that the current conveyor is both versatile and convenient for many applications. In many cases, circuits made up using current-conveyors are extremely simple in structure. Often fewer parts are needed than with the traditional op-amp counterpart, due to the very attractive combined voltage/current capability of the current-conveyor.

In many applications, op-amp realisations are significantly less practicable than the equivalent current-conveyor implementation. This is particularly so for circuits involving high impedance current output capability.

Further, the current-conveyor can provide high speed and bandwidth, due to the inherent local feedback nature of the follower-based internal structure of the device.

Finally, we would like to acknowledge the work done by Prof. Chris Toumazou and Dr Alison Payne of the Imperial College, London for their role in the CCII01 design and development. ■

In last month's article, the current conveyor in Fig. 4, the lower conveyors in Figs 6 and 7 and the top conveyor in Fig. 8 all had their Y and X inputs transposed. Apologies.

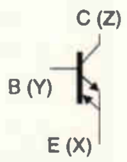


Fig. 5. 'Diamond' transistor schematic – useful for getting an idea of how a current conveyor works, but not an ideal representation.

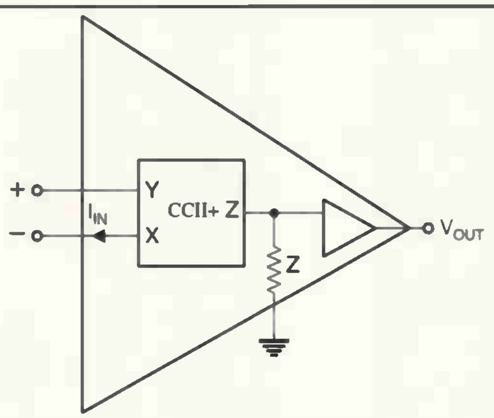


Fig. 6. Current-feedback op-amp. Examination of the internal structure of the current-feedback op-amp is revealing as this device is essentially a CCII+ with the internal high-impedance Z node connected to an output voltage-follower.

The authors
John Lidgey and Khaled Hayatleh, are in the Department of Electronic Engineering at Oxford Brookes University, Oxford, UK. John Lidgey is Professor of Electronics and Head, and Dr Khaled Hayatleh is Senior Lecturer in Electronics & Communications. John is also a Co-Director of LTP Electronics Limited, Oxon.

JLH

a lifetime in electronics

In this second article, John Linsley-Hood looks back at the pre-transistor days, to a time when his early experiments with hi-fi were interrupted by the war, and to the end of the war, when the hottest topics were FM radio and the Williamson.

Following my early experiments with wireless, I started to look at other uses for electronics.

The second most interesting application for electronic circuitry was in playing gramophone records, by way of a turntable and gramophone 'pick-up'. These were generally piezo-electric devices. They used a somewhat fragile and hygroscopic crystal of Rochelle salt sandwiched between two strips of aluminium foil.

A popular manufacturer of piezo-electric pick-ups was Cosmacord. My schoolfriend John Brown and I both had record players based on these units.

Although the pick-up had a fairly high peak electrical output – probably around 500mV rms – it needed additional amplification to make it operate a loudspeaker.

In my case, to begin with, I used a DIY three-valve amplifier, shown in **Fig. 1**. My friend John simply plugged his pick-up into a socket on the back of the Brown family's table radio.

Quite apart from the fairly obvious difference in sound quality, which favoured the table radio, there was the consideration that the HT battery of my battery-powered radio needed regular replacement. This problem worsened if I lowered the grid bias voltages to make the sound better.

The advent of mains power

To address the battery problem, I found a suitable sized wooden box once used for shoe polish and brushes. Within it I built a 120V mains transformer powered HT power supply.

Although this solved the battery problem, since the 2V accumulator was readily recharged and the grid bias batteries seemed to go on for ever, it was clearly only an interim measure. The wireless magazines I read had frequent circuit descriptions of amplifiers with output power ratings of eight watts or more, at distortion levels of less than one percent.

These more powerful amplifiers mainly used phase-splitter circuitry to avoid the need for output-valve driver transformers, which introduced distortion unless they were very well made – and hence expensive. This made me keen to try out these new circuit ideas.

Without exception though, these circuits were based on valves with indirectly heated cathodes. Most operated at either 4V or 6.3V, except for rectifiers, for which 5V was the conventional heater rating.

Tidal flows

This was the first of what I think of as the tidal flows in electronics technology, which left a number of amateurs washed up in its wake. These experimenters were quite happy using battery powered valves with directly heated filaments or cathodes, and 120V HT supplies, but the thought of HT supplies of up to 450V, and power transformers of comparable ratings was, frankly, a frightening one to the inexperienced.

Mains-powered circuitry was prone to annoyingly obtrusive background hum levels. These problems were easily remedied by attention to supply-line smoothing and the layout of the wiring and components, but they were off-putting to the novice.

RF gain stages using valves

Most radio enthusiasts find difficulty in getting either adequate stage gain or adequate selectivity from their rf stages. This problem is enshrined in the equation,

$$Q=\frac{1}{r}\sqrt{\frac{L}{C}}$$

where 'Q' is the 'quality factor' of the tuned circuit.

Both the circuit voltage magnification factor and its sharpness of tuning are defined by Q. Thus, for a high Q value, inductance L should be high in relation to capacitance C. Likewise, the equivalent circuit series loss resistance, designated r, should be small.

Stray circuit inductances, which are usually lossy, are mainly due to the wiring between components. Most general purpose valves have internal wiring lengths of the order of 5cm, as would tuning capacitors. At least twice that wiring length would be incurred by any frequency changing switching. For these reasons, most amateur radio constructors regarded 28MHz – i.e. the 'ten metre' band – as about the highest 'easy' frequency to build for.

In the case of FM radio, 10.7MHz was soon adopted as the normal superhet intermediate frequency. Components like 'Foster-Seeley' and 'ratio-detector' FM demodulators, and bandpass-coupled IF transformers, were soon commercially available. They came in neat metal cans, to smooth the path of the amateur constructor.

However, the ideal, drift-free, and motor car ignition noise-free FM tuner was as elusive at the end of the 1950s as it had been for me in 1947.

A moment of anarchy

By now, Britain had been involved in the Second World War for some years. The effect on life in Reading was relatively slight. Some things, however, such as new electronic components, were becoming difficult to obtain. In addition, some nameless civil servant had thought up a ban on the purchase of directly-heated triode valves having anode dissipations greater than four watts. It was possible to obtain a replacement power valve, but one had to fill in a tiresome form from the GPO, and have it countersigned by a JP.

The reason given for the ban was that such valves could be used by spies wanting to construct clandestine radio transmitters. Any interested schoolboy though – me for instance – could have told the 'powers that be' that one could just as easily make a transmitter using an output pentode valve, for which no permit was required.

To prove the point I built a nominally five-watt transmitter, with which I re-broadcast the BBC 'Home Service' on a new frequency, somewhere near the bottom of the medium-wave band. A tour on bicycle among my friends established that my transmissions were receivable over much of the Reading area – in some cases at better strength than the official signal.

To be on the safe side, I took my BBC 'spy' transmitter to pieces again the following day, since I felt that I shouldn't abuse my father's hospitality. I could imagine the wrath of the authorities if my actions were uncovered.

Pentode versus triode – the quest for sound quality

The original design of the thermionic valve, as an amplifying device, was the triode. It involved a spiral wire 'grid' mounted between the filament, which was also the cathode, and the metal plate anode.

Such early triodes worked well at low frequencies, and introduced relatively little distortion as an amplifier, but they were prone to instability when used at higher frequencies. This was due to the effect of feedback through the inter-electrode capacitances.

If the structure was elaborated to include a 'screening grid', as in the tetrode or pentode, the available stage gain was greatly increased. However, there was also an increase in the amount of signal distortion – mainly third harmonic – which couldn't be removed by 'push-pull' operation.

In the middle to late thirties, before the general adoption of overall negative feedback in audio amplifier circuitry, a major topic among amateur audio enthusiasts was the extent to which the efficiency and stage-gain benefits from pentodes could be retained if the output circuit was modified. Such modifications included, for example, the use of unbypassed cathode resistors or other ways of introducing local negative feedback.

A significant step in the direction of greater output stage linearity was made in the late 1930s when Marconi-Osram introduced the 'beam tetrode'. This valve offered pentode-type stage gain with triode type levels of distortion. Such valves, in various power ratings, were listed in my 1940 edition of the 'Premier Radio' component catalogue – the last to be printed before the war. In practice though, they did not become available in the shops until about 1947.

A typical 'high-quality' audio amplifier of the period is shown in **Fig. 2**.

Time testing magnetrons

On leaving school, I had the luck to get a job as a 'student assistant' in the GEC Research Laboratories at North Wembley in London. I was mainly involved in building and using test equipment for the new 10cm magnetrons that had started to be produced.

At the time, these magnetrons were transforming the UK's radar defences. They improved the accuracy of aircraft location due to their higher frequency output signal, and their shorter RF pulse length relative to their predecessors.

Though I greatly enjoyed the work, for me the main attraction of the job was the company of my new colleagues. Their knowledge of electronics seemed encyclopaedic, and made my previous efforts in radio and audio seem clumsy.

However, visiting a new friend, who had a superb record playing set-up, (though, actually, he preferred playing his bagpipes), brought home to me the truth that a better speaker system would often make for better results than any amount of clever electronic circuitry.

A mouth-watering discovery, from those days, was that some parts of the North Wembley laboratories were used for 'life-test' purposes, on a wide range of valves including the new 'kinkless tetrodes'. I remember seeing several thousands of them glowing in the darkness of the gallery in 1942.

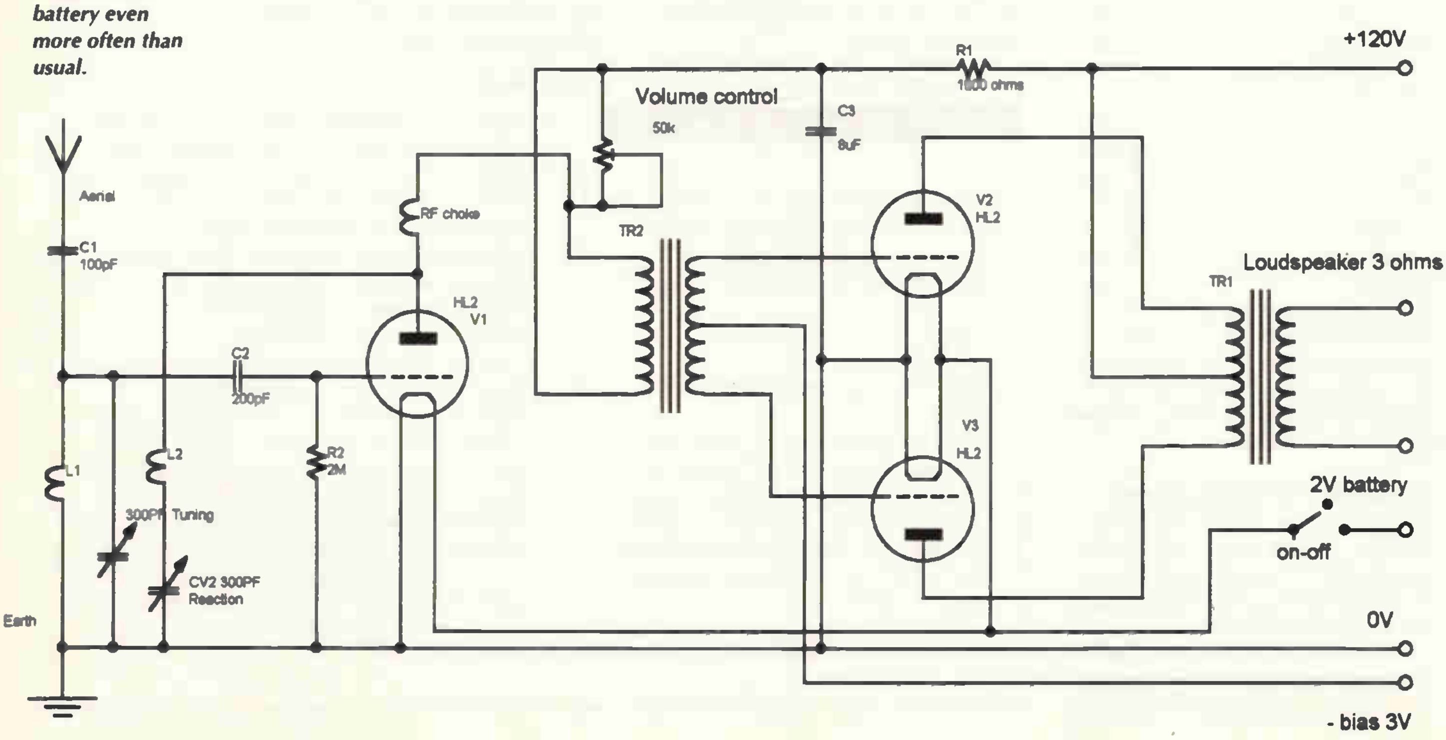


Fig. 1. My home-brewed three-valve amplifier. Its sound quality could be improved a little by lowering the grid bias voltage, but that meant that I had to replace the expensive HT battery even more often than usual.

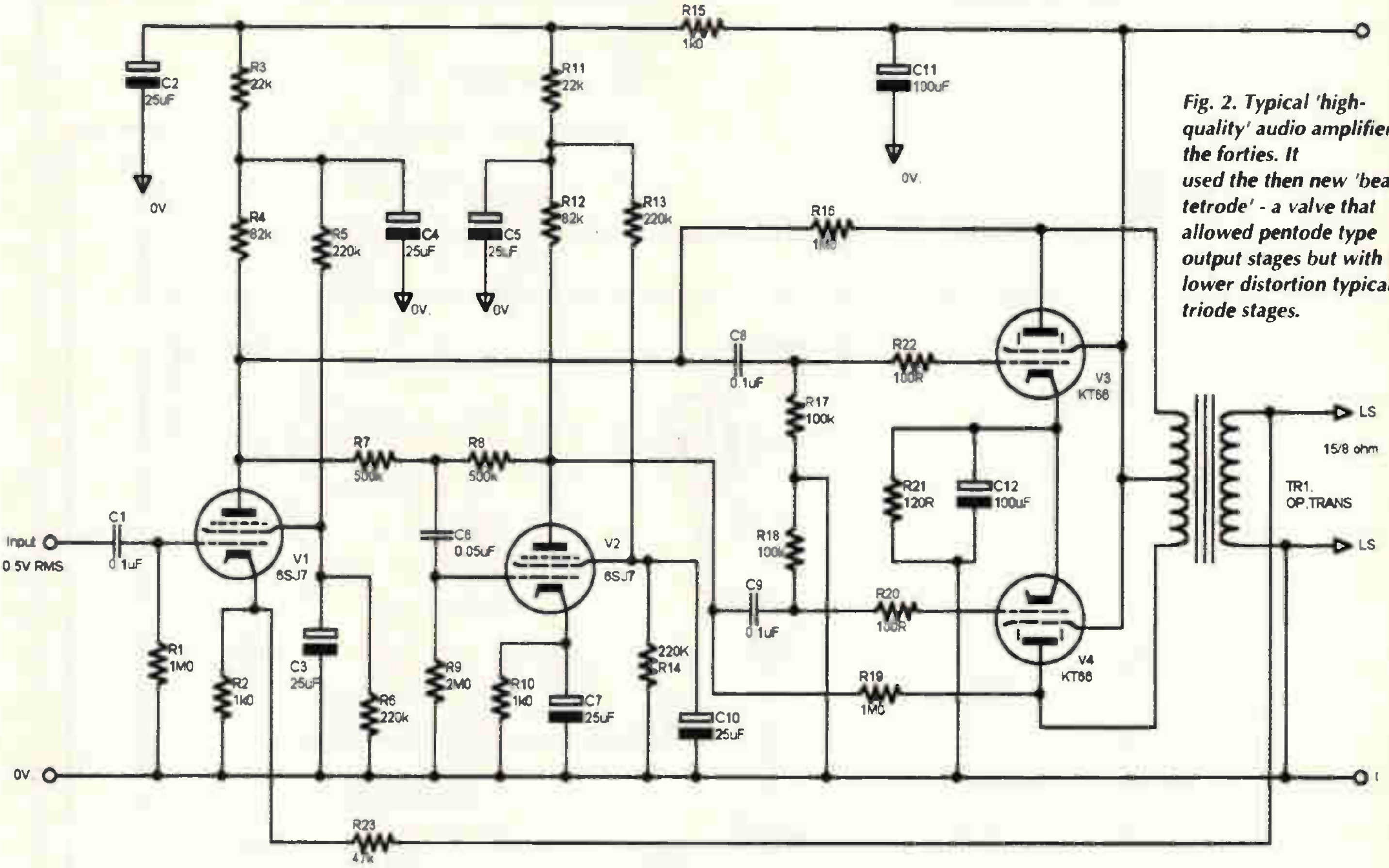


Fig. 2. Typical 'high-quality' audio amplifier of the forties. It used the then new 'beam tetrode' - a valve that allowed pentode type output stages but with the lower distortion typical of triode stages.

These valves were mostly KTZ63 radar IF amplifiers, but there were also some of the legendary, and quite unobtainable, KT66 output valves. I asked the technician in charge what would happen to them. 'Oh', said my informant, 'when the tests are finished, we sling them out. If you ask me again, say in 1945 or 1946, you can take your pick of any that are still working.

Military service

After some ten happy months at the GEC labs, I found, somewhat to my surprise, that in the course of 'Registering' for military service, I had actually volunteered to join the RAF for training as a wireless operator/air gunner with RAF bomber command. However, as is frequently the way with the military, what one is actually doing differed from what one is supposed to be doing.

I spent the next six months or so in various RAF hospitals catching up with sundry childhood ailments, like chicken pox, measles, scarlet fever and the like. These bouts were interspersed with week or ten day spells of quarantine and sick leave.

By the time I had been out of hospital for three weeks, and the RAF had decided I was, once more, fully fit for duty, the priorities had changed again. The RAF was now very happy to accept me, instead, for training as a radar mechanic – an outcome which I welcomed.

This course was divided into two six-month spells, at Glasgow and Yatesbury in Wiltshire, where much of the work tied in with my previous experience at the GEC. I was back once more in familiar territory.

At the conclusion of the course I was promoted to 'Leading Aircraftsman', and posted to the celebrated Telecommunications Research Establishment, at Malvern. In the way of the RAF however, this posting actually turned out to be to the 'Radio Experimental Unit' at Malabar Hill, Bombay – which was in the process of having its name changed to TRE (Asia).

Time in Asia

My immediate boss in Bombay was an RAF Corporal, generally known as 'Mac'. I remember him as the most astonishingly energetic and enterprising bloke I had ever met. He seemed to be able to make the RAF authorities jump through a hoop at his command.

It was said that when he was away from the unit – absent without leave, a frequent event – he would arrange for the Pay Office send his pay to him, through the post, at whichever civilian address he was using at the time.

'Mac' was an excellent instructor, if he could be persuaded to take time off from his various 'foreign' jobs. I recall two of these jobs in particular. One was a one kilowatt mobile, motor-generator powered, public address system. It was based on a raft of double triodes connected in parallel push-pull. This kit was said to have been available, on hire, for a fee, to the various Indian political parties taking part in the 1945 elections.

The second job I recall was an early digital computer that Mac built for Bombay University. It used hundreds more 6SN7 and 6SL7 double triodes. For his work on the computer, Mac was given an early, 'Class B', demobilisation.

At this juncture, Mac and I parted company. I was posted to Jaffna, in north Ceylon, to work on airborne radar, with particular reference to the detection of thunderstorms. This too was fascinating work. It involved much experimentation with oscilloscope time-base circuitry, which came in handy after I had left the RAF, in building my first green-screen TV.

The first true hi-fi

With the end of the war, the attention of many amateur electronics enthusiasts turned again to high-quality audio amplifiers. Particular attention was paid to the use of the new output beam tetrodes. These could also be 'triode connected', when they would operate in a similar manner to output triodes, but without the disadvantage of a low stage gain and a limited power output.

The first – and, in my view, by far the best – circuit using these new valves,

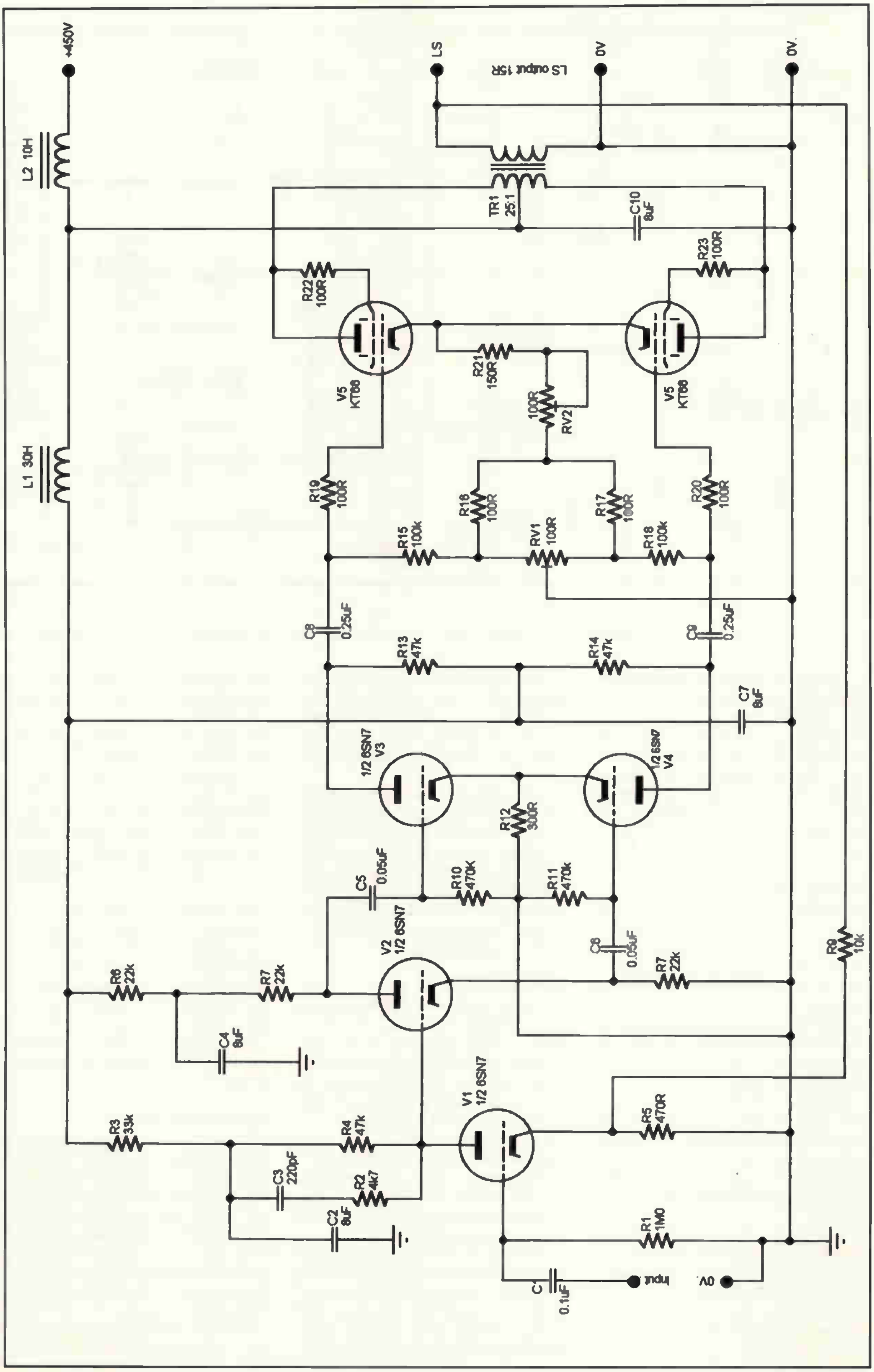


Fig. 3. The first - and, in my view, by far the best - circuit using beam tertrodes, designed by DTN Williamson and published by Wireless World early in 1947. It had a 10Hz to 100kHz response, 15 watts output, and a total harmonic distortion of less than 0.1% - a 'Rolls Royce' design, and it sounded superb.

was a design described by DTN Williamson in *Wireless World* early in 1947. I have shown the circuit of this in **Fig. 3**.

Williamson's amplifier employed a carefully designed and tightly specified output 'loudspeaker' transformer. It also had quite a large amount of negative feedback – 26dB – over the whole system, from loudspeaker output to signal input.

These features gave it a ± 1dB bandwidth of 10Hz to 100kHz, an output power of 15 watts, and a total harmonic distortion of less than 0.1%. It was a 'Rolls Royce' design, and it sounded superb.

Unfortunately, although there were a number of DIY kits for Williamson's design, these generally also commanded 'Rolls Royce' type prices. I had to wait until 1952 to build my own. A wealthy acquaintance of mine bought a kit, but took fright at the prospect of building it, and sold it to me at half price.

Windscale – a hot-bed of technology

Having spent four years at university, reading physics, I joined the electronics laboratory of the Department of Atomic Energy at Sellafield, in Cumbria, in 1951.

'Windscale Works', as it was known, was a fascinating place. It comprised a series of laboratories and chemical processing refinery blocks, built around two huge graphite moderated, natural uranium-fuelled, nuclear reactors. These were just coming on line in 1951, and resulted in a recruitment drive that was filling the local villages with new inhabitants.

Seascale, a small village two miles or so down the coast to the south of the 'works', was the main recipient of this influx of personnel. Its remote location and its large number of technically-qualified inhabitants led to a great interest in home entertainment.

In those days, home entertainment mainly meant radio and gramophone record playing systems. This resulted in a large number of home-designed and home-built loudspeaker systems – mainly notable for their size, in the pursuit of better bass.

I, too, had joined this quest for better bass, and called at the workshops of the village joiner cum undertaker to ask him to cut me up the various odd shaped pieces of wood. These would ultimately fit together to make an exponential horn, that would then form the base of a large 'radiogram' cabinet.

Having looked at my sketches, he walked round to my house to get me to explain how they would fit together. While there, he listened to my record playing system – then my Williamson's predecessor – and offered to make me a cabinet to my design if I would make him the electronics for another identical one for him. This swap was done and resulted in two very happy people. It also resulted in a temporary lull in my amplifier-making activities.

The coming of FM

A further technological tide whose ebb stranded a number of otherwise competent radio enthusiasts was the advent of the BBC 'VHF' radio broadcasts.

This new 'frequency-modulation' (FM) system offered a number of attractive features. These features were actively touted by the broadcasting authorities as solutions to the problems that increasingly beset existing amplitude modulation' (AM) broadcasts.

Among the problems with AM broadcasts were 'fading', coupled with widely variable signal strength, from station to station. In addition there was the increasing congestion of the 'medium' and 'long wave' broadcast bands. This resulted in a lot of adjacent channel interference – especially at night when listeners might particularly wish to relax and listen to the radio.

The use of a 88-1 08MHz band VHF system would solve adjacent channel breakthrough because it was essentially a 'line-of-sight' broadcasting system. In any case, this frequency band would allow a lot more elbow room. However, there were snags. The first – and the most immediately irritating of these – was frequency drift.

A number of the more enterprising radio enthusiasts, particularly those within a 50 mile radius of London, had made their own TV sets. These were tuned to the 41-45MHz transmissions from the BBC's Crystal Palace transmitter, soon supplemented by 'Midlands' transmitters at Sutton Coldfield, and 'Northern' broadcasts from Holme Moss on the hills above Huddersfield.

Home built television sets provided experience in laying out and constructing high-frequency RF amplifiers, but only for wide bandwidth and single-frequency operation. For this type of amplifier, a 'TRF' layout would have been adequate.

With FM broadcasts it was necessary to provide for reception on any one of the 200kHz channels over the whole 88-108 MHz broadcast band. Clearly, only a 'superhet' layout would give the required sensitivity and frequency coverage.

In principle, the drift problem inherent in such designs could be corrected by the use of capacitors with a positive or negative temperature coefficient. These were usually labelled 'N750' or 'P100', and so on, denoting the change in capacitance, in parts per million, per degree Celsius. They only worked though if the compensation component was of the right value, and in the right place, which could prove difficult to achieve.

During my years with TRE in Singapore, I had built a number of short-wave receivers. These included a full specification communications receiver, and several quite good 'bedside' radios for day-to-day reception of the BBC news, current affairs and entertainment broadcasts.

I felt that building the kind of RF amplifier needed for VHF reception would hold no terrors for me. However, I found that I had several fundamental lessons to learn.

Bass, heat and drift

In 1947, on returning to the UK following demobilisation, my parents owned a magnificent 1920s vintage 'Aeolian Vocalion' acoustic gramophone. This was an impressive piece of furniture, whose motor had the ability to play ten 12in record sides, at a splendidly constant speed, at a single winding of its handle. In all other respects though, it was very primitive technology.

I therefore proposed to my father that I should replace the gramophone part of the Vocalion with a proper, high quality, audio amplifier, and moving coil loudspeaker, together with one of the new FM type radio receivers. The massive clockwork motor would be replaced by an electric one. The space released by this change, and the removal of the large metal exponential horn, could then be used to house a Rola (G12) twelve inch loudspeaker driver. The 12in driver was to be added in the interests of better bass – a decision I was later to regret.

In particular, I had not fully anticipated the problem of oscillator frequency drift. The basic difficulty was that the sources of heat – the valves – were in a different thermal environment from the frequency determining components – the tuned circuits. They would heat up or cool down at different rates.

While it was possible to arrange that the correct tuning for any station was the same at switch-on as it was half an hour later, there was an intermediate period when the receiver was audibly off tune. I spent a lot of time trying to solve this problem, but without much success.

My father listened to my technical explanations, but I felt that he was not impressed with my skills. My mother side-stepped the issue by buying a commercial AM/FM radio – mainly because she liked the look of its cabinet.

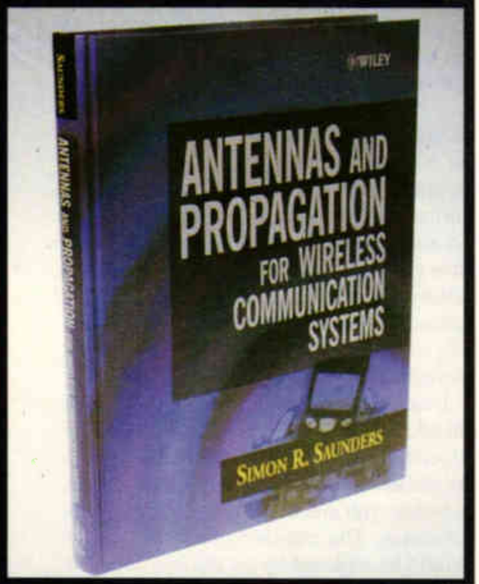
I noted, somewhat wryly, that this commercial product also suffered from oscillator drift, though not quite so badly. Also, this new receiver was used mainly as an AM radio. If FM was used, it would probably be listened to in the evening, when the radio would have been already switched on for hours and uniform in temperature.

My other design problem was due to the proximity of the loudspeaker cone to the underside of the turntable. If one turned up the volume too much, the resulting acoustic feedback could make the pick-up leap about on the surface of the record – thoroughly blunting the thorn needle.

The very good bass response also gave a lot of trouble in minimising mains frequency hum, which I furtively doctored by deliberately injecting a small anti-phase 50Hz voltage into the signal chain. ■

In his next article, John recalls the coming of the transistor.

BOOK TO BUY



CONTENTS

Introduction: The Wireless Communication Channel • Properties of Electromagnetic Waves • Propagation Mechanisms • Basic Propagation Models • Terrestrial Fixed Links • Satellite Fixed Links • Macrocells • Shadowing • Narrowband Fast Fading • Wideband Fast Fading Microcells • Picocells • Megacells • Diversity • Equalisers • Adaptive Antennas • Future Developments in the Wireless Communications Channel • Appendices

416pp £39.95

Antennas and Propagation for Wireless Communication Systems

Antennas and propagation are the key factors influencing the robustness and quality of the wireless communication channel. This book introduces the basic concepts and specific applications of antennas and propagation to wireless systems, covering terrestrial and satellite radio systems in both mobile fixed contexts.

Including:

- Illustrations of the significance and effect of the wireless propagation channel
- Overview of the fundamental electromagnetic principles underlying propagation and antennas
- Basic concepts of antennas and their application to specific wireless systems
- Propagation measurement modelling and prediction for fixed links, macrocells, microcells, picocells and megacells
- Narrowband and wideband channel modelling and the effect of the channel on communication system performance
- Methods that overcome and transform channel impairments to enhance performance using diversity, adaptive antennas and equalisers.

Antennas and propagation is a vital source of information for wireless communication engineers as well as for students at postgraduate or senior undergraduate levels.

Distinctive features of this book are:

- Examples of real world practical system problems of communication system design and operation
- Extensive worked examples
- End of chapter questions
- Topical and relevant information for and about the wireless industry

Post your completed order form to:- Jackie Lowe, Room L333, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Phone your credit card order: 020 8652 3614

Fax your completed order form to 020 8652 8111

email: jackie.lowe@rbi.co.uk

POSTAGE FREE

For air delivery add £5.50 postage

How to pay

❑ I enclose a cheque/bank draft for £____________
(payable to Reed Business Information)

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

Credit Card No: Expiry Date:

____

Signature of Cardholder______________________

Send my order to: (please use capitals)

Name______________________________

Address______________________________

____

Post Code____________ Tel:______________

Fax:______________________ Date__________

Please allow up to 28 days for delivery

Uses for a different kind of log amp

Joe Carr has been investigating a relatively new log amplifier that delivers a demodulated output over a 92dB dynamic range. Applications presented here include an RF wattmeter for microwatts to kilowatts and an RF level meter calibrated in dBm.

A logarithmic amplifier produces an output signal, V_O, that is proportional to the natural base-e logarithm of the input signal, V_{IN}, or V_O=k×log(V_{IN}), where k is a proportionality constant.

Early log amps used a bipolar transistor – usually n-p-n – connected in a common-base configuration in the feedback loop of an operational amplifier between the output and inverting input, **Fig. 1**.

These older log amp circuits work because the collector current of a bipolar transistor is logarithmically related to the base-emitter voltage V_{BE}. Because of the fact that $I_{IN}=I_C$, and $V_O=V_{BE}$, you can write an equation such as V_O =klog(V_{IN}).

Those designs usually suffered from a number of difficulties including bandwidth, thermal drift, and limited dynamic range – three killers. I've built a number of these amplifiers over the years, and all lacked a bit in performance. That's why I was so intrigued when I saw Analog Devices' AD8307 demodulating logarithmic amplifier.

The demodulating logarithmic amplifier

The AD8307 is a logarithmic amplifier that delivers a demodulated DC output over a 92dB dynamic range from –75dBm to +17dBm. Its output scaling has a slope of 25mV/dB, and an intercept of –84dBm. The bandwidth is DC to 500MHz with ±1dB linearity up to 100MHz.

The AD8307 operates from a 2.7 to 5.5V DC power supply. It requires less than 8mA in 'enabled' mode or 150μA in sleep mode. Operating power consumption is a mere 22mW.

The AD8307 is available in eight-pin SOIC and plastic DIP packages. **Figure 2** shows the 8-pin DIP package pin-out. The device operates over the 'industrial' temperature range of –40 to +85°C. Definitions of the pins are shown in **Table 1**.

Applications outline

A logarithmic amp that operates from DC to 500MHz has numerous applications.

Instrumentation examples include decibel meters from very low near-DC frequencies up to full device bandwidth. Published applications have included an RF field strength meter (Hickman 1998), an RF decibel meter (Bolch 1999) and a circuit for controlling the output power of an RF power amplifier (Gilbert and Nash 1999).

Other applications include a 120dB IF amplifier in a spectrum analyser circuit, received signal strength

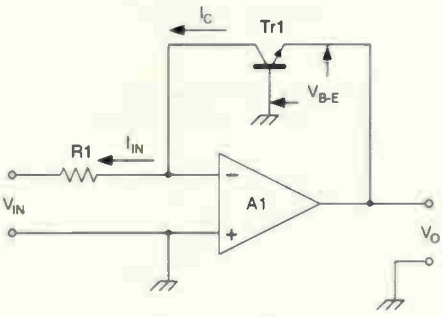


Fig. 1. Traditional logarithmic amplifier relies on the log relationship of collector current to base-emitter voltage.

Fig. 2. AD8307 pin-out.

Table 1. Pin functions of the demodulating logarithmic amplifier.

Pin	Function
1	Inverting input (–in), usually kept at (V+)/2.
2	Common – ground in most cases
3	Offset adjust
4	Output
5	±6dB intercept adjust
6	CMOS chip enable, active high.
7	V+ (+2.7 to +5.5V DC)
8	Non-inverting input (+in), usually kept at (V+)/2.

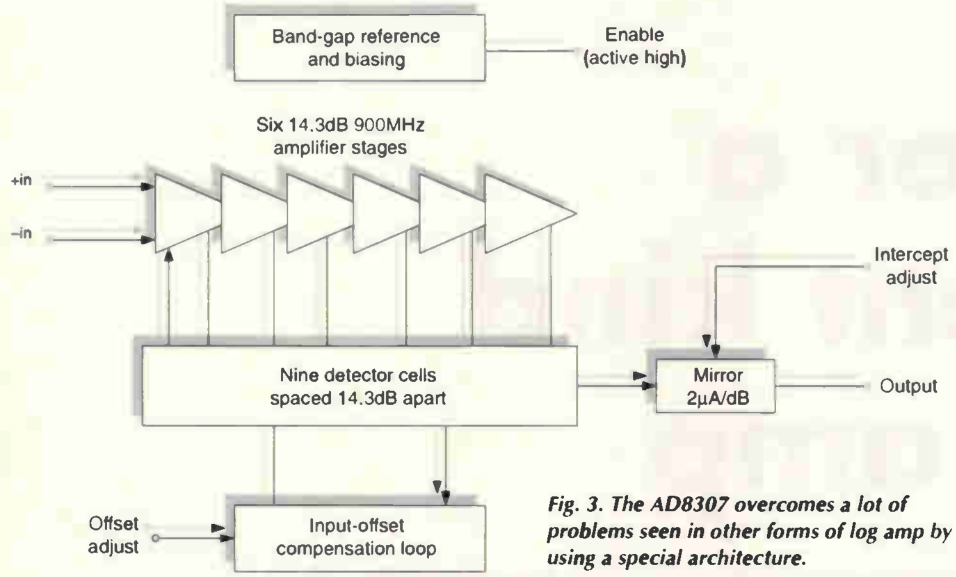


Fig. 3. The AD8307 overcomes a lot of problems seen in other forms of log amp by using a special architecture.

indicator (RSSI), Sonar and Radar signal processing, medical and scientific device amplifiers, and a host of others.

If your application requires a very wide dynamic range, at frequencies from DC to UHF, then the AD8307 log amp may be a candidate solution because the gain slope is compressed at high input signal levels.

How the device works

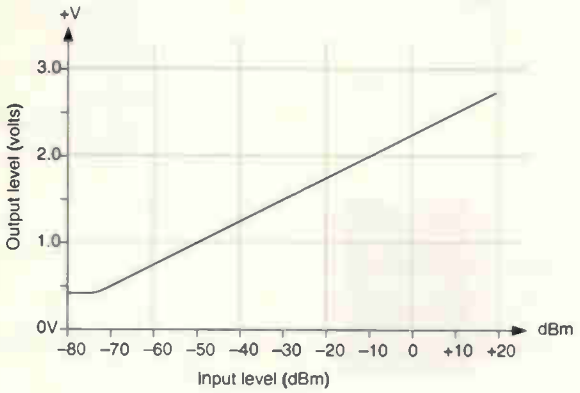
The AD8307 overcomes a lot of problems seen in other forms of log amp by using a special architecture, **Fig. 3**. that enables the 'progressive compression', or 'successive detection' technique.

Each of the six cascaded amplifier/limiters in the design has a –3dB bandwidth of 900MHz. The natural input range of the device is –75dBm to +17dBm, although an input matching scheme can alter this range to –88dBm to +3dBm.

Output from the amplifiers passes to a 2µA/dB current mirror. It is converted to a 25mV/dB output voltage when the current is passed through a 12.5kΩ precision resistance. The DC output voltage will thus vary from 250mV at –74dBm to 2 500mV at +16dBm, Fig. 4.

These levels assume a 5V DC power supply. If a 2.7V DC power supply is used then the output scaling factor can be reduced from 25mV/dB to 15mV/dB in order to utilise the entire output range.

Fig. 4. Output level versus input level in dBm.



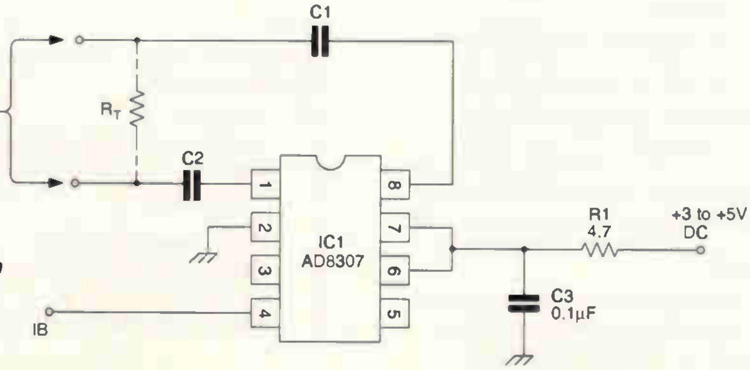


Fig. 5. Basic connection scheme of the demodulating log amplifier.

Basic circuit configurations

Figure 5 shows the basic circuit configuration for the AD8307 log amp.

Power is applied to pins 7 and 6, the latter being the chip-enable pin. A small-value resistor, R_1, and a capacitor C_3 provide a bit of decoupling and isolation. The resistor should be a non-inductive type such as carbon composition or metal film. The capacitor should be usable at frequencies into the UHF region.

The input is differential between pins 1 and 8. Because these pins are at a potential of (V+)/2 capacitors $C_{1,2}$ are required.

Values for C_1 and C_2 should be equal and will vary from 10µF at frequencies near DC to about 2pF at 500MHz. For RF applications it is common practice to use 1000pF capacitors for C_1 and C_2.

Input impedance of the device is normally 1.1kΩ shunted by 1.4pF capacitance between pins 1 and 8. Resistor R_T brings the input resistance down to a specified standard level such as 50Ω for RF systems or 75Ω for TV systems.

The value of R_T should be 52.3Ω if the input impedance is to be 50Ω. One way to obtain this resistance – apart from buying a precision resistor – is to use a 51Ω 5% unit that has an actual measured resistance of 52.3Ω.

Slope and intercept-point adjustment

The 25mV/dB output scale factor is approximate, but is adequate for many applications. If you want to provide higher calibration accuracy, then use the circuit of **Fig. 6**. It is like the basic circuit of Fig. 5, but adds adjustments for the output slope, R_3, and intercept point, R_5.

Resistors R_3 and R_5 connected between the output terminal and ground make up the output slope adjustment circuit. The series combination R_{3+5} is shunted across the internal 12.5kΩ resistor, reducing the output slope to some value close to 20mV/dB. This value depends on the setting of R_3. With the values shown the output slope range will be approximately 18mV/dB to 22mV/dB.

There are two basic methods for adjusting the output slope control. The first is to apply two different signal levels alternately, while adjusting the control for the proper output levels. For example, signals of 0dBm and –60dBm can be alternately applied.

The other method is to use an amplitude-modulated signal with a continuous wave level in the middle of the device's range – say –40dBm – and a standard modulation level. The difference in the two adjustment points will be,

$$\Delta dB = 20\log_{10}\left(\frac{1+M}{1-M}\right) \qquad (1)$$

Where ΔdB is the difference between peak and trough on the AM waveform as observed on an oscilloscope and M is the percentage of modulation expressed as a decimal.

The example given in the AD8307 data sheet is ΔdB=15dB when 70% sinusoidal modulation is applied, i.e. M= 0.70.

It is possible to adjust the intercept point by applying a DC voltage level to pin 5. This technique allows a ±3dB adjustment, which can be used to null out any intercept error in a particular circuit.

The basic method for adjusting this control is to apply a low-level signal to the input that is a specified number of decibels above the desired intercept level. For example, to set the intercept point to –80dBm, apply a signal level of –65dBm, which is 15dB above the desired intercept, and adjust R_5 to 375mV.

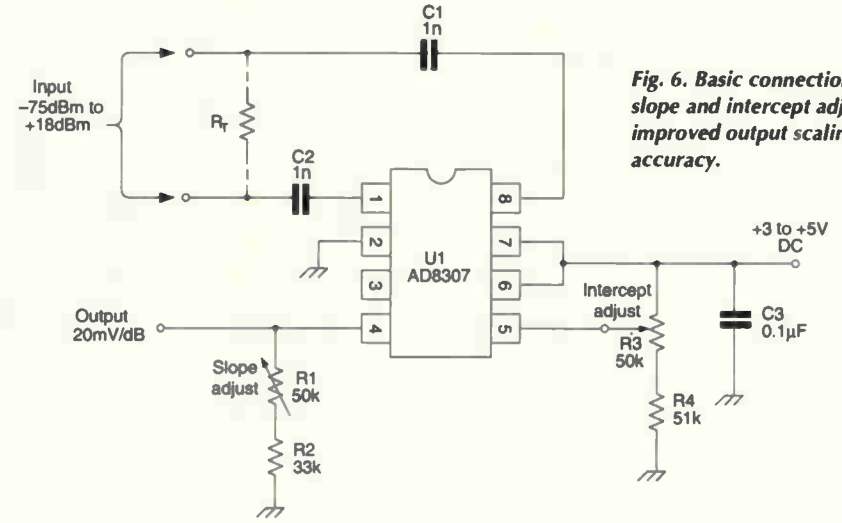


Fig. 6. Basic connection with slope and intercept adjust for improved output scaling accuracy.

Single-ended input operation

Figure 7 shows single-ended operation of the AD8307. It also shows a typical DC power supply circuit that can be used for all of the circuits described here.

Single-ended input operation is unbalanced with respect to ground. This is the type of operation that most RF circuits use, and is consistent with the use of coaxial cable to interconnection circuit elements.

In Fig. 7, the signal is applied directly to pin no. 8 through capacitor C_1. Although a value is shown for C_1 and C_2, the actual value can be scaled to the desired frequency range.

A resistor, R_1, shunts the input in order to reduce the input resistance to approximately 50Ω. The alternative input terminal on pin 1 is bypassed to ground through capacitor C_2. Be sure to keep C_1 equal to C_2.

The DC power system consists of the same low-value resistor, R_2, and decoupling capacitor, C_3, that were used earlier. In addition, a +5V three-terminal IC regulator, IC_2, is provided. This device is the 78L05 100mA regulator.

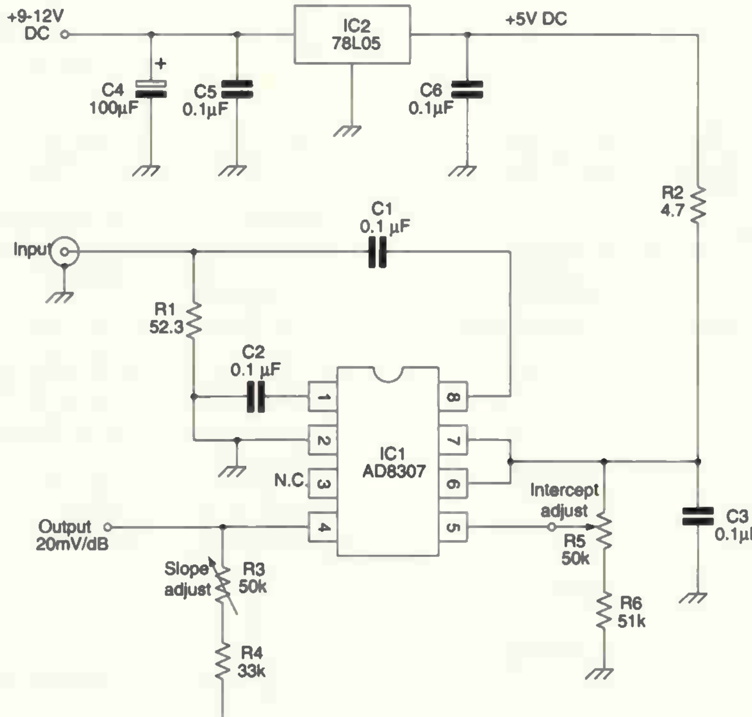


Fig. 7. Single-ended operation, in which the input is unbalanced with respect to ground. Most RF circuits are single-ended, making them easy to interconnect using coaxial cable.

Decibel notation

Decibel notations sometimes provoke a little confusion. Basically a decibel (dB) is the base-10 logarithm of two voltage, current or power levels. It is used because multiplication operations – e.g. amplification – can be accomplished by simple addition, division operations by simple subtraction. The basic decibel formulas are, for power levels P_1 and P_2,

$$dB = 10\log_{10}\left(\frac{P_1}{P_2}\right)$$

and for voltage levels V_1 and V_2,

$$dB = 20\log_{10}\left(\frac{V_1}{V_2}\right)$$

In some cases, special decibel scales are used. Scales commonly used in RF work include dBm, dBµV and dBmv. These compare a signal level against some standard reference level that establishes the 0dB point.

dBm. Compares P_1 to a standard power of one milliwatt dissipated in a 50Ω resistive load. A voltage of 223.6µV RMS (316.2µV peak) across 50Ω represents 0dBm.

dBµV. Compares V_1 to a standard voltage of one microvolt across a 50Ω load.

dBmV. Compares V_1 to a standard voltage of one millivolt across a 75Ω load. This unit is used in TV systems.

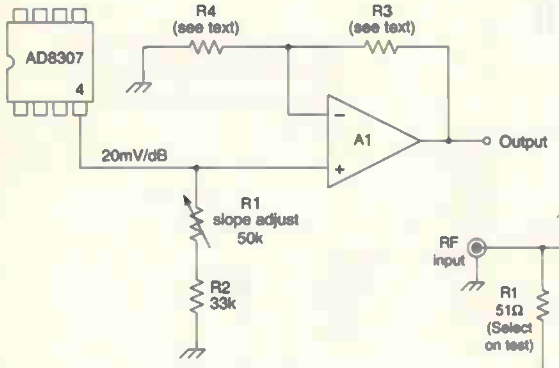


Fig. 8. Buffering may be needed because the output of the log amp is formed by passing mirror current through a 12.5kΩ resistor.

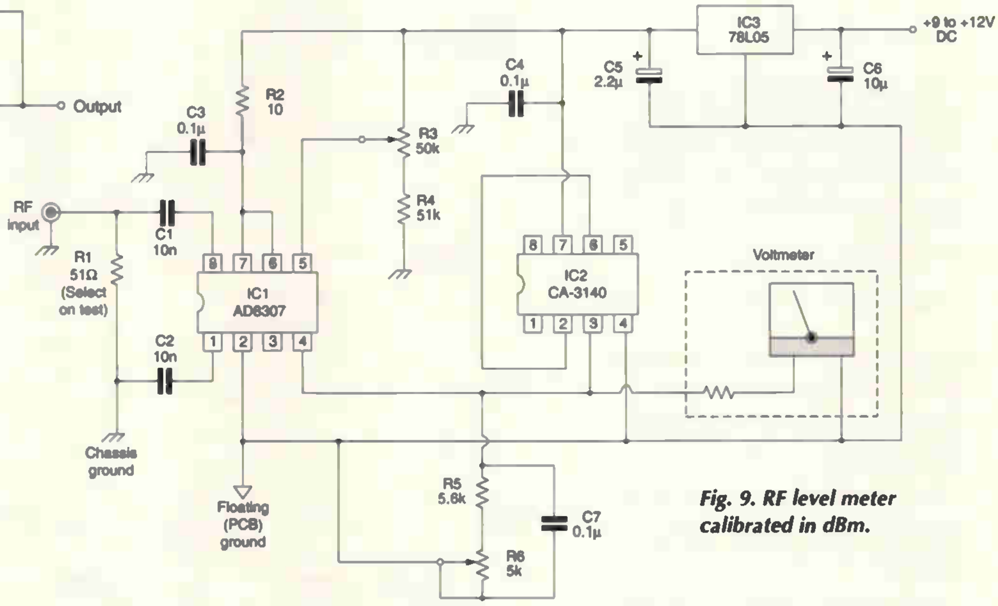


Fig. 9. RF level meter calibrated in dBm.

Capacitors $C_{4\text{-}6}$ are used to prevent noise and voltage fluctuations from affecting the circuit.

Buffering the output

Output from the AD8307 is at a relatively high impedance. This comes about because the output voltage is formed by passing the mirror current through a 12.5kΩ resistor.

Figure 8 shows how to connect an operational amplifier to the output to buffer the output, providing a low output impedance.

If gain is provided by the buffer, output level scaling is added. If no gain is required, then delete resistors R_3 and R_4, and connect the output terminal of the op-amp to the inverting input, –IN.

For other cases, where gain is required, use the standard gain equation for the non-inverting follower,

$$A_V = \frac{R_3}{R_4} + 1 \qquad (2)$$

Where A_V is the voltage gain and $R_{3,4}$ are the resistances.

Make sure you use the same units. The gain required will depend on the desired scale factor, which will be higher than 20mV/dB.

An example of a project based on the idea of a buffered output AD8307 is the RF level meter shown in **Fig. 9**.

This circuit uses the single-ended input configuration for the AD8307, with a 51Ω resistor shunted across the input. Select R_1 for an actual value as close to 52.3Ω as possible.

Calibration for actual levels should be done using an accurate signal generator. The instrument selected must have a calibrated output in either dBμV or dB.

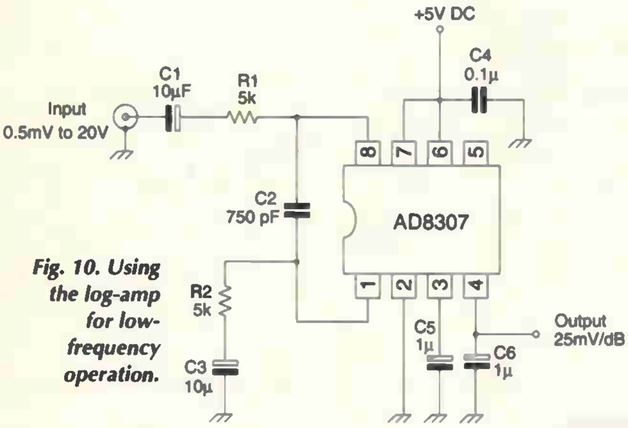


Fig. 10. Using the log-amp for low-frequency operation.

Low-frequency operation

Figure 10 shows a variant of the circuit for low frequency operation. The intercept point of this circuit is shifted from –84dBm to –64dBm. This change provides an output voltage range of 0.5mV to 2V.

The input circuit provides both low-pass and high-pass filtering. High-pass filtering is set by the networks C_1-R_1 and C_2-R_2. With the values shown – namely 10μF and 5kΩ – the high-pass –3dB knee frequency is about 3Hz.

The low-pass filter consists of C_3 and the 1.1kΩ input resistance of the AD8307. With the values shown the –3dB low-pass frequency is near 200kHz.

Additional low-pass filtering is provided for the output signal by capacitor C_6 across the output line.

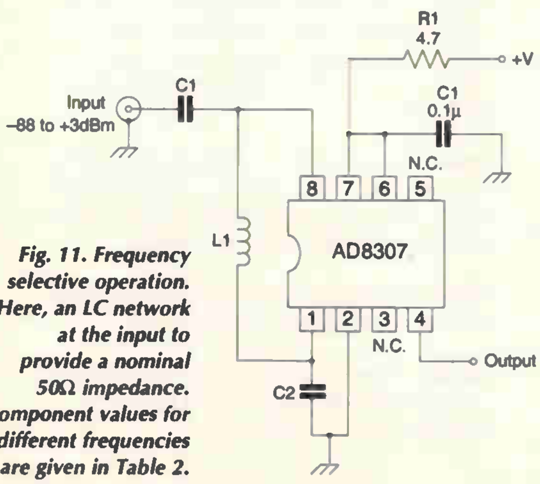


Fig. 11. Frequency selective operation. Here, an LC network at the input to provide a nominal 50Ω impedance. Component values for different frequencies are given in Table 2.

Table 2. Component values for the frequency-selective circuit of Fig. 11.

F_C (MHz)	C_1 (pF)	C_2 (pF)	L_1 (μH)
10	160	150	3.3
20	82	75	1.6
50	30	27	0.68
100	15	13	0.33
150	10	8.2	0.22
200	7.5	6.8	0.15
250	6.2	5.6	0.10
500	3.9	3.3	0.039

High-frequency input matching

The circuit of **Fig. 11** uses an *LC* network to tune the inputs of the AD8307. The values for C_1, C_2 and L_1 for a nominal 50Ω input impedance are shown in **Table 2**. Note that this particular circuit uses unbalanced values of C_1 and C_2.

Wide-range RF wattmeter

The AD8307 can be used to make an

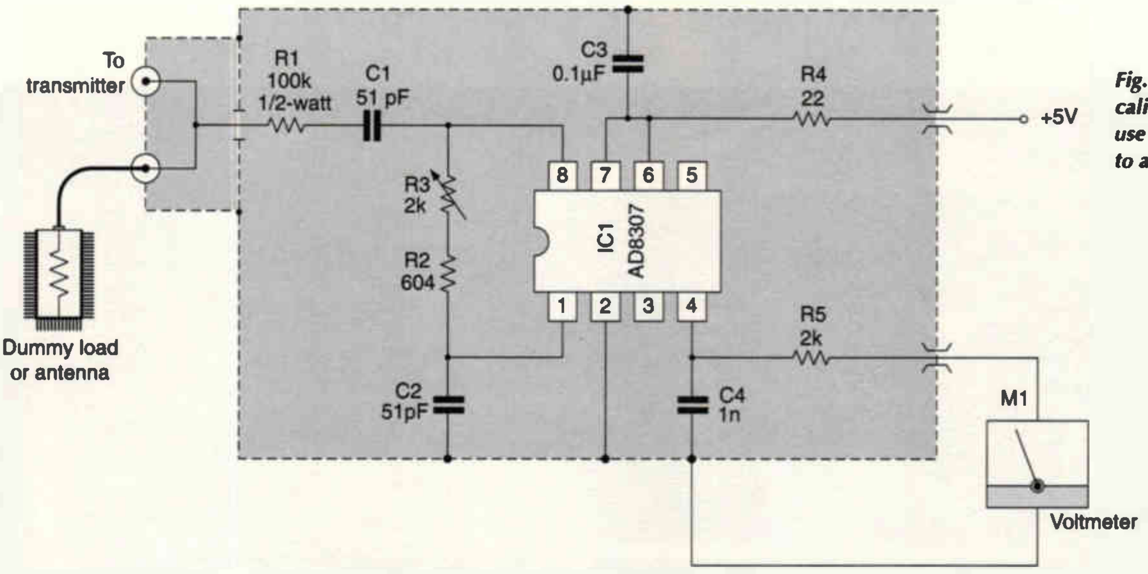


Fig. 12. RF wattmeter, calibrated in dBm, for use from a microwatt to a kilowatt.

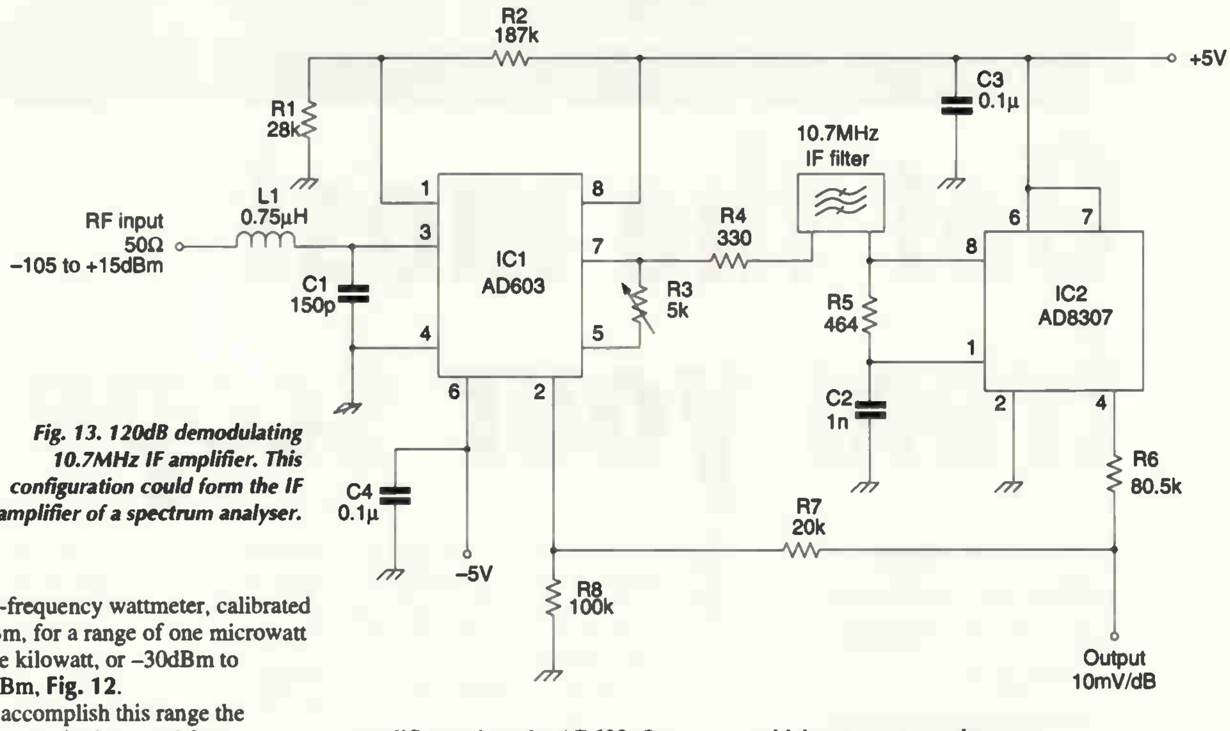


Fig. 13. 120dB demodulating 10.7MHz IF amplifier. This configuration could form the IF amplifier of a spectrum analyser.

radio-frequency wattmeter, calibrated in dBm, for a range of one microwatt to one kilowatt, or –30dBm to +60dBm, **Fig. 12**.

To accomplish this range the intercept point is moved from –84dBm to -40dBm to produce an output scale factor of 250mV per decade of RF power.

With the values of the coupling capacitors C_1 and C_2 the wattmeter operates at frequencies greater than 10MHz. Larger capacitors will drop the frequency limit lower.

The voltage appearing across the dummy load or antenna is reduced by R_1, producing a 158:1 attenuation ratio to accommodate the input range of the device.

120dB IF measurement system

The AD8307 can be used to form a high-gain demodulating IF amplifier when paired with a variable gain amplifier such as the AD603. One application for this type of circuit is as the IF amplifier of a spectrum analyser instrument.

The circuit of **Fig. 13** provides a gain of 120dB. A ceramic IF filter, such as the Murata SFE10.7MS2G-A, is used to provide bandpass limiting. This circuit works by using the AD8307 output signal to control the gain of the AD607.

In summary

The AD8307 demodulating logarithmic amplifier is a clever chip that will solve a number of problems at frequencies from DC to UHF.

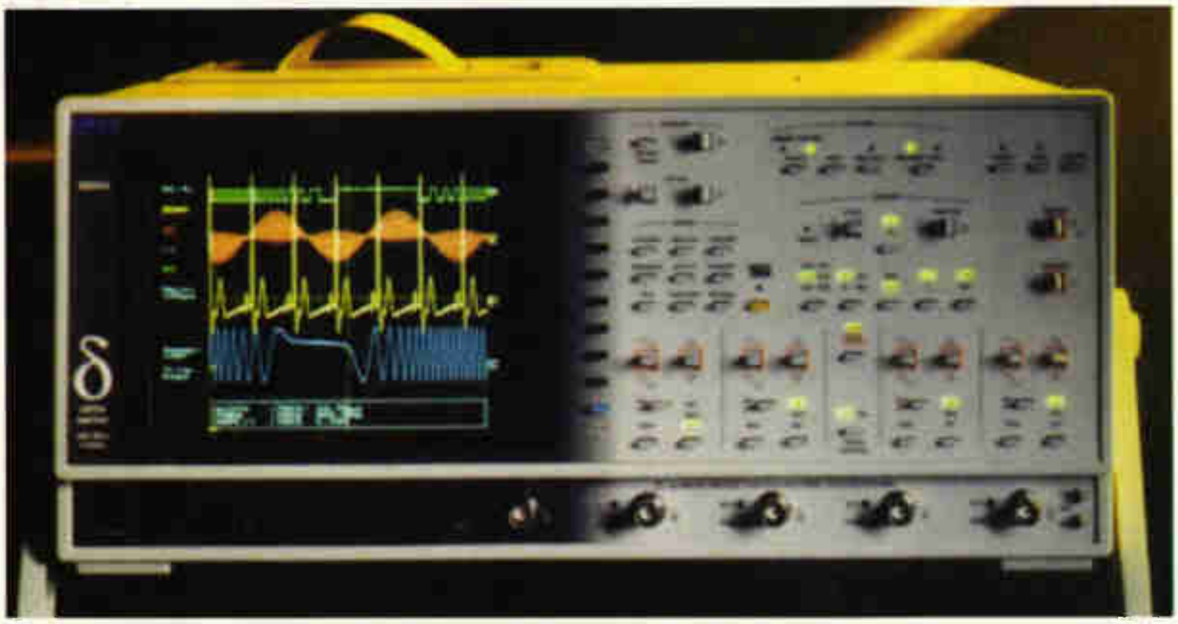
A related device – but using different pin-outs – is the AD8313, which operates over the range 100MHz to 2.5GHz, with a range of 70dB. Both AD8303 and AD8313 are offered with evaluation boards by adding the suffix '-EB' to the part number, i.e. AD8307-EB and AD8313-EB. ■

References

Bolch, P., 'RF Decibel Meter', *Elektor*, January 1999, pp. 26-29.

Gilter, Barry and Eamon Nash, 'Demodulating Log amps Bolster Wide-Dynamic-Range Measurements,' *Microwave & RF Globalnet*, April 1998 (http://www.rfglobalnet.com).

Hickman, Ian, "How Strong is Your Field?', *Electronics World*, November 1998, pp. 929-934.



Get the most from your scope

Les Green reveals which waveforms suit conventional analogue oscilloscopes and which are best captured using a DSO in this second article.

In this second article. I am going to go through a series of measurement situations. in terms of waveforms only, to show which are suitable for which type of scope.

The first group of measurements are 'easy' in the sense that they can be done using a real-time or digital storage oscilloscope. Clearly the actual measurement may be very difficult for other reasons. radiated interference for example. and some of these difficulties are highlighted in subsequent sections.

All waveforms have to have a repetition rate above about 10Hz to be considered easy. Sine. square and triangular waveforms are easy. Rectangular waveforms with duty cycles that are not too low are also easy.

Repetitive-pulse burst waveforms – this could be a set of five pulses followed by a long pause before the next set of five pulses – are easy provided you have a slightly more expensive real-time oscilloscope with a delayed timebase facility. This will allow close examination of each of the pulses in the burst.

Difficult measurements for DSOs

Digital-storage oscilloscopes have difficulty handling X-Y displays. The main problem is the dot joining. Even the cheapest real-time scope does dot joining between time-adjacent points automatically. no problem at all.

Cheaper DSOs may not support X-Y at all. and much more expensive ones try very hard to emulate the performance of real-time scopes. Lissajous figures for equal frequencies are not too bad but the higher-order patterns are not so nice.

Very-high-frequency repetitive signals are a difficult area for DSOs. On the other hand. real-time oscilloscopes lend themselves to this sort of waveform. The trace is bright and updates very rapidly, following changes in the signal almost instantaneously.

Digital storage oscilloscopes have difficulty with this type of waveform as super-fast analogue to digital converters cost super-large amounts of money.

In order to enhance the measurement capability of their DSOs, most manufacturers design their instruments to enter a mode called equivalent time sampling, or ETS, at high timebase speeds. This can boost the sampling speed – but for repetitive signals only – by at least a factor of 10, without costing very much.

Equivalent time sampling mode involves taking a group of several acquisitions. Data points from these are then interleaved, which results in a higher effective sampling rate.

Single transient events can not be captured in this mode. This is no loss compared to a real-time scope, but notice that the waveform has to be constructed out of multiple acquisitions; the speed at which this occurs is critical.

With great effort, some DSOs claim to keep up with real-time scopes in this respect: mostly they fail to keep up and therefore at best suffer from a less immediate feel to the controls. The only small comfort you can get from using a DSO in this application is that you can easily plot the waveform or do mathematical manipulations on it.

What is 'auto triggering'?

Auto trigger is a misleading, somewhat historic term. It used to be called 'bright line' by some.

The idea is that if there is no signal available to trigger the trace then the oscilloscope invents one in order to get an updating trace on the screen. This is essential for setting the ground position, measuring DC levels and seeing how big a signal is. Without it, the sensitivity and trigger controls cannot be adjusted.

A key requirement is that the auto trigger circuit should not make the trigger LED illuminate. If it does, it makes the trigger level much more difficult to set.

There is a relatively new trigger feature available for oscilloscopes that automatically tracks the signal and keeps the trigger in the middle of it; this automatic trigger level feature is useful and should not be confused with the original auto trigger mode.

How many samples per cycle? Note that a DSO does not have to have any minimum sampling rate in order to display the correct amplitude of a given signal frequency.

True, you will get an 'alias' if the sampling rate is too low. An alias is a false representation of a signal due to there being too few samples to reconstruct it properly. However, the peaks of the envelope of the alias will get to the correct amplitude, provided that the sampling clock is not an exact submultiple of the input signal frequency.

Having said this, a 20MHz bandwidth DSO with 20MS/s is not particularly useful at 20MHz. This is because there is only one dot per cycle. Nyquist sampling – two samples per cycle – is all very well for mathematicians, but if you were to look at such a waveform on a display it wouldn't look like much of anything.

Really, you want as many samples as possible on the waveform. About five or six dots per cycle is the absolute limit of sensible viewing: 1GS/s for a 20MHz DSO is not uncommon, resulting in 50 dots per cycle.

Complex, variable frequency bursts on a waveform can be tricky on DSOs. Many people are used to looking at video data on TV lines using real-time scopes. The answer you get on a DSO is completely different; this can be disturbing.

Two particular things can be seen; either an alias or a solid block of trace.

Maxi minis and aliasing. Whether you see an alias or a solid block of trace depends on whether or not 'max-min' – also known as peak detect and glitch detect – has been selected. The 'max-min' block of trace tells you that something is going on in that area. It is up to you to zoom-in on that area by using a faster timebase to see exactly what is going on.

The latest generation of digital storage oscilloscopes can give intensity or colour-graded traces according to the probability distribution of the trace. This gives the newer DSOs a much more analogue 'feel'.

By far the biggest problems with aliasing occur when you are not aware that it is going on. Of course you could just leave the max-min feature on all the time but this will give you waveforms which appear to be very noisy. The trick is to select max-min when you first view the waveform to make sure that there is nothing funny going on.

You should not buy or rent a DSO unless it has a max-min facility.

Beating. Digital-storage oscilloscopes often have very accurate crystal controlled timebases. If they are used to view crystal-generated signals, the beat frequency between the sampling clock and the waveform can be very low, displaying an envelope modulation of a signal that has no such modulation on it.

False triggering. Familiarity with a piece of equipment gives you confidence in its ability and gives you clues as to possible problems with the displayed data. If, for example, the trigger LED is illuminated but the trace is not locked on the display, then this is a good indication that something strange is going on.

Of course you may be triggering on another channel, which is not currently being displayed, but if this is not the case then try winding the timebase up to a higher speed or putting the max-min on: the waveform might be an alias.

Variable bandwidth. A real-time scope has a bandwidth marked on the front that is generally fairly believable. Sometimes though, you will find that the most sensitive range has less bandwidth than the rest. This will be mentioned in fine print somewhere.

A small, but significant, proportion of DSOs change their bandwidths according to what you are doing. This is particularly iniquitous if the oscilloscope manufacturer buries reference to this in the manual. What you really need is alarm bells and flags waved in front of you to warn you that your alleged 400MHz bandwidth has just dropped to under 150MHz because you clicked the timebase!

This is something you really need to watch out for: always read the manual – get a new manual if the original one has been lost. One justification used for this oversight is that it is done to 'protect' against aliasing. If there *is* high-frequency content in the waveform though, I want the scope to tell me it's there, not filter it out!

Note that it is convenient for oscilloscope designers to minimise the bandwidth of the measurement as it reduces the perceived noise: one has to view this from the user's point of view and improve the noise performance without reducing the bandwidth.

Difficult measurements for real-time scopes

Repetition rates much below about 10Hz are difficult to view clearly on real-time scopes.

The exact repetition rates that cause problems are a function of the persistence of the phosphor, the brightness of the tube and whether or not you are prepared to use an oscilloscope hood to cut out ambient light. Any digital storage oscilloscope will handle this speed of waveform easily, although some will handle it better than others.

Good DSOs have a feature called 'roll-mode'. At low speeds the scope display can be made to look like a chart recorder display with the 'paper' moving from left to right across the screen and the 'pen' at the right edge.

At one second per division, the display on a DSO without roll-mode will update every ten seconds. This is annoying, as you can not see what is going on as it happens. At this sort of speed it is also important to be able to stop the acquisition as soon as you have captured the desired event. Given that you don't necessarily know what the event is going to look like, a big 'STOP' button is required to keep the data on the screen.

Instruments with these roll and hold features are no more expensive than others; if you are buying or renting a DSO, get one with these features. They are particularly useful for looking at low-speed events such as the start-up conditions in an electronic system.

One-off signals. Transient events are clearly not visible to any great degree on real-time oscilloscopes. Sometimes, with the brightness turned up to maximum and with your face buried in a scope hood, you may just catch the shape of the waveform but you stand no chance of analysing it, saving it or plotting it.

Even the cheapest digital storage oscilloscope will happily sit there all day waiting for a single transient to come along; when you arrive the next day, the trace will be there on the screen waiting for you.

Transients of repetitive waveforms. There is a different type of transient event that a real-time oscilloscope also misses. This is the occasional transient on an otherwise regular waveform.

Together, the real-time scope and the human eye conspire to do an averaging operation on the trace. Hence single spikes running through a waveform, due to an interference noise source not locked to the main waveform for example, may well not be easily visible or analysable. They could be 100 times dimmer than the main trace.

Certainly low-frequency rejection trigger coupling would help with this

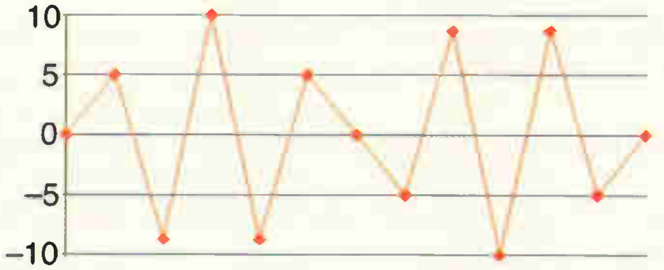
Joining the sample dots

These are all representations of the same input waveform – five cycles of a sinusoid – but with different numbers of samples per waveform. It is clear that the number of samples per cycle has a significant effect on how the original waveform is reconstructed.

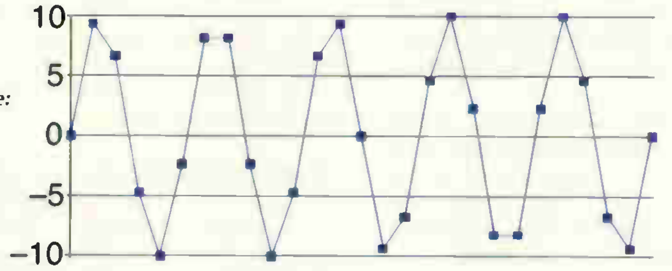
Digital oscilloscopes usually incorporate dot-joining filters known as interpolators. These are intended to make the displayed waveform clearer by drawing lines between the sample points.

Simple linear interpolation shows where the real data points are, as in the top trace . Sin(x)/x interpolation makes the trace look prettier, but can give the user a false sense of what is actually being measured.

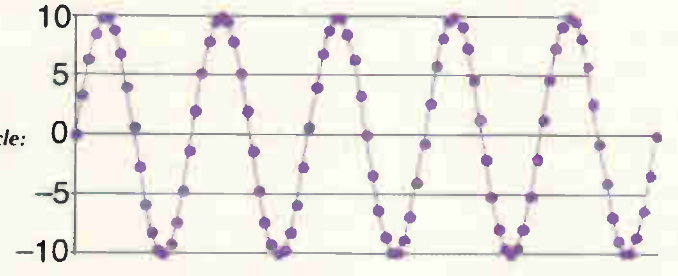
a) 2.4 dots per cycle:



b) 5.2 dots per cycle:



c) 18.4 dots per cycle:



problem, but it may not be enough. Any DSO could give a picture of some of these events as the spikes will be displayed at full brightness, to help you find out what is going on.

There are two additional ways of solving this measurement problem that may be found on more expensive DSOs. The first is a type of persistence mode. You trigger on the main waveform and allow multiple waveform acquisitions to be overlaid on each other. The scope can be left in this mode indefinitely and the display will show the max-min limits of the waveform over that period.

The second way is by using some form of advanced triggering, generally only found on more expensive DSOs. The DSO can be programmed to trigger only on narrow pulses and hence will capture these events as required.

Transients in digital systems. Another example of this type of transient event occurs in digital systems. Looking on a logic bus to view the exact voltage levels is next to useless on a real-time scope.

Different sources feed the bus so that some logic transitions can be clean whereas others ring. The real-time scope will just average them out; this can actually be worse than useless because it makes you think that everything is fine when it may not be.

Even an average DSO will display rings on logic edges fairly easily. Better yet, more advanced DSOs can be made to trigger on partial pulses that don't make it to the logic threshold (runts).

Real-time oscilloscopes have analogue timebases so that if you wish to measure the period or pulse width of some rectangular waveform you may well get an answer that is only accurate to a percent or so. A DSO, on the other hand, generally has a crystal controlled digital timebase. These timebases are therefore given worst case error specifications around the 100ppm level, at least 100 times more accurate than their analogue counterparts.

Note that this measurement accuracy is not achieved by displaying the whole waveform on the screen and using cursors. Even a 1000 point display means that the measurement uncertainty of two dots will give a time uncertainty of 0.2%.

Bandwidth versus sample rate

It is important to appreciate the difference between bandwidth – measured in megahertz – and sample rate – measured in megasamples a second. It can get confusing for people new to the subject when the term megahertz is used for sampling rate.

For an oscilloscope, the specified bandwidth is the frequency at which a sinusoidal waveform – as displayed on the screen – drops by 3dB, i.e. to 0.707 of its real value.

The accurate way to measure it is to move the timebase up to a high sweep speed then use the trigger delay to view the next edge. Alternatively, turn the store length up to 100 000 points or more.

Permanent records. Real-time oscilloscopes are not good at giving a permanent record of the displayed waveform. DSOs can provide internal printers, can drive standard ink-jet printers and can transfer their data to PCs via serial links or floppy disks.

Using real-time oscilloscopes you have to resort to an oscilloscope camera or to tracing the waveform onto film. These out-dated techniques are still used under the pretext of saving costs. This is often a false economy though. In electronics design, is important to keep design details in log-books. There is no better way to encourage this than to provide simple plots from internal printers or pretty plots for reports stored in convenient formats such as JPG or WMF.

Such instruments can provide time and date annotation, in addition to waveform data, as physical evidence that tests have been performed. It is possible to continue to use an old analogue sampling oscilloscope in a modern world. By feeding the analogue outputs of the sampling oscilloscope into a modern DSO and digitally rescaling the measurements, rise time and overshoot readings can be taken with considerably greater accuracy and repeatability than is possible by eye. The trace is also available in WMF format for inclusion in reports.

Small repetitive signals. Low-level repetitive noise sources are not particularly easy to track down on real-time scopes. With a DSO you can trigger on a particular potential noise source then investigate the noise using another channel on the DSO.

If you want to check for mains related noise for example, you can put a mains reference into the external trigger input, or use 'Line' trigger, then put the noisy signal into one of the oscilloscope inputs. The noise may fill the screen, but if you select averaging then the noise that is synchronous with the trigger signal is isolated from the other non-synchronous noise sources.

This technique cuts through lots of general measurement noise and pick-up to give a much more sensitive measurement of the synchronous noise source. It is not difficult to guess which things are likely to cause noise: mains transformers, switched-mode supplies, scan circuits, high-voltage drivers and high current drivers are all a good bet as potential noise sources. Get and use a DSO with an averaging capability if you are trying to get the best noise performance from your system.

Averaging differences

Note that although I have said that real-times scopes average, they do not do so in the same way that a DSO does. This is easy to see by a simple example.

On a real-time scope, a square wave that is not locked to the display will display two half-brightness lines corresponding to the max and min values of the waveform. On the same test, the DSO in averaging mode could display a single line half way between the two limits; the DSO is performing the mathematical averaging operation that you expect when the term averaging is used.

The real-time scope is actually displaying a probability density function; the areas where the trace occurs most often are the brightest. ■

Les's next article looks at noise and other factors that can influence how effectively an oscilloscope does its job.

LETTERS

Letters to "Electronics World" Quadrant House,
The Quadrant, Sutton, Surrey, SM2 5AS
e-mail jackie.lowe@rbi.co.uk using the subject heading 'Letters'.

Synchrodyne?

On page 171 of the February 2000 issue, George Short asks who invented the Synchrodyne. Here are two early documents to relating to the question.

First is a photocopy of part of a servicing manual for receivers sold by 'Radio L.L.' (Lucien Levy) under the trade name 'Synchrovox' in 1937. These circuits are plain superhet models, without any 'synchronisation'

Second is the front page of a 64 page book by H. de Bellescize, entitled 'La reception synchrone' dated 1932. Reference to this text is made by Professor R. Mesny in the bibliography of his book, 'Radioelectricite' Generale' on page 172: 'Synchronisation: le reception synchrone'.

In this book, Mr de Bellescize describes the technique of single-sideband reception, as developed by American engineers back in 1917 and used for transatlantic communications. He also refers to a paper by A. H. Reeves in *L'onde Electrique* of November 1931 entitled 'Reception asynchrone.'

On page 38 of his book, Mr de Bellescize gives a diagram of a 'synchronous receiver' as shown.

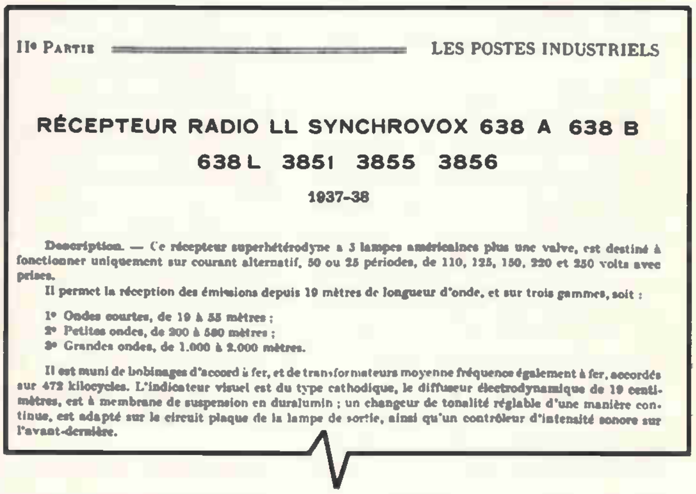
Note the system suggested for keeping the local oscillator in step with any carrier being received. The anode current of the detector varies with the strength of the received signal – and this current is called upon to switch up or down the value of negative bias applied to the RF amplifier of the set.

This AGC circuit was used in receivers made before the introduction of diode detection and variable-mu screen-grid valves.

It could be that the 'Synchrovox' referred to in the advertisement cited by Mr Short was fitted with such an automatic gain control, but I doubt it. The advertisement in '*L'llustration*' would have made a lot of fuss about it.

Independently from the above references by the way, the publication 'Transatlantic radiotelephony', by Nichols is significant. Specifically the section Electrical Communication - 1 - 1923 - 11 - 22, suppressed carrier on 55kc/s, single sideband.

Paul de Lattre
Tilff
Belgium



II° Partie — LES POSTES INDUSTRIELS

RÉCEPTEUR RADIO LL SYNCHROVOX 638 A 638 B
638 L 3851 3855 3856
1937-38

Description. — Ce récepteur superhétérodyne à 3 lampes américaines plus une valve, est destiné à fonctionner uniquement sur courant alternatif, 50 ou 25 périodes, de 110, 125, 150, 220 et 250 volts avec prises.

Il permet la réception des émissions depuis 19 mètres de longueur d'onde, et sur trois gammes, soit :

1° Ondes courtes, de 19 à 55 mètres ;
2° Petites ondes, de 200 à 580 mètres ;
3° Grandes ondes, de 1.000 à 2.000 mètres.

Il est muni de bobinages d'accord à fer, et de transformateurs moyenne fréquence également à fer, accordés sur 472 kilocycles. L'indicateur visuel est du type cathodique, le diffuseur électrodynamique de 19 centimètres, est à membrane de suspension en duralumin ; un changeur de tonalité réglable d'une manière continue, est adapté sur le circuit plaque de la lampe de sortie, ainsi qu'un contrôleur d'intensité sonore sur l'avant-dernière.

Part of the cover of a 1937 servicing manual for 'Synchrovox' receivers.

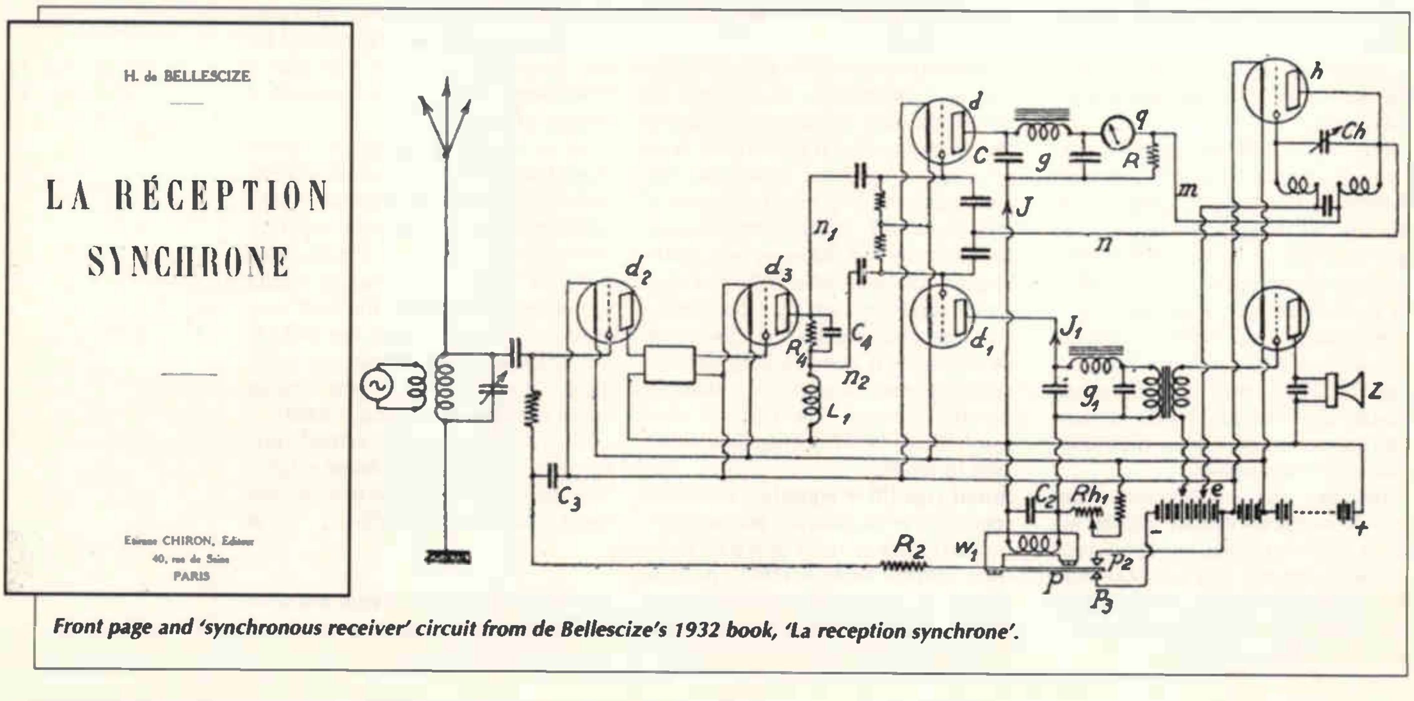
In his letter 'Who invented the synchrodyne' in the February issue, George Short suggests that homodyne and synchrodyne can be used synonymously. However it appears to be general practice now for many years to use the term synchrodyne to describe a direct conversion receiver in which a local tuned oscillator is used to select and demodulate the required signal.

The term homodyne is nowadays used to describe a direct conversion receiver in which the incoming signal is selected by a tuneable filter and separated and mixed with itself to give the desired demodulation.

While I do not have immediate access to the original papers by Tucker, my impression was always that he differentiated between the meanings of these two terms.

See my article in *Electronics World*, November 1998.

Michael Slifkin
Jerusalem College of Technology



Front page and 'synchronous receiver' circuit from de Bellescize's 1932 book, 'La reception synchrone'.

Long-life lights

I was interested to read of radio sets using a capacitor as a lossless voltage dropper. During and after the war, it was customary to leave a light burning in a hallway, suggesting the occupants were there. I used a 60W lamp in series with a 4MFD capacitor and that lasted until we left London.

Here in France, we do a similar trick to give a little light in a small lobby. Full light, when needed, is done by shorting the 4MFD capacitor. This combination is still going after 24 years of continuous use.

The trick gives the lamp filament an easy time. Switching to full light avoids the huge starting current pulse.

I tried the same thing with a flash-lamp bulb and 2MFD as a permanent pilot light. This worked perfectly until the first thunderstorm.

Another trick I have used is to put a silicon rectifier in series with the load – which has to be resistive of course.

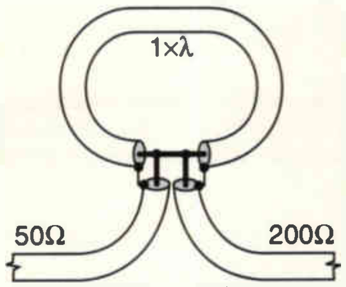
Ralph L West
Devillac
France

Co-axial-cable transformers

There are some flaws in Chris Hancock's article in the January issue.

It took me some time to realise that the unbalanced feedpoint to the baluns was supposed to be on the end of the λ/2 line-sections.

It then became clear that the connection of balun-to-balun is useless, as can be seen in the redraw below.



Balun-to-balun

It then became clear that the connection of balun-to-balun is useless...

The 1×λ section feeds itself via its own output and is therefore of no importance or use. There remains solely the connection of a 50Ω cable to a 200Ω cable, what is a greatly unmatched condition.

Figures 4 and 6 also give for one and the same point two different voltages, a thing that never is seen.

The problem of figure 6 can be solved with just one λ/2 balun which transforms the 50Ω generator and feed cable to the 200Ω impedance of the load.

Chris should also have pointed out that in a (cable) balun the characteristic impedance of the λ/2 piece is immaterial.

Peter Rook
Apeldoorn
Holland.

Chris replies

Peter's comments are very useful and I thank him. Referring to Figs 4 and 6, I should have shown a break between the start of the first λ/2 section and the end of the second λ/2 section, then used a λ/4 transformer (simplest) or a λ/2 coupler to combine the two signals before subsequent launch into the third λ/2 transformer to provide the balanced condition and further voltage/ impedance multiplication.

I was interested to read Dr Hancock's article 'Transformers from Coax' in the January issue.

Perhaps I missed it, but I didn't see what the optimum tapping point on the half-wave line was. Clearly it is not at the 50% point, as this would not phase split as required. By symmetry we can say that it must be from 0% to 50%.

Simulations suggest that tapping at less than 20% from any end is necessary to minimise the attenuation.

It is then interesting to note that the line can be tapped at 0% and this achieves the same result. A half wave line phase inverts the signal as required. Thus it seems that there is no need to tap the line at all, since this is a difficult task – as stated in the article.

Is there some deeper significance to tapping the line?

Leslie Green CEng MIEE,
Senior Principal Engineer
Gould Nicolet Technologies,
Via e-mail

Chris replies

Thank you to Mr Green for the comments regarding the position of interconnect to the λ/2 line. In my experiments I merely connected the unbalanced feed line as close as physically possible to the start of the λ/2 section. Apologies if my comments on tapping the line at 0% were misleading.

Referring to the article 'Transformers from coax', why was the task so complicated? Take for instance the problem of Fig. 5. Here a load of 12.8kΩ has to be transformed to a source of 50Ω or *vice versa*.

A far simples solution using less hardware, and thus with less loss, is to use three-quarter wave transformer sections resp. Z_o=100, 400, and 1600Ω transforming from 50Ω to 3200Ω and then using a ×4 balun to arrive at the proposed 12800Ω balanced load.

In my opinion the drawings of the baluns as depicted in the article are misleading in so far that neither the impedance nor the length of the pieces of coaxial cable beyond the connection point of the input coaxial part and the load are mentioned.

In the simple solution for transforming 50 to 200Ω, the characteristic impedance of the stubs between the 50Ω balun and the load should be 100Ω. If no lengths of coaxial cable are inserted between the load and the balun, putting in series two baluns is the same as using a re-entrant loop of twice halve a wave – in other words inserting nothing.

A far better and easier means of transforming different impedances, while obtaining better broad-band operation, can be found in the literature concerning Thebychev impedance matching. (*cfr.* Mathei *et al*) Do not reinvent the wheel.

A A De Gryse
Overijse
Belgium

Chris replies

I agree with your comments that the transformers could in fact be made using multiple λ/4 sections, which would be in principle be simpler than using λ/2 sections. Although, as you pointed out, a balun is still required at the output to achieve balanced conditions, which may make the structure equally complex. Referring to Fig. 5, this was included solely for illustration purposes and did indicate that it would be totally impractical due to the dimensions required for the 3.2kΩ and 6.4kΩ sections. I apologise if the figure is misleading, but hope that you would not attempt to build such an arrangement. Referring to Fig. 6, I agree with the comments made. I have indeed shown that the output at the end of the second balun is in phase with the input, though in practice this arrangement appeared to provide better isolation to currents flowing back along the outer sheath of the co-axial cable. This investigation could possibly be taken further to prove or disprove this. I thank you for pointing out literature on broadband impedance matching and I have looked at Chebyshev λ/4 transformers and the Chebyshev tapered transmission line. These do not provide the balanced condition required, but are interesting in as much as they reduce discontinuities between sections and increase in bandwidth. A very good reference book for understanding the operation is by Robert E Collin and is called 'Foundations for Microwave Engineering' (ISBN 0-07-112569-8).

Auto-intermodulation

During a study of power amplifier designs I reverted to Dr Ed Cherry's article 'Ironing out distortion' in the July 1997 issue of *EW*. In the article Dr Cherry points out a specific distortion mechanism – auto-intermodulation – in the input differential stage of the standard common-collector output power amplifier configuration.

A question to Dr Cherry: would one way to reduce this auto intermodulation be to use overall shunt voltage feedback instead of the standard overall serial voltage feedback? The output from the differential stage then has to be taken from the second semiconductor of the input pair.

This approach was used in the JC-3 Power Amplifier designed by John Curl during the 1970s.

Another feature of this configuration is that the capacitance of the input semiconductor does not suffer from the Miller effect, which is useful, when using FETs as input devices. Are there any specific drawbacks of this approach, as it never became popular?

Dr Cherry is an advocate of the common-emitter output stage. Could he possibly publish one of his designs suitable for home constructors?

Clas Wanning
Sao Paulo
Brazil

CAD for Linux

Many thanks to the readers who wrote in with their lists of Linux CAD programs in response to my editorial in the February issue.

When I wrote the editorial I was thinking of the established Windows programs and the Windows-oriented CAD firms that are studiously ignoring the presence of Linux. Fortunately, there are signs of movement here, with Corel very recently entering the fray with its easy-to-use version of the Linux o/s and more specifically the Eagle schematic capture and POB drawing program, available in both Windows and Linux format. This package has a good quality autorouter and is worth attention

By the way, Eagle was omitted from the pcb-cad reviews because there is no UK agent selling it. There are agents in Norway and Singapore, but not here. But in this situation I think a review is called for despite this. ■

Simon Wright
Via e-mail

Adaptable active speaker

Regarding my loudspeaker design article in the February issue, there was a slight error.

In Fig. 2a), resistance R_3 marked 220Ω should be 220kΩ. The effect of this fault is that the amplifier switches in immediately. There is no danger to the amplifier, but it is the intention of this *RC* circuit to delay switch-in.

Christof Heinzerling
Heiligenhaus
Germany

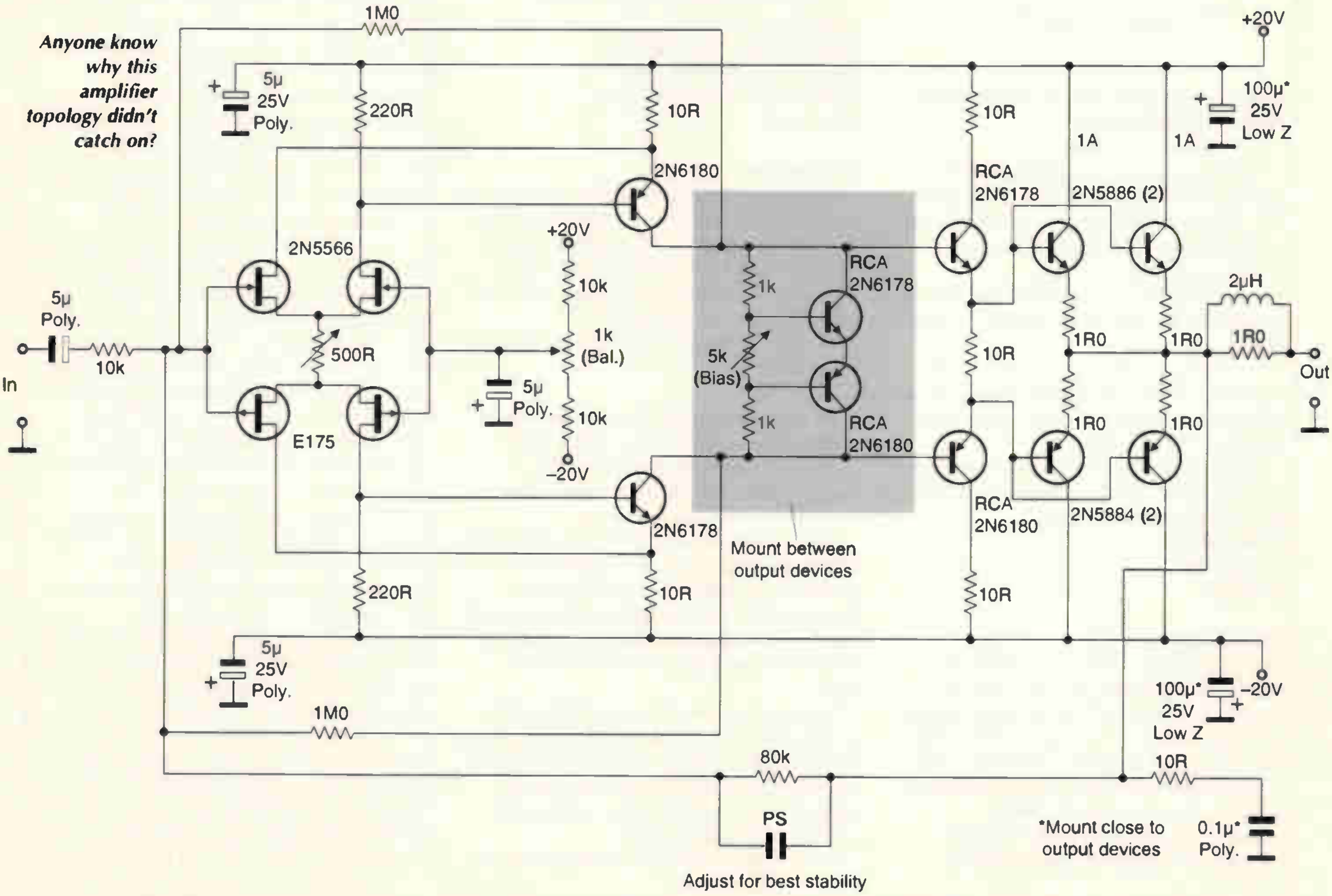
Styropor spheres

Regarding Christof Heinzerling's article on loudspeaker design in the February 2000 do you have any idea where to get the 'Styropor' kits he mentions? I've tried one or two sources and they've never heard of anything like it and the web isn't coming up with anything either.

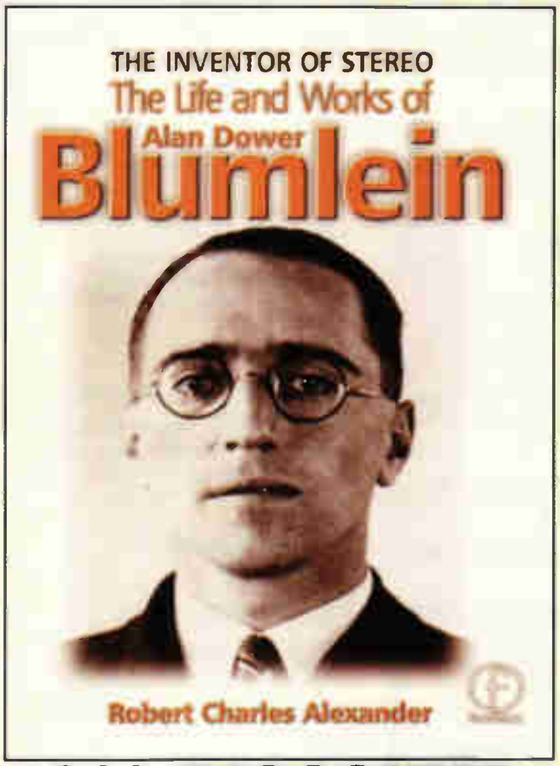
Rob Graham
Via e-mail

I believe that Styropor is a trade name for expanded Polystyrene. Focus Superstores and no doubt other craft and DIY outlets stock 20, 16, 8 and 4cm spheres of expanded Polystyrene. Rings to sit them on are also available – Ed.

Anyone know why this amplifier topology didn't catch on?



BOOK TO BUY



10% DISCOUNT

Reader price £27

Post your completed order form to:-

Jackie Lowe, Room L333, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Phone your credit card order: 020 8652 3614

Fax your completed order form to 020 8652 8111

Delivery please add the following to your order to cover delivery of your books.

UK customers add £2.50. All other countries add £3.50

How to pay
(Blumlein)

❑ I enclose a cheque/bank draft for £__________
(payable to Reed Business Information)

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

Credit Card No: Expirey Date:

____

Signature of Cardholder______________________

Send my order to: (please use capitals)

Name______________________________

Address______________________________

____

____

Post Code__________ Tel:__________________

This book is the definitive study of the life and works of one of Britain's most important inventors who, due to a cruel set of circumstances, has all but been overlooked by history.

Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first electronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' - blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

For many years there have been rumours about a biography of Alan Blumlein, yet none has been forthcoming. This is the world's first study of a man whose achievements should rank among those of the greatest Britain has produced. This book provides detailed knowledge of every one of his patents and the process behind them, while giving an in-depth study of the life and times of this quite extraordinary man.

Contents

WEB DIRECTIONS

AQUILA VISION
http://www.aquila-vision.co.uk

Aquila Vision specialises in supplying and supporting Embedded Microprocessor Development products from PICs to DSPs. We also stock robotics boards, Linux and general interest CD-ROM's.

ALCATEL COMPONENTS
http://www.components @alcatel.de

ASHWELL ELECTRONICS
http://www.ashwell-hq.com

Ashwell provide technical support for Apex Microtechnology op-amps and DC/DC'S; Aeroflex; EMP filtered connectors; M S Kennedy; Mintech obsolescence; NSC Mil/Aero; Teledyne Relays and Isocom mil/optocouplers.

ARCOM
http://www.arcomcontrols.com/ew/

A leading international supplier of communication and control technology to industry, Arcom provides leading edge solutions through a comprehensive range of market leading products.

BROADERCASTING COMMUNICATIONS SYSTEMS
www.broadercasting.co.uk

WINRADIO now brings you a complete choice in personnel computer controlled radio scanning and reception solutions ● Broadcast ● Media ● Monitoring ● Professional Amateur Radio communications

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.

CONCEPT ELECTRONICS
http://www.conceptkey.co.uk

Concept Keyboards are specialists in the design and manufacture of customer specified membrane panels and keyboards, and electronic design. Concept's membrane manufacture is supported by a full electronic production facility to provide a complete turnkey keyboard and electronics service, fully accredited to ISO9001.

CONTROL SOLUTIONS
www.controlsolutions.co.uk

Data acquisition and control for beginners, hobbyists, and professionals. Perform mathematical and logical operations on data in real time. Email: info@controlsolutions.co.uk.

COOKE INTERNATIONAL
http://www.cooke-int.com
e-mail: info@cooke-int.com

Stockists of Quality Used Electronic Test Instruments and Operating & Service Manuals.

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.

DANIEL MCBREARTY
http://www.danmcb.demon.co.uk/eng.html

Experienced engineer based in London, specialist in audio and control systems. Available for design, project engineering or general consultancy. Background of high-quality work.

EQUINOX TECHNOLOGIES UK LTD
http://www.equinox-tech.com

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

ELECTRONICS WEEKLY HYPERACTIVE
http://www.electronicsweekly.co.uk/

ECM SELECTION
http:// www.ecmsel.co.uk

For the pick of the UK's Top High-Tech Software and Hardware career opportunities - from fresh Grad/PhD to Senior Engineer/Manager -- £22,000 - £70,000

ELECTRONICS PRINCIPLES FREE ONLINE
http://www.eptsoft.com

This popular electronics educational title now available to engineers, students and hobbyists absolutely free. A huge 'virtual textbook' of electronics information, from DC to PIC's.

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

FLASH DESIGNS LTD
http://www.flash.co.uk

Flash supply low cost AVR ISP programmers (£39), MINI-ICE starter kits (from £69), Portable Easy-ICE emulators (from £199), ICE Adapters & 'C' compilers for any ATMEL AVR, MCS51, Dallas, Hitachi H8 microcontroller. Download FLASH NEWS now, Watch out for Special Offers'. ARE YOU developing code in a Flash?

HSPS LTD
http://dspace.dial.pipex.com/hsps/

FILTER DESIGNER - Advanced analog and digital filter design software for the PC. - Standard and Professional versions.- Free download of Evaluation version.

LOW POWER RADIO SOLUTIONS
http://www.lprs.co.uk

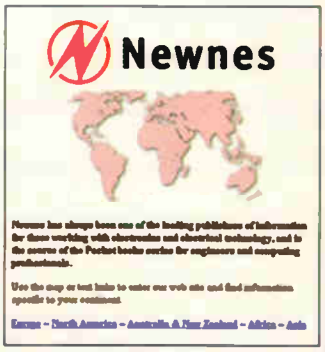
LPRS markets low power radio transmitters, receivers and transceiver modules manufactured by ourselves, Radiometrix, Circuit Designs, RDT and Micrel. Applications for telemetry, video and remote control.

MATTHEY MICROFILTERS
http://www.microfilters.net

30 years experience in the design and manufacture of high quality passive filters and delay lines. Used in Broadcast, Telecommunications, Medical, Multimedia, and Computer industries.

NEWNES - BOOKS FOR THE ELECTRONICS WORLD
http://www.newnespress.com

Over 300 books and information packages for those working with electronics and engineering technology. Visit our site for a free catalogue and downloads



To reserve your web site space contact Pat Bunce
Tel: 020 8652 8339 Fax: 020 8652 3981

OMEG POTENTIOMETERS
http://www.omeg.co.uk

Omeg 16mm and 20mm potentiometers and switched potentiometers with conductive polymer tracks. Web site has full product details, latest news, company contacts, stockists and distributors.

PCA:PHILIP COLLINS & ASSOCIATES PTY. LTD
http://www.pca.cc

PCA manufactures Radphone 2000DX remote control systems for shortwave broadcasters and government agencies wanting worldwide control of communications receivers and transceivers from any tone phone.

POLY-FLEX CIRCUITS LTD
http://www.polyflex.com

Design, manufacture and population of printed polyester flexible circuits, including Flip Chip on Flex providing practical, low cost, reliable solutions for today's small lightweight products.

QUILLER ELECTRONICS
http://www.quiller.com

100+ pages of detailed technical information on Schrack Relays, MEC Switches, Hirose Connections.

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.

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.

RALFE ELECTRONICS
professional test & measurement
www.ralfe-electronics.co.uk

RD RESEARCH
http://www.looking.co.uk/spice

Analogue and digital SPICE modelling software. Full details available on this site. Available on a 30 day evaluation basis.

RS COMPONENTS LTD
http://rswww.com

The award winning on-line service from RS
- 110,000+ products available
- Technical data library
- Stock availability check
- Integrated on-line purchasing
- Order by 8pm - with you tomorrow.

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.

SESCOM, INC.
http://www.sescom.com

SESCOM, INC. is a 30-year manufacturer of audio "problem solvers" and transformers. We also offer easily-fabricated aluminum enclosures for small production runs and prototypes.

STAFFORDSHIRE WIRELESS COMPANY
http://www.staffs-wireless.com

Wireless, communication, test equipment, bought and sold for very competitive prices visit our web site or telephone John on 01889 569928 or 0973 296461.

To reserve your web site space contact Pat Bunce
Tel: 020 8652 8339
Fax: 020 8652 3981

SUPRA AUDIO CABLES
http://www.jenving.se

Jenving Technology AB is the manufacturer of Supra Audio Cables. OEM productions are also accepted.

TEMWELL CORPORATION
http://www.temwell.com.tw

Manufacturer & Exporter of Heelical BPF Filter, 30 Watts BPF Power Filter and Handset/Base Station Duplexers

THERMOSPEED
http://www.thermospeed.co.uk

Temperature and pressure, control and instrumentation. Full on-line purchasing.
- Overnight ex-stock delivery
- Create your own hotlist
- Download datasheets
- Full technical support

Continued over page

Put your web address in front of 21 000 electronics enthusiasts and experts. ***Electronics World*** **acknowledges your company's need to promote its web site, which is why we are now dedicating pages in every issue to announce your WEB ADDRESS.**
This gives other readers the opportunity to look up your company's name, to find your web address and to browse the magazine page to find new sites.

We understand that cost is an important factor, as web sites are an added drain on budgets. But we are sure you will agree that the following rates make all the difference:

FOR 12 ISSUES:
Lineage only will cost £150 for a full year just £12.50 per month.
This includes your company's name, web address and a 25-word description.
Lineage with colour screen shot costs £350 for a full year, which equates to just £29.17 per month.
This price includes the above mentioned information, plus a 3cm screen shot of your site, which we can produce if required.

To take up this offer or for more information ring:
Pat Bunce on 020 8652 8339
or fax on 020 8652 3981.
or e-mail: linda.poyne@rbi.co.uk

Company name		Web address		

WEB DIRECTIONS

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.

TEST EQUIPMENT SOLUTIONS

http://www.TestEquipmentHQ.com

Quality second user test equipment with full warranty and support. All types of equipment from all leading manufacturers including general purpose, communications and industrial test.

TRIDENT MICROSYSTEMS LTD

http://www.trident-uk.co.uk

Visit the Trident website for details and datasheets on their entire LCD and printer product range. Download data and subscribe for our regularly updated newsleter.

TOWER HILL TECHNICAL SERVICES

http://www.towerhillaerials.com

Everything you need for DIY Satellite & TV aerial installation. The one stop shop for TV, FM, Satellite, Amateur Radio PMR Aerials, Distribution Equipment, Cable & Accessories.

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

VANN DRAPER ELECTRONICS LTD

http://www.vanndraper.co.uk

Test equipment from Grundig. Kenwood, Hitachi, Fluke, Avo, Glassman, Advance in a comprehensive site including oscilloscopes, multimeters, power supplies, generators, counters, soldering, digital tv etc.

VUTRAX PCB DESIGN SOFTWARE

http://www.vutrax.co.uk

VUTRAX electronic schematic and pcb

design system for Windows 95, 98 and NT. Limited Capacity FREE version downloads available, all upgradeable to various customised levels.

WOOD & DOUGLAS

http://www.woodanddouglas.co.uk

Wood & Douglas Ltd is the leading independent British designer and manufacturer of quality radio products for International telemetry, data,voice & video wireless communications.

To reserve your web site space contact Pat Bunce Tel: 020 8652 8339 Fax: 020 8652 3981

PROFESSIONAL Development Tools

from Milford Instruments

Milford Instruments Tel 01977 683665, Fax 01977 681465
www.milinst.demon.co.uk info@milinst.demon.co.uk
Milford House, 120 High Street, South Milford, LEEDS LS25 5AQ

PIC Emulators from Tech Tools

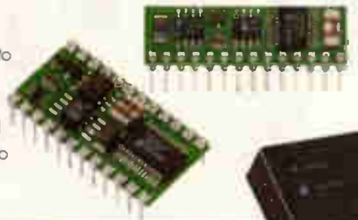
Mathias In-Circuit Emulator

- 16C5X to 20MHz
- 16CXX to 25MHz and data breakpoints
- Modular design
- True Integrated Windows Environment
- Supports standard assemblers and compilers
- True Bondout Chip set based
- Programmers and adaptors also available

Full details at www.tech-tools.com

BASIC Stamps

Still the easiest and fastest way to get your project up and going. 8 or 16 I/O pins, easy-to-read BASIC instructions plus on-board comms and simple interfacing to peripheral chips



ROM Emulators from TechTools

EconoROM, FlexROM and UniROM

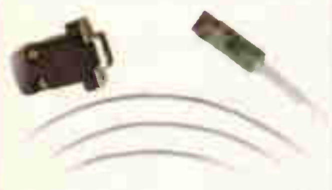
- Fast 90ns, 45ns and 25ns access times
- Fast download (up to 2.5Mbit/second)
- [illegible]
- Full editor and utilities included
- Live editing (UniROM only)
- 8bit & 16bit up to 32Mbit
- EPROM, FLASH and SRAM emulation

Full details and demo software at www.techtools.com

New to PICs or just wanting to learn new tricks?

We stock the excellent Square 1 series of PIC primers. See our web site for contents

Scenix Emulators from Parallax



SX-Key Emulator

SX chips are EEPROM based PIC16C5x pin compatible micros with up to **100mips** performance

- Full speed debugging on production chips
- Integrated Windows environment
- Software configured oscillator
- 18 to 52 pin reprogrammable devices
- SX Blitz low cost programmer also available. Full details and software at www.parallaxinc.com

SERIAL LCDs reduce display hassle-

We stock a range of alphanumeric and graphic displays all fitted with serial RS232 interface boards 2x16 to 4x40 and up to 128x64 graphics size

RS232 data entry terminal unit alsa available

CIRCLE NO.130 ON REPLY CARD

Paul Farnese describes how to put together a low-thd seven-band graphic equaliser using the LA3607 from Sanyo.

Seven-band graphic equaliser

The LA3607 is a seven-band, single channel graphic equaliser housed in a 20-pin dil package. It incorporates selective capacitive/resistive filtering to achieve the desired range of boost and cut.

Frequency range and amount of boost and cut is configurable by the user. The chip's ability to be connected in series enables greater selectivity to be achieved.

Low audio distortion makes it suitable for a wide range of audio applications and the device's low price means that it can add value to a product with little increase in overall price.

Component selection is not difficult, but tends to yield non-standard values as a matter of course. The values shown in the application circuit give seven bands centred on 60Hz, 150Hz, 400Hz, 1kHz, 2.5kHz, 6kHz and 15kHz.

As with most things in life, some compromise is called for. In this case, as always, a decision must be made regarding the cost of non-standard components versus performance trade-off.

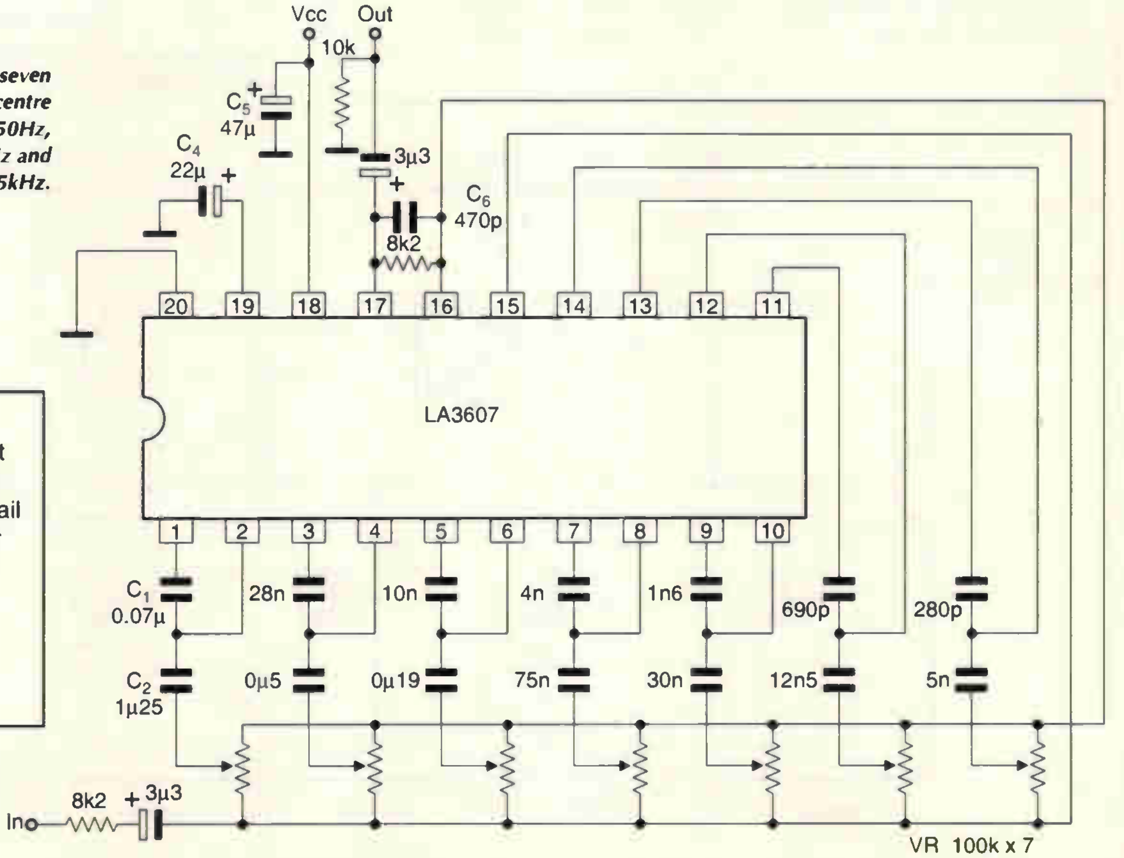
Two formulae are used to calculate component values.

$$Q = \sqrt{\frac{C_1 R_2}{R_1 C_2}} \qquad (1)$$

$$f_o = \frac{1}{2\pi\sqrt{C_1 C_2 R_1 R_2}} \qquad (2)$$

Where R_1 and R_2 are internal values of 1.2kΩ and 68kΩ

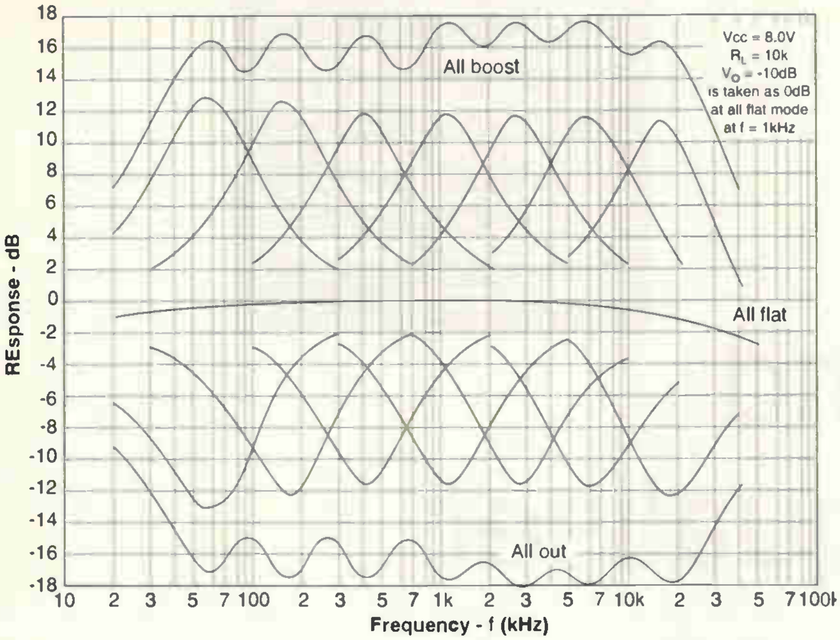
Application circuit for a seven band equaliser with centre frequencies of 60Hz, 150Hz, 400Hz, 1kHz, 2.5kHz, 6kHz and 15kHz.



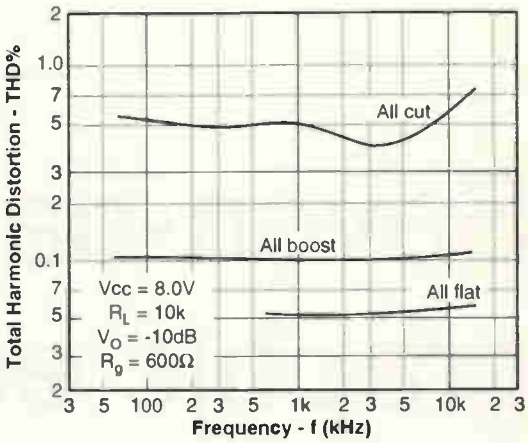
Technical support

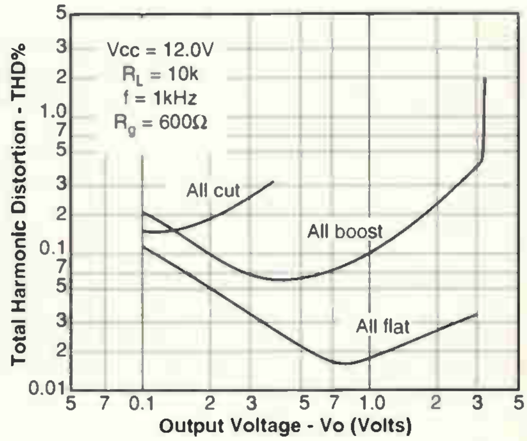
Specialist audio component supplier Profusion supplies the LA3607 in the UK. E-mail sales@profusionplc.com or fax 01702 543700 for more details.

A data sheet can be downloaded from www.profusionplc.com



Boost and cut curves for each channel of the application circuit together with flat and boost/cut curves for all channels combined.





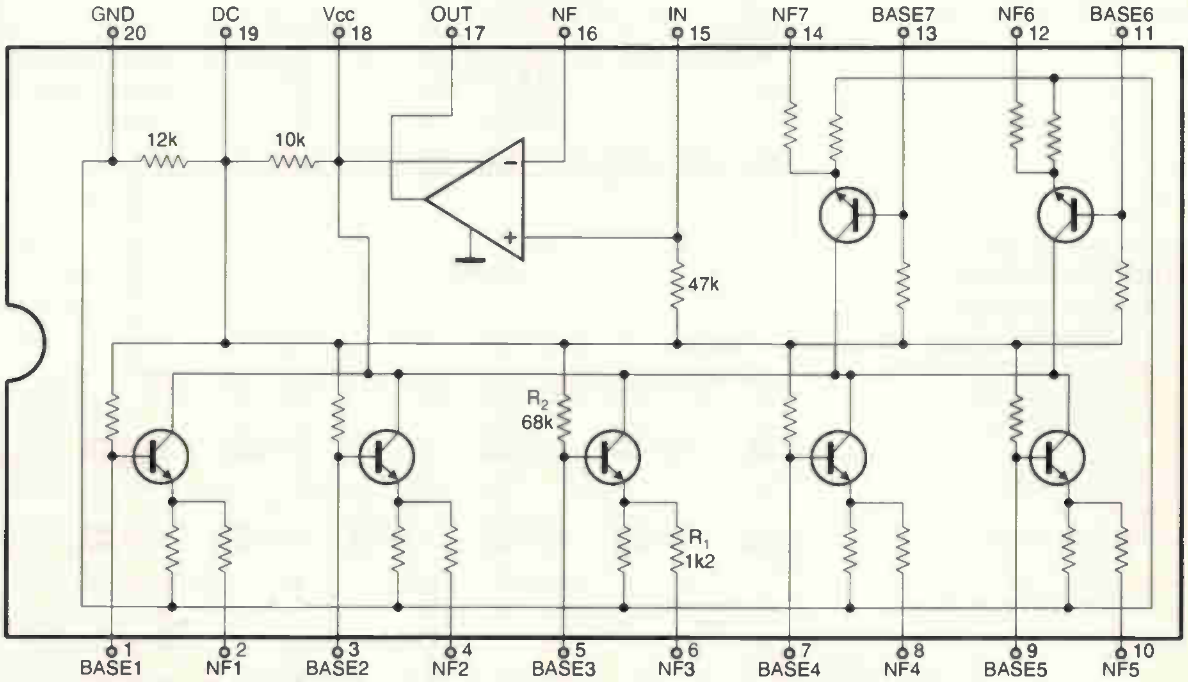
Distortion curves versus frequency, top and versus output voltage at 1kHz, bottom

Technical specifications

Recommended supply voltage, 8V
Operating voltage range, 5 to15V
Max. power dissipation, 300mW

	Min	Typ	Max
Boost gain relative to flat mode	10dB	12dB	14dB
Cut attenuation relative to flat mode	–14dB	–12dB	–10dB
Total harmonic distortion		0.02%	01%
Output noise input s/c. All flat mode		7.0μV	40μV
Voltage gain relative to flat mode	6.2dB	9.2dB	12.2dB
Quiescent current at 8V		7mA	9mA

Internals of the LA3607 graphic equaliser chip.



respectively. Two things to bear in mind when calculating values are,

- Avoid using electrolytic capacitors. This will then give a starting point in the calculations for the maximum value of C_2, which will be in the order of 1μF and by definition, the lowest centre frequency.
- Aim to make the 'Q' of the selective *CR* networks between 1.5 and 2.0. This value is chosen on the basis of the manufacturer's recommendation for best overall performance.

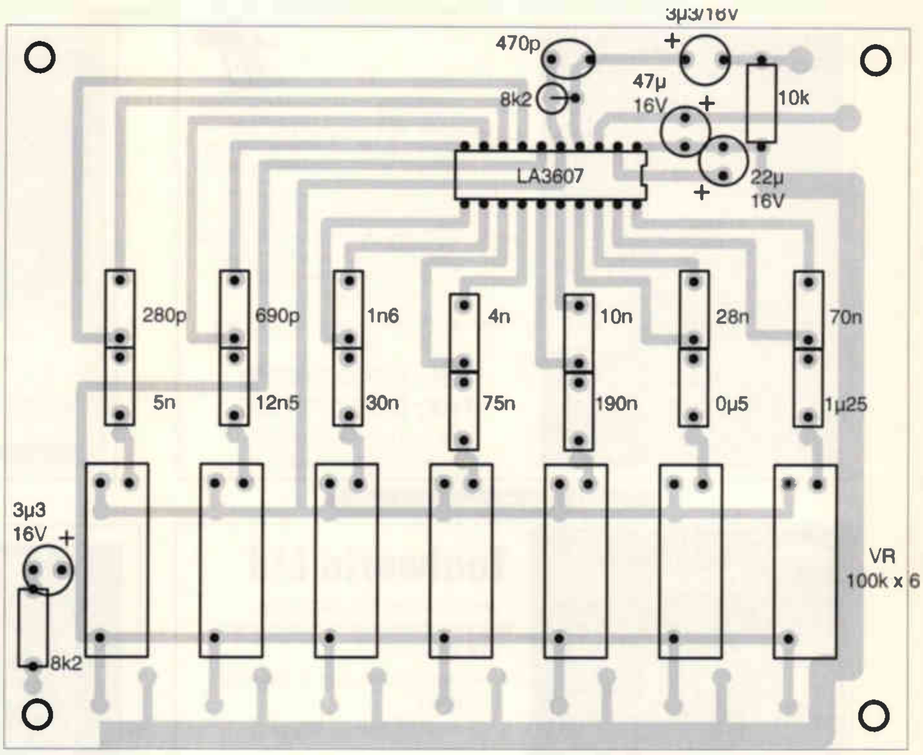
Working out the values

1) Assume C_2 to be 1μF. Using equation 1 and a value for 'Q' of 2, calculate the value of C_1.
2) Substitute the values of C_1 and C_2 into equation 2 and calculate f_0.
3) Recalculate C_1 by the simplified method, if the value of f_0 obtained above is not accurate enough.

$$C_{1(new)} = \frac{f_o}{f_{o(new)}} C_{1(old)} \qquad (3)$$

4) Re-check the new value of Q to ensure it is still within limits.

You can calculate other values of C_1 for different f_0 frequencies using equation 3. The ratio of C_1 to C_2 for all f_0 values is the same, and hence the calculation of new values of C_2 is quite straight forward. ■

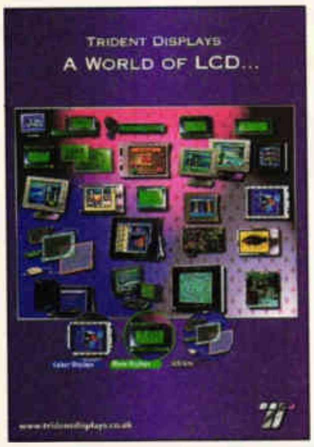


Suggested board layout for a seven-band equaliser.

Contact Pat Bunce on
0208 652 8339

ELECTRONICUPDATE

A regular advertising feature enabling readers to obtain more information on companies' products or services.



The widest range of colour LCDs, LCD monitors and plug and play kits available in the UK, all in one easy to use brochure, is now available FREE!

It includes information on products ranging from 2.9" monitors to 16.1" colour LCD screens, mono/colour STN TFTs and touch screen technology from the world's leading manufacturers.

Phone TRIDENT today for your free copy.

TEL: 01737 780790
FAX: 01737 771908

OR VISIT OUR WEBSITE:
www.tridentdisplays.co.uk

CIRCLE NO.131 ON REPLY CARD

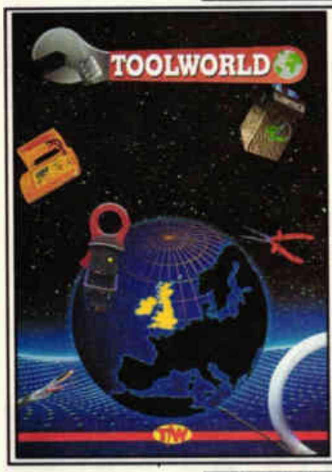
New 2000 Catalogue

2000 Computer-Based Measurement and Automation Catalogue The National Instruments 2000 catalogue features hundreds of software and hardware products for solving your measurement and automation applications. New products include additions to our modular Compact PCI (PXI) platform, new computer-based instruments, and our latest software offerings such as LabView RT for making real-time applications easy.

Phone 01635 523545
Fax: 01635 524395
E-mail: info.uk@ni.com
Website: www.ni.com/uk

CIRCLE NO.132 ON REPLY CARD

Toolworld Ltd



Call now for the TW Catalogue featuring thousands of quality brand name products.

- Adhesives, Aerosols & Cleaning Supplies
- Datacom/Telecom, Cables & Connectors
- Test & Measurement
- Cutting & Polishing Tools
- Toolkits, Cases & Bags

TW Ltd

Tel: 01249 822100
Fax: 01249 821919

CIRCLE NO.133 ON REPLY CARD

Video On-Screen Display Products

LSdesigns supply a range of simple-to-use and cost-effective On-Screen Display devices that superimpose text and graphics directly onto composite video signals. These products offer new possibilities for designers looking for a simple method of displaying data and information in conjunction with a video image.

For the simple solution to your On-Screen Display requirements call LSdesigns today

Tel: 0115 932 4488

CIRCLE NO.134 ON REPLY CARD

Free Software Showcase CD

The free Software Showcase CD from National Instruments, provides engineers and scientists with extensive information and demonstration version of industry leading application software for measurement and automation applications, such as LabVIEW™/CVI, Lookout™, HiQ™ and more. Now in standard HTML format, Software Showcase delivers an easy to use interface and direct access to information via the internet.

For your FREE CD call National Instruments on 01635 523545

E-mail: info@natinst.com

Website: www.natinst.com/uk

CIRCLE NO.135 ON REPLY CARD

SMART COMMUNICATIONS

PROGRAMMERS

- Hand held and bench top
- Single socket to 16 gang
- Stand alone and PC based
- DOS and Windows 3.1/95/NT
- Fast algorithms
- Vast range of adaptors:-
  - -PLCC, QFP, SOIC,
  - -SSOP, BGA, etc...

Tel: +44(0) 181 953 9292
Email: sales@smartcom.co.uk
Web: www.smartcom.co.uk

CIRCLE NO.136 ON REPLY CARD

TO ADVERTISE YOUR CURRENT CATALOGUE / CD ROM CONTACT PAT BUNCE FOR DETAILS

TEL: 0181 652 8339
FAX: 0181 652 3981

ADVERTISERS' INDEX

CLASSIFIED

WANTED: Brüel & Kjaer type 2606 or later measuring amplifier in good working condition. Manuals etc not necessary. All reasonable offers considered. M. Edinger, Bjaelkevangen 10B, dk-2800, Lyngby, Denmark. Contact: Email: Musiklab@image.dk, phone +45 45 874977, fax +45 45 874976.

WANTED TO BUY. Used Neutrik chart recorder system. Fax USA 702/565-4828 Franklin Miller. Email fjm@anv.net

WANTED: good M49KZK16X Tube or Sony monitor Model CPD20SF2T5 non working or incomplete. Must have good CRT. Can collect. Also for sale LEADER LCT910A CRT tester/rejuvenator complete. Sensible offers. Contact John on W-ton 01902 781599.

'COP 8 Microcomputer' evaluation and programming unit including simulator/emulator. All you need to start. NEW. Half price – £50. Tel: 01737 844420.

PCB MAKING EQUIPMENT, everything you need for A4 circuits. New and unused equipment, originally cost £400. Yours for £160. (01223) 501 288.

'TEKTRONICS' S/MANUALS, originals. Plug ins, D, K, P, G, H, L, £3.50 each. Probes 6006, 6008, 6075, 60p each. Oscilloscope D11-15 manual, £5. Racal 907/-76 operating manual, £3. Tel: 01395 273977.

Nelson Jones Ultra low distortion class A amplifier and IC stereo pre-amplifier (Wireless World March and July 1970) for sale Tel: 0780 336 6894.

P&P Electronics Analogue and digital design services. Tel: 01924 402931.

PRINTED CIRCUITS production from CAD design. To obtain details including costs to make PCB's write to: Mr Belt, 5 Velden Way, Mill Road, Market Rasen, Lincs LN8 3HD (including an SAE).

Wanted: Working P.S.U. for satellite receiver. Amstrad SRD 2000. State price. Hughes, 51 Standard View, Ynyshir, Rhondda, Mid-Glam CF39 0HR. Phone 01443 685044.

CIRSIM. Circuit simulation program for Windows. Circuits up to 100 nodes. Graphical output. Many examples. £10. Tel: 01753 643384.

Wanted to Buy. Component Data, books/sheets, any age. Email list to: info@sentient-systems.co.uk. Fax list to: 01202 884420.

Please Mention Electronics World When Replying to advertisements

19" Rack Enclosures
New and Used most sizes
16U to 50U side and rear panels
mains distribution 19" Panel mounts
optima eurocraft. Prices from £45 +vat
M&B Radio
86 Bishopsgate Street Leeds LS1 4BB
Tel. 0113 2702114 Fax. 0113 2426881

ARTICLES WANTED

WANTED!
DEAD OR ALIVE P.M.R. RADIOS
* ALL MAKES OF RADIO EQUIPMENT HAND PORTABLES OR MOBILES *
BEST PRICES PAID – CASH WAITING!!!
WE WILL COLLECT ANYWHERE IN THE UK
CALL: P.M.R. 2000
ON: 01502 531212 / 0142 693 4804
OR FAX US YOUR LIST ON: 01502 531111

TOP PRICES PAID
For all your valves, tubes, semi conductors and IC's.
Langrex Supplies Limited
1 Mayo Road
Croydon
Surrey CR0 2QP
TEL: 0181 684 1166
FAX: 0181 684 3056

BEST CASH PRICES PAID FOR VALVES
e.g. KT88, PX25, EL37, DA100
and Valve Tester VCM163
Ask for our free Wanted List
WIDE RANGE OF OBSOLETE VALVES STOCKED
Visitors please phone for an appointment
Email:
billingtonexportltd@btinternet.com
Billington Export Ltd, Billingshurst, Sussex RH14 9EZ
Tel: (01403) 784961 Fax: (01403) 783519

WANTED
Valves & Semiconductors
All types e.g. Discrete & IC's
Good Rates Paid
CHELMER VALVE CO.
130 New London Road
Chelmsford
Essex
Tel: 01245 265865
Fax: 01245 490064

SERVICES

From **Concept** To **Production**
48 HOUR SERVICE
Electronic design and engineering services for the new millennium:
- Embedded control
- Telecommunication products
- Datacommunication products
- SM PSU and battery management
- Wireless transmission systems
- Audio and Video processing
- DVD control systems
- Internet site and graphics authoring
- PCB design
- Schematic layout and re-drawing
- Technical documentation & translation

Tel/Fax: +44 (0) 1872 223306
Email: designer.systems@btinternet.com
see our web site @ http://designersystems.co-ltd.net
Designer Systems

ARTICLES FOR SALE

RF DESIGN SERVICES
All aspects of RF hardware development considered from concept to production.
WATERBEACH ELECTRONICS
TEL: 01223 862550
FAX: 01223 440853

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

ADVERTISERS PLEASE NOTE FOR ALL YOUR ENQUIRIES ON ADVERTISING RATES PLEASE CONTACT PAT BUNCE ON
TEL: 0181 652 8339
FAX: 0181 652 3981

ELECTRONICS WORLD
INCORPORATING WIRELESS WORLD

READER INFORMATION SERVICE

For more information about any of the products or services in this issue of ELECTRONICS WORLD, simply ring the relevant enquiry number.
Enquiry numbers may be found at the bottom of each individual advertisement.

101	102	103	104	105	106	107	108	109	110	111
112	113	114	115	116	117	118	119	120	121	122
123	124	125	126	127	128	129	130	131	132	133
134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150					
						500	501	502	503	504
505	506	507	508	509	510	511	512	513	514	515
516	517	518	519	520	521	522	523	524	525	526
527	528	529	530	531	532	533	534	535	536	537
538	539	540	541	542	543	544	545	546	547	548
549	550	551	552	553	554	555	556	557	558	559
560	561	562	563	564	565	566	567	568	569	570
571	572	573	574	575	576	577	578	579	580	581
582	583	584	585	586	587	588	589	590	591	592
593	594	595	596	597	598	599	600			

Name

Job title

Company Address

Telephone APR 2000

Only tick here if you do not wish to receive direct marketing promotions from other companies. ☐

Newsagent order form

Pass this order form to your newsagent to ensure you don't miss the next issue of *EW*.

To ....
(name of Newsagent)

Please reserve me the May issue of *Electronics World* and continue to order every month's issue until further notice

Name...

Address...

....

....

....

Thank you

Subscribe today!

Guarantee your own personal copy each month

Save on a 2 year subscription

ELECTRONICS WORLD
INCORPORATING WIRELESS WORLD

Postage will be paid by licensee

Do not affix postage stamps if posted in Gt. Britain, Channel Islands, N. Ireland or the Isle of Man.

Business Reply Service
Licence No. CY711

ELECTRONICS WORLD
Reader Information Service
Reed Business Information
Oakfield House
Perrymount Road
Haywards Heath
Sussex RH16 3BR

SEE OVER!

ELECTRONICS WORLD

INCORPORATING WIRELESS WORLD

SUBSCRIPTION CARD

Please enter my subscription to ELECTRONICS WORLD. I enclose Cheque/Eurocheque to the value of £ ____________ made payable to **Reed Business Information**

Please charge my Mastercard/Visa/Amex account ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

With £ ____________ Expiry Date ____________

Signature ____________

Name ____________

Job Title ____________

Address ____________

____

____________ Postcode ____________

Tel: ____________ Country ____________

SUBSCRIPTION RATES

UK 1 year	£36
UK 2 years	£58
UK 3 years	£72
Student rate (proof required)	£21.30
Airmail	
Europe 1 year	£51
Europe 2 years	£82
Europe 3 years	£103
Rest of the world 1 year	£61
Rest of the world 2 years	£98
Rest of the world 3 years	£123
Surface mail 1 year	£41

Post to:
ELECTRONICS WORLD
P.O. Box 302
Haywards Heath,
West Sussex RH16 3DH UK.

CREDIT CARD HOTLINE
Tel: +44 01444 445566
Fax: +44 01444 445447

Please tick here if you do not wish to receive direct marketing-promotion from other companies ☐

049

ELECTRONICS WORLD

INCORPORATING WIRELESS WORLD

SUBSCRIPTION CARD

Please enter my subscription to ELECTRONICS WORLD. I enclose Cheque/Eurocheque to the value of £ ____________ made payable to **Reed Business Information**

Please charge my Mastercard/Visa/Amex account ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

With £ ____________ Expiry Date ____________

Signature ____________

Name ____________

Job Title ____________

Address ____________

____

____________ Postcode ____________

Tel: ____________ Country ____________

SUBSCRIPTION RATES

UK 1 year	£36
UK 2 years	£58
UK 3 years	£72
Student rate (proof required)	£21.30
Airmail	
Europe 1 year	£51
Europe 2 years	£82
Europe 3 years	£103
Rest of the world 1 year	£61
Rest of the world 2 years	£98
Rest of the world 3 years	£123
Surface mail 1 year	£41

Post to:
ELECTRONICS WORLD
P.O. Box 302
Haywards Heath,
West Sussex RH16 3DH UK.

CREDIT CARD HOTLINE
Tel: +44 01444 445566
Fax: +44 01444 445447

Please tick here if you do not wish to receive direct marketing-promotion from other companies ☐

049