

20% discount on Basic Stamp evaluators

ELECTRONICS WORLD

Austria Asch. 66.00
Denmark DKr. 67.00
Germany DM 18.00
Greece Dra. 1100.00
Holland Dfl. 11.75
Italy L. 8800.00
Malta Lm. 1.55
IR £3.30
Singapore S\$7.50
Spain Pts. 850
USA \$5.95

INCORPORATING WIRELESS WORLD

September 1997 £2.35

A REED BUSINESS PUBLICATION
SOR DISTRIBUTION

**Self on the audio
power interface**

**Switched
capacitor psus**

Microammeter

**Digital tv
explained**

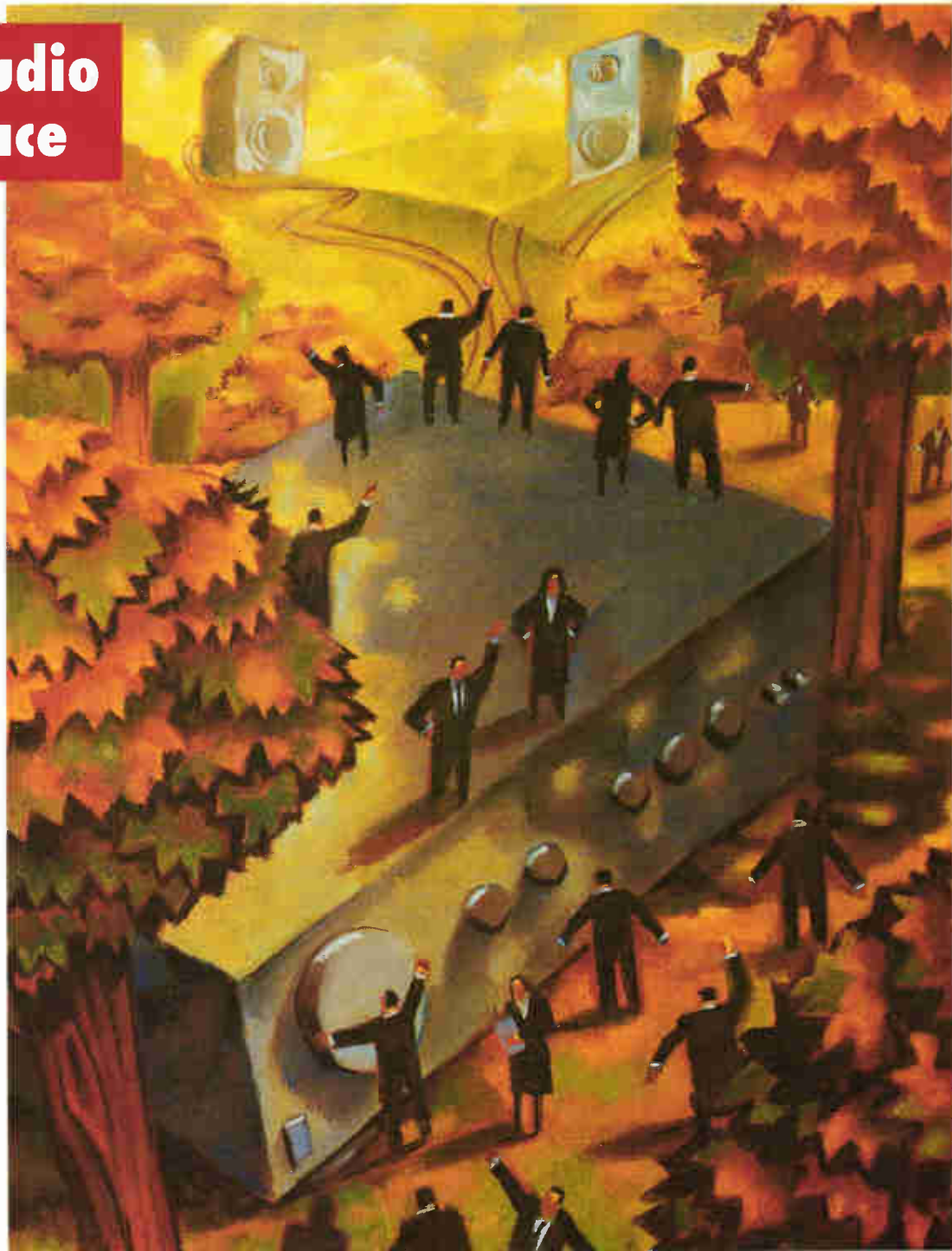
**MSF clock
interface**

Yagi by genes

**Air-cored coil
designer**

10 circuit ideas

**Internet for
designers**



£600 for a circuit idea?



9 770959 833035

NOW, THE BATTLE IS REALLY OVER

After ten years and with more than 20,000 users ULTimate Technology now offers exactly the performance and design capacity you need. Upgrades to larger versions are possible based on the price difference. Call us to determine which ULTboard fits your requirements.

START

ULTIBOARD 10 YEARS

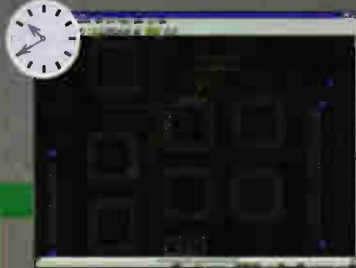
20,000 USERS

CHALLENGER The affordable route

The core of each package is the ULTboard PCB Design system, renowned for its short learning curve, Real-Time Design Rule Check (preventing errors) and the powerful interactive functionality. The low cost Challenger (£775 for 1400 pins design capacity) adds the gridded auto-router ULTroute GXR (1/20" & 1/40"; suited for designs with thru-hole components). This best-seller is much in favour with interactive designers.



The schematic is ready, the board outline established and all components are imported. The components with a fixed location are placed interactively. (10 min.)



The placement of the components is done with the real-time help of the Force Vectors indicating the preferred location. Detailed placement is performed with the help of the rats-nest. (10 min.)



A Thermal analysis along with real-time GNC. Removal of the board outline showing of traces (including vias) without losing components. ULTroute GXR finishes the design. (20 min.)

SPECIAL OFFER

Each ULTboard package with >1400 pins design capacity will be supplied with a FREE ULTcap Schematic Design System until September 30th. Call us for the reduced price!

UPDATE POLICY

During this summer those who order the above (and also existing users with a valid update subscription) will receive a free upgrade with the SpiceAge Mixed Mode Simulator, integrated with the release of ULTcap Windows 95 and ULTbase, the latest components database, with which up to 14 relevant specs per component, as well as design-in data about equivalents, can be stored.

The Wizard adds advanced Auto-Placement to the Designer, which gives a tremendous boost to efficiency, and a powerful interactive Autorouter, which means the designer remains in charge! Top class performance from £2590.

All prices are excl. VAT.

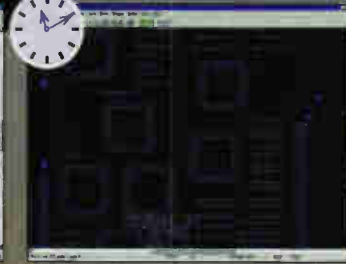
DESIGNER

 The FAST lane

The ULTboard designer offers besides all Challenger functions the high-end SPECCTRA SP4 Shape Based Auto-Router, very suitable for complex and/or SMD Designs. With its unequalled price/performance ratio it is the darling of engineering managers: from £1395.



AutoPlace rapidly and conveniently places the remaining components with algorithms that approach the interactive method of expert designers. On-line changes are possible. (5 min.)

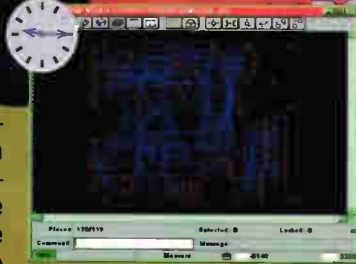


Power and Ground are routed semi-automatically under the management of the designer. The EMC critical connections are also routed interactively. (10 min.)

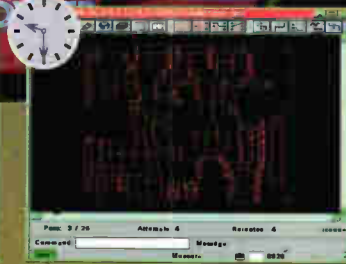


Now the SPECCTRA Autorouter is employed to finish the routing of the design at high speed and with high grade quality. All design rules are fully respected. (15 min.)

WIZARD

 The EXPRESS way


AutoPlace rapidly and conveniently places the remaining components with algorithms that approach the interactive method of expert designers. On-line changes are possible. (5 min.)



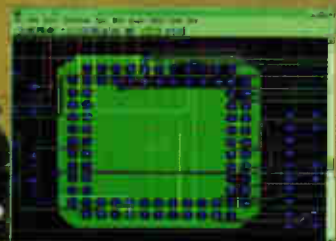
Power and Ground are routed semi-automatically under the management of the designer. The (EMC) critical connections are also routed interactively. (15 min.)



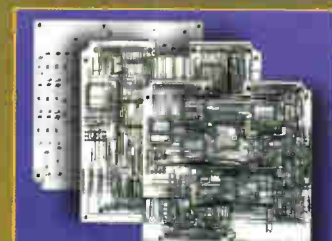
Now the SPECCTRA Autorouter is employed to finish the routing of the design at high speed and with high grade quality. All design rules are fully respected. (15 min.)



FINISH



All adjustments are done quickly and efficiently with the interactive autorouter. All the corners of the traces are chamfered and polygons are placed. (10 min.)



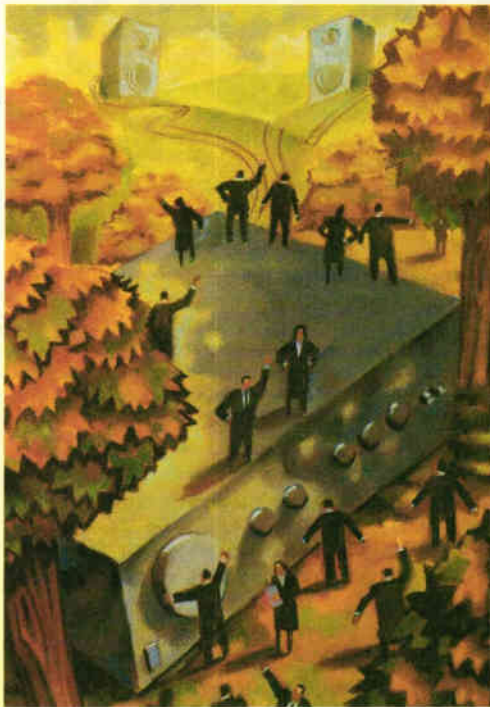
Following the connectivity- and design rule checks, the output on matrix or laser printers, pen or photo plotters can be run. Back-Annotation automatically updates the schematic. (25 min.)

ULTIMATE
TECHNOLOGY (UK) LTD

E-mail: sales@ultiboard.com
Internet: http://www.ultiboard.com

UK/Ireland Sales-Office:
Unit 1, Lodges Barn
Coxbury Lane,
St. Briavels, Lydney,
Glos. GL 15 6QJ
tel. : (+44) 1594 - 810100
fax : (+44) 1594 - 810200

Contents



Cover - Jamel Akib

717 THE AUDIO POWER INTERFACE

So you thought you knew all about damping factor and the like? Doug Self explores what really happens at the audio power amplifier's output.

725 HANDS ON INTERNET

Cyril's monthly findings include non Spice tools for electronics engineers.

730 CAMCORDER DUBBER

Ian Hickman has a cure for camcorder tapes with unwanted soundtracks.

733 SOUND FROM ALL ANGLES

Loudspeaker guru Martin Colloms explains the benefits and pitfalls of home cinema.

739 GENETICALLY DESIGNED YAGI

Richard Formato looks at a progressive method of antenna design and includes a three-element example for 50MHz.

743 DIGITAL TV BROADCASTING

Pat Hawker describes the technology behind the UK's planned digital tv services.

748 CHANGING TIMES

Ed Buckley's PIC-based interface turns raw MSF data in PC-ready RS232 time data.

752 MULTILAYER AIR-CORED COILS

Wheeler's equations are fine if you want to equate inductance from coil dimensions, but the designer's task is usually the reverse.

754 SWITCHED CAPACITOR POWER SUPPLIES

Ian Hegglun looks at the possibilities for efficient power converters without inductors.

771 MEASURING MICROAMPS

Robert Pearson's ammeter has ranges down to 20 μ A and only 0.1 Ω shunt resistance.

780 SKIN EFFECT

Nick Wheeler outlines how rf signals tend to travel along a wire's surface.

782 PWM AMPLIFIER

Richard Lines' simple design is useful for low-frequency control, driving to 5A at 25V.

Regulars

707 COMMENT

History: who needs it?

708 NEWS

GPS for sale? 60ns otp memory, UK research spending, Record audio cds, SiGe technology.

713 RESEARCH NOTES

Micromachines and chips integrated, DNA logic, chemical analysis.

762 CIRCUIT IDEAS NEW REWARDS

- Serial eeprom programmer
- 10pF to 10 μ F meter
- Calculator chip coprocessor
- High-power inductor
- New square rooter
- High-order filters
- Current-dependent rectifier

Your circuit idea could win you a 50MHz virtual instrument plus £100, see page 762.

775 NEW PRODUCTS

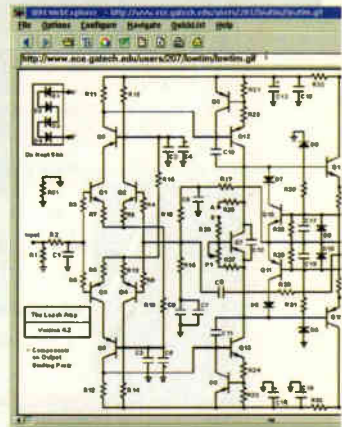
Passive, active and computing products, classified for convenience.

786 LETTERS

Charging alkaline cells, Noise in EMC, Crossover distortion, Loudspeakers.

Special offer

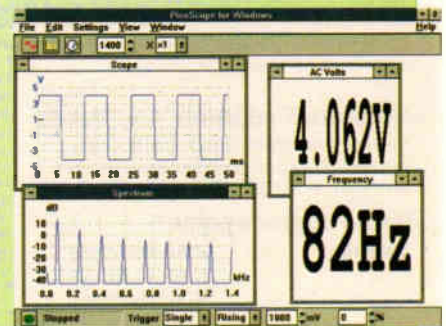
20% reader discount on microcontroller evaluation kits - see page 751.



Findings from the Internet include a high-performance power amplifier - page 725.



Big bang. Explosions have been used at Los Alamos to generate massive magnetic pulses - see page 715.



OCTOBER ISSUE ON SALE 4 SEPTEMBER

History: who needs it?

EDITOR

Martin Eccles
0181 652 3128

CONSULTANTS

Jonathan Campbell
Philip Darrington
Frank Ogden

EDITORIAL ADMINISTRATION

Jackie Lowe
0181-652 3614

E-MAIL ORDERS

jackie.lowe@rbi.co.uk

DESIGN

Alan Kerr

ADVERTISEMENT MANAGER

Richard Napier
0181-652 3620

DISPLAY SALES EXECUTIVE

Joannah Cox
0181-652 3620

ADVERTISING PRODUCTION

0181-652 3620

PUBLISHER

Mick Elliott

EDITORIAL FAX

0181-652 8111

CLASSIFIED FAX

0181-652 8938

NEWSTRADE ENQUIRIES

0171 261 7704

ISSN 0959-8332

SUBSCRIPTION HOTLINE

01622 778000

SUBSCRIPTION QUERIES

rbp.subscriptions@rbi.co.uk
Tel 01444 445566
FAX 01444 445447

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

 REED
BUSINESS
INFORMATION

BT is justifiably proud of its sensitive attitude towards ecological issues, sponsorship of the arts and its community programmes. All the more remarkable then that the company's regard for its own heritage is zero. For by the time you read these words, its highly regarded museum in London, The Story of Telecommunications, will have closed.

In a year that marks the 150th anniversary of the birth of Alexander Graham Bell, this seems a strange kind of celebration.

The collection will remain, but will no longer be open to visitors, and the same applies to the resource centre used by many researchers. BT says the closure is made pending a decision on its heritage policy – a subject of internal debate for the past 12 years without decision. Consultants have come, consultants have gone and still BT has no firm line on how to handle its history.

In reality, the closure is a simple matter of cash. Not a single department within BT is prepared individually to fund the cost of running what could – and should – be a showpiece facility. Hence the museum has been forced to shut its doors, simply to save five clerical salaries amounting to around £100,000 a year – or more graphically, 16 minutes of BT's annual profit.

For this trifling amount, BT is prepared to close down a facility that attracts 21 000 visitors annually – many of these youngsters on educational trips – and disperse to the four winds the public goodwill and accumulated knowledge and expertise of its staff.

It seems Philistine, but this is the same company which, notwithstanding the valiant efforts of the Computer Conservation Society in reconstructing Colossus at the wartime codebreaking headquarters at Bletchley Park, is intent on selling the site for development rather than dedicate it as a national museum of information technology. BT needs to make friends – not enemies – yet the company appears oblivious to the way it is alienating public opinion.

Earlier this year, the GEC company was forced to back down on its planned auction sale of historic Marconi artefacts, when the weight of informed opinion made this policy untenable.

BT's own heritage of what is effectively the national collection of communications is far larger in extent, and embraces an even wider rapport with everyday life, yet it is to be locked up and withdrawn from public gaze. Can this really be termed a responsible action for a major public company?

Had BT offered to donate its collection to the Science Museum, this would have been another matter. If it argued that a national museum of communications should be established on an



...the museum has been forced to shut its doors, simply to save 16 minutes worth of BT's annual profit.

independent basis – with the offer of some funding – this would be greeted with sympathy and understanding.

But the abrupt closure of an established facility purely to satisfy the accountants smacks of putting shareholders' gain before public responsibility.

There is now growing support for creating a National Museum of Information Technology, embracing communications, electronics and computing, with the Bletchley Park campus as the favoured site. Setting past indecision aside, now is the time to build on this momentum and create something for the new millennium. Otherwise our future generations will have to be content with photographs and fading memories.

As the descendant of the nineteenth-century telegraph companies, the old GPO telephones department and more, BT has a clear responsibility to the country to provide a facility for conserving its heritage. This task can be shared with other operators and manufacturers in this booming industry – and the time to start is now.

Ironically, it is one of Britain's newest and smallest telecomms operators which is showing the way. This year ScottishTelecom opened its World of Telecommunications museum in Edinburgh. It is ironic that BT's closure of its London museum has made this new venture the country's premier telecomms visitor centre.

Andrew Emmerson

Electronics World is published monthly. By post, current issue £2.35, back issues (if available) £2.50. 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 0AU 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 £32 UK 2 years £43.00 3 years £75.00. Surface mail 1 year £37.00 2 years £60.00 3 years £86.00 Air mail Europe/Eu 1 year £46.00 2 years £73.00 ROW 1 year £56.00 2 years £89.00

Overseas advertising agents: France and Belgium: Pierre Mussard, 18-20 Place de la Madeleine, Paris 75008. United States of America: Ray Barnes, Reed Business Publishing Ltd, 475 Park Avenue South, 2nd Fl New York, NY 10016 Tel; (212) 679 8888 Fax; (212) 679 9455
USA mailing agents: Mercury Airfreight International Ltd Inc, 10(b) Englehard Ave, Avenel NJ 07001. Periodicals Postage Paid at Rahway NJ Postmaster. Send address changes to above.
Printed by BPC Magazines (Carlisle) Ltd, Newtown Trading Estate Carlisle. Cumbria, CA2 7NR
Typeset by Marlin Imaging 2-4 Powerscott Road, Sidcup, Kent DA1 4 SDT.

© Reed Business Information Ltd 1997 ISSN 0959 8332

GPS is on the market

GEC-Plessey Semiconductors (GPS) is up for sale. GEC managing director, George Simpson, told a stockbrokers' analysts' meeting recently that he was looking to dispose of the UK's last fully integrated microelectronics manufacturer.

It is assumed that GPS and GEC were implementing the disposal before Simpson told analysts. However, GEC refused to make any official comment on the situation other than to say: "We have not announced any disposals."

In a written statement, GPS managing director Tom Urwin said: "GPS is now actively seeking a suitable partner." GPS appears to look on the move as an opportunity

to find an owner which will invest in it appropriately. Under GEC's ownership, investment constraints prevented GPS from maintaining leading edge production process technology.

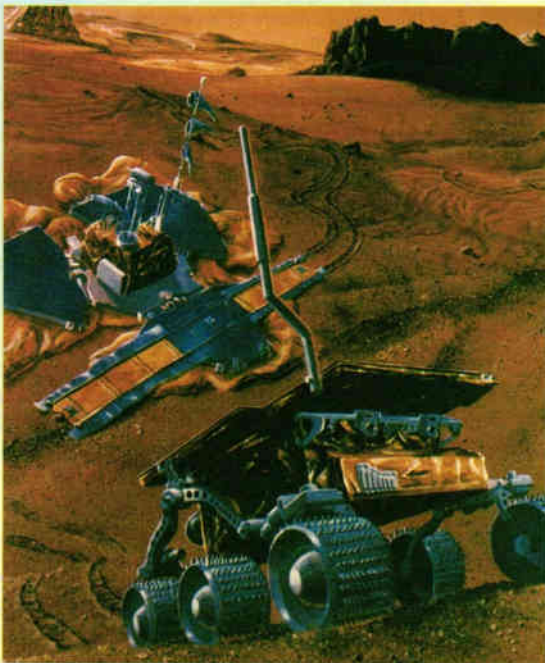
Obvious candidates for ownership of GPS are Rockwell Semiconductor of the US and Siemens of Germany. "GEC-Plessey has some attractive positions – they have a very good bipolar capability," Dr Dwight Decker, president of Rockwell, said last autumn. "What we're looking for is mixed signal technology with a broad application range. There are good reasons why we'd like to be geographically distributed." Rockwell talked to GEC last year

about buying GPS.

Siemens Semiconductor owned briefly a share of GPS following the GEC-Siemens takeover bid for Plessey. Jurgen Knorr, president of Siemens Semiconductor said at the time: "We wanted GPS; we were interested in it years before."

If those two fail to buy GPS, then there is a possibility that one of Korean Big Three – which want to diversify out of dynamic ram – could buy GPS for its logic and system asic capabilities.

GPS is ninth in the world for gate array logic and has an unrivalled capability for putting systems-on-a-chip – expected to be the hottest growth area in the semiconductor business for the next decade.



Independence Day... Nasa's Jet Propulsion Laboratories' (JPL) latest probe, the Mars Pathfinder, is set to land on the planet on 4 July. It comprises the Lander which will oversee the various experiments and communicate the results back to Earth, and the Rover vehicle which will explore the planet surface, taking pictures as it goes. To cut the project's cost, the Mars Pathfinder has made use of commercial-off-the-shelf components including VMEbus cards and Wind River's VxWorks real time operating system (RTOS). The RTOS is used to control the probe's flight and planet descent – triggering the airbags before it hits the planet's surface – and the Rover vehicle.

OTP memory has 60ns access

Philips Semiconductors has introduced a fast 60ns one-time-programmable, or otp, memory process for its microcontroller products. One-time-programmable memory made by this process is now included in Philips XA 16-bit and 80C51 8-bit microcontrollers.

Developed for Philips Semiconductors by Philips Research Labs, the new OTP is claimed to incorporate three innovations.

The first is that it takes only two additional mask steps compared with its standard 0.5 μ m c-mos process.

Secondly, it avoids the use of mask-intensive high voltage (13V) transistors to switch the programming voltage. Instead, it exploits the fact that the transistors only need to survive long enough to program the memory matrix once

and uses low voltage transistors that need no extra masks.

Including a conductivity-improving titanium salicide layer between the metallisation and control gate is the third development.

Philips has extended the control gate sideways so that it forms a top hat over the floating gate. This shields the control gate from contact with the salicide.

Each memory cell measures 7 μ m² and can operate between 1.8 and 3.3V. Blocks of up to 4MByte can be created at a time.

The company claims with the conventional vertical stack of equally sized floating gate-insulator-control gate, any salicide deposited on top of the stack also gets on to the stack sides and shorts out the two gates.

EASIER ROUTE TO ELECTRONICS WORLD SUBSCRIPTIONS

You can now obtain or renew a subscription by e-mailing rbp.subscriptions@rbi.co.uk
Our Hotline number 01622 778000 remains the same, as do the normal enquiry lines, 01444 445566 voice, Fax 01444 445447.

UK research spending worsens

The proportion of UK electronics companies' sales turnover spent on research and development fell last year, according to the DTI's *UK R&D Scoreboard 1997*.

Although r&d expenditure went up two per cent to £1.204bn, as a percentage of sales it fell by 0.1 per cent to just 3.1 per cent of sales turnover. This fall was not as great as that in the previous year, however, when it fell from 4.2 to 3.2 per cent.

"Too many of our companies appear to lag behind the competition," said science, energy and industry minister John Battle, commenting on the scoreboard. "Evidently those companies may be under-investing in absolute amounts and in terms of research and development intensity [percentage of sales spent on r&d] when compared with their top international competitors. This could have serious implications for the long term."

1996

Rank	Company	R&D spend	% of sales
1	GEC	£432m	6.9
2	Siemens	£133.6m	8.9
3	IBM	£112m	2.2
4	ICL	£101.3m	3.5
5	Racal Elec	£70.8m	6.7
6	Motorola	£36.7m	1.2
7	HP	£31.9m	1.7
8	BICC	£30m	0.7
9	Bowthorpe	£23.5m	4.5
10	Rank Xerox	£20m	0.6

1995

Rank	Company	R&D spend	% of sales
1	GEC	£412m	7.1
2	ICL	£149.6m	4.8
3	Siemens	£132.6m	10.3
4	IBM	£100.7m	2.2
5	Racal Elec	£64.7m	6.8
6	Motorola	£36.7m	1.2
7	BICC	£31m	0.7
8	HP	£29.8m	1.7
9	Rank Xerox	£21m	0.5
10	Cray Elec	£20.3m	7.7

GEC maintained its position at number one spending £432m, increasing its expenditure by five per cent on the previous year. Siemens unseated ICL, whose research and development expenditure dropped 32 per cent, and moved to number two with a spend of £133.6m. IBM, ICL and Racal came third, fourth and fifth respectively.

Despite wanting more investment, Battle called for greater focus on the management of r&d. "Of course, devoting simply more money to r&d is not the only answer to ensuring the long term competitiveness of UK companies," said Battle. "Investment needs to be managed carefully so that it leads to successful development of new ideas."

CDs allow audio recording

Philips Electronics says it will introduce one of the first audio cd recorders by the year end. The cd recorder is based on Philips' recordable cd technology and uses cd recordable disks that allow only one recording or cd rewritable disks that can be recorded and erased several times.

The cd recorder will be introduced in Europe first and then into markets worldwide. It is expected to cost

£450. However, the market for the recorder may be limited to just two or three years especially once recordable DVD systems become available in 1999.

Recordable DVD will be able to record audio and video sources and could also be used as a computer peripheral, recording computer data.

The recorder will implement copy protection agreements such as the Serial Copy Management System.

DVD - slow take off?

DVD players for television sets will penetrate less than two per cent of homes during the next five years, says a study from Strategy Analytics, an electronics and IT consultancy. The report claims that less than half a per cent of European homes will have DVD by the year 2000. Worldwide, DVD will only become accepted when recordable DVD becomes available, thereby replacing VHS video recorders. Annual sales are expected to reach 10m units by 2010.

Actel £1000 fpga design tools is now free on a Web page

Actel has made a version of its fpga design tools free for distribution over the Web, saving designers over £1000.

"Customers have asked for many years why they have to pay for this software," said Vaughan Price, European sales director. "We've taken the big step. This is something that has to be done."

Actel is the first company to make its design software for fpgas free, claimed Price. Altera is expected to follow suit, later this year.

The Designer Lite software includes all the features needed for fpga design. The only drawback is

the tool is limited to designs of 8000 gate or fewer.

"Below 8000 gates, people look at fpgas for first choice in logic integration. We want to remove all the obstacles," said Price. At these gate counts, designers will save up to \$2500 on the cost of tools. "But the real saving," he said, "is in the time and the convenience."

Included in the software is place and route, timing driven layout and analysis, and Verilog and Vital libraries. By the month end a VHDL synthesis tool will be added to the kit.

Designer Lite is available from www.actel.com.

Europeans show interest in buying digital radio

Over a third of households in Europe are interested in buying digital radios. This is one of the results of a consumer study conducted by RSL/Ipsos for the World DAB Forum.

The survey was undertaken across six European countries with the participation of 5000 people. More than a third of those sampled who are also car drivers confirmed their interest in buying a DAB car radio due to its better reception.

A similar level of interest was shown for hi-fi sets and portable radios. pc-linked DAB services also appealed to special interest groups who use IT systems and pcs on a regular basis. The respondents were prepared to pay up to 50 per cent more for car radios and hi-fi receivers featuring DAB features, and twice as much for portables.

This was the largest ever consumer study of potential DAB penetration in Europe.

SiGe device costs could be cut by new process

An Italian research group is attempting to reduce the cost of silicon-germanium devices by using ion implantation for their fabrication.

SiGe heterojunction bipolar transistors, or hbts, are faster than silicon-based ones, letting devices operate at 5GHz without resorting to GaAs technology.

The group, called IMETEM, comprises 15 people from the University of Catania. It resides at SGS-Thomson Microelectronics' wafer

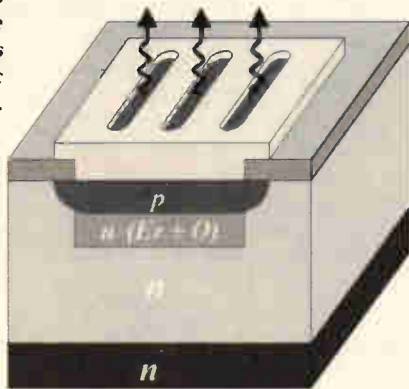
fab and research centre in Catania.

The group claims that existing techniques for producing SiGe structures, like molecular beam epitaxy (MBE) and chemical vapour deposition (CVD), although successful, are difficult to incorporate into current ULSI technology. This, it says, is delaying the adoption of SiGe commercially.

Its proposed approach for fabricating SiGe heterojunctions is a technique based on high dose germanium ion implantation into silicon. Ion implantation offers a high wafer throughput and can be confined to particular regions of the wafer.

Other IMETEM devices under development include an infra-red silicon led (see diagram). Silicon is not normally suitable for leds but, by including erbium-oxygen complexes in the material lattice near the PN junction, IMETEM has created an emitter that operates at 1.54 μ m, the fibre-optic communication wavelength. The group is also starting to look at silicon carbide-based semiconductors for high voltage use.

Silicon is not normally suitable for leds, but a new SiGe process from Italy could be used to produce leds for fibre-optic communications.



New ideas for multi-media lans

US firms Microsoft, 3Com and videoconferencing specialist PictureTel are to collaborate to enable local area networks (LANs) to carry moving pictures and voice as well as data.

This, they believe, will "crack the technological barriers" which so far have prevented video communications to every office desktop.

To do this they have brought together PictureTel software – built around LiveManager 3.0, which is designed to handle continuous video and voice traffic without affecting other critical LAN traffic – with Microsoft's NetMeeting 2.0 software and 3Com's PACE high-performance LAN technology.

Meanwhile, Sony Broadcast & Professional UK has signed an ISDN reseller agreement with BT.

This is aimed at reducing the cost of purchasing systems by allowing Sony to sell a combined package of videoconferencing equipment and ISDN.

New c-mos process promises 2.4GHz devices

Texas Instruments has detailed a 0.18 μ m c-mos process at a recent technology symposium in Japan. This is a follow on technology to its 0.21 μ m Timeline process announced last year.

With 25 picosecond delays and 2.4GHz analogue speeds, the company is targeting the 0.18 μ m process at wireless and optical communications. Radio and intermediate-frequency circuits, along with dsp baseband processing could be placed on the same device, claims Richard Kerslake, TI's Asic

marketing manager. The 2.4Gbit/s data rate is aimed at the new STM16 fibre optics communications standard.

"What would be really beautiful," said Kerslake, "would be to run this [STM16] straight into c-mos without using anything horrible like GaAs."

For the process, TI has switched to a shallow trench isolation. This, coupled with the reduced process dimensions doubles the available transistors.

While few, if any, designs will need 250m transistors, halving the die size for a given design could bring

significant cost reductions.

The as yet experimental process is to move to a production standard in the near future. Commercial use for the process is not expected for two years, but Kerslake expects design starts by the end of next year.

Most manufacturers – TI included – have yet to move to full production on 0.25 μ m geometries.

TI's own Timeline process, actually 0.21 μ m drawn, is only now ramping to production on microprocessors. Asics will follow shortly, said Kerslake.

Traffic info for mobile phones

Trafficmaster, the traffic-guidance system firm, is to launch a service in the autumn which will provide mobile phone users with details of road hold-ups and delays.

The traffic firm would not disclose details of its proposed system.

However, it is expected that small in-car receivers will warn drivers of nearby traffic problems, prompting them to call a hotline for further details.

A spokesperson for Trafficmaster

said: "We have recently concluded a three-year deal with a mobile phone operator." However, she could not confirm the operator's identity.

Reports that the deal is with Cellnet were branded as hearsay by both companies. Dave Massey of Cellnet's corporate affairs said: "From our point of view this is speculation."

Altera and Jam

Jam, a programming language for in-system programmable logic devices, has been unveiled by Altera.

The company claims JAM more than halves file sizes, while reducing the average device programming time by a factor of ten. Altera and its supporters are proposing the language goes to JEDEC for adoption as an industry standard.

Programmable logic manufacturers Cypress Semiconductor and Vantis, test equipment companies GenRad, JTAG and Teradyne, and device programmer manufacturers Data I/O and BP Microsystems all support the language. ■

New: Windows software for TiePieSCOPE HS508 and TP508

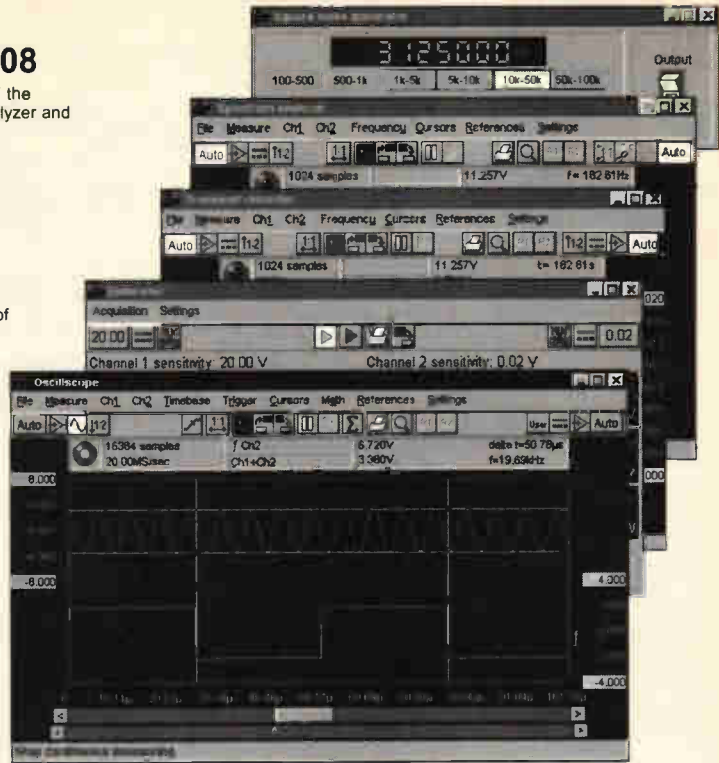
This powerful windows software gives you new possibilities and intuitive control of the five integrated devices (Oscilloscope, Voltmeter, Transient recorder, Spectrum analyzer and Square wave generator) to perform all your advanced measurements

Oscilloscope:

- Number of samples settable between 10 and 32760
- Up to 32K samples on screen
- Free settable pretrigger between 0 and 100%
- Easy time axis zoom: scaleable scrollbar slider
- Free settable sample frequency from 0.01Hz to 50MHz
- Graphical adjustment of vertical offset and gain
- WYSIWYG trigger level, - hysteresis and slope-adjustment with one control
- Place the mouse over a control, press the right button and adjust all properties of that control using the popup menu
- Cursor measurements
- Storing and recalling reference signals
- Math channel available
- Speedbutton toolbar
- Colour printing supported

Voltmeter:

- Up to six clear, fully configurable displays
- 10 math operations, like true RMS, mean, peak to peak, frequency etc.
- 16 display functions like Ch1+Ch2, Ch2-Ch1, Ch1*Ch2, log(Ch/Ch2) etc.
- Data logging to disk and printer
- Speedbutton toolbar



TiePieSCOPE HS508

- interface parallel printer port
- resolution 8 bits
- input range 200mV - 80V full scale
- price £597.00 incl. software, manual and 2 probes (1:11:10 switchable)

TP508

- interface PC-XT/AT ISA slot
- resolution 8 bits
- input range 20mV - 80V full scale
- price £630.00 incl. software, manual and 2 probes (1:11:10 switchable)

Minimum system requirements: Windows 3.1 or higher, 386 processor, 4MB RAM, 4MB free disk space

Prices are excluding VAT

TiePie engineering (NL)

P.O. Box 290
8600 WL SNEEK
The Netherlands
Tel: +31 515 415 416

E-mail: tiepie@tiepie.nl
Site: http://www.tiepie.nl
Fax: +31 515 418 819



TiePie engineering (UK)

28, Stephenson Road, Industrial Estate,
St. Ives, Cambs, PE17 4WJ,
United Kingdom
Tel: +44 1480 460028 Fax: +44 1480 460340

CIRCLE NO. 108 ON REPLY CARD

Takeda Riken Spectrum Analyser Type: TR4122B c/w Digital Memory Unit PRICE: £2000

Adret	740A UHF Generator 0.1-560MHz	£750
Anritsu	MS420A Network Spectrum Analyser 10Hz-30MHz	£1,750
B & K	2032 Signal Analyser	£2,800
Bird	8325 500W 30dB Coaxial Attenuator	£375
Cushman	CE2/4 Frequency Selective Level Meter	£400
Datron	1061A Autocal	£500
Datron	1061 Autocal	£400
Farnell	MP100/50 Power Supply	£900
Farnell	MP60/50 Power Supply Stabilized	£800
Farnell	PSU Type: MP30 Auto Ranging	£350
Fluke	45 Dual Display Multimeter	£400
Fluke	5200A Programmable AC Calibrator	£2,000
Fluke	540B Thermal Transfer Standard c/w Voltage Plug-1	£400
HP	3575A Gain Phase Meter 1Hz-13MHz	£600
HP	11562A Range Calibrator	£250
HP	16310 Logic Analyser	£550
HP	1725A 275MHz Delay Sweep	£500
HP	3312A Function Generator 0-13MHz	£350
HP	3335A Synthesizer Level Generator 81MHz	£1,800
HP	3335B + A Synthesizer Level Generator	£2,000
HP	3455A Digital Voltmeter	£530
HP	3456A Digital Voltmeter	£600
HP	35650 System Main Frame	£2,000
HP	3560A Spectrum Analyser 5Hz-50Hz	£600-800
HP	3581C Selective Volt Meter 15Hz-50kHz	£550
HP	3582A Spectrum Analyser 0.02Hz-25.599kHz	£1,500
HP	54111.0 Digital Oscilloscope 500MHz	£2,700
HP	54200A Digital Oscilloscope	£1,500
HP	54501A 100 MHz Digital Oscilloscope	£1,600
HP	6002A DC 0.50V 0.10A 200W	£400
HP	6261B DC PSU 0-20V 0-50A	£450
HP	8502A Transmission Reflection Test Set 500kHz-1.3GHz	£3,000
HP	8505A 50MHz-1.3GHz Network Analyser	£3,000
HP	8554B RF Section 0-1200MHz	£500
HP	8555A RF Section 10MHz-40GHz	£700
HP	8640B Signal Generator	£1,100
HP	8647A 250kHz-1000MHz Signal Generator	£2,500
HP	8648 5.4-12.5GHz Signal Generator	£2,000
HP	8740A Transmission Test Unit	£350
HP	8741A Reflection Test Unit 0.1-2GHz	£350
HP	8742A Reflection Test Unit 2-12.4GHz	£350
HP	8754A Network Analyser 4-1300MHz	£2,000
HP	8910A Modulation Analyser 150kHz-1300MHz	£2,500
HP	8903B Audio Analyser	£3,200
HP	3325B Frequency, Function & Waveform Synthesizer	£3,000
HP	8620C + HP8622B Sweep Generator 0.01-2.4GHz	£1,500
HP	SAS/8130 Waveform Analyser	£500
Iwatsu	DM2250 Digital Memory Oscilloscope	£400
Iwatsu	DMS/6430 Digital Memory Oscilloscope	£500
JRC	NRO/535 HF Receiver	£1,000
JRC	NJ2/900JN Cellular Tester	£500
Kikusui	PK21/0020/000W Electronic Load	£450
Kikusui	TDS8550 W51 Auto Tester	£1,800
Leader	Loc/7005 Oscilloscope Calibrator	£600
Leclroy	9100 Arbitrary Function Generator	£500

Adret 740A Signal Generator 0.1-1120MHz PRICE: £15000

A & D	AD3522 FFT Analyser + Results Printer	£300
Adret	5104 Driving Synthesizer 90-120MHz	£1,225
Bonton	82AD Modulation Meter	£125
Farnell	SS620 Signal Generator	£200
Farnell	RB1030/35 Electronic Load 1KW 30A 35V	£300
Farnell	GR1101A 12-165Hz Microwave Signal Generator	£1,200
Farnell	D5G Synthesized Signal Generator	£185
Farnell	E350 Stabilized Voltage Supply	£120
Farnell	TSY70 MK2 Stabilized Power Supply	£180
Farnell	PSG250 Pulse Signal Generator 10-520MHz	£250
Ferragorah	RTS2 Recorder Test Set	£200
Fluke	8520A Digital Multi Meter	£250
Fluke	8860A Digital Multi Meter	£150
Giga	GR1101A 12-165Hz Microwave Signal Generator	£1,500
Giga	GU1328A 2-8GHz Microwave Signal Generator	£1,500
Hams	RF/2305 Receiver/Exciter	£200
Hitech	V550B 50MHz Oscilloscope	£200
HP	5363A Time Interval Probes	£150
HP	181A Main Frame c/w 1840A + 1825A	£125
HP	11713A Attenuator Switch Driver	£300
HP	1741A 100MHz Oscilloscope	£275
HP	1742A 100MHz Oscilloscope	£275
HP	3400A RMS Volt Meter	£120
HP	3570A Network Analyser 50Hz-13MHz	£150
HP	3770B Telephone Line Analyser	£200
HP	4353A Distribution Analyser	£300
HP	436A Power Meter	£175
HP	435B Power Meter	£250
HP	489A Microwave Amplifier 1-2GHz	£125
HP	5005A Signature Multimeter	£150
HP	5315A Universal Counter	£200
HP	5328A Universal Counter	£120
HP	8005B Pulse Generator 0.3Hz-10MHz	£150
HP	8058A Pulse Generator 10Hz-200MHz	£150
HP	8015A Pulse Generator 1Hz-200MHz	£150
HP	8018A Word Generator	£150
HP	8412B Phase Magnitude Display	£175
HP	8414A Polar Display	£175
HP	8443A Tracking Generator/Counter	£275
HP	8445B Automatic Presetor	£200
HP	8405A Vector Voltmeter	£250
HP	8552B IF Section	£200
HP	8553B RF Section 0-100MHz	£200
HP	8553L RF Spectrum Analyser 0-110MHz	£200
HP	8556A LF Spectrum Analyser	£200
HP	86601A RF Section 0.1-110MHz	£300
HP	8750A Storage Normalizer	£200
HP	491C Microwave Amplifier 2-4GHz	£125
HP	8413A Phase Gain Indicator Unit	£175
HP	SC7103 Frequency Counter	£160
HP	192 Programmable Digital Multimeter	£200
HP	5056B Signal Source 2-4GHz	£150
HP	6057B/2 Signal Source 5.8-50GHz	£150
Marconi	Rotary Vain Attenuator 6052/1 26.5-40MHz	£150
Marconi	TF2337A Auto Distortion Meter	£150
Philips	PM5519 Colour TV Pattern Generator	£200

HP8660C + HP86632B + HP86603A Synthesized Signal Generator 1-2600MHz PRICE: £2300

Adret	2230A Frequency Synthesizer 1MHz	£50
Adret	6303B Signal Generator	£75
Advance	TC17 Timer Counter	£15
Alker	SW4260P 20-100MHz	£75
AMF/Venner	7738 Digital Counter	£15
APLAB	LVE30/2 Regulated Power Supply 0-30V 0-2A	£25
APT	TCU250 Regulated Power Supply 0-50V 2A	£10
Bradley	525 Millivolt Meter	£40
Brookdeal	123B DC Calibrator	£25
Brookdeal	Orthocloc/SC/905 2 Phase Locking Analyser	£75
Brookdeal	411 Phase Sensitive Detector	£25
Brookdeal	422 Reference Unit	£25
Brookdeal	942A Phase Sensitive Detector	£25
Brookdeal	942S Scan Delay Generator	£25
Cossor	333A Test Set	£75
Cronin/Hite	5300A Function Generator	£40
Dagico	D04 Digital Ohmmeter	£75
Dana	4200 Digital Multi Meter	£20
Datron	1030A RMS Volt Meter	£25
Datron	1065 DC Volt Meter	£25
Datron	1030 RMS Volt Meter	£25
Farnell	F01 Function Meter TM2	£30
Farnell	F01 Function Generator	£30
Farnell	2085 AF Power Meter	£40
Farnell	DM13 Digital Multimeter	£30
Farnell	E30/2B DC PSU 30V 2A	£30
Farnell	LFI 10MHz 1MHz Sine/Square Oscillator	£60
Farnell	LFM2 Sine/Square Oscillator	£60
Farnell	SG18 Signal Generator Interface	£30
Feedback	EW604 Electronic Watt Meter	£50
Fluke	8600A Digital Multimeter	£60
Fluke	8008A Digital Multimeter	£50
Fluke	7261A Universal Counter/Timer	£150
Fluke	1953A Counter/Timer	£80
Fluke	8010A Synthesizer Signal Generator	£50
Fluke	9010A Digital Multi Meter	£20
Fluke	8050A Digital Multi Meter	£25
Gen. Radio	1232A Tuned Amplifier & Null Detector	£25
Gould	136Z UHF Oscillator Z20 920MHz	£25
Gould	J38 Signal Generator	£50
Gould	J3A Signal Generator	£50
Gould	053351 Oscilloscope	£200
Gould	TC314 Timer Counter	£200
Honeywell	1600A Logic State Analyser	£25
HP	10254A Serial to Parallel Converter	£25
HP	3710A IF/BW Transmitter	£75
HP	3720A IF/BW Receiver	£75
HP	431C Power Meter	£150
HP	5245L + 5255A Counter/Converter	£80
HP	203A Variable Phase Generator	£20
HP	675A Sweep Signal Generator/676A Tracking Det.	£75
HP	434A Calorimetric Power Meter	£75
HP	105A Quartz Oscillator	£75
HP	11855B Amplifier Switch + HP8709B Synchroniser	£75
HP	3485B Digital Multimeter	£40

Rohde & Schwartz Polyskop SWOB 5 + Accessories PRICE: £1800

HP	3480D Digital Voltmeter + 3484A Multi Function Meter	£25
HP	461A Amplifier	£50
HP	5004A Signal Analyser	£30
HP	5006A Signal Analyser	£50
HP	5150A Thermal Printer	£40
HP	5245A Plug In Unit + HP5245L Counter	£50
HP	5246L Electronic Counter	£30
HP	5302A 50MHz Universal Counter	£40
HP	5304A Timer Counter	£40
HP	59301A Asci-Parallel Converter	£30
HP	59313A A/D Converter	£30
HP	59501A HP118 Isolated DIA/PSU Programmable	£40
HP	8111A DC Power Supply 0-20V 0-1A	£75
HP	6130C Digitally Controlled Voltage Sources	£60
HP	8403A Modulator	£60
HP	8406A Frequency Combined Generator	£75
HP	8418A/01 Auxiliary Display Holder	£90
HP	8717B Transistor Bias Supply	£50
Iwatsu	SS/5416A DC-40MHz Synthescope	£90
Kemco	177 Millivolt Digital Multimeter	£75
Kemco	0P1 1.0Hz-100kHz Phase Meter	£70
Keppco	E30/2B 30V 2A Power Supply	£25
KSM	T25 Pulse Generator	£30
Levell	TR38 AC Microvolt Meter	£50
Lyons	T066A Transistor Decade Oscillator	£50
Lyons	PG2B Pulse Generator	£30
Lyons	PG750A Pulse Generator	£30
Lyons	PG 714 Pulse Generator	£30
Lyons	PG73N Pulse Generator	£25
Lyons	PG22 Pulse Generator	£25
Malden	100F MK11 10Hz-32MHz P.D. Frequency Counter	£10
Marconi	TF2700 Universal Bridge	£75
Marconi	TF2331A Distortion Factor Meter	£50
Marconi	TF2600B Video Voltmeter	£30
Marconi	TF2604 Electronic Voltmeter	£25
Marconi	TF2162 MF Attenuator DC-1MHz	£30
Marconi	TF2163S UHF Attenuator 3Hz-10GHz	£60
Marconi	TF2102M AF Oscillator 3Hz-30kHz	£30
Marconi	TF2330A Wave Analyser	£25
Marconi	TF2432 560MHz Digital Frequency Meter	£70
Marcovu	TF2104 10Hz-110kHz Automatic Low Distortion Oscillator	£30
Marconi	2304A 80MHz Digital Frequency Meter	£30
Marconi	2437 100MHz Universal Timer/Gaussia	£45
Marconi	2833 Digital Line Monitor	£25
Marconi	2834 Digital Line Monitor	£25
Marconi	650/3 Frequency Meter	£75
Marconi	6460R Power Meter	£50
Marconi	6460/1 ITR Power Meter	£25
Marconi	6500 Programmable ITR Power Meter	£20
Marconi	6550/1 Programmable ITR Power Meter	£20
Marconi	6581 Levelling Amp	£25
Marconi	TF2169 Pulse Modulator	£20
Marconi	TF2173 Digital Synchronizer	£60
Marconi	TF2174 Frequency Counter	£60
Marconi	TF2430 80MHz Digital Frequency Meter	£50

NO WARRANTY, UNTESTED

TELFORD ELECTRONICS

Old Officers Mess. Hoo Farm. Humbers Lane. Horton, Telford, Shropshire. TF6 6DJ. UK

PHONE; (0044) 01952 605451 FAX; (0044) 01952 677978

e-mail: telfordelectronics@telford2.demon.co.uk

CIRCLE NO. 109 ON REPLY CARD

DIFFERENTIAL THERMOSTAT KIT Perfect for heat recovery, solar systems, boiler efficiency etc. Two sensors will operate a relay when a temp difference (adjustable) is detected. All components and pcb. £29 ref LOT93

SOLAR WATER HEATING PLANS E6 REF S0LP

PC POWER SUPPLIES PACK OF 8 FOR £9.95

That's right! 8 power supplies for £9.95! These are all fan cooled (usually 12v) our choice of specs etc, and are sold as seen. But worth it for the fans alone! ref XX17

MAINS POWER SAVER UK made plug in unit, fitted in seconds, can reduce your energy consumption by 15%. Works with fridges, soldering irons, conventional bulbs etc. Max 2A rating. £9 each ref LOT71, pack of 10 £69 ref LOT72

DC TO DC CONVERTERS

DRM58 input 10-40vdc output 5v 8A £15 DRM128 input 17-40vdc output 12v 8A £18 DRM158 input 20-40vdc output 15v 8A £18 DRM248 input 29-40vdc output 24v 8A £12 DRS123 input 17-40vdc output 12v 3A £10 DRS153 input 20-40vdc output 15v 3A £20 DRS243 input 29-40vdc output 24v 3A £8

HITACHI LM225X LCD SCREENS 270x150mm, standard 12 way connector, 640x200 dots, tec spec sheet, £15 each ref LM2

HOME DECK CLEARANCE These units must be cleared! leads, a infra red remote query keyboard and receiver, a standard UHF modulator, a standard 1200/75 BT approved modem and loads of chips, capacitors, diodes, resistors etc all for just £10 ref BAR33.

PORTABLE X RAY MACHINE PLANS Easy to construct plans on a simple and cheap way to build a home X-ray machine! Effective device, X-ray sealed assemblies, can be used for experimental purposes. Not a toy or for minors! £6/set. Ref F/XP1.

TELEKINETIC ENHANCER PLANS Mystify and amaze your friends by creating motion with no known apparent means or cause. Uses no electrical or mechanical connections, no special gimmicks yet produces positive motion and effect. Excellent for science projects, magic shows, party demonstrations or serious research & development of this strange and amazing psychic phenomenon. £4/set Ref F/TXK1.

ELECTRONIC HYPNOSIS PLANS & DATA This data shows several ways to put subjects under your control. Included is a full volume reference text and several construction plans that when assembled can produce highly effective stimuli. This material must be used cautiously. It is for use as entertainment at parties etc only, by those experienced in its use. £15/set. Ref F/EH2.

GRAVITY GENERATOR PLANS This unique plan demonstrates a simple electrical phenomena that produces an anti-gravity effect. You can actually build a small mock spaceship out of simple materials and without any visible means - cause it to levitate. £10/set Ref F/GRA1.

WORLDS SMALLEST TESLA COIL/LIGHTNING DISPLAY GLOBE PLANS Produces up to 750,000 volts of discharge, experiment with extraordinary HV effects, 'Plasma in a jar', St Elmo's fire, Corona, excellent science project or conversation piece. £5/set Ref F/BTC1/LG5.

COPPER VAPOUR LASER PLANS Produces 100mw of visible green light. High coherency and spectral quality similar to Argon laser but easier and less costly to build yet far more efficient. This particular design was developed at the Atomic Energy Commission of NEGEV in Israel. £10/set Ref F/CVL1.

VOICE SCRAMBLER PLANS Miniature solid state system turns speech sound into indecipherable noise that cannot be understood without a second matching unit. Use on telephone to prevent third party listening and bugging. £8/set Ref F/VS9.

PULSED TV JOKER PLANS Little hand held device utilises pulse techniques that will completely disrupt TV picture and sound works on FM too! DISCRETION ADVISED. £8/set Ref F/TJ5.

BODYHEAT TELESCOPE PLANS Highly directional long range device uses recent technology to detect the presence of living bodies, warm and hot spots, heat leaks etc. Intended for security, law enforcement, research and development, etc. Excellent security device or very interesting science project. £8/set Ref F/BHT1.

BURNING, CUTTING CO2 LASER PLANS Projects an invisible beam of heat capable of burning and melting materials over a considerable distance. This laser is one of the most efficient, converting 10% input power into useful output. Not only is this device a workhorse in welding, cutting and heat processing materials but it is also a likely candidate as an effective directed energy beam weapon against missiles, aircraft, ground-to-ground, etc. Particle beams may very well utilize a laser of this type to blast a channel in the atmosphere for a high energy stream of neutrons or other particles. The device is easily applicable to burning and etching wood, cutting, plastics, textiles etc £12/set Ref F/LC7.

DYNAMO FLASHLIGHT Interesting concept, no batteries needed just squeeze the trigger for instant light apparently even works under water in an emergency although we haven't tried it yet! £6.99 ref SC152

ULTRASONIC BLASTER PLANS Laboratory source of sonic shock waves. Blow holes in metal, produce 'cold' steam, atomize liquids. Many cleaning uses for PC boards, jewelry, coins, small parts etc. £8/set Ref F/ULB1.



Water pump motors, mains powered, 165x75mm, 5mm shaft. £6 ea ref MM10.
Pack of 3 for £12 ref MM11.

ANTI DOG FORCE FIELD PLANS Highly effective circuit produces time variable pulses of acoustical energy that dogs cannot tolerate £6/set Ref F/DOG2

LASER BOUNCE LISTENER SYSTEM PLANS Allows you to hear sounds from a premises without gaining access. £12/set Ref F/LLIST1

PHASOR BLAST WAVE PISTOL SERIES PLANS Handheld, has large transducer and battery capacity with external controls. £6/set Ref F/PSA4

INFINITY TRANSMITTER PLANS Telephone line grabber/room monitor. The ultimate in home/office security and safety! simple to use! Call your home or office phone, push a secret tone on your telephone to access either: A) On premises sound and voices or B) Existing conversation with break-in capability for emergency messages. £7 Ref F/TELEGAB.

BUG DETECTOR PLANS Is that someone getting the goods on you? Easy to construct device locates any hidden source of radio energy! Sniffs out and finds bugs and other sources of bothersome interference. Detects low, high and UHF frequencies. £5/set Ref F/BD1.

ELECTROMAGNETIC GUN PLANS Projects a metal object a considerable distance - requires adult supervision £5 ref F/EML2.

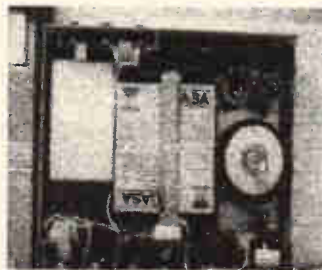
ELECTRIC MAN PLANS, SHOCK PEOPLE WITH THE TOUCH OF YOUR HAND! £5/set Ref F/EMA1.

PARABOLIC DISH MICROPHONE PLANS Listen to distant sounds and voices, open windows, sound sources in 'hard to get' or hostile premises. Uses satellite technology to gather distant sounds and focus them to our ultra sensitive electronics. Plans also show an optional wireless link system. £8/set ref F/PM5

2 FOR 1 MULTIFUNCTIONAL HIGH FREQUENCY AND HIGH DC VOLTAGE, SOLID STATE TESLA COIL AND VARIABLE 100,000 VDC OUTPUT GENERATOR PLANS Operates on 9-12vdc, many possible experiments. £10 Ref F/HVM7/TCL4.

MEGA LED DISPLAYS PCB fitted with 5 seven segment displays each measuring 55 x 38mm. £5 ref LED5.

MOD TRANSMITTING VALVES 5J180E £80 ref LOT112 SWITCHED MODE PSU'S 244 watt, +5 32A, +12 6A, -5 0.2A, -12 0.2A. There is also an optional 3.3v 25A rail available. 120/240v I/P. Cased, 175x90x145mm. IEC inlet Suitable for PC use (6 d/drive connectors 1 m/board). £15 ref LOT135



VIDEO PROCESSOR UNITS 7/6v 10AH BATT/24V 8A TX Not too sure what the function of these units is but they certainly make good strippers! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear. Inside 2 x 6v 10AH sealed lead acid batts, pcb's and a 8A? 24v toroidal transformer (mainin), sold as seen, may have one or two broken knobs etc due to poor storage. £15.99 ref VP2

MINI FM TRANSMITTER KIT Very high gain preamp, supplied complete with FET electret microphone. Designed to cover 88-108 Mhz but easily changed to cover 63-130 Mhz. Works with a common 9v (PP3) battery. 0.2W RF. £9 Ref 1001.

3-30V POWER SUPPLY KIT Variable, stabilized power supply for lab use. Short circuit protected, suitable for professional or amateur use 24v 3A transformer is needed to complete the kit. £14 Ref 1007.

1 WATT FM TRANSMITTER KIT Supplied with piezo electric mic. 8-30vdc. At 25-30v you will get nearly 2 watts! £15 ref 1009.

FM/AM SCANNER KIT Well not quite, you have to turn the knob your self but you will hear things on this radio that you would not hear on an ordinary radio (even TV). Covers 50-160mhz on both AM and FM. Built in 5 watt amplifier, inc speaker. £18 ref 1013.

3 CHANNEL SOUND TO LIGHT KIT Wireless system, mains operated, separate sensitivity adjustment for each channel, 1,200 w

power handling, microphone included. £17 Ref 1014.

Install a coin box telephone at home for less than £5

By using our phone box, you get everything you need to convert any standard telephone into a coinbox telephone. You simply open the box, plug your telephone into a connector inside and then plug the coinbox lead into your telephone socket. It's that simple! There are one or two catches however.

Catch one is that the lock and hinges may be damaged/broken, this doesn't really matter because you could replace the hinges easily and change the lock or you could refit the front panel onto a box of your own choosing.

Catch two is that the three coin slots accept £1, 50p and 10p's this is fine except that the 10p slot for the older 10p piece so you would need to glue a small piece of plastic across the bottom of the slot on the inside to reduce the hole size. Full programming instructions are included with every coinbox Bargain price £4.99 ref CBT1

4 WATT FM TRANSMITTER KIT Small but powerful FM transmitter, 3 RF stages, microphone and audio preamp included. £24 Ref 1028.

STROBE LIGHT KIT Adjustable from 1-60 Hz (a lot faster than conventional strobes). Mains operated. £17 Ref 1037.

COMBINATION LOCK KIT 9 key, programmable, complete with keypad, will switch 2A mains. 9v dc operation. £13 ref 1114.

PHONE BUG DETECTOR KIT This device will warn you if somebody is eavesdropping on your line. £9 ref 1130.

ROBOT VOICE KIT Interesting circuit that distorts your voice! adjustable, answer the phone with a different voice! 12vdc £9 ref 1131

TELEPHONE BUG KIT Small bug powered by the 'phone line, starts transmitting as soon as the phone is picked up! £12 Ref 1135.

12V FLOURESCENT LAMP DRIVER KIT Light up 4 foot tubes from your car battery! 9v 2a transformer also required. £8 ref 1089.

VOX SWITCH KIT Sound activated switch ideal for making bugging tape recorders etc, adjustable sensitivity. £10 ref 1073.

SOUND EFFECTS GENERATOR KIT Produces sounds ranging from bird chips to sirens. Complete with speaker, add sound effects to your projects for just £9 ref 1045.

15 WATT FM TRANSMITTER (BUILT) 4 stage high power, preamp required 12-18vdc, can use ground plane, yagi or open dipole. £69 ref 1021.

HUMIDITY METER KIT Builds into a precision LCD humidity meter, 9 ic design, pcb, led display and all components included. £29

PC TIMER KIT Four channel output controlled by your PC, will switch high current mains with relays (supplied). Software supplied so you can program the channels to do what you want whenever you want. Minimum system configuration is 286, VGA, 4.1, 640k, serial port, hard drive with min 100k free. £24.99

NICKEL PLATING KIT Professional electroplating kit that will transform rusting parts into showpieces in 3 hours! Will plate onto steel, iron, bronze, gunmetal, copper, welded, silver soldered or brazed joints. Kit includes enough to plate 1,000 sq inches. You will also need a 12v supply, a container and 2 12v light bulbs. £45 ref NIK39.

Miniature adjustable timers, 4 pole c/o output 3A 240v, HY1230S, 12vDC adjustable from 0-30 secs. £4.99

HY1260M, 12vDC adjustable from 0-60 mins. £4.99

HY2405S, 240v adjustable from 0-5 secs. £4.99

HY24060m, 240v adjustable from 0-60 mins. £6.99

BUGGING TAPE RECORDER Small voice activated recorder, uses micro cassette complete with headphones. £28.99 ref MAR29P1.

POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref MAG6P9

COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC. £12.00 REF: MAG8P2.

VENUS FLY TRAP KIT Grow your own carnivorous plant with this simple kit £3 ref F34.

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12.

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

ELECTRONIC ACCUPUNCTURE KIT Builds into an electronic version instead of needles! good to experiment with. £9 ref 7P30

SHOCKING COIL KIT Build this little battery operated device into all sorts of things, also gets worms out of the ground! £9 ref 7P36.

HIGH POWER CATAPULTS Hinged arm brace for stability, tempered steel yoke, super strength latex power bands. Departure speed of ammunition is in excess of 200 miles per hour! Range of over 200 metres! £8.99 ref R/9.

COMPAQ POWER SUPPLIES WITH 12V DC FANS Ex equipment psu's, some ok some not but worth it for the fan alone! probably about 300 watt PC unit with IEC input. £3.50 each ref CQ1

9-0-9V 4A TRANSFORMERS, chassis mount. £7 ref LOT19A.

FRESNEL PERSPEX SCREENS 11"x11"x3/16" as used in overhead projectors etc. New. £19 ref FRESN

MEGA LED DISPLAYS Build your self a clock or something with these mega 7 seg displays 55mm high, 38mm wide. 5 on a pcb for just £4.99 ref LOT16 or a bumper pack of 50 displays for just £29 ref LOT17.

SOLID STATE RELAYS
CMP-DC-200P 3-32vdc operation, 0-200vdc 1A £2.50
SMT20000/3 3-24vdc operation, 28-280vac 3A £4.50

FREE COLOUR CATALOGUE WITH EVERY ORDER

WE BUY SURPLUS STOCK FOR CASH SURPLUS STOCK LINE 0802 660335

BULL ELECTRICAL

250 PORTLAND ROAD, HOVE, SUSSEX.
BN3 5QT. (ESTABLISHED 50 YEARS).

MAIL ORDER TERMS: CASH, PO OR CHEQUE

WITH ORDER PLUS £3.50 P&P PLUS VAT.

24 HOUR SERVICE £4.50 PLUS VAT.

OVERSEAS ORDERS AT COST PLUS £3.50 (ACCESS, VISA, SWITCH, AMERICAN EXPRESS)

'phone orders : 01273 203500

FAX 01273 323077

E-mail bull@pavilion.co.uk

CIRCLE NO. 110 ON REPLY CARD

RESEARCH NOTES

Jonathan Campbell

"Second silicon revolution" gets commercial fillip

Traditionally, the focus of the microelectronics industry has been to pack more transistors onto a chip, leading to more powerful computers. But micromachine technology developed by Sandia National Laboratories and being commercialised by Analog Devices could change that strategy by working to integrate electronics with small machines into usable devices.

Such chips will have the ability to sense where they are and what is going on around them, with an early application likely to be in automobile air bag sensors.

A three-axis accelerometer that can detect changes in velocity along three planes of motion has already been built using Sandia technology and designs developed by the University of California at Berkeley's Sensor and Actuator Lab.

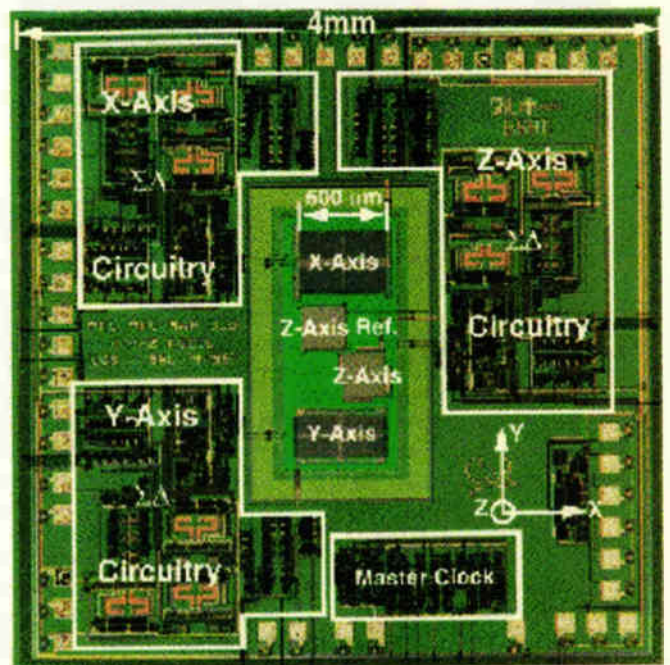
Analog Devices, an industry leader in the manufacture of air bag micromachine sensors, is taking the technology to make integrated micro machines – a tiny, smart machine that combines microcircuits, sensors, and actuators on a single computer chip. In the air bag sensor, Analog uses micro machines to signal when a vehicle is undergoing sufficiently

rapid and sustained deceleration for the air bag to deploy. Sandia is already a world leader in this field and the work is expected to help stimulate production of a new generation of very small consumer and military devices, such as anti-tamper, anti-skid, and active-vibration-control systems.

Sandia estimates the specific market for micromachine-based inertial sensors worldwide is estimated to be \$3.8 billion, and talks in terms of these new devices heralding a "second silicon revolution."

Researchers at the University of California at Berkeley's Sensor and Actuator Lab, credited with making some of the earliest known micro machines, also will be involved in designing new, smarter products.

One advantage of the technology is that batches of silicon micro machines can be fabricated through manufacturing techniques already widely used to make integrated circuits. So micro machines are far cheaper than the complicated multi-metal constructions originally necessary to signal an air bag to inflate. Rather than being made individually, micro machines can be fabricated quickly and cheaply by



the thousands.

Also, because the machines have so little weight, they are less likely to be damaged by sudden deceleration, because force is proportional to mass – which, in this case, is almost non-existent.

Micromachines integrated into a chip promise the next silicon revolution

DNA computers – made on the workbench

Manufacture of biological logic gates has brought forward the possibility of building DNA computers able to process in just a few hours complex information that would take today's conventional computers hundreds of years to solve.

One of the most surprising aspects of this recent breakthrough at University of Rochester is that the DNA logic gates were made using only the most common-place biological laboratory techniques, such as DNA ligation and gel electrophoresis

Conventional logic gates convert the endless series of binary data coursing through the machine into a series of signals that the computer uses to perform its operations. They process electronic signals from transistors, converting two input signals into one output signal in a way that allows a computer to perform complex operations.

Up to now, the only logic gates used for computing have been electronic structures that detect signals coming from transistors.

But the logic gates, developed by Animesh Ray and Mitsu Ogihara at Rochester, rely not on electrical signals to perform logical operations, but rather on DNA codes.

The Rochester gates – actually tiny DNA processing centres – detect specific fragments of the genetic blueprint as input, then splice together the fragments to form a single output. For instance, a genetic And gate links two DNA inputs by chemically binding them so they are locked in an end-to-end orientation, much as two



Scientists at the University of Rochester have built logic gates that rely not on electrical signals but rather on DNA codes to perform operations. Picture shows a sample of DNA against a computer monitor displaying a model of the DNA helix.

Legos might be fastened end-to-end by a third Lego stuck on top.

An enzyme called DNA ligase seals the gap between the ends of the two input strands, yielding a single new strand.

Using regular gel electrophoresis, the length of this new strand can be precisely measured, providing the DNA computer's answer or output to the two input strands.

Ogihara recently showed mathematically that a computer consisting of a series of DNA-filled test tubes can work more efficiently than a digital computer in analysing the information cascading in from a tangled web of logic gates. This includes the type of calculations now done every day, as well as more

complex arrangements.

Ray and Ogihara are among a growing group of scientists who believe that DNA could serve as a very compact, efficient, and accurate form of memory in computers – just as it does in the cells of the human body. The potential benefits of a DNA computer are astounding: 500g of DNA has the capacity to store more information than all the electronic computers ever built, and the computing power of a teardrop-sized DNA computer using the new DNA logic gates could dwarf that of the world's most powerful supercomputer, which even now is the size of a house.

Contact: Animesh Ray, University of Rochester, Tel: 00 1 716 275 8986.

Honey I shrunk the lab!

Si silicon laboratories, where the functionality of specialised chemical analysis instruments has been shrunk down to fit on a computer chip, have come closer to reality following an announcement from a researcher at Purdue University.

Technology has been patented by Purdue, and PerSeptive Biosystems of Boston, that will allow scientists to pack hundreds of laboratories – each fully capable of carrying out complex chemical analyses – on a single silicon chip, reducing the cost and boosting the efficiency of many chemical and medical analyses.

The laboratory chips should be available in three to five years, according to Fred Regnier, professor of chemistry at Purdue and co-founder and chief technical officer of PerSeptive Biosystems. The aim is to allow physicians and medical professionals to perform chemical analyses using the chips that currently are done at specialised laboratories.

For instance, in standard chromatography, a solution to be separated is poured through a tube or column packed with various particles that are coated with a chemical compound. The different components of the solution are attracted to the particles with different affinity. As the mixture flows through the column, it separates into a series of zones, each containing a pure substance.

The miniature laboratories employ the same principle. The difference is in their size and the way they are made. Channels and microscopic 'particles' are created, this time using photolithography and chemical etching – the same technologies that are used to build semiconductors. The entire laboratory – with chemical reaction vessels the size of a speck of dust and chromatography columns the size of a human hair – is cut from a single piece of silicon, similar to the creation of a sculpture. Liquids are moved on the chip by voltage

applied at the ends of the channels.

What makes this device different to similar devices under development is that Regnier has found a way to create tiny, rectangular particles within the channels. These monolith structures, etched into the column as a single unit, serve the same purpose as the packing materials used in conventional chromatography columns, and they allow the miniature laboratory to perform more complex procedures.

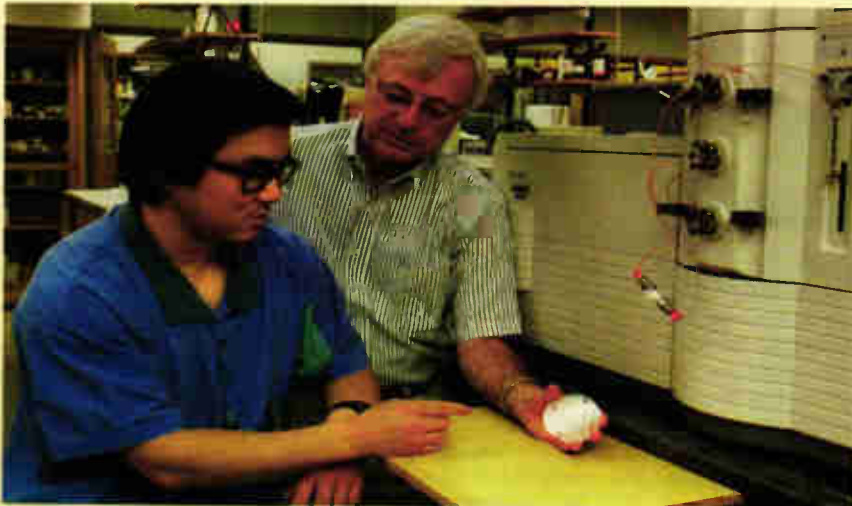
Despite their diminutive size, the laboratories on a chip can obtain accurate measurements using only a fraction of a drop of liquid. Instead of working with microlitres of liquid, the chips need only picolitres. Yet measurements can still be made to within a few percent accuracy.

The mini-laboratories also differ from standard chromatographs in that they contain no moving parts. So they are much simpler device and are much less expensive to build than conventional laboratory equipment. A standard liquid pumping system and column, for example, may cost £10000, but a chip can be fabricated for £300, and up 100 mini-laboratories can be lined up on a single chip.

The ability to fabricate specialised instruments at low cost and to connect large numbers of them together could have a major impact on areas of science such as clinical analysis and drug discovery. The new technology may be particularly useful in pharmaceutical laboratories where scientists analyse thousands of natural and synthetic compounds in search of new drug candidates.

Other applications could include clinical settings such as a doctor's office, where the miniature laboratory could be used by medical professionals to perform diagnostic procedures. For simple diagnostic procedures, laboratories could be designed to work in a fashion similar to pregnancy test kits.

Contact: Fred Regnier, Purdue University, West Lafayette, Indiana. Tel: 00 1 765 494-3878; e-mail, fregnier@purdue.edu



Purdue researcher Fred Regnier (right) and colleague stand next to a liquid chromatograph while examining a silicon wafer that contains a scaled-down version of the device. The mini-laboratory is capable of carrying out many of the same types of chemical separations as the full-sized instrument. (Purdue News Service Photo by David Umberger)

Process adds to coating development

A new coating process that enables novel compounds to be formed and also solves some of temperature problems currently inherent in coating chips has been developed at the University of Buffalo.

By using such extremely high temperatures and then quenching the heat, the new technique solves one of the trickier problems in computer-chip fabrication: how to coat them while avoiding high temperatures that can cause computer chip samples to fail. This has been a serious drawback for fabricators of expensive chips for research-grade supercomputers, such as the Cray.

The new hybrid technique marries the advantages of the two conventional fabrication methods – laser ablation and molecular beam epitaxy – while overcoming their disadvantages. Just as importantly, the method, called laser assisted molecular beam deposition, OR Lambd, can also manufacture new coatings for electronic devices in the same stage.

“Instead of simply sputtering a target material from point A to point B, we’re chemically modifying it at

the same time,” says James Garvey, professor of chemistry and principal investigator.

The key to Buffalo’s fabrication method is that it causes chemical reactions that would be impossible to generate otherwise, and it does it all in one step.

Like laser ablation and molecular beam epitaxy, Lambd uses extremely high heat to remove particles of a target material from one surface and transport it to another, creating a thin film.

What makes Lambd different is that those molecules then collide with a pulse of gas, the identity of which is determined by the type of chemical product desired. The technique also seems to remove from the fabrication process certain toxic precursors that otherwise are necessary in generating thin films.

For example, electronic wafers often must be coated with titanium nitride to act as a diffusion barrier – a process that requires a very toxic precursor, requiring extensive safety and disposal equipment.

With the new technique, nitrogen gas is simply blown over a rod of



titanium, depositing titanium nitride directly on the substrate. The process results in a thin film of protective titanium nitrate without the use of toxic precursors.

So far, several unique materials have been formed using Lambd, such as hybrid organic/inorganic films where an organic material with good optical characteristics has been encapsulated in silica glass. These new materials could have valuable photonics applications for new computer devices.

Laser assisted molecular beam deposition, or Lambd, could open up new chip coating opportunities

Explosion packs punch into magnetic pulse

In a remote corner of Los Alamos National Laboratory, scientists from around the world spent weeks setting up an apparatus designed to measure what happens to certain compounds under extremely high magnetic fields – then they blew it to bits.

The Dirac experimental campaign is an international collaboration begun in 1996 to investigate the atomic structure and chemistry of materials by subjecting them to an exceedingly strong magnetic pulse driven by an explosive charge. Scientists are probing how materials conduct electricity in extreme conditions. The magnetic forces created briefly in the experiment by the explosion make it possible to investigate aspects of the structure of condensed matter that are otherwise impossible to study.

To attain the intense magnetic fields required, the research team placed sample materials inside an electromagnet, with the samples cooled to a few degrees above absolute zero. The magnet was

surrounded with about 18kg of explosives, arranged to produce a perfectly uniform implosion.

In the millionths of a second before the equipment turned to dust, sensors captured measurements of how the sample’s electrical resistance changed as the magnetic field was squeezed and concentrated by the blast.

Magnetic field strength is measured in teslas.

Sustained fields in research magnets are generally around 60 tesla – one tesla is about 20000 times stronger than Earth’s field. The Dirac experiments have achieved momentary pulsed fields reaching 850 tesla. Insights from these experiments may help in the design of superconductors and better semiconductors.

But for the scientists, the pay-off is the glimpse at secrets that are normally hidden from observation. ■



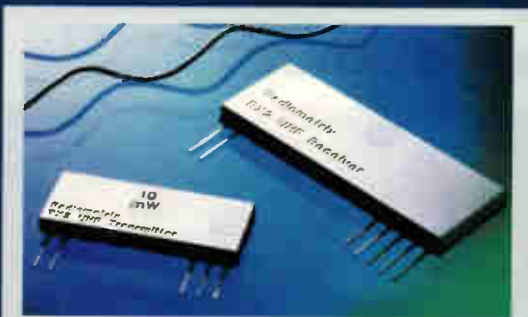
Explosions have been used at Los Alamos to generate massive magnetic pulses.

Contact: Los Alamos National Laboratory, New Mexico, USA.

LOW-COST AND MINIATURE

TRANSMITTER/RECEIVER PAIR

LICENCE EXEMPT UHF MODULES
DESIGNED FOR EMC COMPLIANCE



All TX2 and RX2 modules feature:

- Miniature, PCB-mountable UHF transmitter/receiver pair
- Cable-free data link up to 75m 'in building' and 200m over open ground
- Operation at 433.92MHz (Europe) & 418MHz (UK)
- Full EMC screening and internal filtering
- Ideal for portable, battery-powered applications

RADIO PACKET CONTROLLERS INCORPORATING BiM TRANSCIVER BI-DIRECTIONAL RADIO DATALINKS



All RPC and BiM modules feature:

- Half-duplex data transmission up to 40Kbit/s
- Reliable "in-building" operating range of 30m
- Outdoor operation over distances of 120m
- Duty cycle power saving
- Direct interface to 5V CMOS logic
- Operation at 433.92MHz (Europe) & 418MHz (UK)

Full data available on <http://www.radiometrix.co.uk>

RADIOMETRIX Ltd



Hartcran House, Gibbs Couch, Carpenders Park, Watford, Herts, WD1 5EZ, England.
Tel: +44 (0)181 428 1220 • Fax: +44 (0)181 428 1221
email: radiometrix@dial.pipex.com

CIRCLE NO. 111 ON REPLY CARD

8 CAVANS WAY,
BINLAY INDUSTRIAL ESTATE,
COVENTRY CV3 2SF

Tel: 01203 650702

Fax: 01203 650773

Mobile: 0860 400683

(Premises situated close to Eastern-by-pass in Coventry with easy access to M1, M6, M40, M42, M45 and M69)

INSCCELLANEOUS

Adret 740A - 100kHz-1120MHz Synth. signal generator	£2000
Arutub ME462B - DS-3 transmission analyser	£3000
Arutub ME682A - Pulse pattern generator	£1500
Barr & Stroud - EF3 variable filter (0.1Hz-100kHz)	£150
Danbridge JP30A - 30kV Insulation Tester	£1500
Dranetz 826 - ACDC Multifunction Analyser	£280
E.I.P.331 - 18GHz frequency counter	£350
Farnell AP70-30 P.S.U. - (0-70V, 0-30A) auto ranging	£750
Fluke 5100A - Calibrator	£2500
Fluke 5100B - Calibrator	£3500
Fluke 5101B - Calibrator	£4000
Fluke 5206A - Precision power amplifier	£1500
Fluke 7105A - Calibration system (As new)	£5000
Gullidine 9152 - T12 Battery standard cell	£250
Halden 1107 - 30V-10A Programmable power supply (IEEE)	£260
Hewlett Packard 331A - Distortion analyser	£300
Hewlett Packard 339A - distortion measuring set	£1500
Hewlett Packard 432A - Power Meter (with 478A Sensor)	£275
Hewlett Packard 438A or B - Power Meter (with 9481A/9484A)	from £750
Hewlett Packard 18300 - Logic Analyser (43 channels)	£850
Hewlett Packard 16500A - Fitted with 16510A/16515A/16530A/16531A	
Logic analyser	£4000
Hewlett Packard 3325A - 21MHz synthesiser/function gen	£1500
Hewlett Packard 3335A - Synthesised signal generator (10Hz-21MHz)	£1000
Hewlett Packard 3437A - System voltmeter	£350
Hewlett Packard 3438A - Digital multimeter	£200
Hewlett Packard 3465A - 6 1/2 digit multimeter (auto-scal)	£750
Hewlett Packard 3466A - Digital voltmeter	£750
Hewlett Packard 3478A - Multimeter (5 1/2 digit) HPB	£560
Hewlett Packard 3488A - HP-IB switch/control unit (various plug-ins available)	£850
Hewlett Packard 3711A/3712A/3791B/3793B - Microwave link analyser Sensor	£2495
Hewlett Packard 3776A - PCM Terminal test set	£2000
Hewlett Packard 3779 A/C - Primary mux analyser	£500/£300
Hewlett Packard 4271B - LCR meter (digital)	£300
Hewlett Packard 4276A - Multi-frequency LCR meter	£3950
Hewlett Packard 4279A - 1MHz C/V meter	£8500
Hewlett Packard 4338A - Milliohmmeter (as new)	£2000
Hewlett Packard 4342A - Q meter	£395
Hewlett Packard 4948A - transmission impairment measuring set	£2000
Hewlett Packard 4953A - Protocol analyser	£1995
Hewlett Packard 4972A - Lan protocol analyser	£2000
Hewlett Packard 5316A - (new) 100MHz universal counter	£250
Hewlett Packard 5326A - 100MHz universal frequency counter	£250
Hewlett Packard 5478A - Multimeter (5 1/2 digit) HPB	
Optis 001/003/004/005 - System P.S.U. 0-80V/10a	£395
Hewlett Packard 6034A - System P.S.U. 0-80V/10a	£1500
Hewlett Packard 6181C - D.C. current source	£150
Hewlett Packard 8281B - Power supply 20V-50A	£450
DISCOUNT FOR QUANTITIES	
Hewlett Packard 8011A - Pulse gen. 0.1Hz-20MHz	£500
Hewlett Packard 8152A - Optical average power meter	£1250
Hewlett Packard 8158B - Optical attenuator with opt's 002 & 001	£1100
Hewlett Packard 8186A - 50MHz programmable signal source	£1850
Hewlett Packard 8349B - Microwave broadband Amp (as new) 2-20MHz	£3250
Hewlett Packard 8350B - Sweep oscillator mainframe (plug-ins avail)	£2500

TELNET

Hewlett Packard 8355A - Millimeter wave source 28.5GHz-40GHz	£4000
Hewlett Packard 8356A - Millimeter wave source 33GHz-50GHz	£4250
Hewlett Packard 8403A - modulator	£500
Hewlett Packard 8405A - Vector voltmeter	£500
Hewlett Packard 8620C - Sweep oscillator mainframe	£400
Hewlett Packard 8623A - Microwave signal gen. (2.3-5.5GHz)	£2500
Hewlett Packard 8684A - 5-4GHz to 12.5GHz Sig Gen	£2500
Hewlett Packard 8750A - Storage normaliser	£375
Hewlett Packard 8801A - Modulation Analyser	£2500
Hewlett Packard 8903A - Audio analyser (20Hz-100kHz)	£1895
Hewlett Packard 8958A - Cellular radio interface	£3500
Hewlett Packard 11278B - Carrier noise test set	£2000
Kroh-Hite 5200 - Sweep function generator	£285
Marconi 8938 - A/F power meter	£235
Marconi 2019 - 80kHz-1040MHz synth signal generator	£1750
Marconi 2019A - 80kHz-1040MHz synthesised sig. gen	£1950
Marconi 2022A - 10kHz-1GHz - AM/FM signal generator	£2000
Marconi 2810 - True RMS voltmeter	£850
Marconi 2871 - data communications analyser	£1500
Marconi 2955 + 2958 - Radio Comms test set + tacs adaptor	£3500
Philips PM 5187 - 10MHz function gen	£400
Philips PM 5190 - LF synthesiser with GPIB	£900
Philips PM 5519 - Colour TV pattern generator	£300
Philips PM 5687 - Vectorscope	£550
Philips PM 8673 - 120MHz high resolution universal counter	£350
Philips PM 8670 - 120MHz high resolution timer/counter	£350
Philips PM 8652 - 1.5 GHz programmable high resolution timer/counter	£900
Racal Dana 1982 - 1300MHz frequency counter opts 49-55	£800
Racal Dana 9081 - Synthesised Sig Gen 520MHz	£800
Racal Dana 9084 - Synth. sig. gen. 104MHz	£460
Racal Dana 9301A - True RMS R/F millivoltmeter	£300
Racal Dana 9303 - True RMS R/F level meter	£950
Racal Dana 9321 - 3GHz frequency counter	£450
Rohde & Schwarz SMDU1 - 15Hz-525MHz (FM & AM) Sig-Gen	£500
Rohde & Schwarz SMF72 - 1GHz radio comms test set + options	£2500
Rohde & Schwarz URE - RMS Voltmeter DC 10Hz to 25MHz	£300
Schaffner NSG 203A - Line voltage variation simulator	£395
Schaffner NSG 222A - Interference simulator	£395
Schaffner NSG 223 - Interference generator	£750
Schaffner NSG 431 - Electrostatic discharge simulator	£1250
Schlumberger 2720 - 1250MHz Freq. Counter	£800
Schlumberger 4031 - Radio Comms Test Set	£9000
Schlumberger 4823 - Radio Code Test Set	£300
Schlumberger 7067/7065/7075 - Multimeters from	£350
Systron Donner 1900B - Microwave Sweeper (12-19GHz)	£2500
Tektronix 577 - Curve Tracer	£1150
Tektronix - Plug-ins - Many available such as PG508, FG504, SC504, SW500, SG502 etc	
Tektronix TM6003 + AFG5101 - Arbitrary Function Gen	£1750
Tektronix 1240 - Logic Analyser	£750
Tektronix AM503 + TM501 + P6302 - current probe amplifier	£395
Tektronix AA5001 + TM5006 - Mainframe programmable distortion analyser	£1995
Tektronix PG504 + TG501 + SG503 TM503 - Oscilloscope calibrator	£1995
Time 9814 - Voltage calibrator	£750
Wavetek 171 - Synthesised function generator	£250
Wavetek 172B - Programmable sig. source (0.0001Hz-13MHz)	£460
Wavetek 184 - Sweep generator	£250
Wayne Kerr 8905 - Precision LCR meter	£280
Wayne Kerr 4812 - LCR bridge	£800
Wayne Kerr 8425 - Precision component analyser	£2750
Whitron 6620S - Programmable sweep gen. (3.8-6.5GHz)	£850

DIGITAL OSCILLOSCOPES

Beckman 9020 - 20MHz dual channel	£180
Coswor 3102 - 50MHz dual channel	£250
Gold 9204A/250/256/300/300A/335/1A/6000 - From	£125
Hameg 203/203A/203B/203C - From	£150
Hewlett Packard 180A/180C/181A/182C - From	£200
Hewlett Packard 1740A, 1741A, 1744, - 100MHz dual ch	from £350

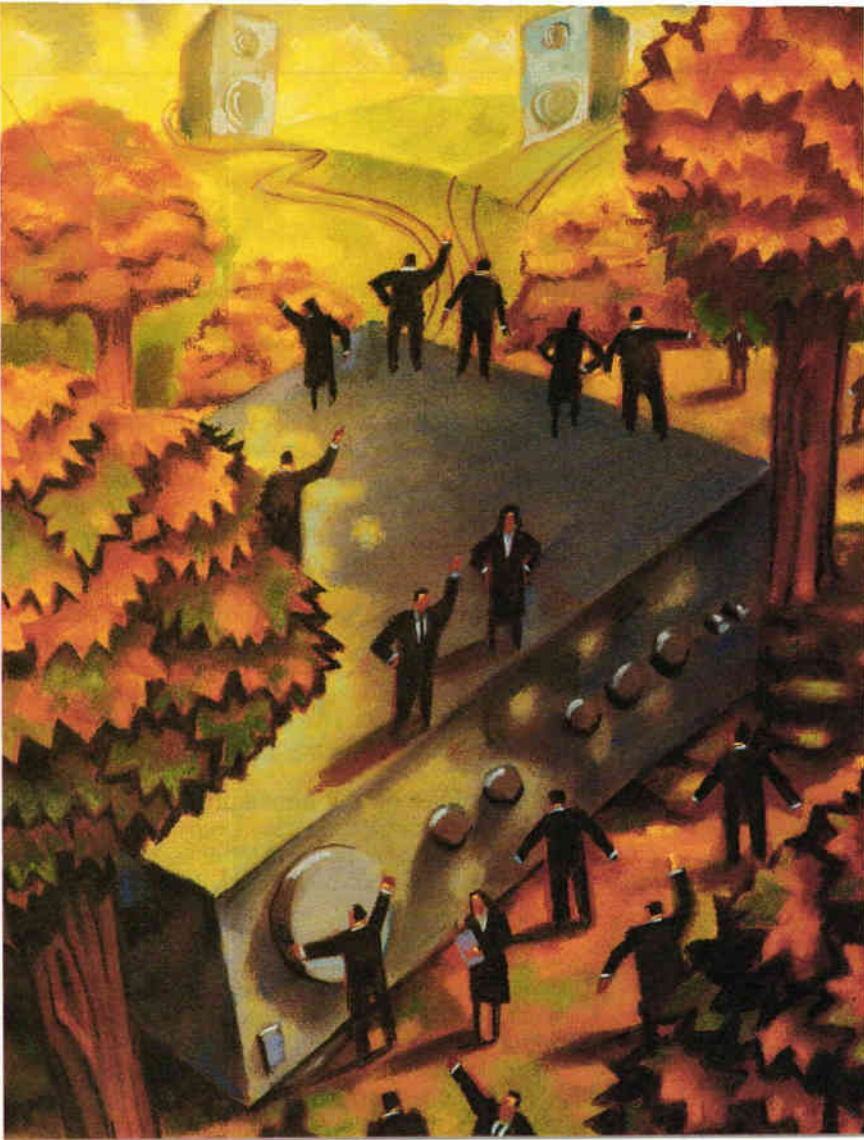
Hewlett Packard 541000 - 1GHz digitizing	£2995
Hewlett Packard 54501A - 100MHz digitizing 4 channel	£1750
Hitachi V152/V12/V22/V302B/V302F/V363F/V550B/V650F - From	£125
Hitachi VC820B - 100MHz digital storage (as new)	£2000
Intron 2020 - 120MHz digital storage (as new)	£850
Iwatsu 55 5710/55 5702 - From	£125
Meguro M50 1270A - 120MHz digital storage (as new)	£850
Klonaal 5100 - 100MHz dual channel	£260
Klonaal CS6 6100 - 100MHz 5 channel 12 trace	£475
National VP 6703A - 100MHz digital storage	£750
Nicolet 310 - LF DSO with twin disc drive	£550
Nicolet 3081 - Low freq D.S.O.	£300
Philips PM 3211/PM 3281/PM 3282/PM 3217/PM 3234/PM 3240/PM 3243/PM 3244/PM 3281/PM 3282/PM 3283/PM 3540 - From	£125
Philips PM3295A - 400MHz dual channel	£1750
Scopec 140-15 - 15MHz dual channel	£100
Tektronix 2408A - 150MHz - 4 channel	£1800
Tektronix 465 - 50MHz dual channel	£350
Tektronix 2221 - 100MHz digital storage	£1500
Tektronix 7854 - 400MHz Waveform processing oscilloscope	£1500
Tektronix 464/468 - 100MHz storage	from £350
Tektronix 2215 - 120MHz dual ch.	from £350
Tektronix 468 - 100MHz D.S.O.	£750
Tektronix 475/476A - 200/250 MHz dual channel	from £475
Tektronix 434 - 25MHz 2 channel + analogue storage	£250
Tektronix 464 - 150MHz 2 channel	£400
Tektronix 2213 - 60MHz dual ch.	£425
Tektronix 2215 - 120MHz dual ch.	£460
Tektronix 2225 - 50MHz dual trace	£460
Tektronix 2235 - 100MHz Dual Trace	£800
Tektronix 2236 - 100MHz Dual Trace with Counter/Timer/Dmm	£395
Tektronix 2236 - 5100MHz dual ch. (portable)	£750
Tektronix 5403 - 50MHz 2 or 4 channel from	£250
Tektronix 7313, 7893, 7813, 7823, 7833 - 100MHz 4 ch.	from £250
Tektronix 7704 - 250MHz 4 ch	from £500
Tektronix 7904 - 500MHz	from £700
Tektronix 7934 - 500MHz with storage	from £1000
Tektronix 3682 - 50MHz dual channel	£200
Teleduquoin DM83 - 20MHz 4 channel	£150
Trio CS - 1822 - 20MHz dual channel	£125

Other scopes available too

SPECTRUM ANALYSERS

Advantest 4131 - 10kHz - 3.5GHz (IGIPB)	£5000
Alftech 757 - 10kHz-22GHz	£2750
Ando AC 8211 - Spec analyser 1.7GHz	£2395
Hewlett Packard 141T + 8552B + 8556A - (10MHz-18GHz)	£1800
Hewlett Packard 182T with 8559B - (10MHz-21GHz)	£3750
Hewlett Packard 182T with 8559B - (10MHz-1500MHz)	£2790
Hewlett Packard 853A with 8559B - (0.01-1500MHz)	£2350
Hewlett Packard 853A with 8559B - (0.01-21MHz)	£4250
Hewlett Packard 3682A - dynamic signal analyser, dual channel	£7500
Hewlett Packard 3680A - 5Hz-50kHz	£395
Hewlett Packard 3682A - 25kHz analyser, dual channel	£2500
Hewlett Packard 853A - 20kHz-40MHz	£5000
Hewlett Packard 3709B - Constellation Analyser with 15708A High Impedance Interface (as new)	£8750
Hewlett Packard 8505A - Network analyser (500kHz-1.3GHz)	£3950
Hewlett Packard 8506A - (0.01-22GHz)	£3750
Hewlett Packard 8754A - Network analyser 1300MHz	£2750
Meguro MSA 4901 - 1-300MHz (as new)	£1500
Meguro MSA 4912 - 1-1000MHz (as new)	£2000
Marconi 2370 - 110MHz spec analyser	£750
Tekada Riken 4132 - 1000MHz	£2750

SEND LARGE S A E FOR LIST OF MANY MORE ITEMS AVAILABLE. ALL EQUIPMENT IS USED WITH 30 DAYS GUARANTEE. PLEASE CHECK FOR AVAILABILITY BEFORE ORDERING. CARRIAGE & VAT TO BE ADDED TO ALL GOODS



The interface between an audio power amplifier and its loudspeakers is important, but not for the reasons you might think, reveals Doug Self.

The audio power interface

A good deal has been written in recent years about speaker cables. Much of this has been raving nonsense – perpetrated by those drawn to audio as it appears to be a subject in which one can profess expertise without the trouble of actually learning anything.

Some approaches are well-intentioned but misguided, such as worrying about how cables perform at 1GHz. This article attempts something most unusual – it looks at what cables actually do in their real situation.

Figure 1 shows the most important elements in the amplifier-cable-speaker system. Their basic interactions must be understood before worrying about possible second-order effects at radio frequencies.

Putting a damper on damping factor

One of the most misunderstood features of this system is the effect of amplifier output impedance on speaker dynamics. The parameter 'damping factor' purports to measure how much this output impedance degrades the electromagnetic damping of loudspeaker units. In fact 'damping factor' must

be the most misnamed parameter in existence, for an amplifier's ability to damp loudspeaker resonances is effectively NIL. This is so important and apparently so little understood that the next section deals with this first.

Damping factor is defined as the ratio of the load impedance R_{load} to the amplifier output resistance R_{out} .

$$damping\ factor = \frac{R_{load}}{R_{out}}$$

Solid-state amplifiers often have output resistance around 50 to 100m Ω so an 8 Ω speaker means a damping factor of at best 160 times. This simple definition ignores the fact that amplifier output impedance usually varies considerably across the audio band, increasing with frequency as negative feedback factor falls; the output 'resistance' is actually more like an inductive reactance at high audio frequencies. The presence of an output inductor to give stability with capacitive loads increases this reactance.

A further condemnation of damping factor is that the bass

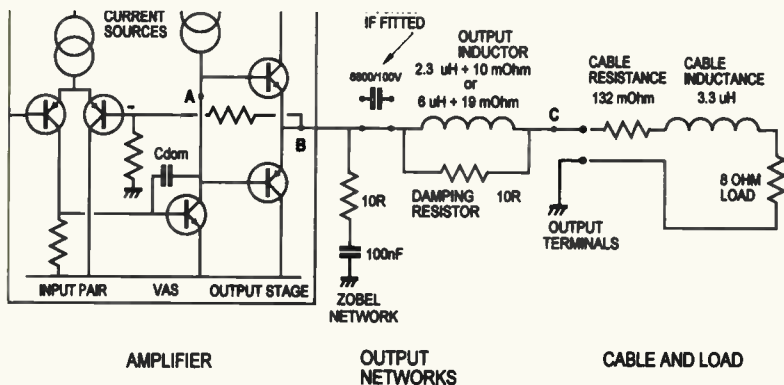


Fig. 1. Amplifier-cable-speaker system. Simplified amplifier with Zobel network and output inductor, 5m of cable with series resistance and inductance, and a resistive load. Values are typical.

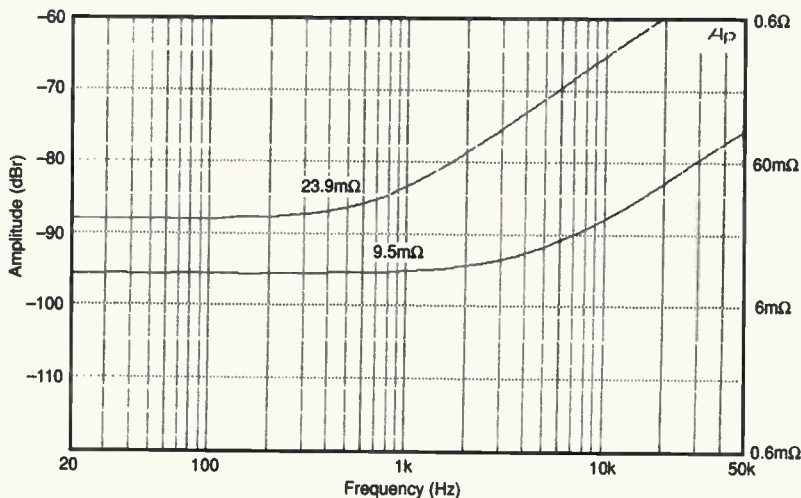


Fig. 2. Output impedance of a 'blameless' amplifier, with and without 6μH output inductor. Adding the inductor, upper trace, increases both the flat low-frequency output impedance, due to its series resistance, and the rising high-frequency impedance.

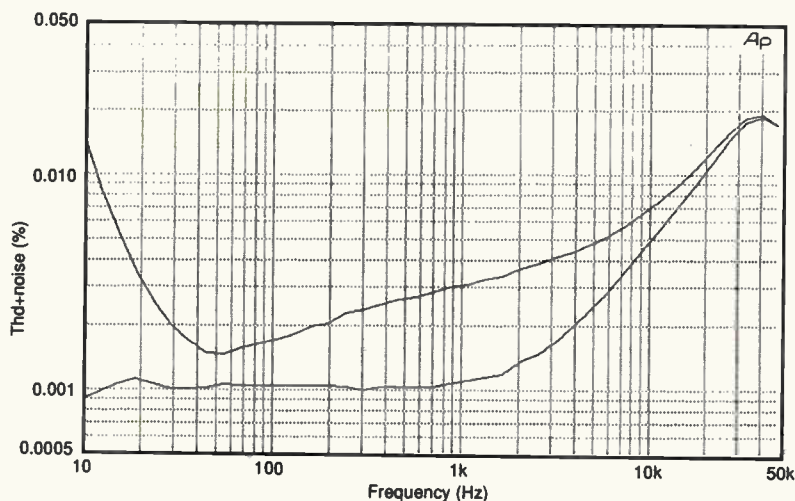


Fig. 3. Distortion with and without a standard 6800μF/100V electrolytic at 40W into 8Ω. There is extra distortion across the audio band, as well as a sharp rise at ff.

resonance is the one frequency where a real loudspeaker can be pretty much guaranteed to have an impedance nothing like 8Ω. With a sealed box, peak resonance impedance is often 30Ω or more.

In the face of these potential complications, it is a mercy that damping factor as such has very little effect on loudspeaker behaviour. A factor of 160 times, as derived above, promises a truly radical effect on cone response – implying that resonances and such have been reduced by 160 times as the amplifier output takes an iron grip on cone movement. Nothing could be further from the truth.

The electrical damping of a loudspeaker unit depends on the total series resistance in the voice-coil circuit. This is the sum of speaker coil resistance, resistance in the crossover, speaker cabling, and, last of all, amplifier output impedance. Values for these will be typically 7Ω, 1Ω, 0.2Ω and 0.05Ω, so the amplifier only contributes 0.6% of the total, and its effect on speaker dynamics must be negligible.

Does amplifier output impedance matter?

Setting guidelines for crossover inductors, Neville Thiele states that a winding resistance of 5% of the voice-coil resistance was low enough to have no significant effect on drive unit dynamics.^{1,2}

If it was possible to make an amplifier change the speaker low-frequency resonance, this would be a really poor idea; the bass resonance is an integral part of the speaker design, and tampering with its frequency and Q is unlikely to improve anything.

The irrelevance of 'damping factor' was practically investigated and fully confirmed by James Moir as far back as 1950³, though this has not prevented periodic resurgences of controversy, nor stopped writers from claiming that inadequate loudspeaker cables have a direct effect on bass transient response, with 'bad' cables usually alleged to yield 'flabby' or 'woolly' bass. In contrast, Martin Colloms deals very sensibly with damping factor in reference 4.

So 'damping factor' is almost an arbitrary ratio, with little physical reality. Nonetheless, one reason to strive for a high figure – which after all, can do no harm – is the numbers game of impressing potential customers with specifications figures. It is as certain as anything can be that the subjective difference between two amplifiers, one with a damping factor of 100, and the other boasting 2000, is undetectable by human perception. Nonetheless, the two specifications look very different in the brochure, so minimising output impedance to maximise the damping factor may be of commercial importance. See the end of this article for more details.

Although amplifier output impedance is of little interest in terms of speaker dynamics, it is still worth minimising. Too high an output resistance causes power losses into low-value loads. These look more significant than they are when expressed in watts.

A potentially more serious problem is that non-zero output resistance causes output voltage to vary as speaker impedance varies with frequency, introducing unwanted response irregularities.

Despite this demonstration of its irrelevance, the rest of this article continues to refer to damping factor, to show how an apparently impressive figure shrivels away as more parts of the system are taken into account.

Amplifier output impedance

Audio amplifiers, with a few very special exceptions,⁵ approximate to perfect voltage sources and aspire to zero output impedance across the audio band. The amplifier output is

essentially unaffected by loading, so that the frequency-variable impedance of loudspeakers does not give an equally variable frequency response.

While a true zero impedance is impossible with simple negative feedback, a very close approximation is possible if even modest feedback factors are used. A judicious mixture of voltage and current feedback can make the output impedance zero, or even negative – in other words, heavier loading makes the output voltage *increase*. This is clever, but usually pointless, as you will see. Solid-state amplifiers are quite happy with lots of feedback, but it is usually impractical in valve designs.

The highest output impedances are found in valve equipment, where global feedback inclusive of the output transformer is low or non-existent; impedances around 0.5Ω are usual. Some idiosyncratic semiconductor designs also have high output resistances⁶ with 0.6Ω ; far too high.

Figure 1 shows a simplified amplifier plus output networks – Zobel network and output inductor – and simple representations of the speaker cable and load. The output impedance of a real solid-state amplifier is very low indeed if it has a reasonable amount of global negative feedback.

Using a 'blameless' Class-B amplifier with a complementary feedback pair output stage⁷ the negative feedback factor at 20kHz is 29dB as usual, increasing at 6dB/octave as frequency falls. Figure 2 shows the resulting output impedance of this 'blameless' design in its 'naked' state, ie measured at point B before the output inductor, by injecting a 10mA signal current into the output via a 600Ω resistance.

At low frequencies, the output impedance is approximately $9m\Omega$, corresponding to an 8Ω damping factor of 890. To put this into perspective, one metre of 32/0.2 equipment cable, i.e. 32 strands of 0.2mm diameter, has a resistance of $16.9m\Omega$. It is thus quite possible for the internal cabling resistance in an amplifier to equal or exceed the output impedance of the amplifier itself at low frequencies.

Output impedance rises at 6dB/octave above 3kHz, as global negative feedback reduces, reaching $36m\Omega$ at 20kHz. The 3kHz break frequency does not correspond with the amplifier dominant pole frequency, which is much lower, at around 10Hz.

More to output impedance than meets the eye

The closed-loop output impedance of an amplifier is determined by its open-loop output impedance and the negative feedback factor. The former is not simply the output impedance of the output stage, because it is driven from the voltage amplifier stage, giving a significant and frequency-variable source impedance at point A, Fig. 1.

For the standard emitter follower and complementary feedback pair stages I have considered before, *driven from a zero-impedance source*, the raw output impedance is in the region of 150 to $180m\Omega$ for both, if the emitter resistors R_e are my usual 0.1Ω . Increasing R_e to 0.22Ω increases the output impedance to 230 to $280m\Omega$, demonstrating that these resistors form the greater part of the output impedance.

Taking the average open-loop output impedance as $200m\Omega$, and the negative feedback factor at 20kHz as 29dB, or 28 times, you would expect the closed-loop output impedance to be $200/28$, ie $7m\Omega$. Since it is actually about $33m\Omega$ at this frequency, there is clearly more going on than simple theory suggests.

In a real amplifier the output stage is not driven from a zero impedance, but a high one that falls proportionally with frequency; for my 'blameless' Class-B design it falls from $3k\Omega$ at 1kHz to about 220Ω at 20kHz⁸. A 220Ω source impedance gives an open-loop output impedance of about 1Ω , which

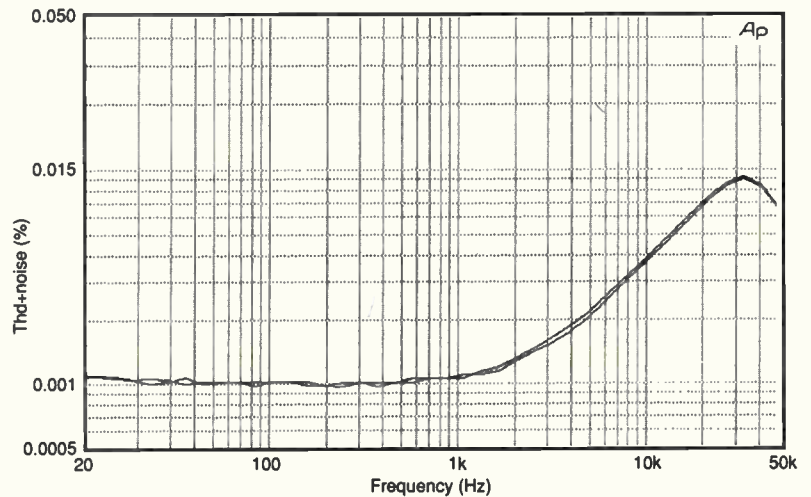


Fig. 4. With and without a very large output capacitor, the BHC Aerovox $100\,000\mu F/40V$ driving $40W$ into 8Ω . Capacitor distortion is eliminated.

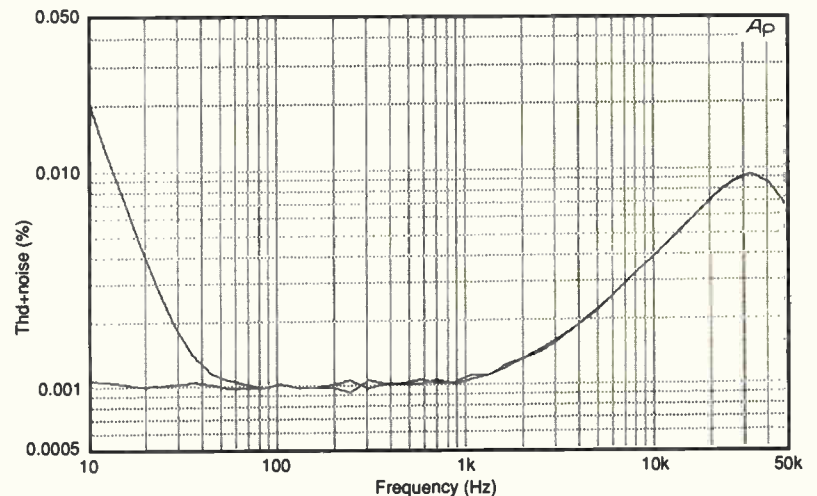


Fig. 5. Distortion with and without an 'audiophile' Cerafine $4700\mu F/63V$ capacitor. Midband distortion is eliminated but the low-frequency rise is much the same as with the standard electrolytic.

divided by 28 gives $35m\Omega$ – very close to the measured value.

Fortunately, all these measured closed-loop values are so low compared with other impedances in the amplifier-cable-speaker system that they can be ignored. There seems little point in deeper investigation at this stage.

In practice, my 'blameless' design has an output inductor of $6\mu H$. This is at the high end of the permissible range of inductance, the aim being absolutely ensured stability into capacitive loads.

My version has 20 turns of 1.5mm diameter copper wire, with a dc resistance of $19m\Omega$. This is a heavyweight component, designed to minimise resistive losses into a 4Ω load, but even so its extra resistance pushes the flat part of the impedance curve up to $24m\Omega$, so inductor resistance dominates the low-frequency output impedance as measured at the amplifier terminals, point C.

Damping factor is abruptly reduced from 890 to 330. If low output impedance is a priority, the coil wire must be as thick as cost/quality trade-offs allow. Naturally the coil inductance makes the rising portion of the impedance curve higher. The

output impedance now rises from 700Hz, still at 6dB/octave, and reaches 0.6Ω at 20kHz.

Since it is clear that the output networks of an amplifier have important effects on its output impedance, their role and component values are worth a look.

The role of the output capacitor

AC-coupled amplifiers have the advantage that there are no dc-offset problems, yet they remain unfashionable. The output capacitor used to be condemned for reducing the low-frequency damping factor, but as explained above, this is actually the least of our worries.

Large output electrolytics have significant equivalent series resistance, or esr, and some series inductance. For typical amplifier-output sizes esr will be of the order of 100mΩ; this is probably why ac-coupled amplifiers rarely had output inductors, as it is enough resistance to provide isolation from capacitive loading, as discussed later.

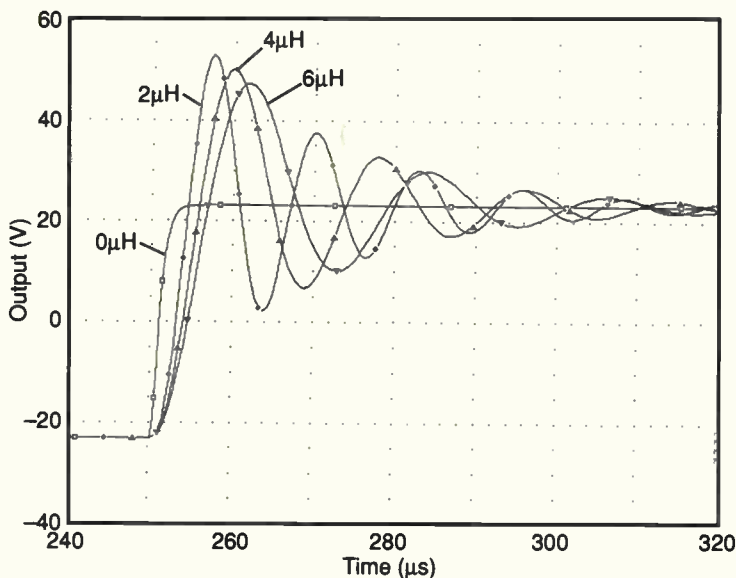


Fig. 6. The output inductor value has little effect on ringing amplitude.

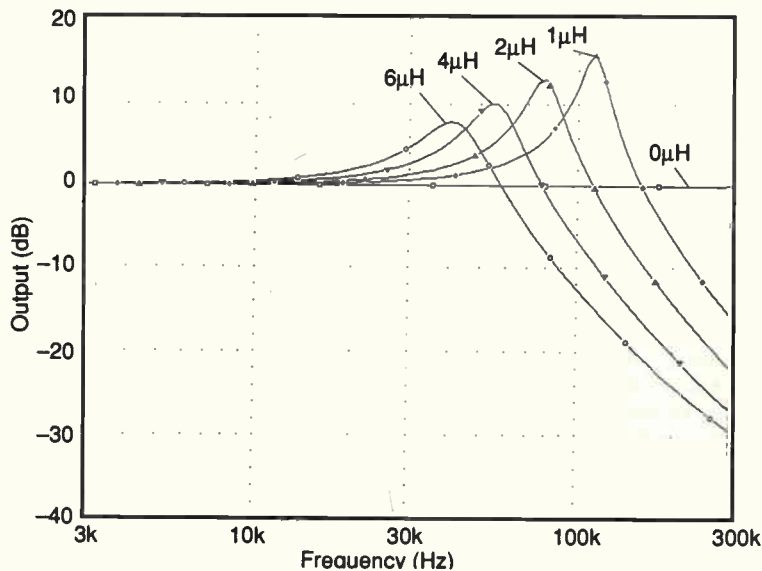


Fig. 7. Effect of output inductor value on frequency response. Higher values cause more invasion of the audio band.

The series inductance is very low and probably irrelevant, being quoted by one manufacturer as "...a few tens of nanohenries". Capacitor esr alone is enough to reduce the damping factor to 80.

A more serious problem with amplifier output capacitors is the distortion they cause. Like other forms of capacitor distortion, this seems to be something people just don't like to talk about.

Output capacitor distortion is a serious problem; it is not confined to low frequencies, as is the case in small-signal circuitry. For a 6800μF/100V output capacitor driving 40W into 8Ω, there is 0.0025% mid-band third-harmonic distortion, as in Fig. 3. This is five times more than the amplifier generates in this frequency range.

The harmonic distortion rise at the low-frequency end is much steeper than for small-signal capacitor distortion, for reasons that are not yet clear. A load of 4Ω doubles the distortion at a given frequency.

I know only two cures for this problem. The head-down no-messing approach uses a huge output capacitor, far larger than required for a good low frequency response. A 100mF/40V *Aerovox* from BHC gave Fig. 4. Alternatively, an allegedly 'audiophile' capacitor gives some interesting results; a *Cerafine Supercap* of only moderate size, at 4700μF/63V, gave Fig. 5, where the midband distortion is gone, but the low-frequency rise remains.

What special audio properties this component is supposed to have is unknown; electrolytics are never advertised as 'low midband thd', but that seems to be true here. The case volume is about twice as great as conventional electrolytics of the same value, so the difference may be a thicker dielectric film than normally used for this voltage rating.

Either of these special capacitors is more expensive than the rest of the amplifier electronics put together. A dc-coupled amplifier with protective output relay looks like the more economical option.

The Zobel network

Almost all power amplifiers have a Zobel network in their arrangements for stability. This simple but enigmatic network comprises a resistor and capacitor in series from the amplifier output rail to ground, on the amplifier side of the output inductor.

The resistor is usually 10Ω, and the capacitor almost invariably 100nF. These convenient values and their constancy in differing amplifier designs suggests they are not critical, but not so; my experiments suggest that the traditional values really are optimal for stability.

The function of the Zobel network – also called a Boucherot cell – is rarely discussed, but it is sometimes said to prevent an excessively inductive reactance being presented to the amplifier output by a loudspeaker voice-coil. The implication here is that this could cause high-frequency instability.

It is intuitively easy to see why a capacitive load on an amplifier with a finite output resistance might cause global hf instability by introducing extra lagging phase-shift into the global negative feedback loop. But it is less clear why an inductive load should be a problem; if a capacitive load reduces stability margins, surely an inductive load would increase them.

Some experiments were clearly necessary. I removed the standard 10Ω+0.1μF Zobel from a 'blameless' Class-B amplifier with my usual negative feedback factor of 29dB at 20kHz. This amplifier had a complementary feedback pair output.

With an 8Ω resistive load, the thd performance and stabil-

ity were unchanged. However, a 0.47mH inductor in series with 8Ω, roughly simulating a loudspeaker unit, provoked what appeared to be local vhf instability in the output stage. There was definitely no Nyquist instability of the global negative feedback loop, and no evidence that an inductive load presented difficulties in the audio band.

Increasing the Zobel resistance from 10 to 22Ω gave some evidence of stability problems, and I had to conclude that the standard values are just about right. Note that the Zobel network is at much too high an impedance to have any shunting effect on the amplifier output impedance.

A few designs have a second Zobel network after the output inductor; the thinking behind this is obscure. Reference 9 shows that a second Zobel network can be useful – if it is assumed that cable capacitance is at least 50nF. Since 500pF is a more usual value, the relevance of this is unclear.

The output inductor

The function of an output inductor is to prevent instability when a capacitive load is connected. It does this by isolating the amplifier from the shunt capacitance without causing significant losses at audio frequencies.

Low-value resistors have been used instead, but their efficiency is questionable, and they seriously degrade damping factor. Direct connection is only safe for simple amplifiers with very low feedback factors.

The resistance of even thick inductor wire causes an apparently disastrous collapse in the damping factor from 890 to 330. As such, this is unimportant. The worst effect of resistance is probably unwanted response irregularities due to speaker impedance variations with frequency.

An output inductor must be air-cored to eliminate the possibility of distortion due to magnetic saturation. Ferrite vhf chokes give stability, but their linearity must be regarded as dubious. In the seventies, there was a fashion for using one of the big power-supply electrolytics as a coil-former; this is not a good idea. The magnetic characteristics of the capacitor are unknown, and its lifetime will be reduced by heat dissipated in the coil resistance.

Usually, the output inductor has a value of between 1 and 7μH, the upper limit being set by the need to avoid significant roll-off at 20kHz into a 4Ω load. Great caution is required when designing an amplifier for home construction, and so when I designed the Class-B 'blameless' amplifier,¹⁰ the inductor value was set near the upper limit at 6μH to ensure stability. If 2Ω loads are contemplated this upper limit must be halved.

What is the least inductance needed?

Further investigations into the minimum inductance required for stability showed that a 'blameless' amplifier without its inductor is still fairly immune to capacitance-induced oscillation. This is possibly because the level of global feedback is fairly modest at 29dB at 20kHz.

The capacitances tried in parallel with 8Ω were 100nF, 470nF, 1μF, and 2μF, and a fast square wave was used to test for ringing. A 100nF capacitor caused close to continuous oscillation, but there was only well-damped ringing on the amplifier output A for 470nF, 1μF, and 2μF.

With the 6μH inductor replaced there was complete amplifier stability in all cases. The 6μH inductor was then cut in half, giving 2.3μH and 10.1mΩ dc resistance; this was also stable for all capacitor values, but has not been tested with real speakers.

An alternative method of stabilisation is a series resistor instead of an inductor. Even with 100nF, a 0.1Ω wire-wound output resistor completely removed ringing on the amplifier

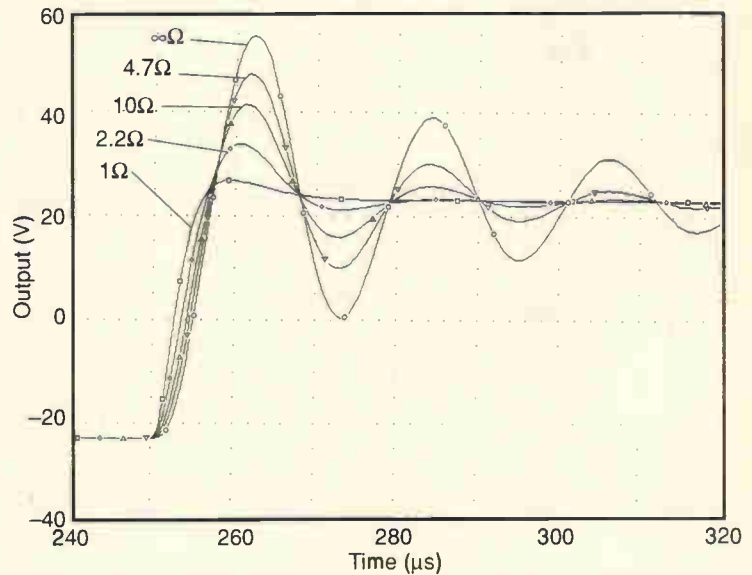


Fig. 8. Damping resistor value has a powerful effect on ringing; 2.2Ω reduces it greatly, and 1Ω prevents it completely.

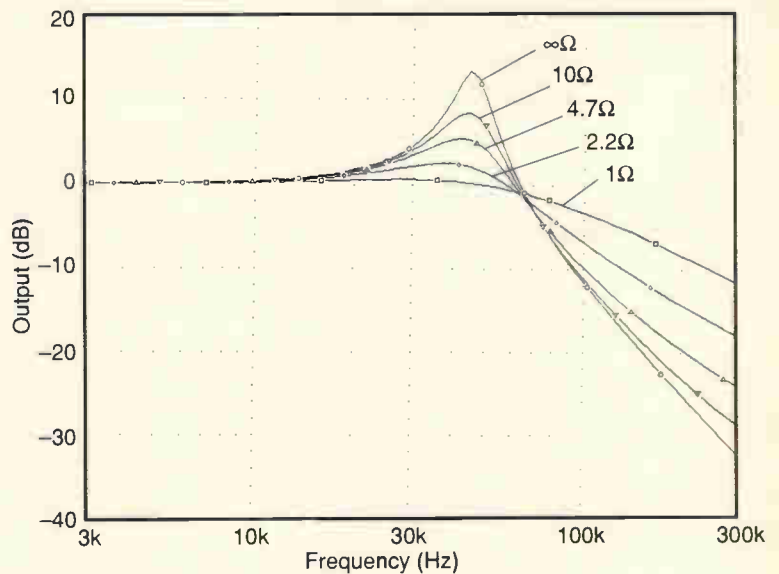


Fig. 9. The effect of damping resistor value on frequency response. Lower values damp the LC resonance better.

output. This is cheaper, but obviously less efficient than an inductor, as 100mΩ of extra resistance has been introduced instead of 10mΩ for our new 2.3μH inductor.

With 0.1Ω, the damping factor cannot exceed 80. A more important objection is that the 4Ω output power appears to be significantly reduced. An amplifier capable of driving 200W into 4Ω is reduced to a 190W unit. This doesn't look so good in the specifications – even though the reduction in perceived loudness is negligible.

The output inductor is only actually wanted for its isolating qualities, but it has at least two other effects. It adds to the cable inductance and the combination causes a high-frequency roll-off when driving an 8Ω load. Secondly, it introduces major confusion into testing with capacitive loads, as described next.

Effects of load characteristics

Amplifier transient response is usually tested with a square-wave. The output is loaded with 8Ω and 2μF in parallel to roughly simulate an electrostatic loudspeaker, as this is often

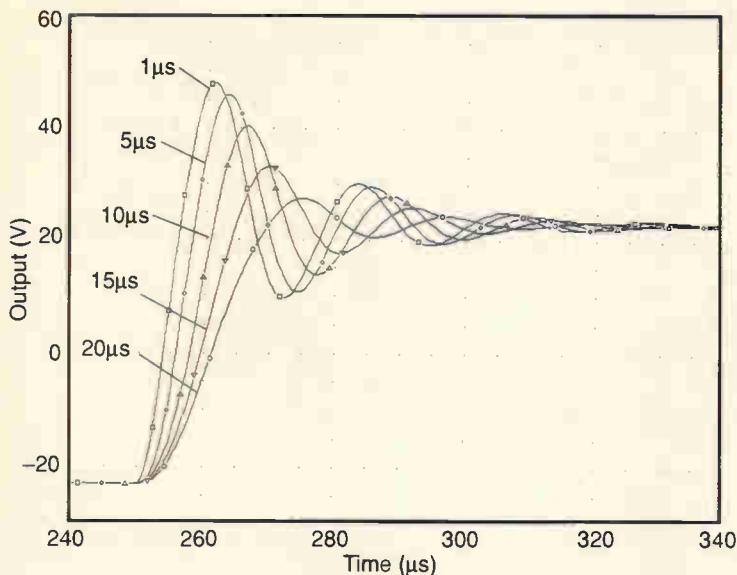


Fig. 10. Test-signal rise time has more effect on ringing than any other parameter. Varied here from 1 to 20 μ s.

regarded as the most demanding condition.

When there is an inductor in the amplifier output, and significant capacitance in the load, they resonate together. This produces a peak in the frequency response at hf, together with overshoot and ringing on fast edges. It is usual to put a low-value damping resistor across the inductor; this reduces the Q of the output LC combination on capacitive loading, and thus reduces overshoot and ringing.

The damped ringing that is seen during these capacitive loading tests is visible at point C but absent at A and B. It is due to the output inductor resonating with the test load capacitance, and has nothing whatever to do with amplifier stability; this test does not really examine amplifier response at all. The ringing is usually around 40kHz or so, and this is much too slow to be blamed on any normally compensated amplifier.

If a power amplifier is provoked by shorting out the output inductor and applying a capacitive load, the oscillation is normally around 100-500kHz, which is destructive of output transistors if it persists. It is nothing like the neat ringing seen in typical capacitive load tests. In the power amplifier itself there is no such thing as 'nicely-damped' ringing; damped oscillation at 500kHz means you are one shaved inch from disaster.

A 'blameless' amplifier is rather resistant to capacitance-induced oscillation. Paralleled with 100 nF directly across the output, a resistance of 8 Ω induced damped ringing at 420kHz, while 470nF gave ringing at 300kHz, and 2 μ F at 125kHz.

The 8 Ω /2 μ F test reveals nothing about amplifier transient response, but it is embedded in tradition, and it is too optimistic to expect its doubtful nature to be universally recognised. Several factors affect output ringing, and can be manipulated to tidy up overshoot and avoid deterring potential customers:

Output inductance. Increasing the inductance with all other components held constant reduces the overshoot, Fig. 6, and the amount of response peaking, but the peak moves downward in frequency so the rising response begins to invade the audio band, Fig. 7.

The damping resistor across the output coil. Reducing it to below 10 Ω lowers the Q of the output LC circuit, reducing overshoot and ringing. It may be wire-wound without self-inductance problems.

Adding a 10 Ω damping resistor reduces overshoot from 58% to 48%, and greatly reduces ringing, Fig. 8. Response peaking is reduced, with only a slight effect on its frequency, Fig. 9. The damping resistor can be reduced to well below 10 Ω , if stability remains dependable. This can cut transient overshoot further to 20%, and eliminate ringing altogether.

Load capacitance. Increasing this with the shunt load resistor held at 8 Ω gives more overshoot and lower frequency ringing that decays more slowly. Response peaking is both sharper and lower in frequency, which is not a good combination. However, the capacitance is part of the standard test load and outside the designer's control, so it is not considered further.

Rise time. It is a commonplace that in audio technology, the real truth is quite different from the conventional wisdom. In fact, by far the most important factor affecting overshoot and ringing is the rise-time of the applied square wave. Figure 10 demonstrates how the overshoot given by the circuit of Fig. 1 is 51% for a 1 μ s rise-time, but only 12% for a 20 μ s rise-time.

The 'transient response' apparently being measured depends critically on the details of the test gear and amplifier slew-rate, and can be cynically manipulated to give the result you want.

Minimising output impedance

Leaving aside specmanship, it is worthwhile minimising output impedance, not because it optimises speaker dynamics, but because it minimises frequency response variations due to varying speaker impedance.

The naked amplifier output impedance will be less than the inductor resistance. To minimise the latter, first determine how low the output inductance can be for stability with capacitive loads. Lower inductance means fewer turns and less wire. However, the inductance of the usual single-layer coil varies with the square of the number of turns. Halving inductance only reduces turns, and hence series resistance, by root-two.

It will also be desirable to minimise the resistance of the amplifier internal wiring, and carefully consider any extra resistance introduced by output relays and loudspeaker switching. ■

References

1. Dickason, V, 'The Loudspeaker Design Cookbook,' 5th edn, 1995, p. 122. Distributed by Old Colony Sound Lab. (Thiele on crossover inductor DC resistance).
2. Thiele, N, personal communication, April 1997.
3. Moir, J, 'Transients and Loudspeaker Damping' *Wireless World*, May 1950, p166.
4. Colloms, M, 'Loudspeaker and Headphone Handbook,' ed John Borwick. Focal Press (Butterworth-Heinemann) Pub 1994. ISBN 0-240-51371-1. p. 230.
5. Mills, A, 'Distortion Reduction in Moving-Coil Hawksford Loudspeaker Systems Using Current-Drive Technology,' *JAES* March 1989, p. 129.
6. Olsner, D, 'Times One RFS400 Power Amplifier Review,' *Stereophile*, Aug 1995, p. 187. (0.6 Ω output resistance).
7. Self, D, 'Distortion In Power Amplifiers,' Part 7, *Electronics World* Feb 1994, p. 137. (Blameless Class-B amplifier)
8. Self, D, 'Audio Power Amplifier Design Handbook,' Newnes 1996, p. 127, ISBN 0-7506-2788-3.
9. Brown, I, 'Between Amplifier and Speaker' *Electronics World*, Feb 1995, p. 114.
10. Self, D, as ref. 7 but p. 139.

Surplus always wanted for cash!

THE ORIGINAL SURPLUS WONDERLAND!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

Surplus always wanted for cash!

LOW COST PC's -

SPECIAL BUY 'AT 286'

40Mb HD + 3Mb Ram



LIMITED QUANTITY only of these 12MHz HI GRADE 286 systems Made in the USA to an industrial specification, the system was designed for total reliability. The compact case houses the motherboard, PSU and EGA video card with single 5 1/4" 1.2 Mb floppy disk drive & integral 40Mb hard disk drive to the front. Real time clock with battery backup is provided as standard. Supplied in good used condition complete with enhanced keyboard, 640K + 2Mb RAM, DOS 4.01 and 90 DAY Full Guarantee. Ready to Run!
Order as HIGRADE 286 **ONLY £129.00 (E)**

Optional Fitted extras: VGA graphics card	£29.00
1.4Mb 3 1/2" floppy disk drive (instead of 1.2 Mb)	£19.95
Wordperfect 6.0 for Dos - when 3 1/2" FDD option ordered	£22.50
NE2000 Ethernet (thick, thin or twisted) network card	£29.00

LOW COST 486DX-33 SYSTEM

Limited quantity of this 2nd year, superb small size desktop unit. Fully featured with standard simm connectors 30 x 72 pin supplied with keyboard, 4 Mb of RAM, SVGA monitor output, 256k cache and integral 120 Mb IDE drive with single 1.44 Mb 3.5" floppy disk drive. Fully tested and guaranteed. Fully expandable only
Many other options available - call for details. **£399.00 (E)**

FLOPPY DISK DRIVES 3 1/2" - 8"

5 1/4" or 3 1/2" from only £18.95!

Massive purchases of standard 5 1/4" and 3 1/2" drives enables us to present prime product at industry beating low prices! 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 90 day guarantee and operate from standard voltages and are of standard size. All are IBM-PC compatible (if 3 1/2" supported on your PC).

3 1/2" Panasonic JU363/4 720K or equivalent RFE	£24.95 (B)
3 1/2" Mitsubishi MF355C-1.4 Meg. Laptops only	£25.95 (B)
3 1/2" Mitsubishi MF355C-D. 1.4 Meg. Non laptop	£18.95 (B)
5 1/4" Teac FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95 (B)
5 1/4" Teac FD-55F-03 U 720K 4080 (for BBC's etc) RFE	£29.95 (B)
5 1/4" BRAND NEW Mitsubishi MF501B 360K	£22.95 (B)
Table top case with integral PSU for HH 5 1/4" Flopp or HD	£29.95 (B)
8" Shugart 800/801 8" SS refurbished & tested	£195.00 (E)
8" Shugart 810 8" SS HH Brand New	£195.00 (E)
8" Shugart 851 8" double sided refurbished & tested	£250.00 (E)
Mitsubishi M2894-63 8" double sided NEW	£275.00 (E)
Mitsubishi M2896-63-02U 8" DS simline NEW	£285.00 (E)
Dual 8" cased drives with integral power supply 2 Mb	£499.00 (E)

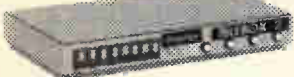
HARD DISK DRIVES

End of line purchase scoop! Brand new NEC D2246 8" 85 Mbyte drive with industry standard SMD Interface, replaces Fujitsu equivalent model. Full manual. Only £299.00 or 2 for £525.00 (E)

3 1/2" FUJII FK-309-26 20mb MFM I/F RFE	£59.95 (C)
3 1/2" CONNER CP3024 20 mb IDE I/F (or equiv) RFE	£59.95 (C)
3 1/2" CONNER CP3044 40mb IDE I/F (or equiv) RFE	£69.00 (C)
3 1/2" RODIME R03057S 45mb SCSI I/F (Mac & Acorn)	£185.00 (C)
3 1/2" WESTERN DIGITAL 850mb IDE I/F Brand New	£185.00 (C)
5 1/4" MINISCRIIBE 3425 20mb MFM I/F (or equiv.) RFE	£49.95 (C)
5 1/4" SEAGATE ST-238R 30 mb RLL I/F Refurb	£69.95 (C)
5 1/4" CDC 94205-51 40mb HH MFM I/F RFE tested	£89.00 (C)
5 1/4" HP 9745B 850 Mb SCSI RFE tested	£195.00 (C)
5 1/4" HP C3010 2 Gbyte SCSI differential RFE tested	£195.00 (C)
8" FUJITSU M2322K 160Mb SMD I/F RFE tested	£195.00 (E)
Hard disc controllers for MFM, IDE, SCSI, RLL etc from	£16.95

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 made by makers such as MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD etc. 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. A composite video output is located on the rear panel for direct connection to most makes of monitor or desktop computer video systems. 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.

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 + 2 sound specification.
*For cable / hyperband reception TELEBOX MB should be connected to a cable type service. Shipping code on all Teleboxes is (B)

DC POWER SUPPLIES

Virtually every type of power supply you can imagine. Over 10,000 Power Supplies Ex Stock
Call for info / list.

IC's - TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK

6,000,000 items EX STOCK

For MAJOR SAVINGS - CALL FOR SEMICONDUCTOR HOTLIST

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, tilt switching and LOW RADIATION MPR specification. Fully guaranteed, supplied in EXCEL-

LENT little used condition.
Tilt & Swivel Base £A75
VGA cable for IBM PC included.
External cables for other types of computers CALL.
Only £119 (E) Order as MITS-SVGA

As New - Used on film set for 1 week only!!
15" 0.28 SVGA 1024 x 768 res. colour monitors.
Swivel & tilt etc. Full 90 day guarantee. £145.00 (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 both RGB and standard composite 15.625 KHz video inputs via SCART socket and separate phono jacks. Integral audio power amp and speaker for all audio visual uses. Will connect direct to Amiga and Atari BBC computers. Ideal for all video monitoring / security applications with direct connection to most colour cameras. High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested & guaranteed
Dimensions: W14" x H12 3/4" x 15 1/4" D.
Only £95 (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 bums). In attractive square black plastic case measuring W10" x H10" x 13 1/4" 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 13 1/2" 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)

SPECIAL INTEREST ITEMS

MIT'S FA3445ETKL 14" Industrial spec SVGA monitors 2Kw to 400 kW - 400 Hz 3 phase power sources - ex stock	£245
IBM 8230 Type 1, Token ring base unit driver	£950
IBM 53F501 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
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & HP3782A Error Detector	£POA
HP APOLLO RX700 system units	£950
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP3081A Industrial workstation cw Barcode swipe reader	£175
HP6264A Rack mount variable 0-20V @ 20A metered PSU	£675
HP54121A DC to 22 GHz 4hr channel test set	£POA
EG+G Brookdeal 95035C Precision lock in amp	£1850
View-Brook 1200 computerised inspection system	£650
Ling Dynamics 2kW programmable vibration test system	£POA
Computer controlled 1056 x 560 mm X Y table & controller	£1425
Keithley 590 CV capacitor / voltage analyser	£POA
Racal ICR40 dual 40 channel voice recorder system	£3750
Fiskers 45KVA 3 ph On Line UPS - New batts Dec.1995	£9500
ICI R5030UV34 Cleanline ultrasonic cleaning system	£POA
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£1200
Zeta 3220-05 A0 4 pen HPGL fast drum plotters	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
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 band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 2998 Infrared spectrophotometer	£POA
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3750
Andrews LARGE 3.1 m Satellite Dish + mount (For Voyager)	£950
Seikon SD 150H 18 channel digital Hybrid chart recorder	£750
TAYLOR HOBSON Tallysurf amplifier / recorder	£485
System Video 1152 PAL waveform monitor	£485
Test Lab - 2 mtr square quietised acoustic test cabinets	£300
Kenwood 9601 PAL Vectorscope - NEW	£650

Please call for further details on the above items



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: 77 1/2" H x 32 1/2" D x 22" W. Order as:

OPT Rack 1 Complete with removable side panels	£335.00 (G)
OPT Rack 2 Rack, Less side panels	£225.00 (G)

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 louvers. 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 23 3/4" W)
Sold at LESS than a third of makers price !!



A superb buy at only £195.00 (G)

Over 1000 racks - 19" 22" & 24" wide
3 to 44 U high. Available from stock !!
Call with your requirements.

TOUCH SCREEN SYSTEM

The ultimate in 'Touch Screen Technology' made by the experts - MicroTouch - but sold at a price below cost!! System consists of a flat translucent glass laminated panel measuring 29.5 x 23.5 cm connected to an electronic controller PCB. The controller produces a standard serial RS232 or TTL output which continuously gives simple serial data containing positional X & Y co-ordinates as to where a finger is touching the panel - as the finger moves, the data instantly changes. The X & Y information is given at an incredible matrix resolution of 1024 x 1024 positions over the entire screen size !! A host of available translation software enables direct connection to a PC for a myriad of applications including: control panels, pointing devices, POS systems, controllers for the disabled or computer un-trained etc. Imagine using your finger with 'Windows', instead of a mouse !! (A driver is indeed available!) The applications for this amazing product are only limited by your imagination!! Complete system including Controller, Power Supply and Data supplied at an incredible price of only: £145.00 (B)
Full MICROTOUCH software support pack and manuals for IBM compatible PC's £29.95 RFE - Tested

LOW COST RAM & CPU'S

INTEL 'ABOVE' Memory Expansion Board. Full length PC-XT and PC-AT compatible card with 2 Mbytes of memory on board. Card is fully selectable for Expanded or Extended (286 processor and above) memory. Full data and driver disks supplied. RFE. Fully tested and guaranteed. Windows compatible. £59.95 (A1)
Half length 8 bit memory upgrade cards for PC AT XT expands memory either 256k or 512k in 64k steps. May also be used to fill in RAM above 640k DOS limit. Complete with data.
Order as: XT RAM UG. 256k. £34.95 or 512k £39.95 (A1)
SIMM SPECIALS
1 MB x 9 SIMM 9 chip 120ns Only £16.50 (A1)
1 MB x 9 SIMM 3 chip 80 ns £19.50 or 70ns £22.95 (A1)
1 MB x 9 SIMM 9 chip 80 ns £21.50 or 70ns £23.75 (A1)
4 MB 70 ns 72 pin SIMM -with parity- Only £95.00 (A1)
INTEL 486-DX3 CPU £55.00 INTEL 486-DX6 CPU £69.00 (A1)
FULL RANGE OF CO-PROCESSOR'S EX STOCK - CALL FOR LIST

FANS & BLOWERS

EPSON DQ412 40x40x20 mm 12v DC	£7.95 / £65
PAPST TYPE 612 60x60x25 mm 12v DC	£8.95 / £75
MITSUBISHI MMF-061 120L 60x60x25 mm 12v DC	£4.95 / £42
MITSUBISHI MMF-081 120M 80x80x25 mm 12v DC	£5.25 / £49
MITSUBISHI MMF-09B1 20H 92x92x25 mm 12v DC	£5.95 / £53
PANACEA 12-3.5 92x92x18 mm 12v DC	£7.95 / £69
EX-EQUIP AC fans. ALL TESTED 120 x 120 x 38 mm specify 110 or 240 v. £6.95. 80 x 80 x 38 mm. specify 110 or 240 v. £5.95	
IMHOF B26 1900 rack mnt 3U x 19" Blower 110/240v NEW	£79.95

Shipping on all fans (A). Blowers (B). 50,000 Fans Ex Stock CALL

Issue 13 of Display News now available - send large SAE - PACKED with bargains!

display
-ELECTRONICS-

ALL MAIL & OFFICES
Open Mon-Fri 9.00-5.30
Dept WW. 32 Biggin Way
Upper Norwood
LONDON SE19 3XF

LONDON SHOP
Open Mon - Sat 9.00 - 5.30
215 Whitehorse Lane
South Norwood
On 68A Bue Road
N. Thornton Heath &
Selhurst Park S.R. Rail Stations

NEW DISTEL ©
The Original
FREE On line Database
Info on 20,000+ stock items!
RETURNING SOON!

ALL ENQUIRIES
0181 679 4414
FAX 0181 679 1927

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. Carnage charges (A)=£3.00, (A1)=£4.00, (B)=£5.50, (C)=£8.50, (D)=£12.00, (E)=£15.00, (F)=£18.00, (G)=CALL. Allow approx 6 days for shipping - faster CALL. Scotland surcharge 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 etc acknowledged. © Display Electronics 1996. E & O. 06/6

CIRCLE NO. 113 ON REPLY CARD

COMPUTER IC'S

TMS 9900L-40 PULLS	£20 ea
S9000 NEW AMD EQUIVALENT	£30 ea
MC6802 PROCESSOR	£2 ea
HD68HC000PB	£5
PR271 BBC DISC CONTROLLER CHIP EX EQPT	£25
2817A-20 (2K X 8) EPROM ex eqpt	£2
D41256C-15 256K X 1 PULLS	9 FOR £5
8748 used/wiped	£4
MK48202-20 ZERO POWER RAM EQUIV 6116LP	£4
USED 4164-15	£6p
BBC VIDEO ULA	£10
8051 MICRO	£1.25
FLOPPY DISC CONTROLLER CHIPS 1771	£16
FLOPPY DISC CONTROLLER CHIPS 1772	£17.50
27C4001 USED EPROMS	£4
27C2001 USED EPROMS	£2.50
1702 EPROM NEW	£6
2114 EX EQPT .50p	4416 EX EQPT .70p
6264-15 8k STATIC RAM	£1.50
Z80A SIO-O	£1.25
7126 3 1/2 DIGIT LCD DRIVER CHIP	£2 ea
2816A-30 HOUSE MARKED	£2
USED TMS2532JL	£2.50
2708 USED	£2
HME167LP-8	£5p
8255-5	£1.40
2114 CMOS (RCA 5114)	£1.60
WD16C50-PC UART	£5
ZN448J	£11
TC55257BPL-85L 32K x 8RAM	£2.50
27C256-25 USED/WIPED	£1.30

REGULATORS

LM338K	£6
LM323K 5V 3A PLASTIC	£3
LM323K 5V 3A METAL	£3
LM350K (VARIABLE 3A)	£3
78H12AS 12V 5A	£5
LM317H T05 CAN	£1
LM317T PLASTIC TO220 variable	£2.20
LM317 METAL	£1.20
7812 METAL 12V 1A	£1
7805/12/15/24	30p
7905/12/15/24	30p
CA3085 TO99 variable reg	2/E1
78HGASC + 79HGASC REGULATORS	£30 ea
LM123 ST93 5V 3A TO3 REGS	£3 ea
UC3524AN SWITCHING REGULATOR IC	60p
78L12 SHORT LEADS	10/E1
LM2950ACZ.0	50p
STR451 SANKEN switch mode regulator	£10
78S05/78S24 2 amp TO-220	£1
78L05	5/E1

CRYSTAL OSCILLATORS

307 2KHZ 1M000000 1M8432 2M457600 3M6864 4M000000	
5M000000 5M06800 5M760000 6M000000 6M1440 7M000000	
3M372800 7M5 8M000000 9M21610M000 10M0 12M000000	
14M318 14M3818 16M00 17M625600 18M00000 18M432 19M050	
19M2 19M440 20M000 20M0150 21M676 22M1184 23M587	
24M0000 25M1748 25M175 25M1889 27M + 36M 27M00000	
28M322 32M000000 32M0000 'S/MOUNT 33M3330 35M4816	
38M100 40M000 41M559 42M000000 44M444 44M900 44M0	
48M00000 50M00 55M000 56M00020 64M000000 66M667 76M1	
80M0 84M0	£1.50 ea

CRYSTALS

32K768 1MHz 1M8432 2M000 2M1432 2M304 2M4576 3M000	
3M2768 3M400 3M579545 3M58564 3M600 3M6864 3M93216	
4M000 4M190 4M194304 4M2056 4M33614 4M608 4M9152 5M000	
5M0688 6M000 6M041952 6M200 6M400 7M37280 8M000 8M06400	
8M448 8M863256 8M8670 9M3750 9M8304 10M240 10M245	
10M368 10M70000 11M000 11M0052 11M98135 12M000 12M5	
13M000 13M270 13M875000 14M000 14M318 14M7450 14M7456	
15M0000 16M000 17M6250 18M432 20M000 21M300	
21M400M15A 24M000 25M000 26M995 28 27M045 RD 27M095 OR	
27M145 BL 27M145 YW 27M195 GN 28M4696 30M4696 31M4696	
31M4696 34M368 36M75625 36M76875 36M78125 36M79375	
36M80625 36M81875 36M83125 36M84375 38M900 48M000	
51M05833 54M1916 55M500 57M7416 57M7583 69M545 69M550	
96M000 111M800 114M8	£1 ea

TRANSISTORS

MPSA42	10/E1
MPSA92	10/E1
2N2907A	10/E1
BC477, BC488	10/E1
BC107 BCY70 PREFORMED LEADS	
full spec	£1 £4/100 £30/1000
BC238C, BC308B	£1/30 £3.50/100
2N2907 PLASTIC CROPPED	£1/15 £4/100
BC548B SHORT LEADS	£3/100 £20/1000

POWER TRANSISTORS

OC29	£2 ea
2SC1520 sim BF259	3/E1 100/E22
TIP 112/42B	2/E1
TIP 140F	£1
IRF620 TO-220 5A 200V MOSFET	2/E1
SE9301 100V 10A DARL SIM TIP121	2/E1
BD680	4/E1
BUS48AP	£2
BUW13A	£2
2SC156 900V 6A 120W	£3
2SD1397 npn TV/MONITOR O/P TRANSISTOR	£2

TEXTPOOL ZIF SOCKETS

28 PIN USED	£3
ZIF 64 WAY SHRINK DIP SKT TEXTPOOL 264-1300-00 1.78mm	
SPACING ON PCB WITH 4MHz RESONATOR	£10
SINGLE IN LINE 32 WAY CAN BE GANGED FOR USE WITH ANY DUAL IN LINE DEVICES . . . COUPLING SUPPLIED . . .	2/E1.50

KEYTRONICS

TEL. 01279-505543
FAX. 01279-757656

e-mail keytronics@btinternet.com
PO BOX 634
BISHOPS STORTFORD
HERTFORDSHIRE CM23 2RX
http://www.btinternet.com/~keytronics

POWER FETS

IXFH75N10 75A 200V 20 Milli-ohm 200 WATT ideal for UPS	£5
IRFP450 500V 14A 0.4ohm 180 W	£2

SOLID STATE RELAYS

zero volts switching. Control volts 3.5V to 26V DC	
50AMP 240V ac D2450-10	£15
80AMP 240V ac D240D80-10sp	£20
25AMP 240V ac	£10

MISCELLANEOUS

AAA NiMH'S HI CAPACITY 240mA/HR 3 CELL PACK	£3
XENON STROBE TUBE	£1.60
OPTO IC'S also available TLP555 TLP666GF	
68 way PLCC SKT 100 available	£1 each
100 way PLCC SKT 100 available	£1.50 each
1250pF POSTAGE STAMP COMPRESSION TRIMMER	£1
LM324 (Quad 741)	4/E1
MINIATURE FERRITE MAGNETS 4x4x3mm	10/E1
TL071 LO NOISE OP AMP	5 for £1
TL081 OP AMP	4 for £1
12 way diol sw	£3 for £1
10NF 63V X7R PHILIPS SURFACE MOUNT 100K available	
SWITCHED MODE PSU 40 WATT UNCASED QTY. AVAILABLE +5V 5A, +12V 2A, 12V 500mA FLOATING	£30/4000 £9.95 (£2)

CMOS 555 TIMERS

2/3 AAA LITHIUM cells as used in compact cameras	2/E1.50
PASSIVE INFRA RED SENSOR CHIP + MIRROR + CIRCUIT	£2 ea
EUROCARD 96-WAY EXTENDER BOARD	£10 ea
290 x 100mm	
DIN 41612 96-WAY A/B/C SOCKET PCB RIGHT ANGLE	£1.30
DIN 41612 96-WAY A/B/C SOCKET WIRE WRAP PINS	£1.30
DIN 41612 64-WAY A/C SOCKET WIRE WRAP PINS	£1
DIN 41612 64-WAY A/C PLUG PCB RIGHT ANGLE	£1
DIN 41612 64-WAY AB SOCKET WIREWRAP (2-ROW BODY)	£1
BT PLUG + LEAD	3/E1
MIN. TOGGLE SWITCH 1 POLE c/o PCB type	5/E1
LCD MODULE sim. LM018 but needs 150 to 250V AC for display	
40 x 2 characters 182 x 35 x 13mm	£10
6-32 UNC 5/16 POZI PAN SCREWS	£1/100
NUTS	£1.25/100
PUSH SWITCH CHANGEOVER	2/E1
RS232 SERIAL CABLE D25 WAY MALE CONNECTORS	
INMAC LIST PRICE	£5.90 ea (£1.30)

25 FEET LONG, 15 PINS WIRED BRAID + FOIL SCREENS	£30
AMERICAN 2/3 PIN CHASSIS SOCKET	2/E1
WIRE ENDED FUSES 0.25A	30/E1
NEW ULTRASONIC TRANSDUCERS 32kHz	£2/pr
SMALL CYLINDRICAL MAGNETS	3/E1
SMALL MICROWAVE DIODES AE1 OC1026A	
D.L. SWITCHES 10-WAY 1/8 W 80V 4/5/6-WAY	80p
180VOLT 1 WAY ZENERS also 12V & 7.5V	20/E1
MIN GLASS NEONS	10/E1

RELAY 5V 2-pole changeover looks like RS 355-741 marked STC	
47Wbost	£1 ea
MINIATURE CO-AX FREE PLUG RS 456-071	2/E1
MINIATURE CO-AX PCB SKT RS 456-093	2/E1
PCB WITH 2N2646 UNIJUNCTION WITH 12V 4-POLE RELAY	1/E1
400 MEGOHM THICK FILM RESISTORS	4/E1
STRAIN GAUGES 40 ohm Foil type polyester backed	
balco grid alloy	£1.50 ea 10+ 2/E1
ELECTRET MICROPHONE INSERT	2/E1
Linear Hall effect IC Micro Switch no 613 S54 sim RS 304-267	
£2.50 100+ £1.50	

1 pole 12-way rotary switch	4/E1
AUDIO ICS LM380 LM386	£1 ea
555 TIMERS £1 741 OP AMP	6/E1
ZN414 AM RADIO CHIP	80p
COAX PLUGS nickel ones	4/E1
COAX BACK TO BACK JOINERS	3/E1
INDUCTOR 20uH 1.5A	5/E1
1.25 inch PANEL FUSEHOLDERS	3/E1
12V 1.2W small w/e lamps fit most modern cars	14M/17
STEREO CASSETTE HEAD	50p
MONO CASS. HEAD £1 ERASE HEAD	£2
THERMAL CUT OUTS 50 77 85 120°C	£1 ea
THERMAL FUSES 220°C/121°C 240V 15A	5/E1
TRANSISTOR MOUNTING PADS TO-5/TO-18	£3/1000
TO-3 TRANSISTOR COVERS	10/E1
PCB PINS FIT 0.1 inch VERO	200/E1
TO-220 micas + bushes	10/50p 100/E2
TO-3 micas + bushes	15/E1
POTS SHORT SPINDLES 2K5 10K 25K 1M 2M5	4/E1
LM335Z 10MV/degree C	£1
LM234Z CONST. CURRENT I.C.	£1
BNC TO 4MM BINDING POST SIM RS 455-961	£1
MIN PCB POWER RELAYS 10.5v COIL 6A CONTACTS 1 pole c/o	£1

LCD MODULE 16 CHAR. X 1 LINE (SIMILAR TO HITACHI LM10)	£5
OP11264A 10kV OPTO ISOLATOR	£1.35 ea 100+ £1 ea
'LOVE STORY' CLOCKWORK MUSICAL BOX MECHANISM	£1
MADE BY SANKYO	£1 ea
Telephone cable clips with hardened pins	500/E2
10,000uF 16V PCB TYPE 30mm DIA x 31mm	2/E1
EC CHASSIS FUSED PLUG B-LEE L2728	3/E1
2A CERAMIC FUSE 1.25 inch QB	10/E1
46 WAY IDC RIBBON CABLE 100 FOOT REEL	£5 + CARR
20mm PCB FUSEHOLDER	5/E1
ASTEC MODULATOR VIDEO + SOUND UM1287	£2.25
BARGRAPH DISPLAY 8 RED LEDS	£1.50
NE567 PHASE LOCKED LOOP	2/E1
NE564	£1
TL084	4/E1
IR2432 SHARP 12 LED VU BAR GRAPH DRIVER	£1.25
10A CORCOM MAINS RFI FILTER EX. EQPT	£2 100 + £1.50
8 OHM MYLAR CONE LOUDSPEAKER 55mm DIA x 10mm DEEP	2/E1
AD592AN Temperature sensor TO-92 package with 1.5m lead	2/E1
DC FANS 12V 50, 62, 80, 92mm	£5 each

DIODES AND RECTIFIERS

A115M 3A 600V FAST RECOVERY DIODE	4/E1
1N5819 1A 60V SCHOTTKY wire ended	4 for £1
1N5407 3A 1000V	8/E1
1N4148	100/E1.50

SEND £1 STAMPS FOR CURRENT IC+ SEMI STOCK LIST -
ALSO AVAILABLE ON 3 1/2" INCH FLOPPY DISK

MAIL ORDER ONLY

MIN. CASH ORDER £10.00. OFFICIAL ORDERS WELCOME
UNIVERSITIES/COLLEGES/SCHOOLS/GOVT. DEPARTMENTS
MIN. ACCOUNT ORDER £10.00. P&P AS SHOWN IN BRACKETS (HEAVY ITEMS) OTHERWISE 95p

ADD 17 1/2% VAT TO TOTAL

ELECTRONIC COMPONENTS BOUGHT FOR CASH

1N4004 SD4 1A 300V	100/E3
1N5401 3A 100V	10/E1
BA481 SMALL GLASS SCHOTTKY diode	10 for £1
BA158 1A 400V fast recovery	100/E3
BY254 800V 3A	8/E1
BY255 1300V 3A	6/E1
6A 100V SIMILAR MR751	4/E1
1A 600V BRIDGE RECTIFIER	4/E1
4A 100V BRIDGE	3/E1
6A 100V BRIDGE	2/E1
10A 200V BRIDGE	£1.50
25A 200V BRIDGE £2	10/E18
25A 400V BRIDGE £2.50	10/E22
BY297	10/E1
KBPC304 BRIDGE REC 3A 400V	4/E1

SCRS

PULSE TRANSFORMERS 1.1 +1	£1.25
MEU21 PROG UNIJUNCTION	3/E1

TRIACS

2N6073 4A 400V	3 for £1 100/E22
NEC TRIAC AC08F 8A 600V TO220	5/E2 100/E30
TXAL225 8A 500V 5mA GATE	2/E1 100/E35
BTA 08-400 ISO TAB 400V 5mA GATE	90p
TRAL22300 30A 400V ISOLATED STUD	£5 ea
TRIAC 1A 800V TLR381T 16k AVAILABLE	5 FOR £1 £15/100

PHOTO DEVICES

HI BRIGHTNESS LEDS COX24 RED	5/E1
SLOTTED OPTO-SWITCH OPCOA OPB815	£1.30
2N5777	50p
TL181 PHOTO TRANSISTOR	£1
TL38 INFRA RED LED	5/E1
4N25, OP12252 OPTO ISOLATOR	50p
PHOTO DIODE 50P	6/E2
MEL12 (PHOTO DARLINGTON BASE n/c)	50p
LEDs RED 3 or 5mm 12/E1	100/E6
LEDs GREEN OR YELLOW 10/E1	100/E6
FLASHING RED LED 5mm 50p	100/E40
HIGH SPEED MEDIUM AREA PHOTODIODE RS651-995	£10 ea
OPTEK OPB745 REFLECTIVE OPTO SENSOR	£1.50
RED LED - CHROME BEZEL	3/E1
OP1108 HI VOLTAGE OPTO ISOLATOR	£1
MOC 3020 OPTO COUPLED TRIAC	2/E1
Narrow angle infra red emitter LED55C	2/E1 100/E35
PD410PH Sharp photo diode RS 195-619	2/E1 100/E35
TLP371 opto isolator	3/E1

STC NTC BEAD THERMISTORS

G22 220R, G13 1K, G23 2K, G24 20K, G54 50K, G25 200K, RES 20°C	
DIRECTLY HEATED TYPE	£1 ea
FS22WB NTC BEAD INSIDE END OF 1 inch GLASS PROBE RES	£1 ea
20°C 200R	£1 ea
A13 DIRECTLY HEATED BEAD THERMISTOR 1k res. ideal for audio Wien Bridge Oscillator.	£2 ea

CERMET MULTI TURN PRESETS 1/4 inch

10R 20R 100R 200R 250R 500R 2K 2K2 2K5 5K 10K 47K 50K	
100K 200K 500K 2M.	50p ea

IC SOCKETS

14/16/18/20/24/28/40-WAY DIL SKTS	£1 per TUBE
8-WAY DIL SKTS	£2 per TUBE
32-WAY TURNED PIN SKTS	3 for £1
SIMM SOCKET FOR 2 x 30-way SIMMS	£1

POLYESTER/POLYCARB CAPS

330nF 10% 250V AC X2 RATED PHILIPS TYPE 330	£20/100
100n, 220n 63V 5mm	20/E1 100/E3
100n/15n/22n/33n/47n/66n 10mm rad.	100/E3.50
100n 250V radial 10mm	100/E3
100n 600V Sprague axial	5 for £1
2u2 100V 15mm rad.	100/E10
10n/33n/47n 250V AC x rated 15mm	10/E1
1u 600V MIXED DIELECTRIC	50p ea
1u 0 100V rad 15mm, 1u 0 22mm rad.	100/E6
0.22u 250V AC X2 RATING	4/E1
0.22u 900V	4/E1

RF BITS

FX3286 FERRITE RING ID 5mm OD 10mm	10 for £1
ASTEC UM1233 UHF VIDEO MODULATORS (NO SOUND) 1250	
STOCK	£1.50
MARCONI MICROWAVE DIODES TYPES OC2929, OC2962,	
DC4229F1F2	£1 ea
XTAL FILTERS 21M4 55M0	£2 ea
ALL TRIMMERS	3 for 50p
VIOLET	5-105pF
RED 10-110pF GREY 5-25pF SMALL MULLARD	
2 to 22pF	3 for 50p £10/100
TRANSISTORS 2N4427, 2N3866	80p ea
CERAMIC FILTERS 4M5/6M9M 10M7	60p ea
FEED THRU CERAMIC CAPS 1000pF	10/E1
(BFY51 TRANSISTOR CAN SIZE)	
2N2222 METAL	5/E1
2N2222A PLASTIC	10/E1
2N2369	5/E1
2N3866 + 2N4427	£1 ea
74N16 TACS CAR PHONE O/P MODULE	
EQUIV MH	

Hands-on Internet

In addition to tips for helping you save time on the Internet, Cyril Bateman offers pointers to non-Spice electronics CAD software and details of a competent audio power amplifier design.

While searching Alta Vista for Smith chart software, following a link which turned out to be broken, to my surprise instead of the usual error message, I found myself at the 'Cern' site¹ in Switzerland, Fig. 1.

After a few moments I recalled that Tim Berners-Lee, the originator of the hypertext mark up language, was based at Cern in 1991 when the whole concept of the Internet Web page system was devised.

HTML is a method for linking to other relevant documents and forms the backbone of the present day World Wide Web. Originally it was a text based system. When I first used Internet in 1994, browsers for use on a pc were available. In their earlier days, for many users, Cern was an essential entrance gateway, using 'Telnet'.

Not previously having visited the Cern site, I spent a few minutes looking around. In 1991, to keep track of the Web system, Tim Berners-Lee started the WWW Virtual Library Project. It continued at Cern until handed over to the WWW Consortium² in January 1996, with Tim Berners-Lee as its director. With its continuing rapid growth, this library is now distributed between several caretaker organisations, according to discipline, Fig. 2.

My curiosity aroused, I decided to look into the background of Alta Vista³, which is my favourite keyword search engine. Bearing in mind current disk and memory capabilities, the size, power and speed of the searcher seem quite impossible.

The main advantage of a keyword database is its ability to respond to a search query, regardless of the position of the keyword in any document. The disadvantage is the volume of results returned to the user and the storage needed.

Alta Vista's keyword index consists of more than 30 million pages and 10 billion words, taking up some 40Gbyte of disk space. Maintenance of this index requires the combined efforts of six Digital Alpha computers using 11.5Gbyte of ram and 463Gbyte of disk space.

This index is constantly rebuilt using a software robot called Scooter to crawl the Web, retrieving three-million pages a day. These are then indexed using Alta Vista's Web indexing computer, capable of

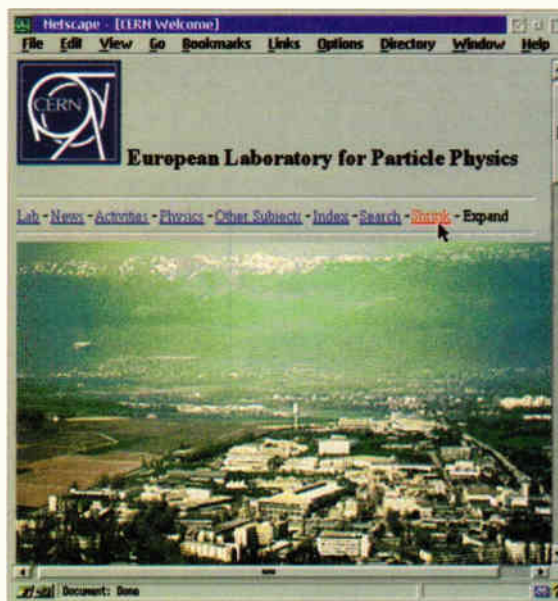


Fig. 1. Birthplace of the Web – Conseil Européen pour la Recherche Nuclear (Cern). The World's largest scientific laboratory has two sites which bridge the French/Swiss border. It has the world's biggest large electron positron accelerator – 27.6km in circumference. Cern is a 19-member collaboration of international states, appropriately located near Geneva.

Where to look

1. European Laboratory for Particle Physics. <http://www.cern.ch>
2. The Virtual Library. <http://www.w3.org/pub/DataSources>
3. Alta Vista search engine. <http://www.altavista.digital.com>
4. Cobb Group. <http://www.cobb.com/go/altavist>
5. The Internet Sleuth. <http://www.isleuth.com>
6. Industry Net. <http://www.industry.net>
7. Spread Spectrum Scene. <http://sss-mag.com/swindex.html>
8. Max Froding. <http://users.aol.com/maxfro/private/mstrip.html>
9. Rogers Corporation. <http://www.rogers-corp.com/mwu>
10. The Leach amplifier page. <http://www.ece.gatech.edu/users/207/lowtim>

Fig. 2. The WWW Consortium manages the WWW Virtual Library. Engineering sections of the WWW Virtual Library are supervised by NASA.

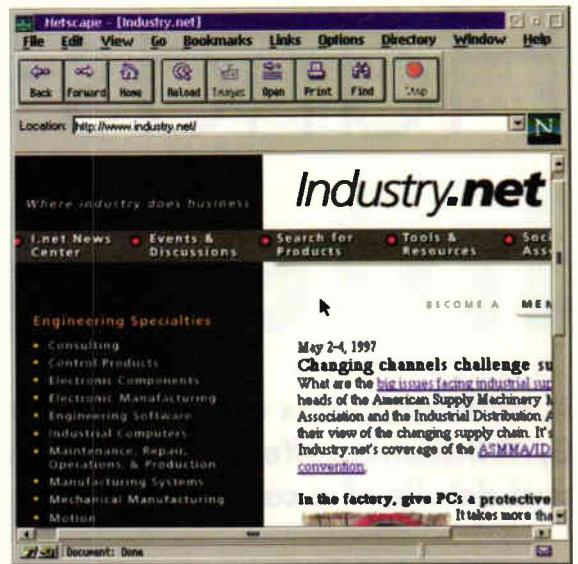
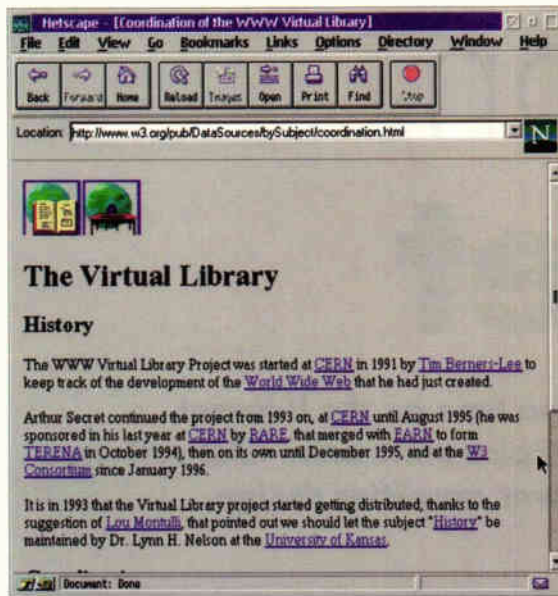


Fig. 5. Universal Engineering Manufacturing Forum. Excellent multi discipline engineering shareware repository.

Fig. 3. Advanced techniques ensure the best search results. Find how to manage Alta Vista searches.

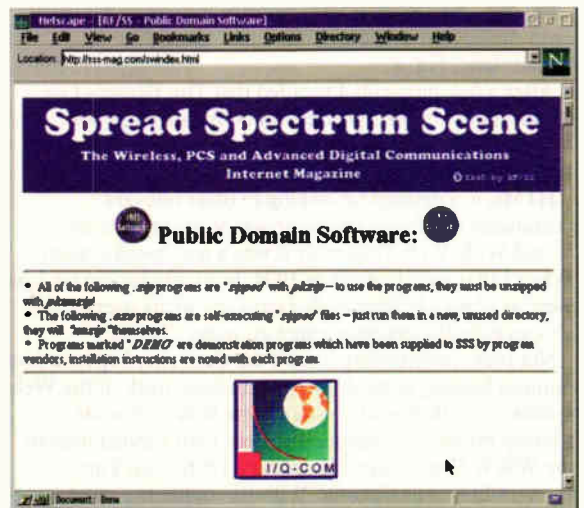
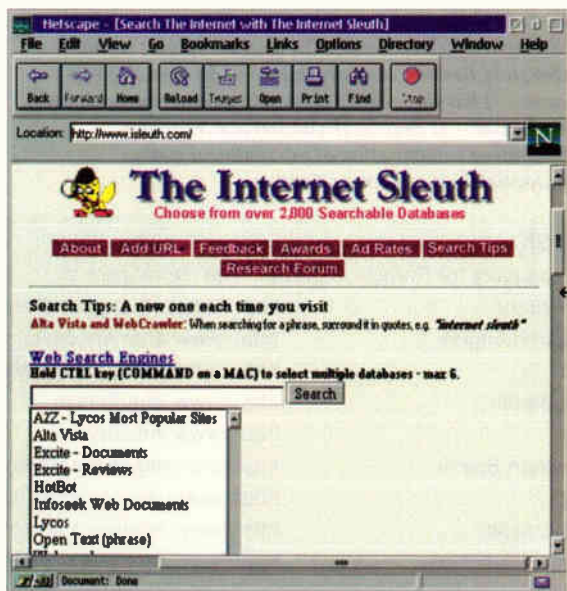


Fig. 6. Meeting place for all electronic designers - especially those involved in rf. Software library includes many hard to find utilities.

Fig. 4. Use a Meta-Search engine to maximise search information. Select your choice for multiple searches.



indexing 1Gbyte of text in an hour. However Scooter cannot update if the page is held on a computer behind a server gateway, or on one protected by a 'Firewall.' This explained my broken link.

The volume of 'hits' returned from searching a keyword index can be reduced using advanced search techniques. A newsletter publication 'Power Searching with Alta Vista'¹⁴ from The Cobb Group claims to provide answers to search problems as well as using the Alta Vista Private Extensions software to access data within your own system, Fig. 3.

Even given the power of Alta Vista, it is not possible to ensure that any keyword search database is complete and up to date. Last month I covered use of the new limited area search engines. This can usefully target some engineering areas, but should both methods fail to locate the needed information, all is not lost.

The Internet Sleuth⁵ provides the facility to search your choice of any six from over 2000 databases simultaneously. These include the popular Alta Vista,

Excite and Infoseek indexes, which should guarantee a successful result. A possible downside, due to the volume of data searched, is that each search takes longer and can result in large amounts of returned data to be sifted, Fig. 4.

Simulation and design software

Sources of Spice simulators have been well covered in past issues, but electronics design encompasses many problems that cannot be solved using Spice. Two such

involve metalwork of housings and radio frequencies circuit design. An excellent source of shareware solutions targeted to design engineers in the widest sense can be found at Industry.Net.⁶ This is a forum for all industrial manufacturing, which has an excellent thirteen page selection of essential engineering packages, both for mechanical and electronic design, Fig. 5.

This month's electronic topic centres on rf needs. *Spread Spectrum Scene*⁷ is an Internet magazine

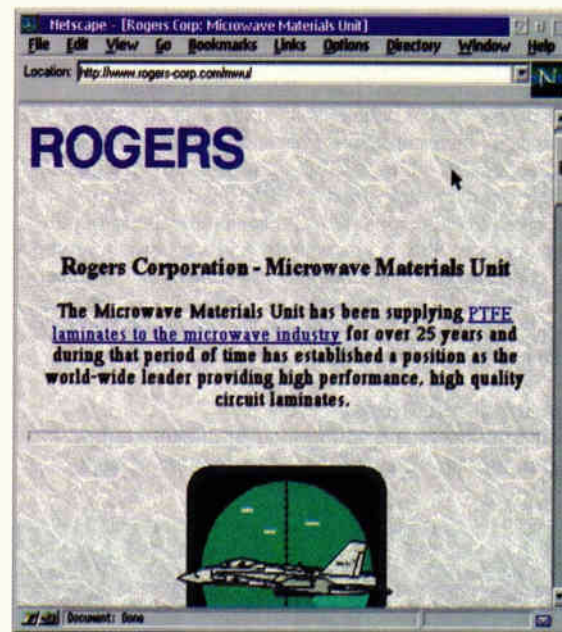


Fig. 8. Specialist supplier of low loss high-frequency laminates. Track widths designed using the laminate makers own utility, give maximum confidence.

Fig. 7. Design microstripline widths/impedances on-the-page. Another unique Max Froding rf utility.

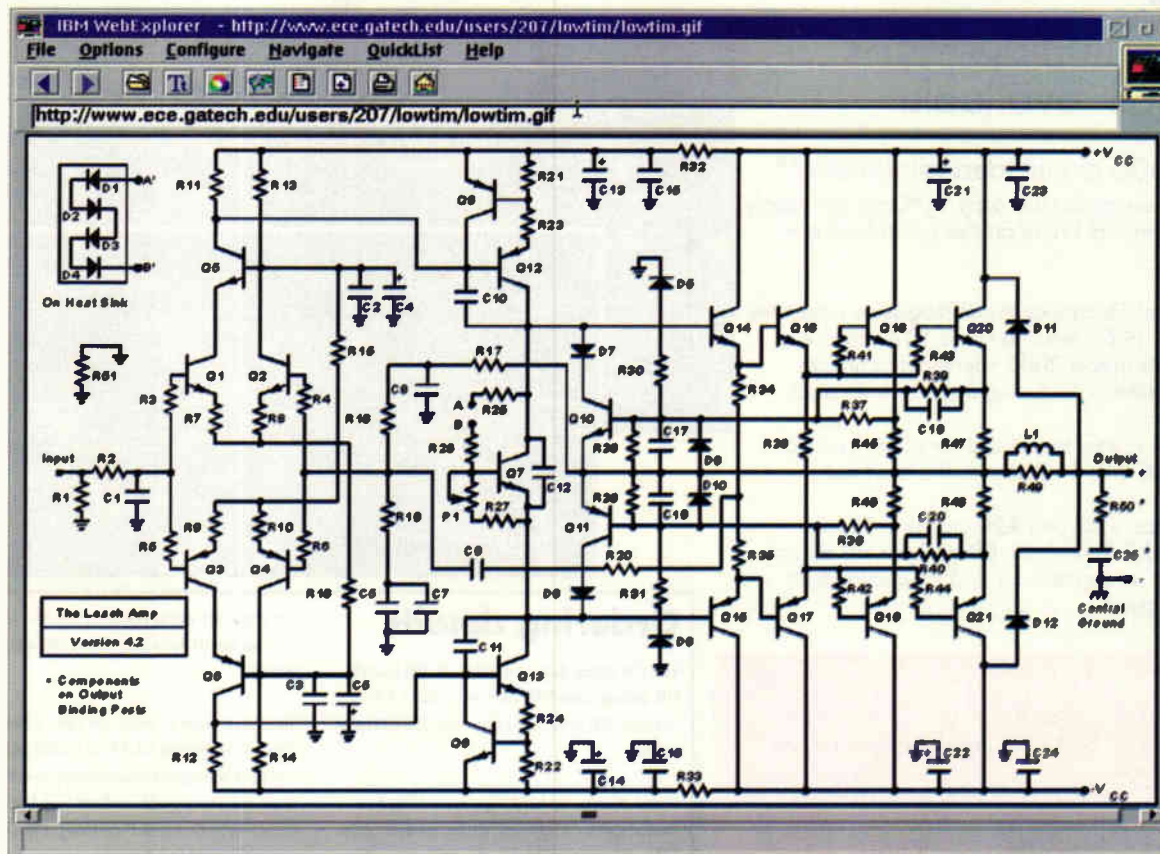


Fig. 9. The Marshall-Leach amplifier - an interesting well proven low-tim design. Fast slewing, low imd and full power into 4Ω, with this 120W version. Full constructional details for this design are published on this Web page.

embracing wireless, pcs and digital communication. Its public domain software page lists more than 150 useful packages that are easily downloaded.

Most packages are easy to find, but some are difficult. I spent some time trying to locate Motorola's excellent Smith Chart program on Motorola's page without success. I was able to download it immediately from SSS, Fig. 6.

In my November '96 Internet article, I outlined an add-on for generating net-lists from Max Froding.⁸ It was produced for the ARRL rf circuit simulator. This month Max offers an on-the-page micro-stripline design tool in two versions. It uses JavaScript for the Netscape browser and Visual Basic for Microsoft's Internet Explorer. The Javascript version includes a useful table of dielectric constants for most common microstrip materials, Fig. 7.

Rogers Corporation⁹ has supplied PTFE based microwave copper laminates for more than 25 years. In the past, using their laminates, I have relied on their excellent book of design tables when designing microstrip circuits.

The company now offers its MWI.ZIP microstrip impedance calculator which can be downloaded from the page, or from SSS. If you want to find out how successfully the company bonds its copper foils – as thin as 1/4 ounce – to a slippery PTFE glass substrate material, visit the page for a description. Included are micro photographs of both rolled and electro-deposited copper foils, Fig. 8.

Circuit applications

Following the recent strong interest in audio topics, a search on 'amplifier design' led me to some pages

written by Professor W. Marshall Leach, Jr¹⁰. He teaches both audio engineering and transistor circuit analysis at the Georgia Institute of Technology.

Professor Leach has contributed many published papers on audio, and on Spice models for loudspeakers and microphones. He is a Fellow of the AES, a senior member of IEEE and a member of the Acoustical Society.

His pages are particularly interesting since they include the circuit diagram together with full constructional detail for an interesting power amplifier. There is also a parts list with US sources.

The amplifier was originally designed some years ago following the vogue for designs achieving low transient intermodulation distortion. Over the years, countless versions have been built by his students, and all bugs have been worked out. The current version 4.2 is thus well proven and represents the results of many detail design refinements

This amplifier uses a cascode input stage together with feedback split into two separate high and low frequency paths. It also has feed-forward frequency compensation above 150kHz around the driver and paralleled transistor complementary output stages.

The design supplies 120W into 8Ω with SMPTE intermodulation distortion of less than 0.01% below clipping. It can drive a 4Ω load to full power without current limiting. Further features are an 8.5MHz gain-bandwidth product and a 70V/μs large-signal slew rate. It is also stable with capacitive loads, Fig. 9. ■

Nine year index – new update

Hard copies and floppy-disk databases both available

**** Includes over 600 circuit idea references ****

Whether as a PC data base or as hard copy, SoftCopy can supply a complete index of *Electronics World* articles going back over the past nine years.

The computerised index of *Electronics World* magazine covers the nine years from 1988 to 1996, volumes 94 to 102 inclusive is available now. It contains almost 2000 references to articles, circuit ideas and applications – including a synopsis for each.

The *EW* index data base is easy to use and very fast. It runs on any IBM or compatible PC with 512k ram and a hard disk.

The disk-based index price is still only £20 inclusive. Please specify whether you need 5.25in, 3.5in DD or 3.5in HD format. Existing users can obtain an upgrade for £15 by quoting their serial number with their order.

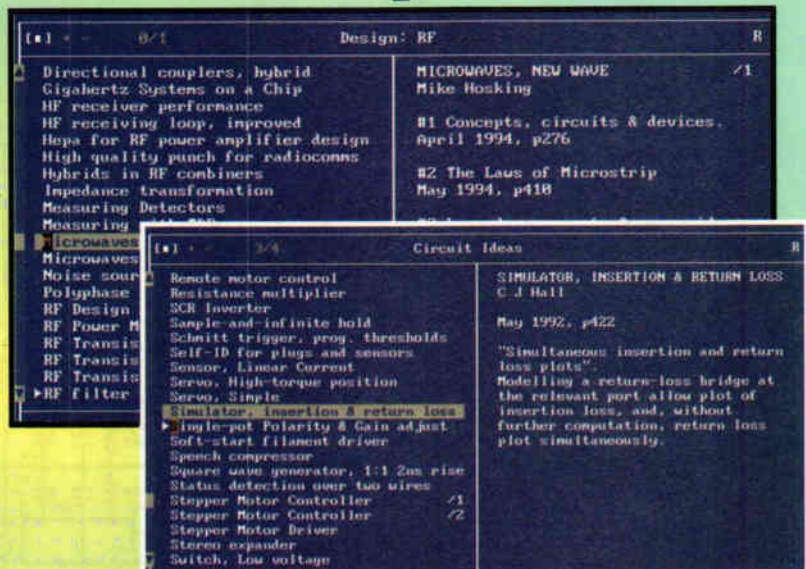


Photo copies of *Electronics World* articles

Photo copies from back issues of *Electronics World* are available at a flat rate of £3.50 per article, £1 per circuit idea, excluding postage

Hard copy *Electronics World* index

Indexes on paper for volumes 100, 101 and 102 are available at £2 each, excluding postage.

Ordering details

The *EW* index data base price of £20 includes UK postage and VAT. Add an extra £1 for overseas EC orders or £5 for non-EC overseas orders.

Postal charges on hard copy indexes and on photocopies are 50p UK, £1 for the rest of the EC or £2 worldwide.

For enquiries about photocopies, etc, please send an sae to SoftCopy Ltd at the address below.

Send your order to SoftCopy Ltd., 1 Vineries Close, Cheltenham GL53, tel 01242 241455, or e-mail at softcopy@compuserve.com. Please make cheques payable to SoftCopy Ltd – not *EW* or Reed Business Publishing. Please allow up to 28 days for delivery.



a **powerful** combination

For the past ten years Weir Electronics has been part of the Lambda Group – the largest power supply company in the world. Weir are now trading under the name Weir Lambda, to show that Weir is part of this major worldwide force. Same company, same people, same trusted power supplies and power systems, but with all the benefits of being part of the largest power supply company in the world – a partnership that packs a powerful punch. Call us today to find out how Weir Lambda can provide your next power solution

Weir Electronics Ltd Durban Road Bognor Regis Sussex PO22 9RW

Tel: 01243 885991 Fax: 01243 841628

e-mail sales@weirlambda.com <http://www.weirlambda.com>

**WEIR
LAMBDA** 

CIRCLE NO. 115 ON REPLY CARD



A Siebe Group Company

Camcorder dubber

As every camcorder owner knows, a car engine sound track does nothing to enhance scenery filmed from a moving vehicle. Ian Hickman's mixing circuit is designed not only to remove unwanted sound but also to replace it with whatever you want.

On a winter holiday recently, we took a camcorder with us, for the first time. Not wanting to tie up the expensive HI8 metal tapes for ever, and have to play holiday movies through the camcorder, the obvious step was to transfer the material to VHS tapes. But that raised the question of what to do about the sound.

In earlier times, with 8mm home movies, usually there was no sound, or at least it was added afterwards, by 'striping' the film. The camcorder, by contrast, gives one stereo sound, whether you want it or not. This is fine when shooting a street carnival, or for catching everything but the smell of a loco in steam. But often – as when shooting snow covered mountains through the windscreen of a car for example – the sound is more of a nuisance than a help.

A simple applique box

What was needed was a gadget to permit the sound on the VHS tape to originate from either the camcorder, or from a cassette recorder, at will.

Further consideration made it clear that it should be possible to 'cross fade' the two sound sources, to avoid any clicks due to switching transients. And a further useful facility would be a microphone input, so that comments, or at least a simple introduction, could be added to the soundtrack. To avoid further switching arrangements, the microphone input should operate a 'ducking circuit', to reduce the volume of the background music when speaking.

The outcome was an applique box, interconnecting the various items of kit as illustrated in Fig. 1.

The circuitry

Figure 2 shows the circuit of the applique box. Unity-gain buffers are provided for the camcorder sound and the input from the cassette recorder's DIN connector. These turned out to be at much the same level. A gain of 30dB is provided by the microphone input buffer.

The microphone and tape inputs are summed at the virtual earth, pin 13, of IC₁, and applied to one end of 1kΩ linear potentiometer, R₁₈. Buffered stereo sound from the camcorder connects to the other end, the wiper of R₁₈ being connected to volume control R₁₉ which is a 4.7kΩ logarithmic potentiometer.

Thus the sound output from buffer IC₁ pin 7 can be cross faded at will between the stereo output and tape/microphone inputs, and its level adjusted from normal down to zero. The

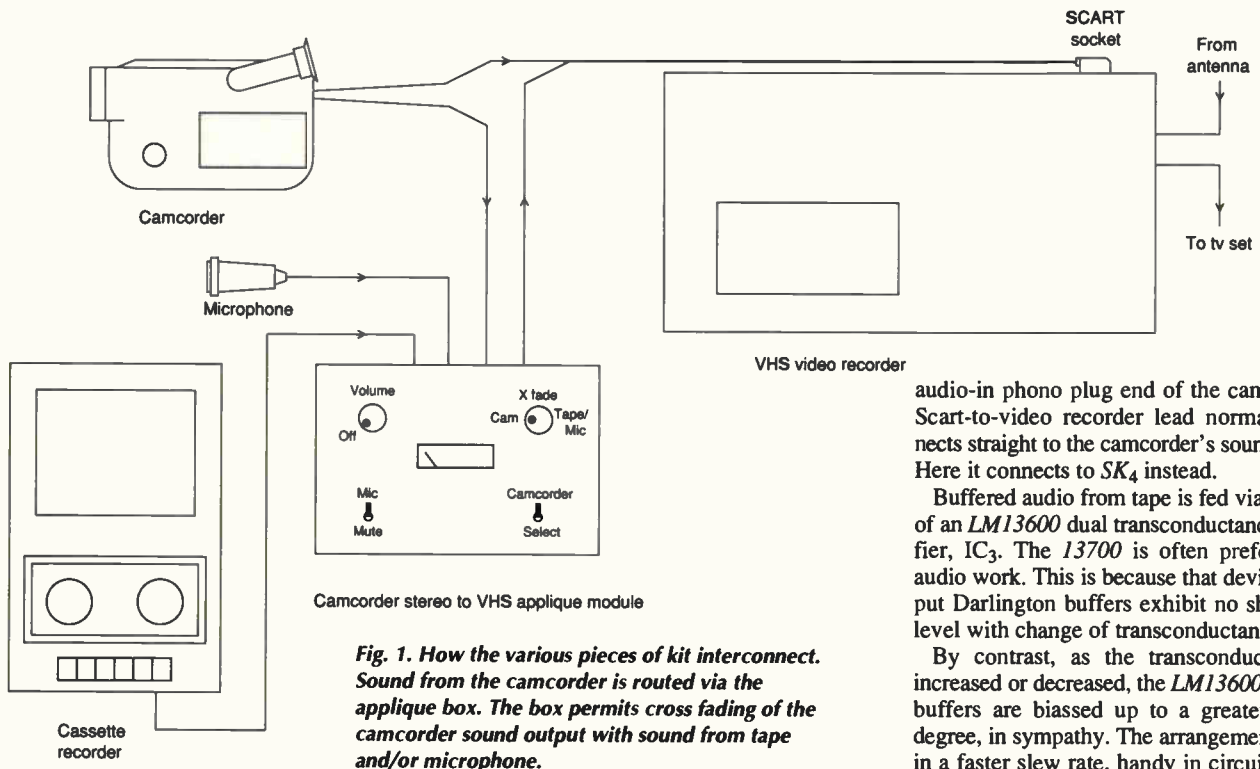


Fig. 1. How the various pieces of kit interconnect. Sound from the camcorder is routed via the applique box. The box permits cross fading of the camcorder sound output with sound from tape and/or microphone.

audio-in phono plug end of the camcorder's Scart-to-video recorder lead normally connects straight to the camcorder's sound output. Here it connects to SK₄ instead.

Buffered audio from tape is fed via one half of an LM13600 dual transconductance amplifier, IC₃. The 13700 is often preferred for audio work. This is because that device's output Darlington buffers exhibit no shift in dc level with change of transconductance.

By contrast, as the transconductance is increased or decreased, the LM13600's output buffers are biased up to a greater or less degree, in sympathy. The arrangement results in a faster slew rate, handy in circuits where

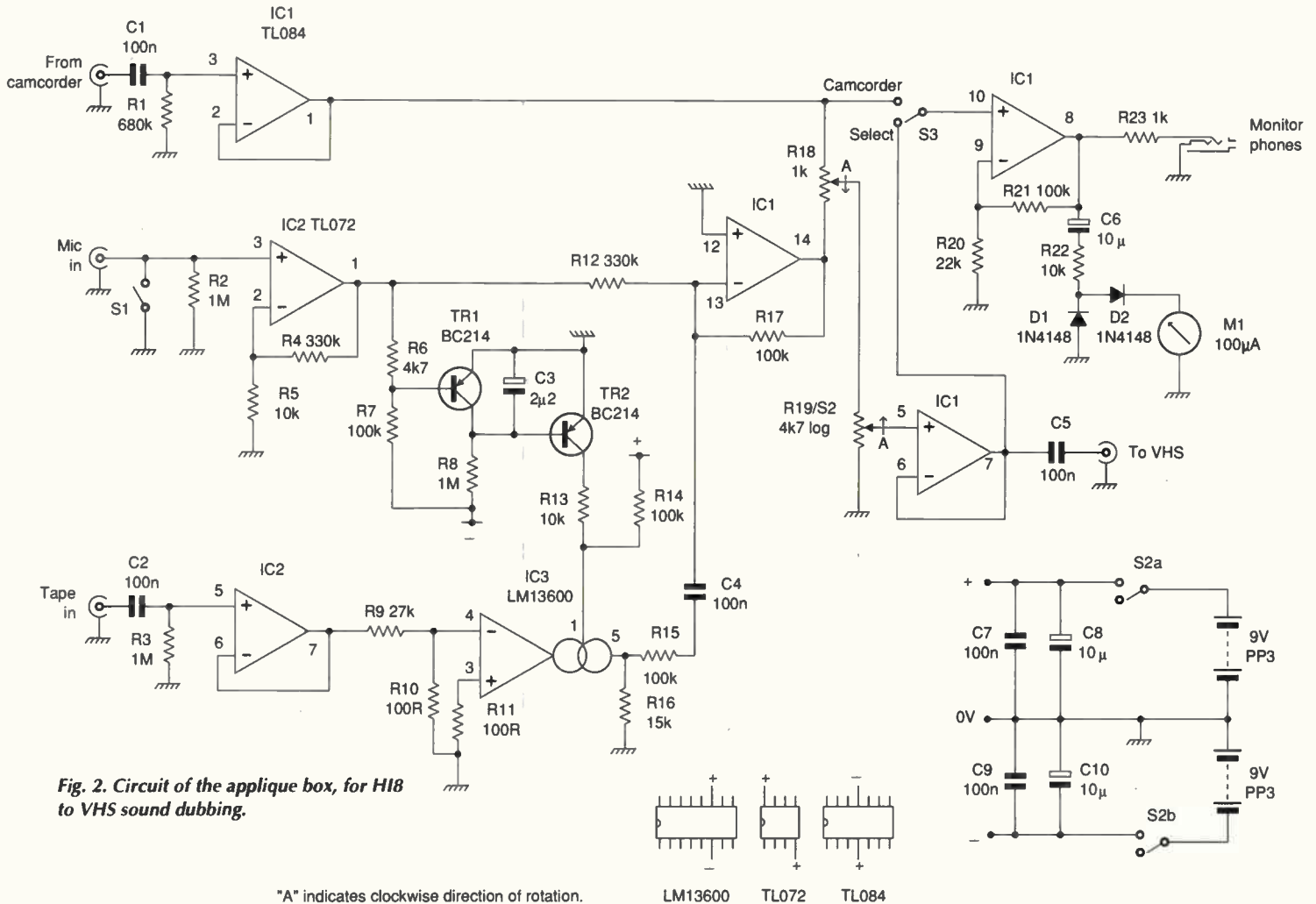
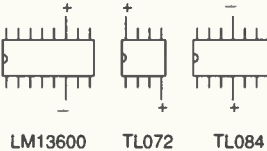


Fig. 2. Circuit of the applique box, for Hi8 to VHS sound dubbing.

"A" indicates clockwise direction of rotation.



fast settling is needed. But it can result in 'pops' in an audio circuit, when there are rapid changes in gain. However, in this application the Darlington output buffers are not used, so either device will do.

The transconductance of IC₃, and hence its gain, is set by the bias current I_{ABC} injected into pin 1. This consists of two components, the larger proportion coming via $R_{13} - Tr_2$ is normally bottomed - with about another 25% or so coming from the positive rail, via R_{14} . When a voice-over output from the mike appears, the negative-going peaks at pin 1 of IC₂ bottom Tr_1 . This discharges C_3 and removes the base current from Tr_2 . The gain of IC₃ thus drops by some 12dB or more, this proving a suitable degree of ducking.

The microphone used was a small dynamic type with a 50kΩ output impedance. In fact, it needed only 20dB of gain to raise its output to the same level as that from the camcorder and cassette.

The extra gain, together with a little forward bias for Tr_1 via R_7 , was incorporated to provide reliable operation of the ducking function. The extra microphone circuit gain was simply disposed of by making R_{12} 330kΩ, as opposed to 100kΩ at R_{15} and R_{17} .

Switch S_1 shorts the mike when not needed, preventing adventitious extraneous noises appearing on the soundtrack of the dubbed

tape. Output from the fourth section of IC₁, at pin 8, acts as a buffer to drive monitor phones, which can be plugged into SK₅. It also drives a simple level monitor indicator, M_1 . Switch S_3 draws the output monitor/meter buffer's input either from the camcorder stereo input or from the current 'select' input, be it camcorder stereo, cassette or microphone. In a stereo version of the dubber, potentiometers R_{18} and R_{19} could be ganged.

In my prototype, power is supplied by two PP3 9V batteries, the on/off switch being ganged with R_{19} . Capacitors C_7 and C_9 were duplicated adjacent to each IC, in accordance with good practice.

Using the dubber

When transferring video from a camcorder to VHS tape in the video recorder, the latter is set to use the Scart socket as the programme source. On our video recorder, this is achieved by setting its channel number to 0, which brings up the legend 'AV' in the channel number display - a fairly standard arrangement, I imagine.

When we view video tapes, our tv is usually supplied with baseband video via a Scart interconnection. This avoids the picture degradation caused by transferring the video via the rf modulator and demodulator.

While dubbing is taking place, the Scart

socket is not available as it is required for the lead from the camcorder and applique box. But tuning the tv receiver to the recorder's rf channel enables visual monitoring of the Hi8 output as it is recorded. It also enables sound to be sourced via the dubbing box's 'select' setting. Thus the main use for the phone monitor is to keep an ear on the original camcorder sound track, ready to cross fade to it when appropriate.

Figure 2 is configured for my particular collection of kit. Depending on your particular microphone and cassette recorder, cd player, or even record deck, different gain settings of the input buffers may be needed. Here, the level meter M_1 is handy, as it indicates the typical level of stereo sound from the camcorder.

Stereo enthusiasts with a suitable video recorder can double up on IC₁ and use a quad op-amp in place of a dual at IC₂, to provide stereo working. A second transconductance amplifier is of course already available in IC₃. Stereo working for the voice-over channel seems a little over the top.

Instead of cross fading the two sound sources, R_{19} may alternatively be used in conjunction with R_{18} to fade one out and then the other in, if preferred. If voice-overs are going to be fairly infrequent, S_1 can usefully be a biased toggle, so that the microphone input is permanently muted, except when required. ■

ANCHOR SUPPLIES Ltd



The Cattle Market Depot
Nottingham NG2 3GY, UK

Telephone: +44 (0115) 986 4902/
+44 (0115) 986 4041 24hr answerphone
Fax: +44 (0115) 986 4667

SPECTRUM ANALYSER SPECIAL OFFERS

MARCONI TF2370 SPECTRUM ANALYSERS + TK2373 Frequency Extenders 1250Mhz Range
Digital readout and Memories... Bandwidth down to 5Hz. Resolution 20Hz to 10Mhz per division
ONLY £1495 (TF2370 + TF2373)

Extender available alone £995 (TK2373)

Important Note: We have a large quantity of these systems available BUT only a very small quantity of 3 way connecting leads for the extenders. The leads we have will be included free of charge with COMPLETE systems only, on a first come, first served basis...
Wiring diagrams for the leads will be issued with later sales and the extenders alone.

OSCILLOSCOPE SPECIAL OFFERS

TEK 7000 Series Oscilloscope Main Frames (NO Plug-In's)

7603 (100Mhz) ONLY £225 7633 (100Mhz) ONLY £250

7704 (250Mhz) ONLY £300 7844 (400Mhz) ONLY £350 7904 (100Mhz) ONLY £450

Many other Oscilloscopes in stock... Please Phone to check stock.

SIGNAL GENERATOR SPECIAL OFFERS

Farnell DSG2 Synthesised Sig Gens 0.1mHz (milli Hertz) to 110Khz..Sine/Square. ONLY £175

FARNELL PSG 520 Synthesised to 520Mhz ONLY £325

MARCONI TF 2015 10Mhz to 520Mhz AM/FM. ONLY £195

MARCONI TF 6055 820Mhz TO 2150Mhz ONLY £195

HP 8614 800Mhz TO 2.4Ghz ONLY £95

HP 8663A 2.3Ghz to 6.5Ghz ONLY £499

GIGA GR 1128 2.0Ghz to 8.0Ghz Digital Readout of Frequency and RF level ONLY £595

GIGA GR 1118 8.0Ghz to 18.5Ghz Digital Readout of Frequency and RF level ONLY £595

DIGITAL FREQUENCY COUNTER SPECIAL OFFERS

Racal Dana 9904M 7 Digit LED to 50Mhz TXO HiStab Oscillator ONLY £50

Racal Dana 9915 8 Digit LED to 520Mhz TXO HiStab Oscillator ONLY £60

Racal Dana 9916 8 Digit LED to 560Mhz TXO HiStab Oscillator ONLY £60

Racal Dana 9918 9 Digit LED to 560Mhz TXO HiStab Oscillator ONLY £75

Racal Dana 9921 9 Digit LED to 3000 Mhz TXO HiStab Oscillator ONLY £175

EIP 451 Microwave Pulse Counter 7 Digit LED 925Mhz to 18Ghz ONLY £275

RF EQUIPMENT SPECIAL OFFERS

BIRD 4385 Digital RF Power Analysers. Accepts 2 standard Bird Elements. Digital Display of:
CW (fwd/rev).. PEP (fwd/rev).. dBm (fwd/rev).. Return loss... Min/Max levels.. % Mod.. SWR
Limited Quantity available... BE QUICK these sell FAST... ONLY £150

BIRD Elements... Models available as follows:

5B (5W 200Mhz-500Mhz) £20.. 10A (10w 25Mhz-60Mhz) £20.. 10B (10W 50Mhz-125Mhz) £20..

50D (5W 200Mhz-500Mhz) £25.. 100D (100w 200Mhz-500Mhz) £25.. 1KP (1kW 0.45-2.5Mhz) £25

Genuine Leather BIRD Element Cases for 12 elements... ONLY £10

MARCONI TF2300S Mod meter 3.5Mhz-1000Mhz 0-500Khz FM and 0-100% AM ONLY £75

SAYROSA 252 Automatic Modulation meter to 2Ghz 0-100Khz FM 0-100% AM ONLY £195

DYMAR 2081/100 RF Power Meters 1Mhz-560Mhz 30mW-100W fsd in 8 Ranges ONLY £95

CCD SURVEILLANCE EQUIPMENT IN STOCK AS USUAL
PLEASE SEE PREVIOUS ADVERTS OR A FIRST CLASS SAE FOR LATEST CATALOGUE.

OPEN 6 DAYS A WEEK

Mon-Fri 9am-6pm Sat 8am-4pm

NO APPOINTMENTS NEEDED. CALLERS ALWAYS WELCOME
NATIONAL AND INTERNATIONAL MAIL ORDER A SPECIALITY
VISIT OUR NEW WEB SITE

<http://www.anchor-supplies.ltd.uk>

e-mail sales@anchor-supplies.ltd.uk

Please note: Requests for catalogues MUST be accompanied by a first class SAE



Sound from all angles

Home theatre and surround sound

Domestic audio systems are becoming increasingly mixed-media installations – combining hi-fi loudspeakers allied to direct view or projection video. Described as home theatre, or home cinema, these systems include surround sound capability from video and non-video programmes. Stereo, two channel sources, range from traditional vinyl disc and analogue tape, predominately cassette, to RDAT digital tape, cassette-based data reduced digital tape known as DCC, compact disc, data reduced mini disc, and radio tuner. There is also videotape, laser disc, DVD, broadcast television and video disc, plus cable and satellite transmissions.

An increasing proportion of software – particularly video based – is multi-channel encoded. Where the installation gives surround sound, a full sound field is available all around the audience. In addition, audio processors are available which can extract and/or synthesise surround sound information from suitable sources.

The most popular home theatre format at present is five channel, and typically includes a centre channel speaker; this is often called the dialogue channel because it generally carries the vital speech components of a movie.

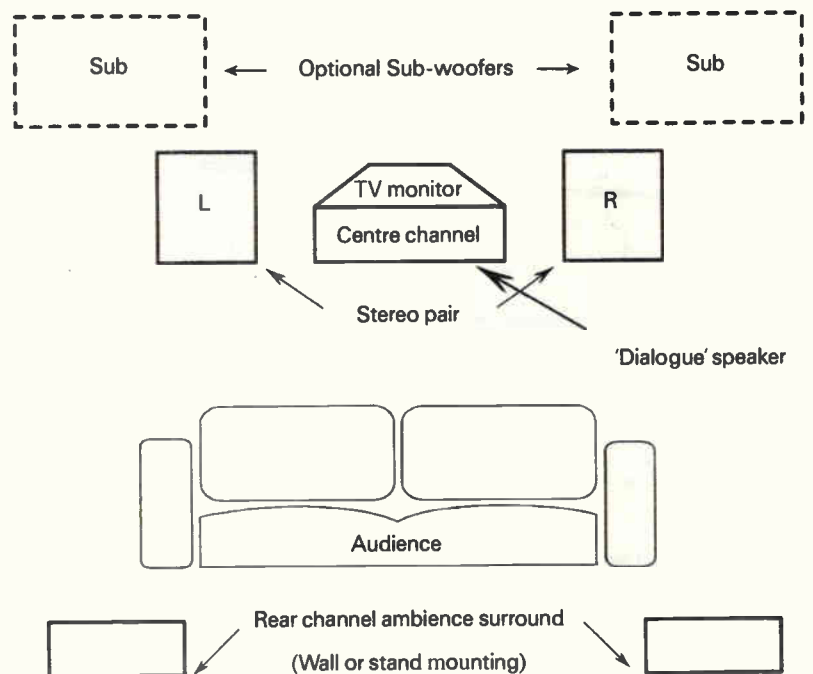
The development of a sound stage, with characteristics of width and depth, is the responsibility of the front left and right audio channels. These are generally conventional high quality loudspeaker systems, often full-range types flanking, or placed relatively close to, the television monitor or projection screen. In some cases projection screens are acoustically transparent so that the centre-channel speaker may be hidden behind them. A superior blend of sound and visual image results, with better entertainment value, Fig. 1.

In basic installations, a pair of small ambience speakers located near the back of the room, preferably elevated to reduce localisation effects. Ambience channels should not draw too much attention to themselves; excessive level or proximity to the listeners can easily disturb the sound field balance.

The rear-channel speakers may reproduce a common, mono ambience channel, which may or may not be served by individual amplifier channels, as with Dolby Pro-Logic. More recent systems for digital discrete, multi-channel encoding, including DTS and the industry standard Dolby

Martin Colloms explains the benefits and pitfalls of home cinema sound options in this article, which is based on a section of his newly updated book High Performance Loudspeakers.

Fig. 1. Basic home theatre surround sound system – a five-speaker layout using speakers with good low frequency performance for front left/right. Dotted sub-woofer(s) are optimal, only required if the 'stereo' pair have limited bass. Ambient speakers may be mounted on the side walls.



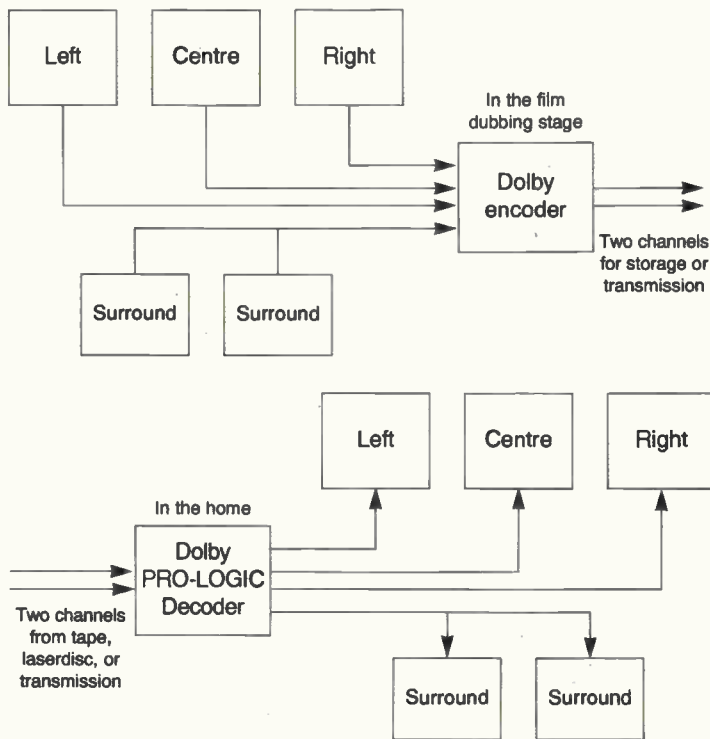


Fig. 2. Dolby surround Pro-Logic. Four channels are matrixed/encoded to two channels which reproduce as stereo. When decoded, especially with Pro-Logic steering circuitry, improved separation is achieved for four output channels. Optional fifth channel for the sub-woofer is not shown (after Harley).

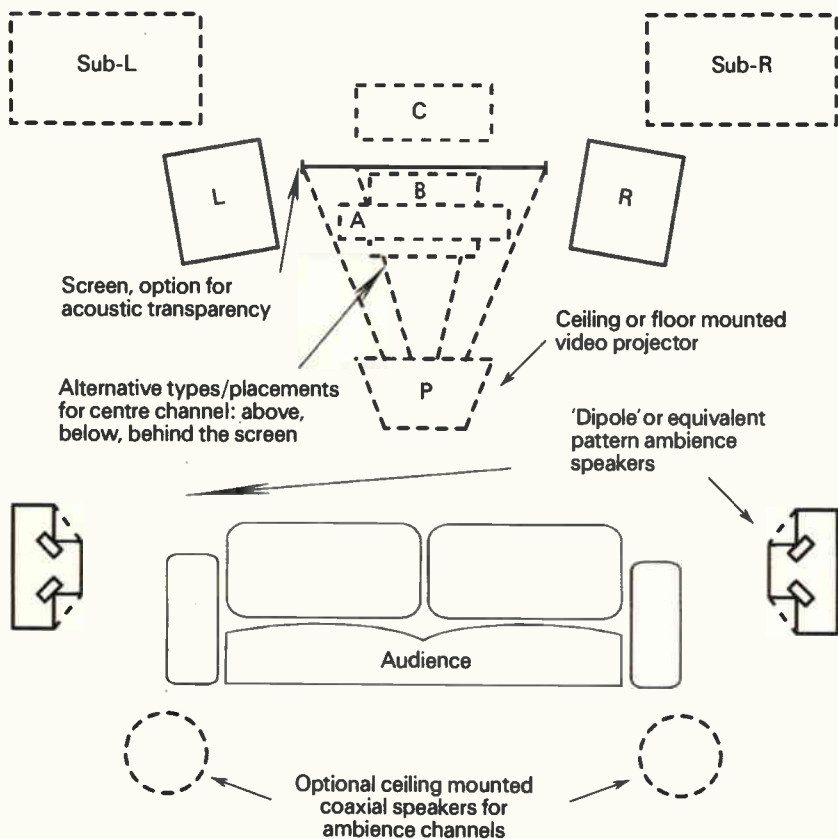


Fig. 3. THX based home theatre system. Projection video or large screen monitor, powerful sub-woofer(s) and THX style dipole or equivalent local ambience speakers. THX specification defines directivity; stereo, centre channel and ambience speakers. High sound levels typically used generally overcome the disadvantage of projector fan noise.

AC-3, can deliver discrete signals on five channels or more with the right processing – and up to eight in some instances.

Smaller, neater speaker arrangements can be used without compromising bass performance by adding a sub-woofer. In home theatres, bass is important in view of the powerful low-frequency effects commonly found on film sound tracks. Sub-woofers are generally recommended for all good home theatre installations.

Most popular surround systems incorporate decoders for Dolby Pro-Logic coded sound tracks. Decoders are available over a very wide price range and are often conveniently incorporated into multi-channel amplifiers. A specially filtered sub-woofer feed may be available, Fig. 2.

Stereo compatibility

It is possible to configure very good multi-channel systems, but there is always a degree of conflict between the requirements for best quality stereo reproduction. The best sound for a pair of high-performance speakers is obtained when they are the only significantly sized speakers in the listening room. Precision and power in the bass are diluted by the presence of additional speakers.

Furthermore, a direct view television frequently contains its own speakers and is placed in the centre stage position. It also constitutes a large acoustic obstacle, reflecting and redistributing the sound field formed between left and right-hand speakers. In addition, the speaker placement for optimal two-channel stereo is generally wider than that defined for good video-based multi-channel working. However, when a television monitor is replaced by a projection screen, this has rather less impact on the local acoustics and may be set farther back away from the stereo pair, Fig. 3.

Given the present state of the art, the fidelity of multi-channel electronics, processors and amplifiers in home theatre is not as high as that of discrete component stereo systems. Some compromise in respect of two-channel high-fidelity performance is inevitable.

Multi-channel advantage

It may be argued that multi-channel working conveys additional information and that the greater sensory experience resulting from surround sound working balances the loss in absolute fidelity when compared with pure stereo.

Greater versatility will be demanded from surround-sound systems as the new digital coding systems are introduced. These include the discrete channel Dolby AC-3. By comparison Pro-Logic is a two-channel system using matrix techniques for coding the additional directional information, Fig. 4.

THX and cinema-quality sound

The THX sound laboratory has set specifications, and provides design recommendations, relating to home theatre sound. These are intended to promote the production of a tonal balance and sound field in the home which more closely mirrors professional cinema practice.

In theory, the guidelines make for a closer sonic match with the film production intentions. Higher sound system cost and performance is the result, together with some divergence from normal Dolby surround practice.

THX-compatible decoders provide shaped audio signals, while speaker design also has some special features which will emerge in the following sections.

Speaker design

Specific requirements and acoustic environments for the different types of speaker system in a multi-channel installation

need careful consideration. The objective should be a well-distributed sound field of uniform quality and tonality, such that no speaker or room region draws undue attention to itself and thus impairs the stability of the surround sound effect.

Equipment critics have found many instances of poor matching of the sound characters of the various speakers in a multi-channel system.

Design rules follow good speaker engineering practice. But in addition, they incorporate some specific factors, outlined below. Top quality systems conforming to the THX specification have their own set of standards and systems must qualify via direct evaluation at the THX laboratory.

Speakers for front left and right. Almost any good stereo speaker – floor or stand mounted – will serve for the front stereo pair. If the application does not include a sub-woofer, then full-range speakers with more powerful bass are advisable, probably of floor standing design.

Front speakers are likely to be close to each other, near to the monitor, and potentially not far from the rear wall. As a result, the bass alignment should be somewhat overdamped, for example with a Q of 0.5. This avoids excess energy in the 50-100 Hz range.

If the speakers are not properly damped, the reproduction of normal television speech, whether mono or two channel, may sound unnaturally heavy and boomy. This could cause early aural fatigue – even if the results are impressive on movies.

For THX working, a vertical driver array is favoured. This reduces the reverberant contribution from the floor and ceiling reflections. Mid-range tonal balance may also benefit from some subtle adjustment to take account of the proximity of the television monitor casing, and its likely supporting cabinet.

Rear channel. For simply reproducing ambient effects, an extended frequency response is unnecessary and compact slim-line enclosures are favoured. These are typically sealed-box types with a bass driver and treble unit with an alignment balanced for wall boundary location, possibly a downwards directed polar response. In some cases just a full-range single cone driver is used.

A maximum level of 100dB, an 85-90dB/W sensitivity and a 90Hz to 12kHz bandwidth is usually satisfactory, provided that the general quality, colouration standard, etc. match the primary system. Rear speaker bandwidth need only be a little wider than that imparted by the processor, Fig. 5.

In some installations ceiling-mounted speakers have been used successfully. These are usually coaxial types, which have the advantage of a symmetrical radiation pattern. Complications include the acoustics of the ceiling and the lack of a defined enclosure, which results in some variations in performance. The advantage is almost perfect concealment, while the additional height above the listeners aids dispersion of the ambient sound field, Fig. 6.

With digital multi-channel sound, the rear channel feed may be discrete, well localised, of higher quality and full bandwidth. For top quality systems superior 'ambience' speakers will be worthwhile, Fig. 7.

Centre-channel or dialogue speaker. For projection systems, acoustically transparent screens are available and any suitable high quality speaker may be concealed behind them.

Where a television monitor is involved, the dialogue speaker should be placed centrally to optimise the acoustic/optical alignment. Since the image cannot be obstructed it must be

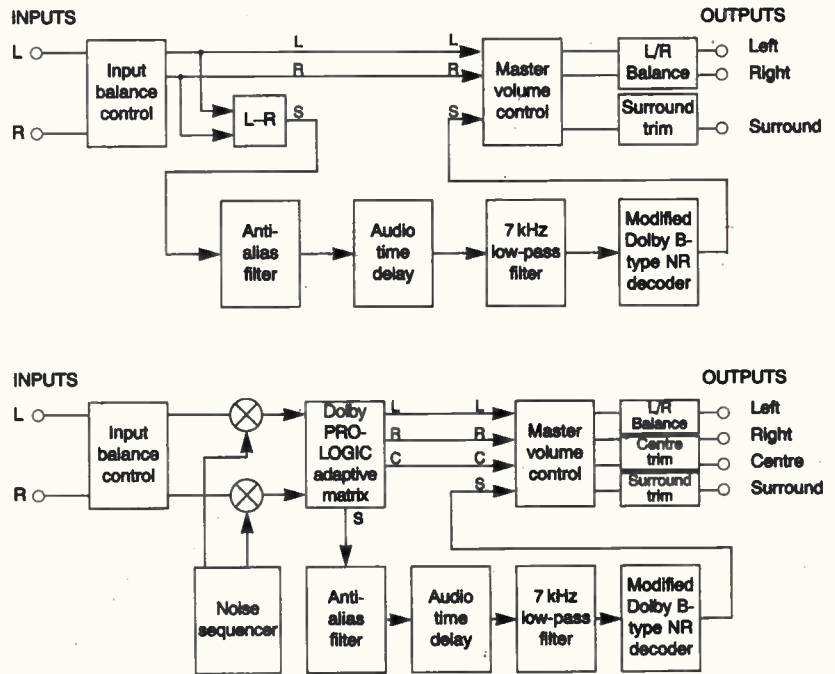


Fig. 3. Comparing the passive decoding of Dolby Surround with the active matrix system used for Pro-Logic for home theatre. Note that both systems include bandwidth limiting for the surround channel, specified at 100Hz to 7kHz -3dB. In practice, this reduces the demands made on rear channel speakers; a single full-range driver may be sufficient.

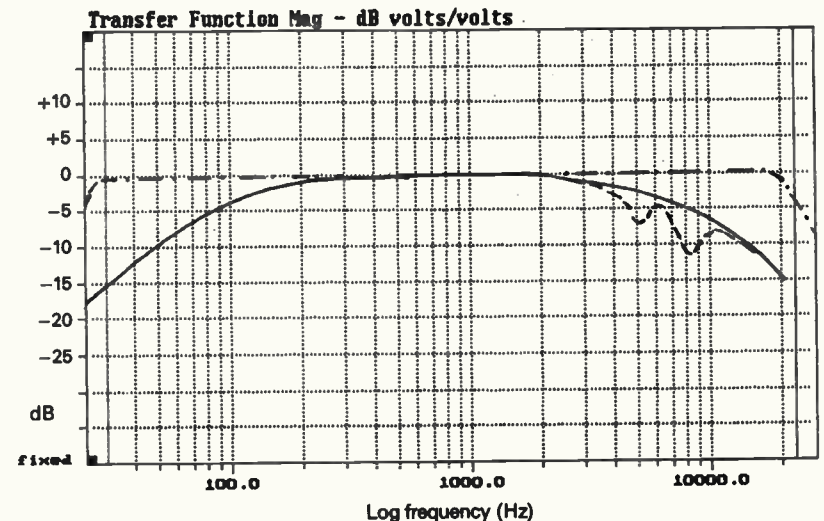


Fig. 5. Frequency responses for decoded rear channel signals. Pro-Logic (—) has a 100Hz to 7kHz bandwidth, THX augments with extra filtering (- - -) while AC-3 digital decoding offers discrete rear channels with an additional user option – full bandwidth 20-20kHz (- · - · -).

located directly above or below the faceplate.

Vertically orientated drivers offer the best angle of horizontal directivity for the audience. Many THX speakers are vertically mounted. But aesthetic considerations generally dictate a low profile, slim-line, horizontally disposed enclosure, matching the monitor as closely as possible.

However, a horizontal driver disposition is the least favourable arrangement for audience coverage. Conventional two-driver designs have been tried, but inevitably the responses in one direction are unbalanced relative to the other due to asymmetry.

Symmetrical arrangements are favoured, and use a centre, preferably narrow chassis dome tweeter, slimmed by the use

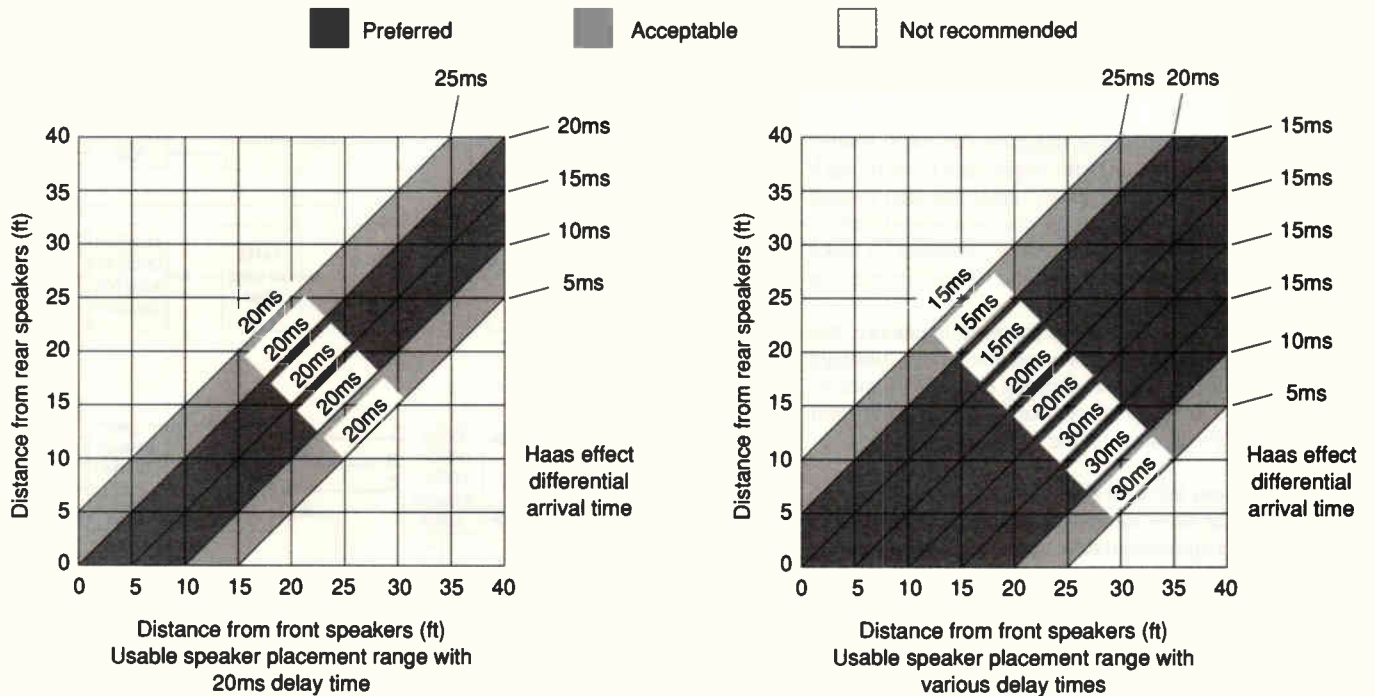
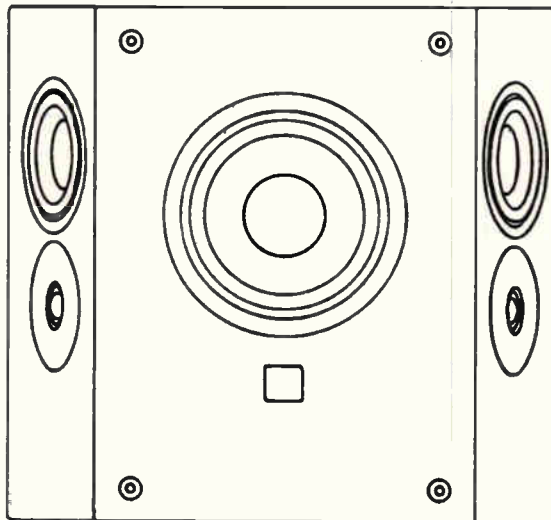


Fig. 6. Recommendations for speaker placement – rear channel relative to front – to allow good frontal localisation but avoid ‘echo’ effect from ambience channel feed. Some systems provide programmable delay for greater versatility but 20ms is a standard delay.

Fig. 7. An example of a dipole ambience field speaker system. Angled driver pairs operate in anti-phase above 300Hz. The centre driver gives omnidirectional radiation below 300Hz. Drivers are 170mm, 100mm and 25mm. THX application, after Aerial Acoustics Corporation, for side wall placement.



of a closed field, and thus magnetically screened, miniature magnet made from neodymium alloy. On each side is a bass-mid unit typically of 80-120 mm chassis size. The overall enclosure height is held in the region of 160mm.

Factors that help widen the radiation angle in the crossover range are high slope crossovers, and a lower than usual crossover frequency of around 2kHz instead of the usual 3kHz and 4kHz.

The use of a driver baffle structured to angle the bass drivers away from the central treble unit, for example by 10° or 20° helps to widen the acoustic lobe in the crossover range. This also needs to be well screened magnetically.

Note that these horizontal designs have another notch in their response, this time due to the relative delay, for the two mid sections appearing off-axis. This notch may be 12dB deep in the 1kHz region and adds a further complication.

A frequency range of 80Hz to 15kHz is worthwhile. Reflex loading, despite the small enclosure volume, is common to help improve the power handling. The centre channel may need to play loudly – at 103dB or more – and needs an 88-92dB/W sensitivity with up to 100W power handling.

Fine centre channel speakers have also been made with concentric drivers, such as the UNI-Q or the ICT. Such drivers have good directivity on all axes.

Specific voicing may be applied to a centre channel speaker. The proximity of the television screen also requires consideration. In addition, high clarity, intelligibility and articulation are paramount – even at high sound levels. The actor’s words must be heard clearly, no matter how complex the mix of sound effects.

On balance there is a trend towards a taut, fast upper bass, occasionally some midrange and presence-range prominence

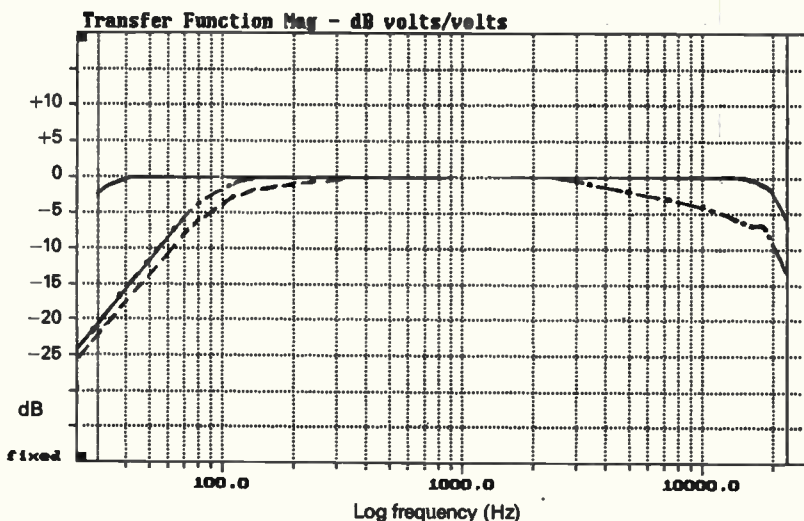


Fig. 8. Frequency response for decoded outputs of surround-sound processors, centre channel. Pro-Logic offers full bandwidth and high-pass -3dB at 100Hz options (—, - - - -). Processing via THX, aimed at producing a tonal quality close to cinema sound, also filters the bass and softens the treble (- · - · - ·).

of a few decibels, and an upper treble which does not draw undue attention to itself. For THX's narrow bandwidth setting, a range of only 60Hz to 10kHz is required, Fig. 8.

Screening problems

Magnetic screening is now recommended for the front left and right speakers in addition to the centre channel units, in view of the magnetic sensitivity of the larger direct view television monitors.

Steel plates may be required to line the cabinet sides. These may be bonded with an appropriate visco-elastic adhesive to improve resonance damping. Even screened speakers may result in some colour shifts when placed on a monitor and this matter needs careful checking at the design stage.

Low frequency power

Considerable output is required in the bass for a suitably impressive film playback. It is rumoured that many of the 'foley' originated low frequency sound effects are simply shaped and/or gated bursts of third octave pink noise at 30Hz! These can reach peak level, which accounts for the THX requirement for 105dB, 30Hz at 1m for moderate listening rooms.

Two sub-woofers sound rather better than one – more than their arithmetic sum would suggest. Placement in the room corners generally gives the smoothest and most powerful bass. Good boundary matching is important because it reduces the demands made on the woofer, resulting in improved performance and a higher dynamic range.

Multi-channel discrete processors

Speaker systems for home theatre have evolved around matrix processed signals, often band limited to reduce the audibility of spurious processing artefacts. Such practice also makes good economic sense. There is no point in over-specifying the auxiliary speaker systems, centre and rear, if the result is to price the system out of the market.

However, with the introduction of discrete multi-channel processors, the European MPEG variants, the US designed DTS and Dolby AC-3 systems plus multi-channel (rather than synthesised) surround sound, all the audio channels may have a discrete, wide band, high quality identity.

Potentially, with the right replay system, the sound producer will be able to place a virtual acoustic image anywhere in the listening room, anywhere in the defined sound field. Even at this early stage, systems such as DTS can reproduce a full circle 'walkaround' with stable geometry, using a sound as complex and transient rich as closely miked orchestral chimes.

With such a potential for high quality, it is obvious that the more costly home theatre and surround sound systems are going to need better speaker systems for all quadrants of the sound field. Revisions may be anticipated with regard to existing practice, performance specifications, response shaping and required bandwidth to meet these new demands. ■

Further reading

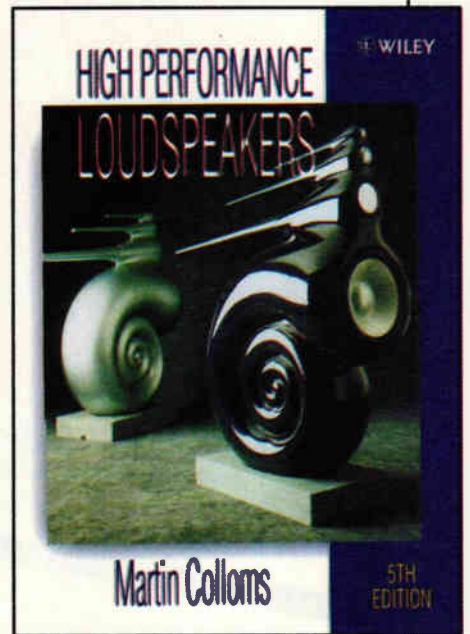
- Dressier, R, 'The (Near) Future of multi-channel Sound,' Dolby Labs S94/1009, 1994.
- Haxley, R, 'The Complete Guide to High-End Audio,' Acappella Publishing, 1994.
- Holman, T, 'New factors in sound for cinema and television', *J. Audio Eng Soc.*, July/August (1991).
- Holman, T, 'Home THX: Lucasfilm's approach to bringing the theatre experience home', *Stereo Review*, April 1994.
- Smyth, M and S, 'DTS coherent acoustics: The future of audio', *Widescreen Review*, 14, 16, 18, Parts 1, 2, 3.

High Performance Loudspeakers: completely revised and updated

With 478 pages, the fifth edition of Martin Colloms' book *High Performance Loudspeakers* has been completely updated and revised. Features of the new edition are,

- First technical assessment of bending-wave panel speaker technology (NXT), reverse horn loudspeakers (Nautilus) and flat plane speakers.
- Major section on digital speaker design, optimised digital filters, system requirements and digital active speakers.
- Unique and non-partisan interpretation of manufacturers' technologies and claims.

The work includes chapters on diaphragm theory, transducer technology, room analysis, driver types and choices, crossovers, enclosures and speaker assessment.



Please mail this coupon to *Electronics World*, together with payment. Alternatively fax credit card details with order on 0181 652 8111. You can also telephone your order on 0181 652 3614, but only Mondays, Tuesday's or on Friday mornings. Address orders and all correspondence relating to this order to, Electronics World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

Use this coupon to order your copy of High Performance Loudspeakers

Please send me copies of Dictionary of Communications Technology.
Each copy of the book costs £24.95 plus £4 UK p+p, £8 Europe, £12 ROW per book.

Total amount £.....

Name

Company (if any)

Address

Phone number/fax

Make cheques payable to Reed Business Information Group.
Or, please debit my Master, Visa or Access card.

Card type (Access/Visa)

Card No

Expiry date

The right card for every occasion



R.S.V.P.

Contact Card Professionals for the most advanced portfolio of PCMCIA PC Cards, StarCards, 38edge Cards and compatible interface solutions

Centennial: major franchised stocking distributor for Centennial PCMCIA cards

ITT Canon: authorised stocking distributor for 38pin StarCards, 38pin StarCard connectors and 68pin PC Card connectors

Calluna: authorised stocking distributor for Calluna's type III ATA PC card range

Centennial: 38 edge card flash memories and connectors

A wide range of Reader/writers are available with ISA, SCSIII, parallel and serial host interfaces for cards in our portfolio



Card Professionals Limited

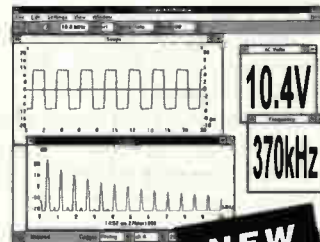
Card Professionals Limited, Cedarmount House, Owlsmoor Road, Owlsmoor, Sandhurst, Berkshire, GU47 0SS.
Tel: +44 (0) 1344 779632.
Fax: +44 (0) 1344 779633.
www.card-professionals-uk.com

Data Acquisition
Environmental Monitoring
Virtual Instrumentation

Pico Technology

'Pico's Virtual Instrument is the most powerful, flexible test equipment in my lab.'

Pico's virtual instruments emulate the functions of traditional instruments such as **Oscilloscopes, Spectrum Analysers and Multimeters**. Controlled using the standard Windows interface, the software is easy to use with full on line help.



NEW
100 MS/s

ADC-200
Dual Channel High Speed

- ▼ 100, 50 or 20 MS/s sampling.
- ▼ 50, 25 or 10 MHz spectrum analysis.
- ▼ Advanced trigger modes - capture intermittent one-off events.
- ▼ Less than half the cost of a comparable benchtop scope.

ADC 200-100	£549.00
ADC 200-50	£499.00
ADC 200-20	£359.00

Supplied with cables and power supply.



ADC-100
Dual Channel 12 bit resolution

The ADC-100 offers both a high sampling rate 100kS/s and a high resolution. Flexible input ranges ($\pm 50\text{mV}$ to $\pm 20\text{V}$) make the unit ideal for audio, automotive and education use.

ADC-100 with PicoScope software	£199.00
with PicoScope & PicoLog software	£219.00

ADC-40/42
Single Channel - low cost

- ▼ 20 kS/s sampling.
- ▼ 10 kHz spectrum analysis.
- ▼ $\pm 5\text{V}$ input range.

ADC-40 8 bit resolution	£59.00
ADC-42 12 bit resolution	£85.00



Call for free demo disk or download our web site:
<http://www.picotech.com>

All prices exclusive of VAT.

Broadway House, 149-151 St Neots Rd, Hardwick, Cambridge. CB3 7QJ UK
Tel: (0)1954 211716 Fax: (0)1954 211880
E-mail: post@picotech.co.uk

PICO
Technology Limited

CIRCLE NO. 117 ON REPLY CARD

Genetically designed yagi

Richard Formato explains how a natural-selection like design process produces better antennas, and provides evidence in the form of a three-element Yagi example for 50MHz work.

Genetic algorithms, or GAs, are a class of optimisation techniques that mimic natural selection, i.e. 'survival of the fittest'. Such algorithms are applicable to many types of problems, and they are becoming increasingly useful in antenna design^{1,2}. This note describes a genetically designed three-element Yagi that provides very good performance and illustrates how effective genetic algorithms can be.

Unlike deterministic optimisation schemes, GAs are based on random selection. A binary-coded genetic algorithm starts by creating a population of 'chromosomes' which are random one and zero bit sequences. Each chromosome contains a complete antenna

design – in this example – a complete three-element Yagi antenna.

The chromosome is made up of 'genes' which are strung together one after another. Each gene corresponds to one of the antenna's design parameters.

The Yagi gene relationship appears in Table 1. A design is fully specified by eight genes: reflector length and radius *REF*, driven element length and radius *DE*, director length and radius *DIR*, and location along the boom *DE/DIR*. Gene length is its length in bits – for example, *REF* length is five bits.

The minimum and maximum values of each design parameter also appear in the table, and all dimensions are in wavelengths, 'waves'. The *DE* length, for example, cannot be longer than 0.6 wave or shorter than 0.4 wave.

Since each design parameter is a decimal number, not a bit sequence, the actual value of the parameter is computed by decoding its binary gene using the following transformation equation,

$$X = X_{\min} + \left(\frac{X_{\max} - X_{\min}}{2^L - 1} \right) \times D$$

where *X* is the decimal value of the parameter, *D* is the decimal value of the gene's binary sequence, and *L* is the gene's length.

To illustrate how this decoding scheme works, consider the 37-bit chromosome that contains the design for the Yagi discussed below:

0010111000011011111001011100010111100

The *DE* length is coded in gene No 3, which starts at bit No 10 and ends with bit No 14. The binary sequence for the *DE* length gene is 00110, and its decimal value is,

$$0(2^0) + 0(2^1) + 1(2^2) + 1(2^3) + 0(2^4) = 12$$

Since gene No 3 is five bits long, the denom-

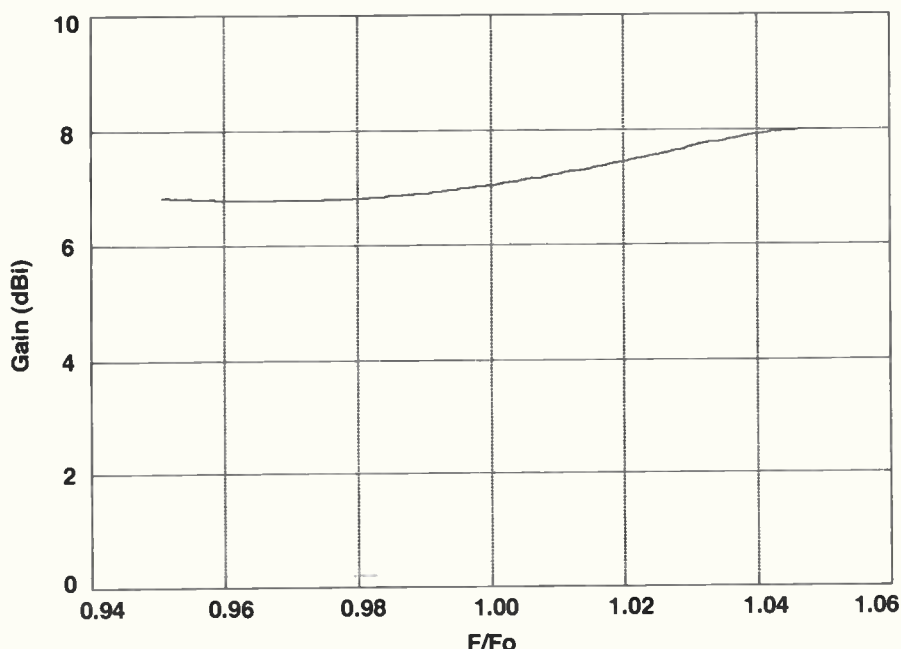


Fig. 1. Main lobe gain for the genetically-designed Yagi example.

Table 1. Gene table for three-element Yagi.

Gene #	Name	Length	Min	Max
1	REF Length	5	0.4	0.6
2	REF Radius	4	0.0005	0.002
3	DE Length	5	0.4	0.6
4	DE Radius	4	0.0005	0.004
5	DE Separation (from ref.)	5	0.05	0.3
6	DIR Length	5	0.4	0.6
7	DIR Radius	4	0.0005	0.002
8	DIR Separation (from DE)	5	0.05	0.3

* PO Box 747, Boylston, MA 01505-0747, tel. (508) 869-6077, fax (508) 869-2890

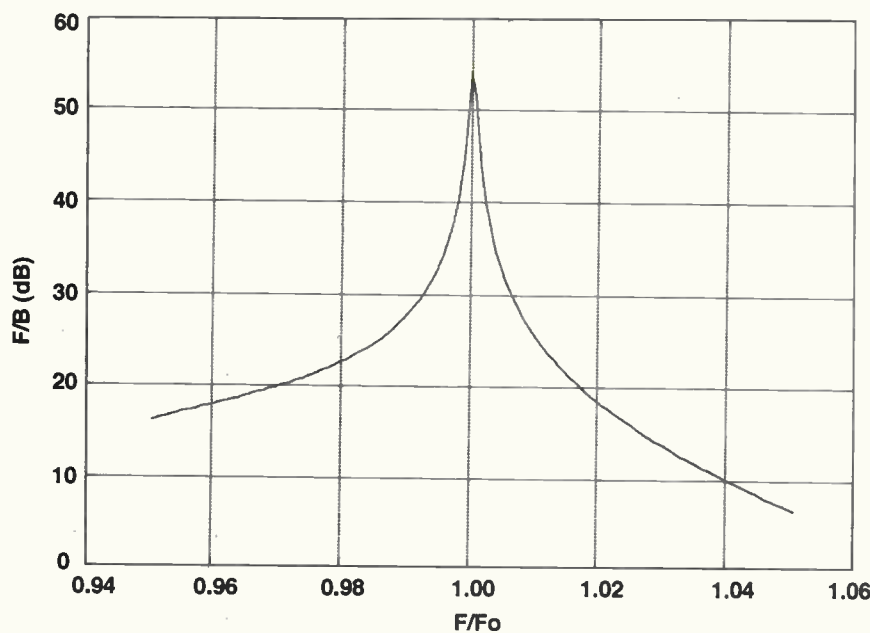


Fig. 2. Front-to-back ratio for the genetically-designed Yagi example.

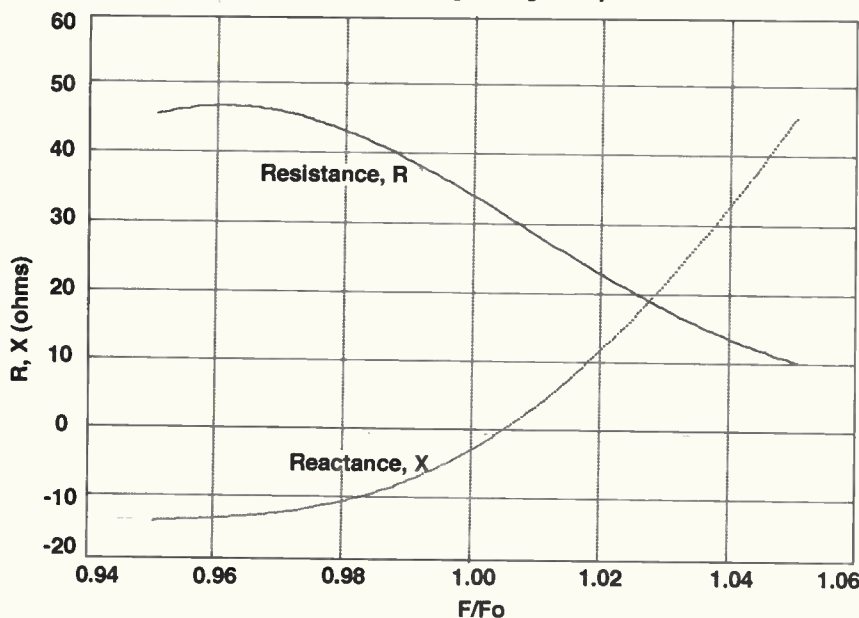


Fig. 3. Genetically-designed Yagi's input impedance.

inator in the transformation equation is $2^5 - 1 = 31$. This makes the DE length,

$$\frac{0.4 + (0.6 - 0.4)12}{31} = 0.477419355$$

wavelengths. Because the computer model used to calculate the Yagi's performance inputs the half-length of DE instead of its overall length, this value is divided by two and rounded to three places to give 0.239 wave. This decoding scheme is used to evaluate each of the Yagi's design parameters. The DIR radius, gene No 7, for example, evaluates to 0.0015 wave, and so on.

The genetic algorithm begins by creating an initial population of random 37-bit chromosomes. It then applies the operators of 'selection', 'crossover', and 'mutation' to filter out 'unfit' designs while retaining the better ones.

Successive applications of these operators create 'generations' of antenna designs, with each subsequent generation hopefully containing better designs than the previous one. But, because of the algorithm's inherently random nature, there is no guaranty of obtaining better designs. They may actually become worse from one generation to another.

Well-designed genetic algorithms, however, usually produce progressively better designs, at least on the average. Every new run holds the intriguing possibility of producing a previously unseen 'best' design.

The selection operator determines which chromosomes are fit enough to survive to the next generation. Some may be automatically discarded - for example, the worst 10% - while others are typically 'killed' at random, as they would be in nature. Others may be automatically retained - the best 5%, for example.

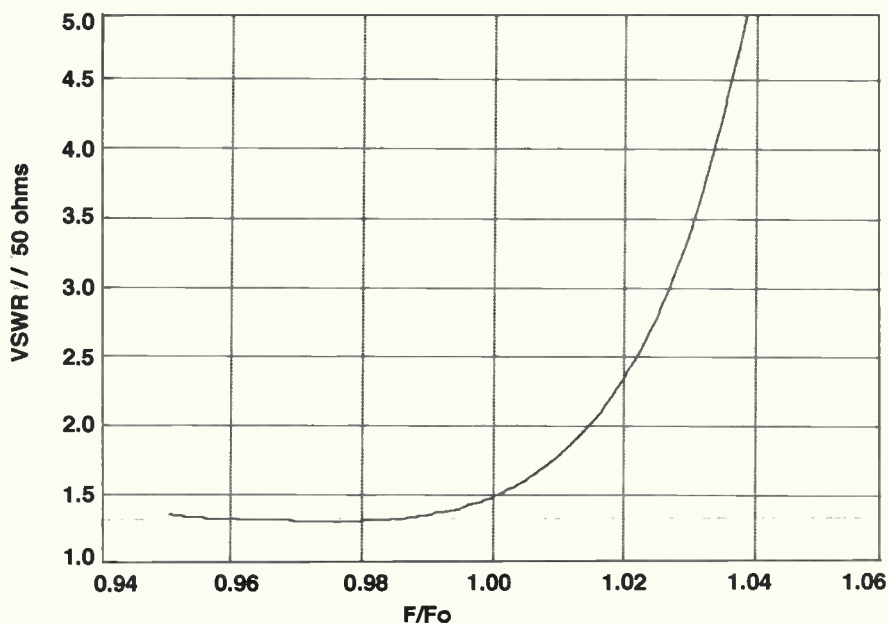
The algorithm designer is free to implement whatever selection process seems best. The crossover operator 'mates' two chromosomes, or 'parents', to produce two new chromosomes, or 'children', which become members of the next generation. Child chromosomes usually maintain a constant population from one generation to the next, although the population could grow if desired.

Each parent's chromosome is split at a gene boundary, usually randomly selected, and the pieces are swapped (concatenated together) to form two different chromosomes. This is the primary process by which genetic algorithm propagate 'good' genes from one generation to the next.

Finally, the mutation operator randomly flips a bit here and there with some small probability. This simulates the genetic mutation that occurs randomly in Nature.

Deciding which is best

In each generation, all of the designs, or chromosomes, are ranked from best to worst using a figure-of-merit. The figure-of-merit combines various antenna performance measures



The boom length – the sum of *DE/DIR* separations – is only 0.229. This is less than a quarter-wave, which is quite short. At the 6m amateur band frequency of 51MHz, for example, this Yagi is only 53in long. The *REF*, *DE* and *DIR* lengths are 122.66, 110.62, and 103.22in, respectively, with diameters of 0.37, 1.85, and 0.694in.

Gene *DE* is located 28.47in from *REF*, while *DIR* is located 24.53in from *DE*. It is interesting that the genetic algorithm converged to the maximum allowable value for the *DE* radius, because it is known from analytical considerations that increasing *DE* diam-

Fig. 5. Azimuth, a), and elevation pattern, b), of the antenna.

Fig. 4. Standing-wave ratio performance.

computed by a modelling engine, which is another computer program separate from the genetic algorithm.

Individual antenna performance parameters, for example, can be calculated with any suitable antenna modelling program. The figure-of-merit used for the Yagi described below is

$$\frac{5(G) + 4(FB) - SWR}{10}$$

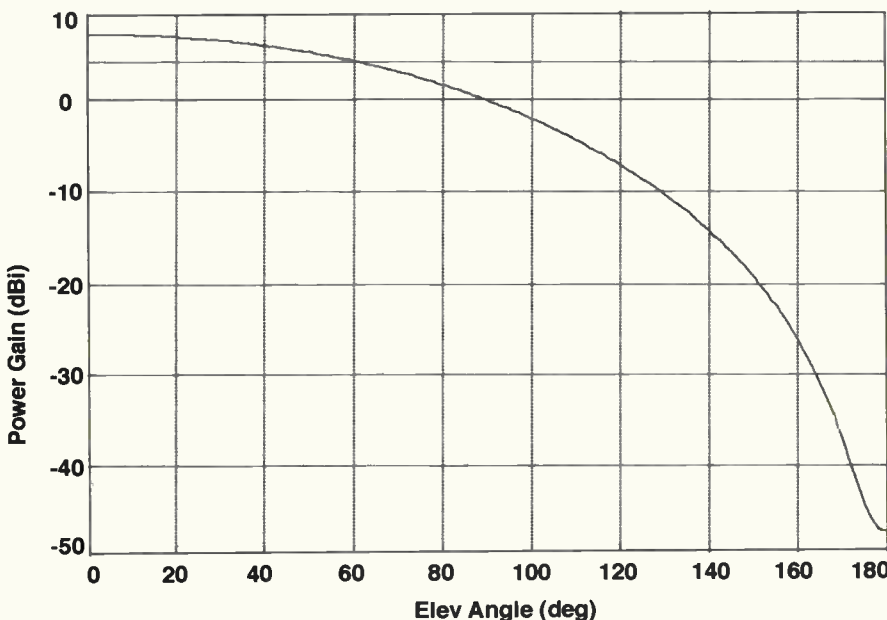
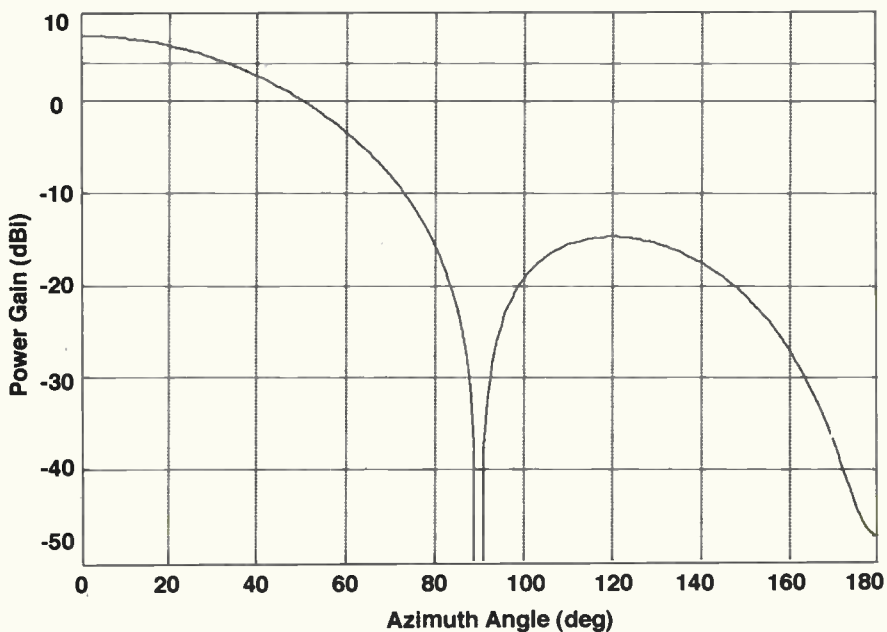
This particular figure of merit gives slightly more weight to the main lobe gain *G* than to the front-to-back ratio *FB*, and relatively less weight to the input standing-wave ratio *SWR*.

The algorithm designer is free to define any figure of merit that reflects the relative importance of different performance measures, including even non-electrical parameters such as cost or time to build, or amount of material required, and so on. This feature is a major distinction between genetic algorithm and deterministic optimisations, which frequently cannot optimise arbitrary figures of merit.

Other significant differences are that genetic algorithms produce *groups* of designs with similar figures of merit, instead of the single 'best' design, and they usually require much less computer time than deterministic algorithms.

The genetically optimised three-element Yagi has the following dimensions, in wavelengths at the design frequency F_0 :

Reflector length	0.530
Reflector radius	0.0008
Driven element length	0.478
Driven element radius	0.004
DE distance from REF	0.123
Director length	0.446
Director radius	0.0015
DIR distance from DE	0.106



eter can improve Yagi performance substantially³.

Free-space main lobe gain, front-to-back ratio, input impedance (resistance and reactance), and standing-wave ratio relative to 50Ω are plotted in Figs 1-4, respectively. These parameters were computed over a 10% band centred at the design frequency F_0 .

The azimuth and elevation patterns at F_0 appears in Figs 5a) and b). Key performance measures are shown in Table 2.

The band-centre gain of 7dBi is typical of well-designed three-element Yagis, and the optimised antenna's FB of 54dB is exceptionally good. For comparison, this FB figure is more than 16dB better than the best FB s of typical quarter-wave designs described in W2PV's treatise on Yagi antennas⁴ (see especially Fig. 2.9).

The optimised antenna also exhibits good FB bandwidth, with values exceeding 20dB from $0.97F_0$ to $1.017F_0$, which equates to 4.7%. The optimised Yagi is nearly resonant at F_0 at an input reactance of 3Ω capacitive, which is less than 10% of the input resistance.

From $0.95F_0$ to $1.015F_0$, a difference of 6.5%, the standing wave ratio is less than two. If desired, this antenna can be fed directly with 50Ω coaxial cable, eliminating the insertion loss introduced by a matching network or antenna tuner.

Table 2. Performance of the genetically designed Yagi.

Gain	FB	Z_{in}	SWR	HPBW
7dBi	54.2dB	$33.9-j3\Omega$	1.49	66° az, 122° el

Of course, a balun should be used to maintain feed system balance. But it would be interesting to build this antenna with and without a balun to see how much difference it makes.

For the 51MHz design, the standing-wave ratio is below two, and the FB is greater than 20dB, from 49.47 to 51.76MHz – a bandwidth of 4.5%. The lower band edge can be shifted up to 50MHz by increasing the design frequency to $F_0=51.55$ MHz and recalculating the dimensions. Note that the wavelength is computed as $299.7956/F_{MHz}$, which is more accurate than the commonly used formula $300/F_{MHz}$.

The optimised Yagi's E-plane azimuth pattern has a characteristic two-lobe structure with a deep broadside null. The -3 dB half-power beamwidth is 66° . The rear lobe is about 22dB down, which is quite low. The H-plane elevation pattern is plotted in Fig. 5b). It has a single, broad lobe with half-power beamwidth at 122° .

The genetically optimised, three-element Yagi is a very compact antenna that provides

excellent performance. This example illustrates that genetic algorithms can produce very good antennas indeed. Such algorithms are easily implemented on a pc and can provide significant advantages over deterministic techniques.

Communications engineers will probably hear more and more about the genetic design approach. It certainly merits serious consideration by designers who are interested in antennas.

References

1. Weile, D S, and Michielssen, E, 'Genetic Algorithm Optimisation Applied to Electromagnetics: A Review', *IEEE Transactions on Antennas and Propagation*, 45, 3, March 1997, p. 343.
2. Cohen, Nathan, N1IR, 'Antennae Exotica: Genetics Breeds Better Antennas', *Communications Quarterly*, Fall 1996, p. 55.
3. Formato, Richard A, K1POO, 'Improving Impedance Bandwidth of VHF/UHF Yagis by Decreasing the Driven Element L/D Ratio', *VHF Communications (UK)*, 26, Autumn, 3/1994, p. 142.
4. Lawson, James L, W2PV, 'Yagi Antenna Design', ARRL, Newington, CT, 1986.

LANGREX SUPPLIES LTD
 DISTRIBUTORS OF ELECTRONIC VALVES
 TUBES, SEMICONDUCTORS AND I.C.S.
 1 MAYO ROAD • CROYDON • SURREY CR0 2QP
 24 HOUR EXPRESS MAIL ORDER SERVICE ON STOCK ITEMS

PHONE 0181 684 1166 FAX 0181 684 3056

AZ31	£ p	EL86	2.75	PY500A	4.00	6BA7	5.00	6SK7	3.00
CBL31	£12.50	EL91	3.00	PY800	1.50	6BE6	1.50	6SL7GT	4.50
CL33	10.00	EL95	2.00	PY801	1.50	6BH6	2.50	6SN7GT	4.50
DY86/7	1.50	EL360	10.50	QOV02-5	12.00	6BK6	2.25	6SS7	3.00
EB8CC Mull	1.50	EL509	12.00	QOV03-10	5.00	6BN6	2.50	6U8A	1.50
E180F	3.50	EM34	15.00	QOV03-20A	15.00	6BQ7A	3.50	6V6GT	4.25
E810F	22.00	EM81	4.00	QOV06-40A	17.50	6BR7	6.00	6X4	3.00
E8BC0	2.00	EM84	4.00	QOV3-12	10.00	6BR8A	4.00	6X5GT	2.50
EB91	1.50	EM87	4.00	U19	10.00	6BS7	4.00	12AT7	3.00
EBF80	1.50	EM91 Mull	7.50	UABC80	1.50	6BW6	4.50	12AU7	3.00
EBF89	1.50	EY51	2.50	UBCA1	4.00	6BW7	1.50	12AX7	3.50
EBL31	15.00	EY86	1.75	UBF89	£1.50	6BZ6	2.50	12AX7A GE	7.00
ECC33	7.50	EY88	1.75	UCM42	4.00	6CA	2.00	12BA6	2.50
ECC35	7.50	Z280	3.50	UCM81	2.50	6CS	5.00	12BE5	2.50
ECC81	3.00	EZ81	3.50	UCLR2	2.00	6C86A	2.00	12BH7A GE	7.50
ECC82	3.00	GY501	3.00	UCLR3	3.00	6CD6GA	5.00	12BY7A GE	7.00
ECC83	3.50	GZ32 Mull	0.50	UF89	4.00	6CI6	3.75	12E1	15.00
ECC85	3.50	GZ34 GE	6.00	UL41	12.00	6CG7	7.50	12HG7/12GN7	6.50
ECC88 Mull	6.00	GZ37	6.00	UY41	4.00	6CH6	6.00	30P1L2	1.50
ECC91	2.00	KT61	10.00	UY88	2.25	6CW4	8.00	30P19	2.50
ECF80	1.50	KT66	10.00	VR105/30	2.50	6D6	5.00	300B(PH)	110.00
ECH35	3.50	KT88	10.00	VR150/30	2.50	6D6S GE	17.50	57Z8	70.00
ECH42	3.00	N78	0.00	Z759	25.00	6D6GB	12.50	805	50.00
ECH81	3.00	OA2	2.70	Z803U	25.00	6EAB	3.50	807	£75
ECL80	1.50	OB2	2.70	2D21	3.50	6EH5	1.85	811A	16.50
ECL82	3.00	CC3	2.50	3B28	15.00	6F6	3.50	812A	65.00
ECL83	3.00	OD3	2.50	ACR250B STC	55.00	6FQ7	£7.50	813	27.50
ECL86 Mull	3.50	PCF80	2.00	SRA9T	0.80	6G6	4.00	833A	85.00
ECL800	25.00	PCF82	1.50	5V4G	5.25	6GH6	3.00	866A	25.00
EF37A	3.50	PCF86	2.50	5V4G	4.00	6HS6	4.05	872A	20.00
EF39	2.75	PCF801	2.50	5Y3GT	2.50	6I5	3.00	931A	25.00
EF40	2.00	PCF802	2.50	5Z3	4.00	6I6	3.00	2050A GE	12.50
EF41	3.50	PCL82	2.00	5Z4GT	2.50	6I7	4.00	5751	6.00
EF42	4.50	PCL83	3.00	6AH6	4.00	6J86A GE	10.00	5763	10.00
EF80	1.50	PCL84	2.00	6AK5	1.50	6JEC	20.00	5814A	5.00
EF85	1.50	PCL85	2.50	6AL3	1.00	6JSC GE	20.00	5842	12.00
EF86	10.00	PCL86	2.50	6AN6	2.00	6K5GT	3.00	6080	7.50
EF91	2.00	PCL805	2.50	6AN5	5.00	6K7	4.00	514E8 GE	15.00
EF92	2.00	PD500	6.00	6AN8A	4.50	6K8	4.00	5550A GE	20.00
EF183	2.00	PL36	2.50	6AQ5	3.25	6L6G	10.00	6883B GE	16.00
EF184	2.00	PL81	1.75	6AR5	25.00	6L6GCSYL	12.50	7025 GE	7.00
EL32	2.50	PL82	1.50	6AS5	3.50	6L6GC Siemens	7.50	7027A GE	17.50
EL33	10.00	PL83	2.50	6AS7G	0.50	6L6GC GE	12.50	7199	25.00
EL34 Siemens	0.00	PL84	2.50	GAT5	2.00	6L7	3.50	7360	12.00
EL36	4.00	PL504	2.50	6AUSGT	5.00	6L6	20.00	7581A	15.00
EL41	3.50	PL508	5.50	6AUS	2.50	6LQ6	4.00	7586	15.00
ELL80	25.00	PL509/PL519	6.00	6AW8A	4.00	6M7	4.00	7587	23.00
EL81	5.00	PL802	6.00	6B7	4.00	6SA7	3.00	7868	12.00
EL84	2.25	PY81	1.50	6B8	4.00	6SC7	3.00		
EL84 Mull	6.00	PY88	2.00	6BA6	1.50	6SD7	2.50		
						6SI7	3.00		

Prices correct when going to press

OPEN TO CALLERS MON-FRI 9AM-4PM, CLOSED SATURDAY.
 OVER 6,000 TYPES AVAILABLE FROM STOCK. OBSOLETE ITEMS
 A SPECIALITY. QUOTATIONS FOR ANY TYPES NOT LISTED.
 TERMS: CWO/VISA/ACCESS. POST & PACKING: 1-3 VALVES £2.00,
 4-6 VALVES £3.00. ADD 17.5% VAT TO TOTAL INC. P&P.

CVC CHELMER VALVE COMPANY

If you need Valves/Tubes or RF Power Transistors e.t.c. ... then try us!

We have vast stocks, widespread sources and 33 years specialist experience in meeting our customers requirements.

Tuned to the needs of the Professional User

Chelmer Valve Company, 130 New London Road, Chelmsford, Essex CM2 0RG, England

44-01245-355296/265865
 Fax: 44-01245-490064

With the UK now committed to digital television on terrestrial, satellite and cable channels, **Pat Hawker** looks at the technology – discussing both its benefits and drawbacks.



Digital tv broadcasting

The BBC and ITC are now actively working towards an early launch of digital terrestrial television, or DTT for short.

Current viewers have a massive investment in analogue television receivers, many of which will last a good few years. Will they want to buy further equipment that will last them well into the 21st Century? Now is a good time to review the technology being held as opening a new era of multiple-choice television programming – and some of its inherent problems.

Unquestionably, the recent ETSI standards for digital video broadcasting, or dvb, represent an ingenious, if complex, means of squeezing many more programme channels into the available bandwidth. But you can take many of the claims made relating to the quality of digital tv broadcasting with a pinch of salt.

Picture quality will not be perfect, but subject to a new impairment caused when the data rate is reduced. As for wide-screen pictures, analogue PALplus has already been relegated to the back burner because British viewers are reluctant to accept 'letter-box' formats on 4:3 receivers.

Sound quality may be at compact disk levels, but then so is the current Nicam system. Picture resolution will be high too, but it is a pity that the millions spent on developing HD-MAC have largely been flushed down the drain along with the other MAC/packet systems.

Benefits of digital tv broadcasting

But we must put away the suspicion that dvb has been developed by a multitude of committees and may turn out to be a camel rather than a horse. The attraction of dvb to governments is the eventual freeing up of sellable vhf and uhf spectrum; to broadcasters dvb means extra channels available for pay-tv with a convenient conditional access system for terrestrial channels; for viewers, dvb will offer near unlimited 'choice' to those willing to pay subscriptions or pay-per-view. And for industry there will be the incentive of new set-top timers/decoder equipment that will be offered in advance of fully integrated terrestrial-satellite-cable receivers.

It is also worth noting that funding for the BBC will come from the Government

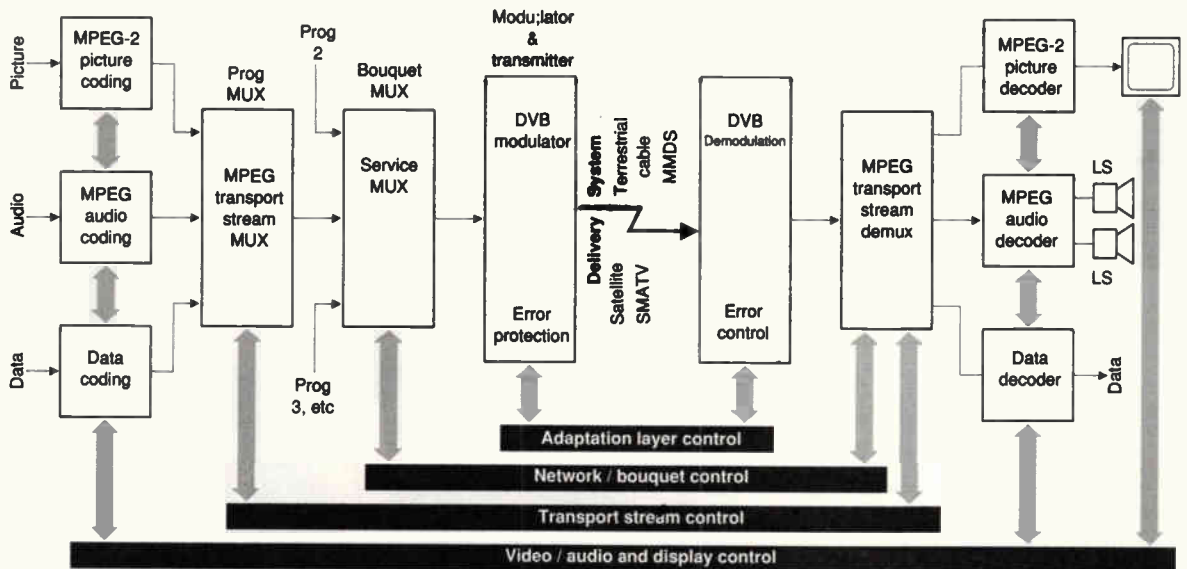
ordered sale of its transmitters to the US firm Castle Television for £244-million.

Background to digital tv

As early as 1992, authorities in many countries were beginning to accept that digital television broadcasting systems were the way forward. This meant the eventual demise of enhanced hybrid analogue/digital systems such as MAC/packet or HD-MAC for satellites. In addition, only limited use is likely to be made in the UK of PALplus. This system can provide wide-screen displays with a 16:9 aspect ratio on compatible terrestrial receivers. It also offers less cross-colour impairment than conventional PAL, but involves the unpopular 'letter box' display on traditional receivers designed for 4:3 aspect ratio. But then digital 16:9 will also involve 'letter box' until receivers with wide-screen picture tubes become the norm.

In the early 1990s, research work funded by IBA showed that cofdm, short for coded orthogonal frequency division multiplex, was a multi-carrier modulation system that could overcome the long recognised problem that multipath reception seriously affects high-

Fig. 1. Overall view of the European digital video broadcasting systems. Each delivery system provides a data container, best described as housekeeping (service information), and a multiplexed 'bouquet' comprising programmes and any other service offered by the provider.



speed digital data signals on terrestrial channels. When combined with bit-rate reduction, *cofdm* offered a realistic prospect of multiplexing a number of programmes within a single channel.

Earlier, in the 1980s, British and European engineers had shown that 216Mbit/s 625-Line component video, described in ITU-R Recommendation 601, could be reduced to about 34Mbit/s with virtually no degradation of picture quality. It could also be successfully applied to microwave and satellite contribution, as well as distribution links.

A turning point

Then, at IBC-1990 in Brighton, General Instruments demonstrated, using a short computer simulation, that its 'Digicipher' system held the promise that much greater bit-rate reduction factors seemed feasible by using complex digital signal processing that took

full advantage of the very large amount of redundancy in typical video material.

It was soon shown that such results were not confined to computer simulations. An ITU-R 601 216Mbit/s component bit stream can be reduced to 5Mbit/s or less, while still providing a picture quality subjectively no worse than analogue 625-line PAL.

A digital video broadcast project in Europe was formally set up in the autumn of 1993. It grew to contain over 200 members, representing broadcasters, programme production houses, transmitter companies, satellite operators, consumer electronics manufacturers, regulatory bodies and government representatives from over 25 countries.

The European Broadcasting Union in Geneva provided project management. In the USA, an advanced tv standard has been developed from a grand alliance based on the merger of several different proposals for advanced

tv. This standard describes a system capable of providing high-definition pictures within the standard American 6MHz terrestrial channels. But it differs from the standards stemming from the European DVB Project in not accepting the use of *cofdm*.

The aim of Project DVB has been to formulate, with the maximum degree of commonality, practical digital transmission specifications for all forms of programme delivery. These include satellite using the DVB-S service, cable using DVB-C, terrestrial systems involving DVB-T and satellite master-antenna tv, or SMATV with DVB-CS. A multi-media system, namely MMDS will use DVB-MS and have an interactive channel.

Dual subsystems

Two sub-systems common to all forms of delivery are service information, or SI, and fixed-format teletext, or DVBTXT. It is envisaged that a digital specification for an interactive channel will also be developed. All systems use the broadcast video and audio bit-rate compression systems of the Motion Picture Experts Group system MPEG.

It is claimed that much emphasis has been given to market requirements. This was not so with the earlier MAC/packet work, which reflected primarily the initiative of broadcast engineers.

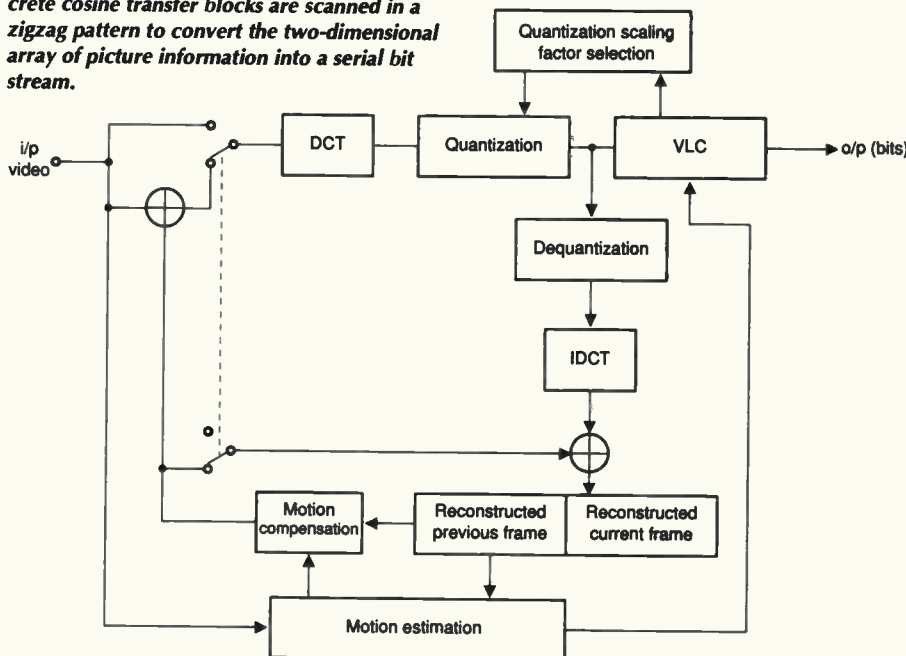
For each class of delivery system, appropriate ETSI specifications have been developed, linked, initially, to MPEG-2 bit-rate-reduction coding. Each delivery system provides a 'data container' with a multiplexed 'bouquet' of programmes and any other data services offered by the service provider. An overview of the DVB system is shown in Fig. 1.

MPEG-2 bit-rate-reduction

Initially a Working Group of ISO/IEC JTCl, MPEG began life in 1988 with the aim of defining standards for digital compression of video and audio signals.

The group's first task was to define a video coding algorithm for digital storage media – in particular cd rom. In 1993 this system,

Fig. 2. Simplified block diagram of an MPEG-2 encoder. After quantisation, 8 by 8 blocks of discrete cosine transfer blocks are scanned in a zigzag pattern to convert the two-dimensional array of picture information into a serial bit stream.



MPEG-1, was published in three parts as ISO/IEC 11172. It is restricted to non-interlaced video formats, primarily used for pc applications. MPEG-1 supports video coding at bit-rates under 1.5Mbit/s.

In 1990, MPEG began work on an algorithm capable of coding interlaced pictures directly, and suitable for high-quality applications at bit rates up to about 10Mbit/s. It was later extended to cover high-definition formats in the range of about 15-30Mbit/s. This system, MPEG-2, is specified in ISO/IEC 137132. It was published in 1994.

Programme-dependent bit-rate adaption is provided for in MPEG-2. For standard-definition 625-line broadcast tv with MPEG-2 bit-rate-reduction, cinema film requires a data rate of 2.5 to 4Mbit/s. Film with only 24 frames a second can look better than electronically-generated interlaced tv pictures at equivalent bit rates. Educational programmes are allocated 2-4Mbit/s, general programmes 3-7Mbit/s, sport 5-11Mbit/s and audio 64-256kbit/s.

It has been claimed that MPEG-2 coding can provide high quality pictures and sound with data rates as low as 1.5 Mbit/s. For transmission however, additional forward error correction bits, etc, need to be added. Further research into sophisticated signal coding algorithms is leading to systems such as MPEG-4. These will permit hdtv pictures to be transmitted in the American 6MHz terrestrial channels.

How does MPEG work?

Video bit-rate reduction, i.e. digital compression, removes redundant and less important information from a video signal prior to transmission. Then, the receiver reconstructs an approximation of the original images from the information reaching the decoder.

In practice, there are three main forms of redundancy and all are exploited in MPEG-2. First are spatial and temporal redundancies. Pixel values are not independent but are correlated with neighbouring pixels both within the same frame and across frames. This implies that for most images, the value of any pixel is predictable.

Second comes entropy redundancy. In any

non-random digitised signal, some code values occur more frequently than others. This enables shorter codes to be used for the more frequently occurring values. Compare this with Morse telegraphy, where frequently used letters have short symbols. The letter E for example is a single dot.

Lastly there is psycho-visual redundancy. By exploiting the limitations of the human eye and brain, information beyond the limits of spatial resolution – fine detail which the eye cannot resolve – and temporal resolution which is the limited ability of the eye to track fast-moving images.

For MPEG-2 an assemblage of compression techniques are used in practice. However, unlike for MPEG-1, reduction of the horizontal sampling rate is not advisable for luminance or chrominance signals. Nor is temporal sub-sampling. Nevertheless, the frequency of the vertical chrominance can be halved with MPEG-2 suitable for 4:2:0 as well as 4:2:2 and 4:4:4 component video.

Removing redundancy

There are two main methods of exploiting redundancy. In discrete-cosine transform, or dct, an orthogonal transform similar to a discrete Fourier transform assists the processing that removes spatial redundancy. It does so by concentrating signal energy into relatively few coefficients. With the second method, motion compensated interframe prediction is used to remove temporal redundancy. This technique is similar to differential pulse-code modulation, dpcm. An outline of a MPEG-2 encoder is shown in Fig. 2.

After quantisation, the 8 by 8 blocks of dct coefficients are scanned in a zigzag pattern to convert the two-dimensional array into a serial string. They are then coded by counting the number of zero coefficients preceding a non-zero coefficient. This is run-length encoding. Finally they are combined with the non-zero coefficients and coded as a variable-length code, or vlc.

The discrete cosine transform coefficient quantisation, the run-length coding and the variable-length coding processes produce a varying bit-rate. The variation depends on the

complexity of the picture information and the amount and type of motion in the picture.

To achieve the constant bit-rate needed for transmission, a buffer is required to smooth out the variations. To prevent overflow or underflow of this buffer, its occupancy is monitored with feedback applied to the coding processes to control the input.

An important feature is that the final bit rate at the output of the encoder can be freely varied; if this is reduced, the buffer will empty more slowly. The encoder compensates for this by making the dct coefficient quantisation coarser, reducing the quality of the decoded picture. Increasing the final bit rate improves the decoded picture quality. There is no requirement to lock input sampling rate to channel bit-rate or *vice versa*.

You should appreciate that this is only a bare outline of an extremely sophisticated bit-rate-reduction system which includes several methods for motion-compensation prediction. These involve both forward and backward prediction from other frames, or interpolation by averaging a forward and a backward prediction.

Where MPEG falls down

While MPEG-2 processing is well suited for the final distribution and broadcast transmission, it is far from ideal for contribution links. Here, further editorial processes, such as chroma keying, are likely to be required at the studio centre. For international satellite links etc an international 34Mbit/s standard has been agreed (ETS 300 174/ITU-T J81).

According to the ITC specification for UK television broadcasting, video encoding has to conform to ISO/IEC 13818-2 with the additional guidelines of ETSI-54. Mandatory video parameters include a frame rate of 25Hz and an aspect ratio of 4:3 or 16:9.

Mandatory audio parameters of ISO/IEC 13818-3 and guidelines ER 154 involve stereo at a sampling frequency of 48kHz with no pre-emphasis. Bit rates recommended for stereo are 256kbit/s and for joint stereo 192kbit/s.

The transport-stream multiplexing feature of MPEG allows a large number of video, audio and data services to be merged into a single

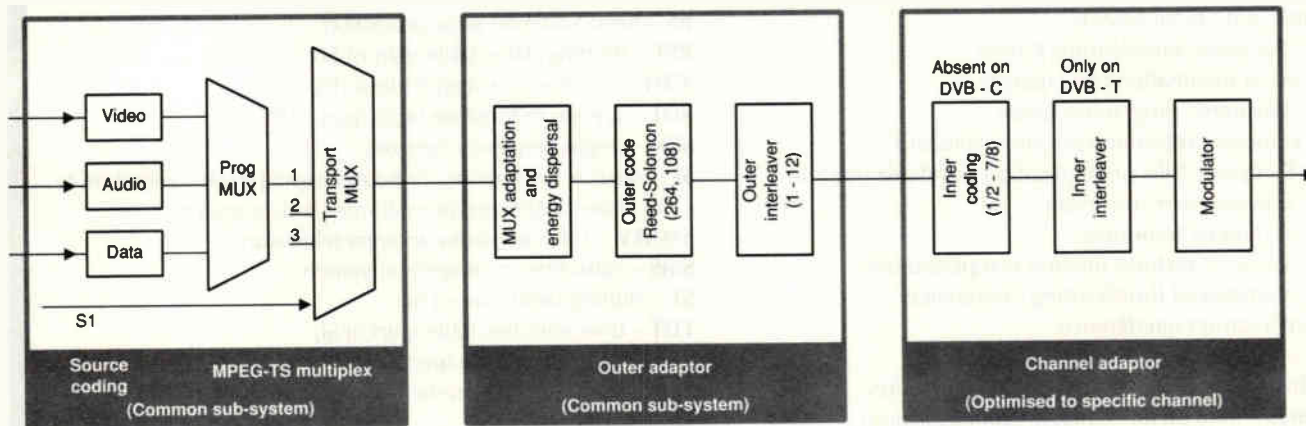


Fig. 3. Basic transmission chain for digital-video broadcast systems, showing how the error protection is added to output from the MPEG transport stream multiplexer. The first two blocks are common to all channels. The channel adaptor is optimised depending on the type of information that the channel is carrying.

transmission stream. Packets are 188 bytes long and delimited by a sync byte.

Since no error protection is provided rugged forward error protection must be added to provide as near possible an error-free data stream to the receiver decoder. Figure 3 shows how the MPEG-2 data stream is further encoded to provide the degree of error protection required by the various delivery systems.

In brief, all first-generation Project DVB systems use the common MPEG-2 transport-stream multiplex. They also use a common service information system providing the decoder with details of the transmission system, and the services being broadcast. All systems incorporate common Reed-Solomon forward error correction system. Where needed by the delivery system, they also have a common punctured convolutional code forward error correction system. Digital video broad-

cast service information – mandatory and optional – is specified in prETS 300 468, plus guidelines on its implementation and use.

MPEG housekeeping

Figure 3 shows how error protection is added to the MPEG transport stream multiplex with an outer adapter which is common to all systems and then a channel adapter optimised to the specific delivery channel. The programme-specific information within the service information includes the programme association table, programme map table and the conditional access table.

Service information also conveys the packet and transport packet layer guidelines, the time and date and three tables. The network information table represents the actual delivery system, the service description table is the actual delivery stream) and the event infor-

mation table describes present/following events only.

Transmission parameter signalling, or tps, in effect tells the receiver which of the many options is in use. Since broadcasters are unlikely to change the modulation options frequently however, it is not essential to decode this information. Broadcasters are more likely to re-configure their multiplex to carry more or fewer programmes by changing the bit rates allotted to individual channels.

Pilot information is provided in two forms. A few carriers – called continual pilots – always have defined amplitudes and phases and are used primarily for synchronisation. Additional 'scattered pilots' are inserted in a regular pattern to facilitate coherent demodulation. ■

In a subsequent article, Pat will describe digital delivery systems.

Digital television glossary

ACATS – Advisory Committee on Advanced Television Systems (USA)

ATV – advanced television

BAT – bouquet association table (part of SI)

BER – bit error rate

B-pictures – bidirectionally predictive pictures (motion compensation)

BRR – bit-reduction rate.

CA – conditional access

CAT – conditional-access table (part of SI)

COFDM – coded orthogonal frequency-division multiplexing

CPE – common phase error

DAB – digital audio broadcasting

DBPSK – differential binary phase-shift keying.

DCT – discrete cosine transform

DPCM – differential pulse-code modulation

DTT – digital terrestrial television

DVB – digital video broadcasting, suffixed S for satellite, C for cable, T for terrestrial, CS for SMATV, TXT for fixed-format teletext and MS for MMDS.

EBU – European Broadcasting Union

EIT – event information table (part of SI)

EPG – electronic programme guide

ETS – European Telecommunication Standard

ETSI – European Telecommunication Standards Institute

FEC – forward error correction

FFT – fast Fourier transform

GOP – group of pictures (motion compensation)

IBC – International Broadcasting Conference

ICI – inter-carrier interference

IDCT – inverse discrete cosine transform

IEC – International Electrotechnical Commission

I-pictures – intra pictures (motion compensation)

IRD – integrated receiver decoder

ISO – International Standardisation Organisation

ITU – International Telecommunication Union

MMDS – multichannel, multipoint distribution system, alternatively, multipoint microwave distribution system

MPEG – video bit-rate reduction systems determined by the Moving Picture Experts Group

NIT – network information table (part of SI)

OFDM – orthogonal frequency division multiplexing

PAT – programme association table (part of SI)

PMT – programme map table (part of SI)

P-pictures – predictive pictures

PPV – pay-per-view

PRBS – pseudo random binary sequence

PSI – programme-specific information (part of SI)

PSP – programme service provider

QAM – quadrature amplitude modulation

QEF – quasi-error-free

QPSK – quadrature phase-shift keying

RLC – run-length coding

RS – Reed Solomon error protection

RST – running status table (part of SI)

SDH – synchronous digital hierarchy

SDT – service description table (part of SI)

SFN – single-frequency network

SI – service information, or housekeeping details added on to the video, audio and/or multi-media data stream

SMATV – satellite master antenna television

SMS – subscriber management system

ST – stuffing table (part of SI)

TDT – time and date table (part of SI)

TOT – time offset table (part of SI)

TPS – transmission-parameter signalling

TS – transport stream

VLC – variable-length coding

HART

The Home of *Hi-Finesse*. Its not what you do, its HOW you do it that counts!.

Hart Audio Kits and factory assembled units use the unique combination of circuit designs by the renowned John Linsley Hood, the very best audiophile components, and our own engineering expertise, to give you unbeatable performance and unbelievable value for money.

We have always led the field for easy home construction to professional standards, even in the sixties we were using easily assembled printed circuits when Heathkit in America were still using tagboards! Many years of experience and innovation, going back to the early Dinsdale and Bailey classics gives us incomparable design background in the needs of the home constructor. This simply means that building a Hart kit is a real pleasure, resulting in a piece of equipment that not only saves you money but you will be proud to own.

Why not buy the reprints and construction manual for the kit you are interested in to see how easy it is to build your own equipment the HART way. The FULL cost can be credited against your subsequent kit purchase.

'AUDIO DESIGN' 80 WATT POWER AMPLIFIER.



This fantastic John Linsley Hood designed amplifier is the flagship of our range, and the ideal powerhouse for your ultimate hi-fi system. This kit is your way to get UK performance at bargain basement prices. Unique design features such as fully FET stabilised power supplies give this amplifier World Class performance with startling clarity and transparency of sound, allied to the famous HART quality components and ease of construction. Standard model comes with a versatile passive front-end giving 3 switched inputs, with ALPS precision "Blue Velvet" low-noise volume and balance controls, no need for an external preamp. Construction is very simple and enjoyable with all the difficult work done for you, even the wiring is pre-terminated, ready for instant use! All versions are available with Standard components or specially selected Super Audiophile components and Gold Plated speaker terminals and all are also available factory assembled.

- K1100 Complete STANDARD Stereo Amplifier Kit, £415.21
- K1100S Complete SLAVE Amplifier Kit, £353.62
- K1100M Complete MONOBLOC Amplifier Kit, £271.20
- RLH11 Reprints of latest Amplifier articles £1.80
- K1100CM Construction Manual with full parts lists £5.50

ALPS "Blue Velvet" PRECISION AUDIO CONTROLS.



Now you can throw out those noisy ill-matched carbon pots and replace with the famous Hart exclusive ALPS 'Blue Velvet' range components only used selectively in the very top flight of World class amplifiers. The improvement in track accuracy and matching really is incredible giving better tonal balance between channels and rock solid image stability. Motorised versions have 5v DC motor.

MANUAL POTENTIOMETERS

- 2-Gang 100K Lin, £15.67
- 2-Gang 10K, 50K or 100K Log, £16.40
- 2-Gang 10K Special Balance, zero crosstalk and zero centre loss, £17.48

MOTORISED POTENTIOMETERS

- 2-Gang 20K Log Volume Control £26.20
- 2-Gang 10K RD Special Balance, zero crosstalk and less than 10% loss in centre position £26.98

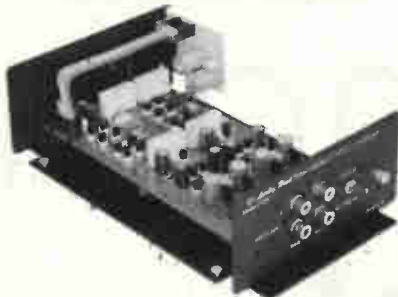
TOROIDAL MAINS & OUTPUT TRANSFORMERS for EL34, 32W VALVE AMPLIFIER

Special set of toroidal transformers, 2 output & 1 mains for the "Hot Audio Power" valve amplifier design described in the Oct. 1995 issue of "Wireless World". Total Wt 4.8Kg. Special price for the set. £99. Post £8
RJM1. Photocopies of the Article by Jeff Macaulay. £2

PRECISION Triple Purpose TEST CASSETTE TC1D.

Are you sure your tape recorder is set up to give its best? Our latest triple purpose test cassette checks the three most important tape parameters without test equipment. Ideal when fitting new heads. A professional quality, digitally mastered test tape at a price anyone can afford.
Test Cassette TC1D. Our price only £9.99

SHUNT FEEDBACK PICKUP PREAMPLIFIER



If you want the very best sound out of vinyl discs then you need our high quality preamplifier with Shunt Feedback equalisation. The K1450 also has an advanced front end, specially optimised for low impedance moving coil cartridges as well as moving magnet types. Selected discrete components are used throughout for ultimate sound quality. The combination of John Linsley Hood design, high quality components and an advanced double sided printed circuit board layout make this a product at the leading edge of technology that you will be proud to own. A recent review in "Gramophone" magazine endorsing this view. Bought in kit form our step by step instructions it is very easy and satisfying to assemble, or you can buy a factory assembled version if you wish.

- This magnificent kit, comes complete with all parts ready to assemble inside the fully finished 228 x 134 x 63mm case. Comes with full, easy to follow, instructions as well as the Hart Guide to PCB Construction, we even throw in enough Hart Audiograde Silver Solder to construct your kit!
- K1450 Complete Kit £116.58
- K1450SA Audiophile Kit £138.94
- A1450SA Factory assembled Audiophile unit £188.94

"CHIARA" HEADPHONE AMPLIFIER.



Highest quality, purpose designed, 'single ended' class 'A' headphone amplifier for 'stand alone' use or to supplement those many power amplifiers that do not have a headphone facility. Easy installation with special signal link-through feature, the unit uses our 'Andante' Ultra High Quality power supply. Housed in the neat, black finished, Hart minibox it features the wide frequency response, low-distortion and 'musicality' that one associates with designs from the renowned John Linsley Hood. Volume and balance controls are Alps "Blue Velvet" components. Very easy to build, or available factory assembled, the kit has very detailed instructions, and comes with Hart audiograde silver solder. A valuable personal listening option and an attractive and harmonious addition to any hi-fi system.

- K2100 Complete Standard Kit £112.50
- K2100SA 'Series Audiophile' Kit with selected audiophile components £115.46
- A2100SA 'Series Audiophile', Factory Assembled £115.46
- CM2100 Construction Manual £2.50

"Andante" Linear Technology AUDIOPHILE POWER SUPPLIES

The HART "Andante" series power supplies are specially designed for exacting audio use requiring absolute minimum noise, low hum field and total freedom from mechanical noise. Utilising linear technology throughout for smoothness and musicality makes it the perfect partner for the above units, or any equipment requiring fully stabilised $\pm 15v$ supplies. There are two versions, K3550 has 2 $\pm 15v$ supplies and a single 15v for relays etc. K3565 is identical in appearance and has one $\pm 15v$. Both are in cases to match our "Chiara" Headphone Amplifier and our K1450 "Shunt Feedback" Pickup preamp.

- K3550 Full Supply with all outputs £94.75
- K3565 Power Supply for K1450 or K2100 £84.42
- A3550 Factory Assembled Full Supply £147.25

SPEAKER DESIGN SOFTWARE.

VISATON "Speaker Pro 6" is a complete speaker design program for use on IBM machines. Covers cabinet and crossover design and contains a full expandable database of drive units. Earning a "most recommendable" accolade it tests this program is ideal for the professional speaker builder or serious audiophile.

- 0303 Speaker Pro 6. 3.5" Disk £45.51
- 0309 Demo Version with Database £9.28

SPEAKER DAMPING MATERIALS

Polyester Wool and Pure Lambs Wool both have optimal damping properties and are pleasant to handle. Standard 125g bag is sufficient for 20 litres enclosure volume.

- 5070 Polyester Wool, 125g £3.20
- 5069 Pure Lambs Wool, 125g £6.73

ROARING SUBWOOFER.

A full revised kit will be available soon for this excellent and imaginative design from Russel Bredon (WW Feb.97). The latest design will use the 30mm maximum cone displacement of the 10" VISATON GF250 Driver to give even better performance at slightly reduced cost. Featuring a rubber suspended fibreglass cone, extended pole plate, vented magnet, Kapton carrier and dual 4ohm voice coils the GF250 is unbelievably good value at only £111.45 each.

SPECIAL OFFER! SOLENOID CONTROLLED FRONT LOAD CASSETTE DECK SFL800

High quality (0.08%WtF) cassette mechanism with capability of using standard or downstream monitor R/P head. Offers all standard facilities under remote, logic or software control. The control requirements are so simple that for many applications not needing all functions manual switches will suffice. Power requirements are also simple with 12v solenoids and 12v speed controlled Motor, total power requirement being under 300mA. Logic control and wiring circuits are included free with each deck.
SFL800 Deck with Standard stereo head £29.50
SFL800D Fitted with High Quality Downstream monitor head. £44.90 (The Head alone is normally over £60!)

HART TECHNICAL BOOKSHELF

Try us for:- Bigger Range of Books, Better Prices, NO "28 Day Wait"

- "AUDIO ELECTRONICS" John Linsley Hood £18.99*
- "THE ART OF LINEAR ELECTRONICS" John Linsley Hood, 1994 £16.95*
- "THE ART OF ELECTRONICS" Horowitz & Hill £35.00*
- "DIGITAL AUDIO AND COMPACT DISC TECHNOLOGY" 3rd.Edn. 0-240 51397 5 £19.95*
- "INTRODUCING DIGITAL AUDIO CD, DAT AND SAMPLING" ISBN 1870775 22 8 £7.95
- "ACTIVE FILTER COOKBOOK" Don Lancaster £19.95
- "THE ART OF SOLDERING" 0-85935-324-3, 0 £3.95
- "TOWERS' INTERNATIONAL TRANSISTOR SELECTOR" 0-572-01062-1 £19.95*
- "AUDIO" F.A.Wilson. BP111 £3.95
- "HOW TO USE OSCILLOSCOPES & OTHER TEST EQUIPMENT" R.A.Penfold. BP267 £3.50
- "THE HART PRINTED CIRCUIT BOARD CONSTRUCTION GUIDE" £2.50
- "A SIMPLE CLASS A AMPLIFIER" J.L.Linsley Hood M.I.E.E. 1969. RLH12 £2.75
- "CLASS-A POWER" Single Ended 15W Amp. J.L.Linsley Hood M.I.E.E. 1996. RLH13 £2.50

LOUDSPEAKERS; THE WHY AND HOW OF GOOD REPRODUCTION. G.Briggs. 1949.

- "THE LOUDSPEAKER DESIGN COOKBOOK" Vance Dickason, (5th Edn.) £23.95*
- ELECTROSTATIC LOUDSPEAKER DESIGN AND CONSTRUCTION Ronald Wagner BKT6 £15.95
- "THE ELECTROSTATIC LOUDSPEAKER DESIGN COOKBOOK" Roger P.Sanders, 1995 £24.95
- "BULLOCK ON BOXES" Bullock & White £10.95
- "AN INTRODUCTION TO LOUDSPEAKERS & ENCLOSURE DESIGN" V. Capel. BP256 £3.95
- "LOUDSPEAKERS FOR MUSICIANS" BP297 £3.95
- "THEORY & DESIGN OF LOUDSPEAKER ENCLOSURES" J.E.Benson £21.95
- "QUICK & EASY TRANSMISSION LINE SPEAKER DESIGN" Larry D.Sharp £8.95
- "THE COUPLED CAVITY HANDBOOK" David Purton £4.90
- "VISATON. HOME HI FI CATALOGUE." Full Specifications and Thiele Small Data on all Drive Units £4.50
- "VISATON. CAR HI FI CATALOGUE." In car guide £3.50
- "VISATON. CABINET PROPOSALS" Book 1. IN GERMAN £6.50
- "VISATON. CABINET PROPOSALS" Book 2. IN GERMAN £6.50
- "SPEAKER PRO 6." VISATON Cabinet Design Software. £45.51
- "SPEAKER PRO 6." Demo Version with drive unit database £9.28

- "VALVE AMPLIFIERS" Morgan Jones, 1995/6 £24.50
- THE VTL BOOK David Manley 1994. BKVT1 £17.95
- MULLARD TUBE CIRCUITS FOR AUDIO AMPLIFIERS BKA27 £11.95
- "THE WILLIAMSON AMPLIFIER." 0-9624-1918-4 £6.95
- AN APPROACH TO AUDIO FREQUENCY AMPLIFIER DESIGN. GEC 1957 £17.95
- AUDIO ANTHOLOGIES, articles from Audio Engineering. Six volumes covering the days when audio was young and valves were king! BKA3/1 to 6. All £12.95 each
- "THE RADIOTRON DESIGNERS HANDBOOK" (CD) £49.00
- "PRINCIPLES OF ELECTRON TUBES" H.D.Reich P.H.D. £25.95
- "POWER AMP PROJECTS" Anthology, 1970-1989. £15.50
- "WORLD TUBE DIRECTORY" 1996-7 Sourcebook of valve related products £5.95
- Fuller descriptions of the contents of all our books is given in our full catalogue, price £4.50

Postage on all books, unless starred, is only £2 per book, maximum £4.50 for any number, any size. Starred items are heavy books costing £3.50 to send.

Don't forget No waiting at HART! All listed books are normally in stock! Just ring with your Credit Card Number for instant despatch!

POSTAGE on UK Orders up to £20 is £2. Over £20 is £4.50.

OVERSEAS Please Enquire.

Fuller Details of ALL kits are given in our List, FREE on request.

Send for Your FREE copy of our LISTS

24 Hr. ORDERLINE 01691 652894 Fax. 01691 662864

All Prices include UK/EC VAT.

CIRCLE NO. 120 ON REPLY CARD

HART

HART ELECTRONIC KITS LTD.
1 Penylan Mill, OSWESTRY,
Shrops. SY10 9AF.
UK

Changing times

For very little outlay, Ed Buckley's atomic clock interface takes the rather unfriendly serial data from an MSF receiver module and turns it into an RS232 time and data stream using a Basic Stamp. Output is a bcd data stream containing year, month, date, day, hour and minutes.

The *Basic Stamp* is a versatile, easy to programme microcontroller. As well as a stand alone unit the *Stamp* is also a very handy interface device- reading in non-standard data, performing some manipulation and then passing the data on in a more usable format.

The following design illustrates this function by combining a *Stamp 1* module with a readily available atomic clock module. To finish up, I will then describe how you can have your cake and eat it too - achieve low software development time by using the *Stamp 1* and low production costs by using a standard *PIC*.

Design overview

We recently needed to fit a data logger to a series of truck-trailers. The data needed time stamping - no pun intended - but there was a serious risk of interruption of power to the real-time clock module.

The obvious solution was to incorporate an operator keypad to allow for clock resetting. As well as being expensive, this solution allowed the opportunity for operator error.

So we decided to look for a different solution. After looking at the atomic clock module

now available, we decided to go down this route. Costs would be about the same as a keypad interface, but this alternative has the advantage that it is fully automatic.

Atomic clock summary

Atomic clock modules were featured in *Electronics World* March 1996. Here I will summarise the important features.

The off-air data stream is repeated every minute. High speed data is sent in the first 17 seconds, followed by null data that can be discarded. Next, low speed data is transmitted at 1bit/s. There is always a unique data format at the end of the minute period, which is 0111110₂. Data timing is shown in Fig. 1 and the minute's data format in Table 1.

The circuit diagram with Stamp/Clock hook-up is shown in Fig. 2.

Writing the software

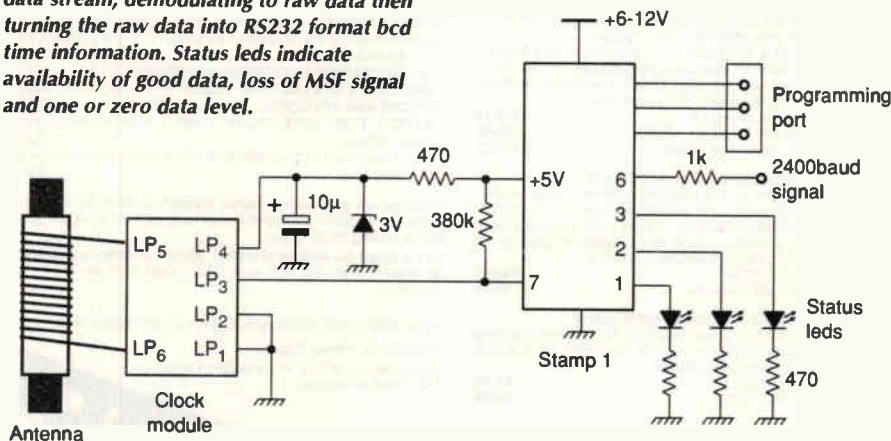
For our application, we require a burst of correct time data at 2400baud once a minute. The main system processor - a *Stamp 2* in this case - polls the signal line from the *Stamp 1* clock module. If valid data is present, it updates the system real-time clock.

The *Stamp 1* interfacing with the atomic clock is dedicated to reading and checking the validity of the incoming radio data. It only transmits the data if it proves valid.

We envisaged that the main problem would be loss of radio signal as the trailer moved around. For this reason the software always counts the number of data bits received from the last required data set until the unique format byte is received - in our case seven. If the counter is anything but seven, then a bit has been lost or found, the data is suspect and there is no transmission to the main system.

List 1 is the program listing. The input and output pins are allocated names to ease programme tracing and ram space allocated to the programme variables. The *Stamp 1* has up to 14 bytes of ram which may be addressed as bytes, for example b₃ or b₇, or words, as w₀ or

Fig. 1. Complete circuit for receiving the MSF data stream, demodulating to raw data then turning the raw data into RS232 format bcd time information. Status leds indicate availability of good data, loss of MSF signal and one or zero data level.



w_3 , where $w_3=b_6+b_7$. Further, two bytes may be addressed by their individual bits, that is bytes b_0 and b_1 provide bits bit_0 to bit_{15} .

The `dirs` statement sets the pins to either input if zero or output if logic one; the msb comes first.

We initially look for the 0111110_2 signature by reading the individual data bits using the `Get_bit` routine into the variable `signal`. The variable `counter` is incremented every time a new bit is read.

Once the signature has been received we now know where we are and proceed to 'continue' where the `good_data` flag is set to false. Here we check to see if we have a good data set by looking at `counter`. If `counter` is does not hold seven, then the data is bad. If the counter does hold seven then the data is good and the `good_data` flag is set to true. This condition allows transmission of the time data ten times during the fast data period at the beginning of the minute period.

Now begins the slow speed data section. The first 16 seconds are unused and discarded. Next we log the year, month, day of month, day of week - which we discard - hour of day and minute.

Now the program returns to the beginning. If all is well the next eight data bits should be the unique signature and counter should return seven to allow transmission.

Most of the grunt work is handled by two subroutines - `Get_bit` and `Read_convert`.

Get-Bit. `Get_bit` decodes the data from the atomic clock module.

The data falling edge is first detected. Once detected, the programme pauses for 150ms before reading the data - if logic one is returned the data is zero and if zero, a one is returned. Note that the clock gives inverted data, which we correct in the line `bit0=clk+1`. The program then waits a further 200ms to ensure the clock data is in the stable high portion of its cycle before continuing.

Read_convert. At the end of each chunk of received data we take the opportunity to convert it into a decimal and then a binary-coded decimal format for easy reading by the system processor. Our main system clock uses bcd format so using bcd minimises the calculations later on.

Rounding up

To aid fault finding and add value, we included several leds - the i/o pins were there unused so why not spend 15p? The three leds have the following functions.

- `Sync_flag` led is on when the `good_data` flag is set, ie the previous minute's data was good.
- `Bit_read` flashes every two seconds - a stable on or off here indicates loss of incoming signal.
- `Data_bit` indicates whether the data bit received was a one or zero data.

`Check_sum` is a byte variable. It is cleared every minute and all data is added to give a

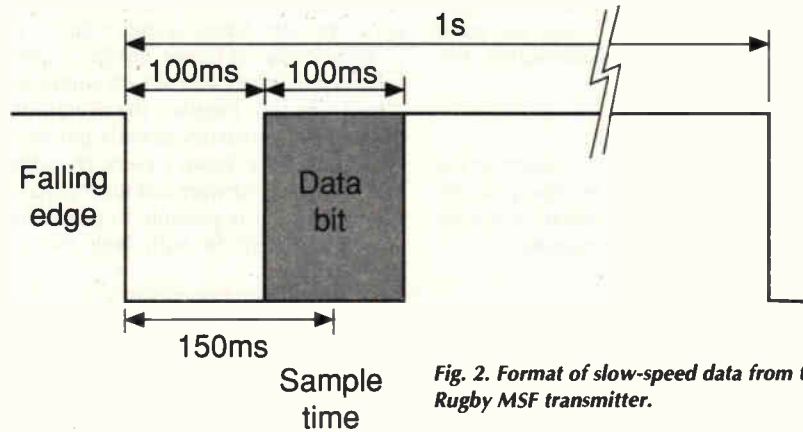


Fig. 2. Format of slow-speed data from the Rugby MSF transmitter.

Table 1. Time telegram of MSF transmitter - binary code for seconds 17 to 30 and data for March 1996. Note that each second value is one or zero. A one in second 17 for example represents 80 and a one in second 18 represents 40.

Second	Function	Value	Detail
0	Fast code	Not used in modules	
1	DUT1 code	Not used in modules	
2-16	-		
17	year (tens)	80	year 00-99, bcd
18	year (tens)	40	
19	year (tens)	20	
20	year (tens)	10	
21	year (units)	8	
22	year (units)	4	
23	year (units)	2	
24	year (units)	1	
25	month (tens)	10	month 01-12, bcd
26	month	8	
27	month	4	
28	month	2	
29	month	1	
30	day of month (tens)	20	day of month, bcd
31	day of month (tens)	10	
32	day of month	8	
33	day of month	4	
34	day of month	2	
35	day of month	1	
36	day of Week	4	day of week 1-7, bcd
37	day of Week	2	
38	day of Week	1	
39	hour (tens)	20	hour 00-23, bcd
40	hour (tens)	10	
41	hour (units)	8	
42	hour (units)	4	
43	hour (units)	2	
44	hour (units)	1	
45	minute (tens)	40	minute 00-59, bcd
46	minute (tens)	20	
47	minute (tens)	10	
48	minute (units)	8	
49	minute (units)	4	
50	minute (units)	2	
51	minute (units)	1	
52	always set to '0'	0	
53-58	always set to '1'	1	
59	always set to '0'	0	

resulting checksum which is used to detect errors between the Stamp 1 and the main system processor – unsophisticated but works.

What about the cake?

We have demonstrated the versatility of the Stamp 1 as an interface. The Stamp scores over raw PICs in terms of speed of producing and debugging a simple programme.

If the application only requires a small number of units the Stamp is fine, either in its IC or discrete chip set format. For larger numbers however, the costs start to look a little heavy.

Realising this, Parallax, the manufacturers of the Basic Stamp has recently introduced a neat solution for Stamp 1 users. By using the latest Stamp 1 software and the Parallax PIC programmer, it is possible to programme a standard PIC16C58 with both the Stamp

interpreter and your programme. This gives low-cost development coupled with low cost production.

This system only works with the Stamp 1, 16C58 and Parallax's programmer, but it is a very useful tool for those quickie programmes that will fit into a Stamp 1. ■

Galleon, distributor of the clock modules, can be reached on 0121 359 0981.

List 1. Stamp 1 program to read and decode the Rugby MSF time clock.

```

MSFCLCK.BAS
Milford Instruments Original version dated March 1997

Stamp decodes the one second pulses using Get_bit and
keeps adding them to signal until the sync byte is received.
First 17 seconds are ignored and remainder are clocked into
relevant bytes. Results are converted to BCD format before
storing in bytes. Time is only transmitted at the start of
the minute - if data is judged to be OK. Program counter
holding number of seconds from last valid time data
until sync byte is received.. should be 7.

Symbol clk      =pin7  'clock signal on pin 7
symbol rs232    =6     'rs232 signal on pin 6
symbol signal   =b1    'byte to receive data
symbol counter  =b11   'general counter variable
symbol good_data =bit1  'good time message flag, 0=false
symbol checksum =b7    'data checksum variable
symbol sync_flag =pin3  'in sync led
symbol bit_read  =2     'data bit received led
symbol data_bit  =pin1  'data bit rec. led, on for log. 1

dirs=%01001110  'set up the pin directions

'First look for the 01111110 signature
start:
counter=0
signal=0
loop:
gosub get_bit          ' go and get a bit
signal=signal*2+bit0   ' add it to signal
if signal=%01111110 then continue 'Sync byte received?
' continue if not and increase counter by one
counter=counter+1
goto loop

continue:              ' sync byte now received
good_data=0            ' reset valid data flag
if counter<>7 then skip1 'check that we've kept in step
'if good data captured then set flag
good_data=1
skip1:
counter=0
sync_flag=good_data   ' light the in_sync led

'Now send the good data transmission whilst waiting to get
'past the fast code section at the start of the minute
'Total loop period approximately 1.4s
for counter=1 to 10   'send the good data at min.start
if good_data<>1 then loop2 'check for good data flag
'Transmit if good data
serout rs232,n2400, ("T",b2,b3,b4,b5,b6,b7)
loop2:
bit3=good_data+1
b9=bit3*35+100
pause b9             'if not jump to here
next

'now discard the first 16 seconds of info
for counter=1 to 16
gosub get_bit
next

'Now start to read wanted data
'Reset the checksum variable
checksum=0
'Now read the year data
b8=7

gosub read_convert
b2=b10               'result in b10 written to b2
checksum=checksum+b2

'Now get the Month
b8=4
gosub read_convert
b3=b10               'result in b10 written to b3
checksum=checksum+b3

'Now get day of month
b8=5
gosub read_convert
b4=b10               'result in b10 written to b4
checksum=checksum+b4

'Now get the day of the week - and discard
b8=2
gosub read_convert

'Hour of Day
b8=5
gosub read_convert
b5=b10               'result in b10 written to b5
checksum=checksum+b5

'And the Minute reading
b8=6
gosub read_convert
b6=b10               'result in b10 written to b6
checksum=checksum+b6

goto start           'return for the next minute

'=====
'                               Sub-Routine to retrieve a bit
'=====

Get_bit:
Marker:
if clk=0 then read_bit          'detect falling
edge
goto marker

read_bit:
pause 150                       'wait until the
middle of the A bit
toggle bit_read
bit0=clk+1                       'read the value on
clk into bit0
data_bit=bit0
pause 200
return

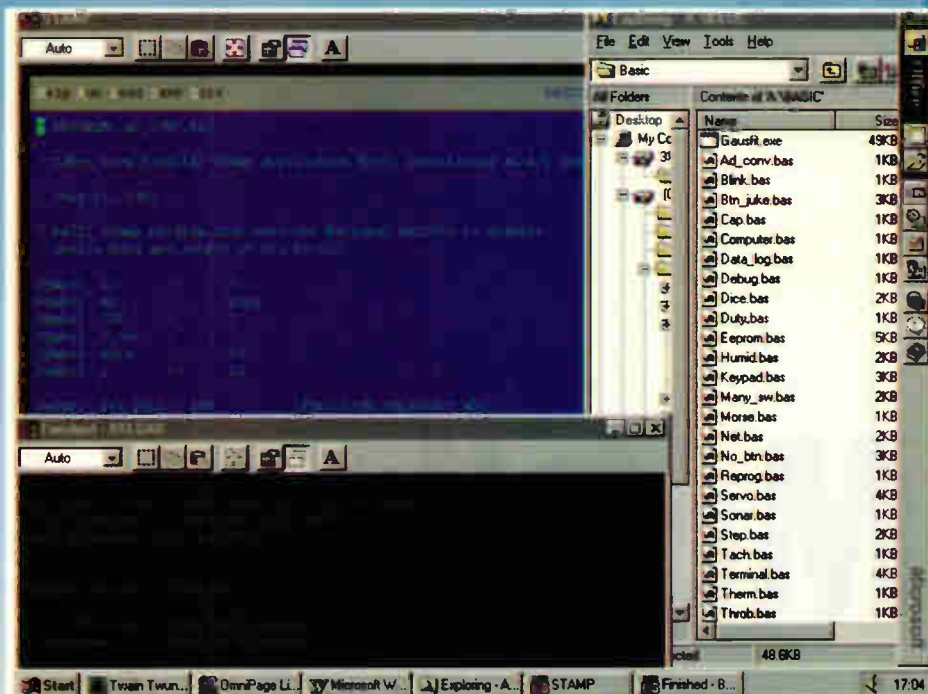
'=====
'                               Read and Convert Routine
'=====

Read_convert:
b9=0                             'Clear b9
for counter= b8 to 0 step-1      'one bit at a time
gosub get_bit
lookup counter, (1,2,4,8,10,20,40,80),b10 'Get the
appropriate scalar
b9=b10*bit0+b9                   'Convert to true decimal
next
b10=b9/10*16                     'now convert to
bcd- first the high byte
b10=b9//10+b10                   'now add the low byte
return
    
```


Reduce your controller application design time and get a 20% EW reader discount

The phenomenal rise in popularity of PIC microcontrollers is evidence that many designers rate ease of use and low cost ahead of device sophistication. In terms of ease of use, the Basic Stamp goes a step further by allowing you to program a microcontroller in familiar Basic code via a pc's COM port.

Simply hook the chip to your pc, download the Basic code into the Stamp's memory, and watch the Stamp's i/o lines follow your code. To make the Stamp do something else, just load new code.



Until 31 October, Milford Instruments is offering *Electronics World* readers an exclusive 20% discount on both Stamp 1 and Stamp 2 development kits. This makes the Stamp 2 only £99 exclusive instead of £119 and the Stamp 1 £79 as opposed the usual £99.

Both development kits include programming software pack, programming cables, project board, manuals including application examples and either Stamp 1 or Stamp 2, depending on the kit.

Overseas readers can also obtain this discount but details vary according to country. Please ring, contact fax Milford at the address on the coupon, or fax on 01977 681465 or telephone on 01977 683665.

Features of Basic Stamp

- Basic language includes instructions for serial i/o, pwm, potentiometer input, pulse measurement, button debounce, tone generation, etc.
- Stamp 1 has 8 i/o lines, Stamp 2 has 16, each programmable as an input or output. Each can sink 25mA and source 20mA.
- Programs are stored in EEPROM so they are retained if power is removed and can be changed as often as required.
- Stamp 2 EEPROM holds 2K code for up to 600 instruction lines while Stamp 1 has a 256 byte EEPROM.
- Stamp 2 operates code at 10000 lines per second, Stamp 1 at 2000 lines a second.
- Stamps need connection to PC only during programming. Thereafter they run independently.
- Powered by 5-12V DC or 9V battery.
- Consume down to just 2mA, typ., or 20µA in sleep mode.)
- The Stamp 1 IC comes in convenient 14-pin SIP package.
- The Stamp 2 package has expanded i/o, more program memory and faster execution speed; all conveniently housed in a 24-pin DIP format package.

Numerous working examples are included on the software disk.

Use this coupon to order your Basic Stamp

Please send me:

Stamp 1 Development Kit at £98.70

Stamp 2 Development Kit at £122.20

Please tick. Prices are fully inclusive.

Name

Company (if any)

Address

Phone number/fax

Total amount £.....

Make cheques payable to Milford Instruments, or, please debit my Master, Visa or Access card:

Card type (Access/Visa)

Card No

Expiry date

Please mail this coupon to Milford Instruments at Milford House, 120 High Street, South Milford, Leeds LS25 5AQ, together with payment. Alternatively fax credit card details with order on 01977 681465 or telephone on 01977 683665.

Address orders and all correspondence relating to this order to Milford Instruments at the above address.

Multilayer air-cored coils

If you want to calculate the inductance of a coil and you know all the coil's other specifications, Wheeler's equation provides a simple and accurate solution. But the designer's task is usually the reverse. Robert Kesler describes the return path.

The most practical way to calculate the inductance of an air-cored multilayer coil is via Wheeler's formula.¹

$$L = \frac{7.87N^2M^2}{3M + 9B + 10C} \quad (1)$$

This formula is claimed to be accurate to within 1%, if the numbers in the denominator are about equal, that is, if the shape of the coil is similar to that shown in the diagram. Of course, the accuracy in practice is also determined by the tolerances on the coil's dimensions.

A given piece of wire, wound in a coil, yields the highest inductance value, if its proportions are, $3M=9B=10C$. It can be proved that this shape yields the highest inductance for a coil, wound from a given piece of wire, or the highest inductance/resistance ratio for a given weight of copper.

The Wheeler formula is fine for calculating the inductance of a coil when everything else is known. But usually, the designer's task is the opposite: at the outset, only the inductance is known. In addition to the four other parameters in the formula, the wire diameter has to be found too.

Working back

A coil's dc resistance can be expressed using the diameter and the length of the copper wire, which can be expressed using the number of turns, and the mean diameter of the coil,

$$R = \frac{NM}{14250W^2} \quad (2)$$

The relationship between the number of turns that can be packed into the cross section of the coil and the wire diameter is,

$$N\left(\frac{W}{P}\right)^2 = BC \quad (3)$$

Considering only the ideal shape, there are two more useful equations,

$$B_i = \frac{M_i}{3} \quad (4)$$

$$C_i = 0.3M_i \quad (5)$$

In this case, formulas 1 and 3 become simpler,

$$L = 0.875N_i^2M_i \quad (6)$$

$$N\left(\frac{W}{P}\right)^2 = 0.1M_i^2 \quad (7)$$

Now the parameters can be expressed, using the formulas 2, 6 and 7,

$$M_i = 0.354\sqrt{\frac{L}{R}} \quad (8)$$

$$N_i = 1.07\sqrt{\frac{L}{M_i}} \quad (9)$$

$$W_i = 0.253\frac{M_i}{\sqrt{N_i}} \quad (10)$$

the inner and the outer diameter of the coil,

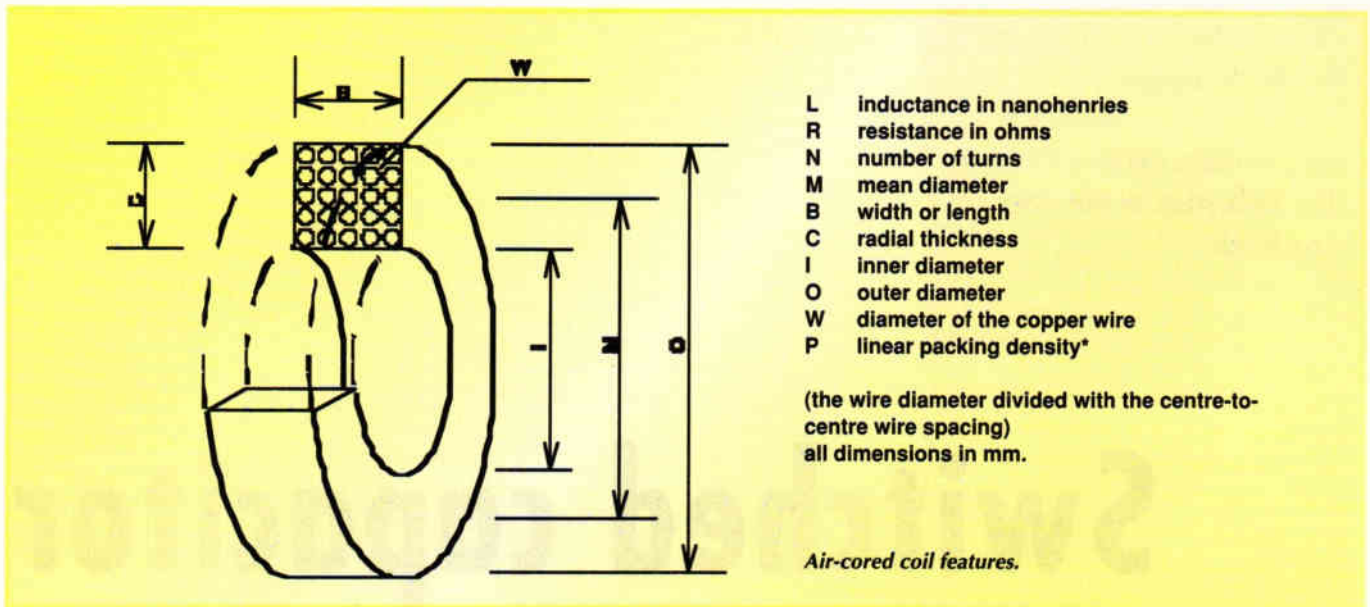
$$I = M - C = 0.7M \quad (11)$$

$$O = M + C = 1.3M \quad (12)$$

and two more useful relationships,

$$M_i = 3.08L^{0.2}W^{0.8} \quad (13)$$

$$N_i = 0.61\left(\frac{L}{W}\right)^{0.4} \quad (14)$$



- L inductance in nanohenries
- R resistance in ohms
- N number of turns
- M mean diameter
- B width or length
- C radial thickness
- I inner diameter
- O outer diameter
- W diameter of the copper wire
- P linear packing density*

(the wire diameter divided with the centre-to-centre wire spacing)
all dimensions in mm.

Air-cored coil features.

Note that formulas containing 'i' subscripts are valid only for ideally shaped coils.

Tips for designing multilayer coils

The above formulas are useful tools for designing multilayer air-cored coils. Two starting points are possible. With the first, the dc resistance is initially specified. For the second, dimensions of an available coil former need to be known.

If the coil is to be used in a high power circuit such as a loudspeaker crossover network, start by specifying the maximum allowable losses in terms of the dc resistance. Calculate the theoretical wire diameter using formulas 8, 9 and 10. Choose the nearest available standard wire size.

The calculated diameter need not be adhered to rigidly, bearing in mind that increasing the diameter will decrease the resistance, but increase the dimensions, and *vice versa*.

Use the chosen wire diameter to calculate the dimensions and the number of turns with formulas 1, 4, 5, 11, 12 and 14.

When working out from a given coil former, calculate the number of turns and the wire diameter, using formulas 1 and 3, with the dimensions of the former. Choose the nearest standard wire size. Using these new dimensions, recalculate the radial thickness and the mean diameter of the coil, then the number of the turns.

Calculate the dc resistance and decide whether or not it is acceptable. Note that in all the calculations, the linear packing density is assumed to be 0.8. Any errors that may arise from this assumption and other causes can be corrected at the final stage.

Measure the diameter of the ready wound coil. Before cutting the wire, calculate the inductance using formula 1 and correct the number of turns, as necessary.

Design examples

This first example shows how to proceed when the initial known quantity is the dc resistance of the coil. The inductance required is 200µH and the resistance assumed is 0.3Ω.

For mean diameter, number of turns and wire diameter,

$$M_i = 0.354 \sqrt{\frac{200 \cdot 10^3}{0.3}} = 28.9 \text{ mm} \tag{8}$$

$$N_i = 1.07 \sqrt{\frac{200 \cdot 10^3}{28.9}} = 89 \tag{9}$$

$$W_i = 0.253 \frac{28.9}{\sqrt{89}} = 0.775 \text{ mm} \tag{10}$$

At this point, the calculated wire diameter can be modified to suit available sizes, provided that you understand the consequences.

Let the new wire diameter be 1mm. Use this diameter in the subsequent calculations,

$$M_i = 3.08 \times 200000^{0.2} \times 1^{0.8} = 35.4 \tag{13}$$

$$B_i = \frac{35.4}{3} = 11.8 \tag{4}$$

$$C_i = 0.3 \times 35.4 = 10.6 \tag{5}$$

$$I = 35.4 - 10.6 = 24.8 \text{ mm} \tag{11}$$

$$O = 35.4 + 10.6 = 46 \text{ mm} \tag{12}$$

$$N_i = 0.61 \left(\frac{200000}{1} \right)^{0.4} = 132 \tag{14}$$

Having finished the winding, remember to measure the outer diameter of the coil before cutting the wire. Calculate the inductance from formula 1, and correct the number of turns, if necessary.

The second design example is for when you are working from a specified coil former.

Inductance required is 2mH. Assume that the former has an inner diameter, *I*, of 12mm, a width, *B* of 16mm and a rim, *C*, of 6mm.

$$2 \times 10^6 = \frac{7.87 \times N^2 \times 18}{3.18 + 9.16 + 10.6} \tag{1}$$

$$N = 450 \tag{3}$$

$$450 \left(\frac{W}{0.8} \right)^2 = 18.6 \tag{3}$$

$$= 0.392 \text{ mm.}$$

Choose the next available smaller wire diameter, *W*, of 0.35mm then calculate the radial thickness of the coil,

$$450 \left(\frac{0.35}{0.8} \right)^2 = 16C \tag{3}$$

$$C = 5.4 \text{ mm.}$$

The new value for the radial thickness – and the mean diameter – may call for re-calculation of the inductance and correction for the number of turns. Alternatively, it may be left to the final correction, before cutting the wire.

Check the dc resistance,

$$R = \frac{17.6 \times 450}{14250 \times 0.35^2} = 4.54 \Omega \tag{2}$$

Decide whether this value is acceptable. If too high, choose a former of bigger diameter and/or cross section. ■

Further reading

H. A. Wheeler, Simple Inductance Formulas for Radio Coils, *Proc. IRE*, Vol. 16, p. 1398, Oct. 1928,

F. E. Terman, Radio Engineer's Handbook, McGraw-Hill, 1943, p. 62.

Can the switched-capacitor technique eliminate inductors in dc-to-dc converters? Ian Hegglin thinks it can, and explores how the technique can be applied.

Switched capacitor power supplies

Switching power supplies normally use inductors and/or transformers for voltage conversion. But this is not the only way to transform voltage efficiently. Voltage multipliers and voltage dividers are another option.

Voltage dividers are less well known. They are simply multipliers reconfigured for voltage step down. There are lots of similarities. Like multipliers, they need no inductors and like multipliers they are limited, mainly because they are difficult to regulate efficiently over a wide range of input or output voltages.

Pulse-width modulation can certainly vary the average voltage of inductorless circuits but the losses in the smoothing process are hardly any different to linear regulation. This is because the equivalent circuit of a switching capacitor arrangement is a low-pass RC filter which is inefficient when pulse modulated at low duty cycles. However, my earlier work showed efficient regulation is possible if a small value air-cored inductor is added to ac input of a full wave multiplier¹. Regulation is then achieved by varying frequency.

This article looks at step down switched capacitor converters. In particular, converters that are capable of delivering tens of watts at 3V and converters delivering hundreds of

watts at around 50V output. When cascades, these converters could form the basis for computer power supplies, but how practical is this?

240V Mains to 3V without inductors?

Breaking the task into two stages with an intermediate voltage at around 30 or 50V helps. This would work in well with the distributed supply technique where one main power supply delivers only one voltage which then supplies various boards, each board has their own converter for their particular needs.^{2,3} This solves a number of problems and makes it relatively easy to add batteries to the intermediate voltage for an uninterruptible supply.

Each converter requires a step-down ratio of at least 8:1. Since there are so many stages, each stage must be very efficient. If you aim for, say, 70% overall efficiency then each of two converters need to be around 85% efficient. With two or three cascades within each converter, efficiency for each stage must be no less than 95%.

Although difficult, this is not impossible. The increasing use of synchronous rectifiers such as the MA767 can give this efficiency even at the 3V level.⁴ Recent developments

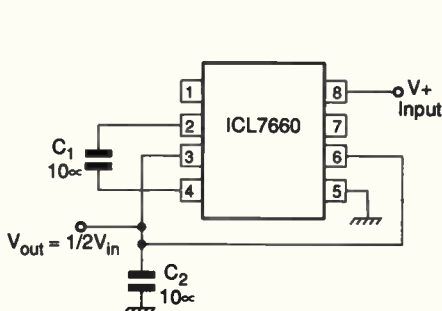


Fig. 1. Voltage divider using a popular IC.

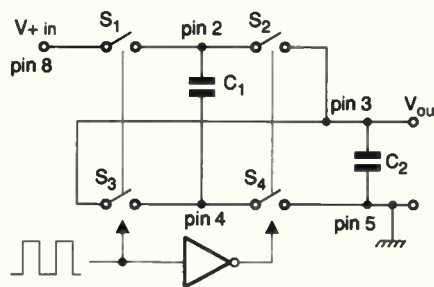


Fig. 2. Voltage divider internal circuit.

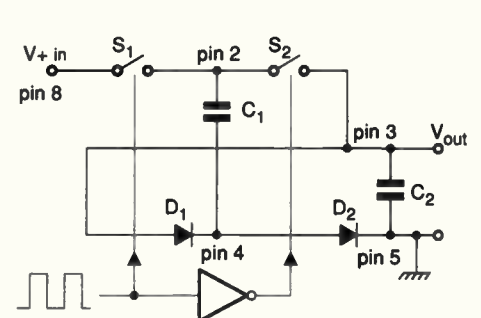


Fig. 3. Diodes being used in place of S3 and S4.

with mosfets, namely Philips' *Trenchmos* and SGS-Thompson's mesh overlay, should reduce the cost of the silicon needed for low losses.

Other necessities for mains conversion are power factor correction and an earthable or non-floating output. Both of these can be provided without using an inductor or transformer.

Literature on voltage dividers

One reference to a voltage divider can be found in the *ICL7660* data sheet.^{4,5} Figure 1 shows the connections required and Fig. 2 shows the internal switching with mosfets.

In the first half cycle when S_1 and S_3 are closed, the supply voltage divides across the capacitors in a conventional way proportional to their value. In the next half cycle when S_2 and S_4 are closed, the capacitors switch from a series connection to a parallel connection. This forces the capacitors to have the same voltage; the charge redistributes to maintain precisely $1/2V+$, across C_1 and C_2 .

A Linear Technology application note describes using four discrete mosfets to convert 12V to 5V at 1A without using an inductor in a similar way⁶. Regulation over a small range is achieved by varying the charge duration while S_1 and S_4 are on.

Two of the switches, S_3 and S_4 , can be replaced with diodes, Fig. 3. With diodes, efficiency is reduced for light loads. This is because mosfets acting as synchronous rectifiers in Fig. 2 can have a low forward voltage drop at low currents, unlike normal diodes.

In the diode version, the output capacitor can be removed and the circuit still operates. Ripple voltage increases, as expected, but the ripple frequency halves –

something not expected.

Investigating further, it appears that a minimum output capacitance is needed to pull the ripple voltage average of the first phase to the same level as the second phase. Simulation on *Tina* showed this effect. The minimum capacitance appears to be around $1/3C_1$, although in tests the ripple current rating requires a minimum of $1/2C_1$.

I also tried simulation on *Electronics Workbench V4*. Although the simulation ran, it did not give the correct waveforms using the same models as *Tina*. In these simulations, the mosfet switches were simply voltage-controlled switches with a series resistance to simulate mosfet on resistance. Doing this speeds up simulation considerably and is obviously acceptable with *Tina*.

Simplifying the switches in this way may explain why *Workbench* gave incorrect results, but I am unable to repeat the analyses with proper mosfets since I no longer have access to the software. Anyone interested in seeing the *Workbench* file can do so by sending a stamped, self-addressed envelope to *Electronics World's* editorial offices.

Using an equivalent circuit

The equivalent circuit is useful for predicting output voltage, ripple voltage and efficiency of a converter. Figure 4 shows the equivalent circuit. The derivation is given in a separate panel. The voltage source is $1/2V_{in}$ and there is a V_D diode drop with a triangular ac ripple voltage (ΔV_{pp}) superimposed on the output.

Ripple voltage is determined mainly by C_1 . Bear in mind that C_1 supplies output current for both phases in this type of converter. Therefore is best to place most of the available capacitance at C_1 .

Finally, there is a series resistance of $R_{DS(on)}$ for the mosfet

ESR of aluminium electrolytic capacitors

Losses in a capacitor are represented by an equivalent series resistance, or esr. Low esr is needed in switching power supplies. A low esr means low internal heating due to ripple current and low ripple voltage. It is common to parallel two or more small capacitors to give an esr lower than a single capacitor of the same total value.

Electrolytic losses vary with frequency and temperature. The graph shows the impedance of several aluminium electrolytic capacitors. At higher frequencies the capacitor becomes net inductive. Some capacitors have a flat region over one or two decades of frequency.

Minimum esr is also related to voltage and capacitance. In general, the same cans size fixes the esr and hence ripple current rating. This can be seen by scanning through the ripple current ratings for various capacitors of the same size within the same brand range.

For non-solid electrolytic capacitors reliability is related to

power loss (average P_{esr}) and the ambient temperature.

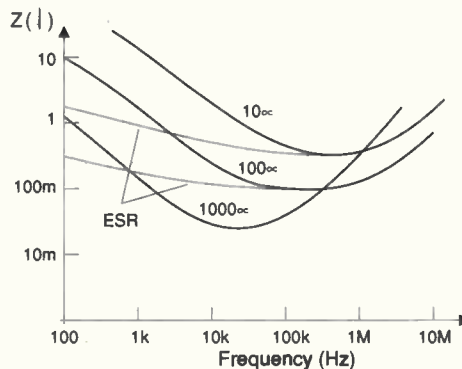
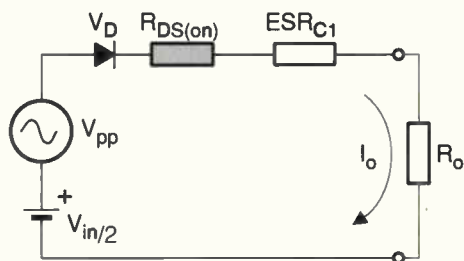
Philips' electrolytic capacitor data book 8 states that a 50% drop in reliability can be expected for each 10°C increase in temperature. Solid electrolytics are not degraded by temperature to the same extent and offer much longer life. Philips quotes a failure rate of 10^{-9} hours for solid electrolytics compared to 10^{-6} hours at a 60% confidence level for their non-solid electrolytics.

The company also gives an equation for calculating ripple current

$$I_R = \sqrt{\frac{P}{ESR}} = \sqrt{\frac{\alpha S(T_C - T_{amb})}{ESR}}$$

where I_R is the ripple current (A), P is heat dissipation (W), α is the heat-transfer coefficient ($W/m^2/^\circ C$), S is surface area (m^2), T_C is the case temperature ($^\circ C$) and T_{amb} is the ambient temperature ($^\circ C$).

Fig. 4. Equivalent circuit for Fig. 3, and curves showing the variation of impedance with frequency for various aluminium electrolytic capacitors.



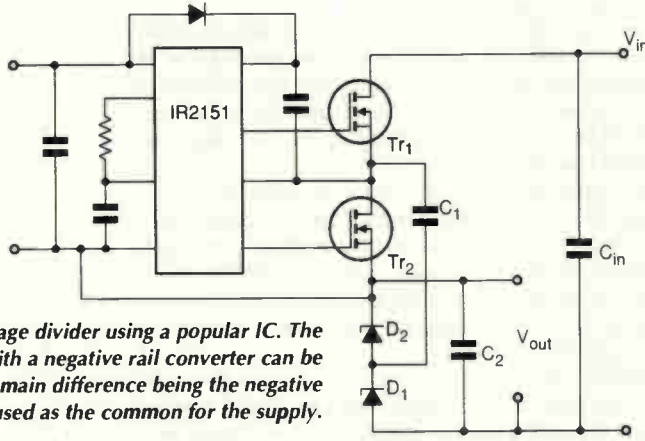


Fig. 5. Voltage divider using a popular IC. The similarity with a negative rail converter can be seen – the main difference being the negative rail is used as the common for the supply.

switches plus ESR_{C1} , as in the diagram in the panel. With significant dead time the losses must be increased according to the form factor.

A 30 to 15V converter

Figure 3 is a relatively easy circuit to implement. Test circuit Fig. 5 uses an *IR2151* to drive two mosfets. Three 6.8µF, 20V tantalum capacitors measuring 7 by 5 by 4mm were paralleled for C_1 . Each capacitor has an esr of 400mΩ at 100kHz. Two of these capacitors are used for the output C_2 .

The input capacitor consists of three 22µF, 50V YXB aluminium electrolytics. These allowed the circuit to deliver 5A continuously. The input voltage was adjusted to give 15V output, requiring 34.9V.

Efficiency is easily calculated by $2 \times 15 / 34.9$, giving 87% efficiency. This calculation is possible because the ratio of output current to input current is precisely 2, due to charge conservation and current used by the driver is negligible at full load.

Analysing losses, 2W is lost in diodes, 2W in capacitors, mainly C_1 , and 4W in the mosfets. This gives a total of 8W for 75W output.

Figure 6, top trace, shows output ripple voltage with a 5A load: the average of this ripple is offset 15V above ground. The lower trace shows the voltage at the output of the mosfets feeding C_1 . Note that the ripple frequency is twice the oscillator frequency.

Dead time can also be seen. It totals about 2µs which means about 40% more current is required causing 40% more ripple and losses. Current through C_1 is 10A peak falling to 5A or 7.5A average. You may notice the similarity with a negative rail converter. The main difference is that the negative rail is used as the common for the supply.

Due to the dead time, the ripple is increased by 50%. Increasing the frequency fails to reduce ripple because the dead time component remains constant. Adding a small 1µH inductor to form a low-pass filter between the load and output with a shunt capacitor across the load can reduce ripple to low levels if required.

The inductor used was removed from a 10A switching power supply output and measures 6mm dia. and 15mm long with five turns of 1.5mm wire. With a 220µF 200mΩ esr electrolytic the ripple was reduced by a factor of five with a 70kHz operating frequency. If the dead time could be reduced and the frequency increased to 150kHz the ripple would fall to around 10mV rms with this filter.

With 5A load, the tantalums ran at about 50°C, or about 35°C above ambient. Operating the converter at higher ambient temperatures, of say 50°C, the current would need to be halved. This means that ripple voltage would also be halved.

Another method for reducing ripple is by running two converters in parallel and clocking them 90° out of phase. This can reduce ripple by a factor of two – more with an LC filter – while also doubling the output current. This technique can also be applied when cascading two converters for higher step down ratios.

At about 1A per capacitor, this is a remarkably high power density. The chip inside measures only 3mm diameter and 3mm long, or 1/25th the volume of an aluminium capacitor of similar rating. These capacitors were removed from a computer pcb some time ago and I don't know where they can be sourced. However, similarly rated special polypyrrole ECG series electrolytics by Panasonic are readily available.

Later tests on an ECG 6.8µF/16V electrolytic revealed an esr of only 40mΩ – the data sheet quotes 0.4Ω maximum at 400kHz – and a minimum impedance at 2MHz. It appears some manufacturers are very conservative when it comes to esr values, possibly because there is a large spread in values. These ECG capacitors are rated at 1A at 105°C, but if they are sorted, most will run at higher currents. Although to make use of this capacity, the frequency needs to be closer to 1MHz.

I also tested a 4.7µF/16V multilayer ceramic in a 1206 package. Its capacitance measured on a dmm was only 3µF at 25°C and only 1µF at 1MHz. Minimum impedance occurred at 8MHz with an esr of 130mΩ. It uses Y5V dielectric and has a temperature coefficient of 1%/°C from 25°C which means the capacitance falls to 1/5th of its room temperature value when heated to 80°C. These Y5V capacitors are not practicable for converters that operate above 40°C.

Comparison with buck

Comparison with a conventional buck converter is a useful exercise. The *L296* application note gives complete design details for a buck converter⁷. Equations for the value of the inductor and output ripple voltage are given below assuming the inductor ripple current is the usual 30% of the peak inductor current,

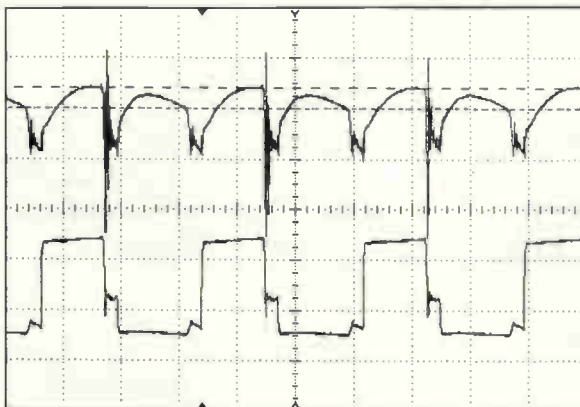
$$L = \frac{(V_i - V_o)V_o}{0.3 I_o f}$$

$$\Delta V_C = \frac{(V_i - V_o)V_o}{8V_i f^2 LC_o}$$

$$\Delta V_R = 0.3 I_o ESR_{C_o}$$

Note that the capacitor ripple voltage is made up of two parts. Since these components are in quadrature they should not be added algebraically, although, if one component dominates by more than three times, the other can be neglected, due to the nature of quadrature addition. For a 2:1 buck configura-

Fig. 6. Ripple voltage (upper trace 1V/div) and the ac drive voltage to C_1 (lower trace 10V/div) with a 5A load. Time base is 5µs/div. The ringing was traced to the driver. Adding gate damper resistors of 47Ω eliminates this ringing.



tion and $V_i=2V_o$ the inductance required and ripple voltages are,

$$L = \frac{V_o}{0.6fI_o}$$

$$V_c = \frac{I_o}{24fC_o}$$

$$\Delta V_R = 0.3I_o ESR_{C_o}$$

Using the L296 as described in the application, the frequency is 100kHz and two 100µF and 150mΩ esr output capacitors are paralleled. When loaded at 4A the ripple voltage is calculated to be 90mV pk-pk and esr ripple dominates.

For the switching capacitor converter of Fig. 3 the ripple voltage is approximately,

$$\Delta V \cong \frac{I_o}{4C_1f} \cong \frac{I_o}{3C_o f}$$

where C_2 is $\frac{2}{3}C_o$ and C_1 is $\frac{1}{3}C_o$. The input capacitor is assumed to be the same in both cases. This equation comes from the equation $I_C=C\Delta V/\Delta t$, where the capacitor current pulse rate is $2f$ and current and the ripple voltage across C_1 is divided by two at the output and verified by measurements. It was also verified that there is no esr ripple component present – unlike the buck converter.

Using the same value of output capacitance as used in the L296 example, the output ripple at 4A is 60mV pk-pk compared to 90mV. However, since the capacitors used in this example are only carrying 1.2A of ripple current ($0.3 \times 4A$) the capacitance required for the same temperature and same life must be three times higher for a third the esr. A plus for the switching capacitor converter is lower electromagnetic radiation, lighter and more compact. The buck scores high on being able to vary the ratio over a wide range efficiently and requires less components.

Silicon utilisation

The buck converter requires one transistor, minimally rated at V_{in} and I_o (average) plus a diode for the same V_{in} and I_o . A switching capacitor converter such as Fig. 3 requires two transistors, each minimally rated at $\frac{1}{2}V_{in}$ and I_o , plus two diodes each rated at $\frac{1}{2}V_{in}$ and I_o . This is twice the number of devices although the total switching capacity ($V \times I$) is the same.

With more parts there is a cost penalty but it also helps to distribute heat and improves reliability. Distributing heat makes natural cooling easier which improves reliability. In many cases a fan can be avoided which is often the most unreliable component.

Single converter divide-by-n

A circuit for a 4:1 step down, Fig. 7, has appeared in this magazine⁹ and more recently in another magazine¹⁰. In this arrangement four capacitors, labelled C_{1-4} on the circuit, are charged in series and later discharged in parallel. They operate as a Mosmarx¹¹ step down converter.

With this technique a 60V peak-to-peak input voltage can be stepped down to around 12V with an efficiency of around 75% using conventional diodes or around 90% with schottky diodes. Adding each extra stage in this circuit involves three additional diodes and one capacitor.

Figure 8 shows a modification that allows the step down ratio to be varied from 4:1 to 1:1 in 4 steps which is useful for regulation or power factor correction for off-line converters. A ratio of three for example is obtained when Tr_1 is held on for both phases, bypassing C_1 during the charge phase and therefore charging three capacitors in series rather than four.

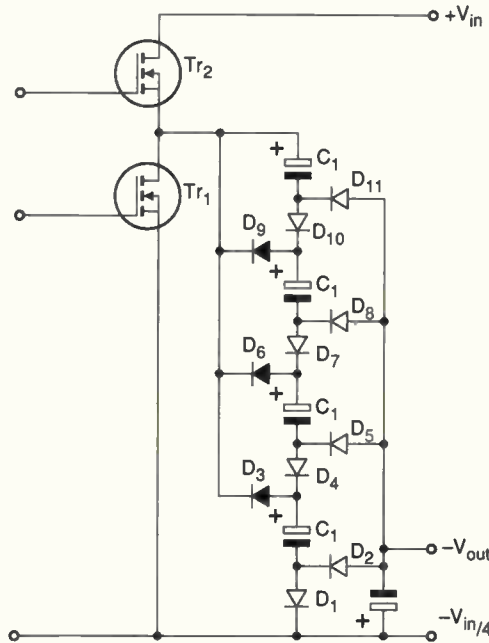


Fig. 7. This network converts V_{in} to negative $\frac{1}{4} V_{in}$.

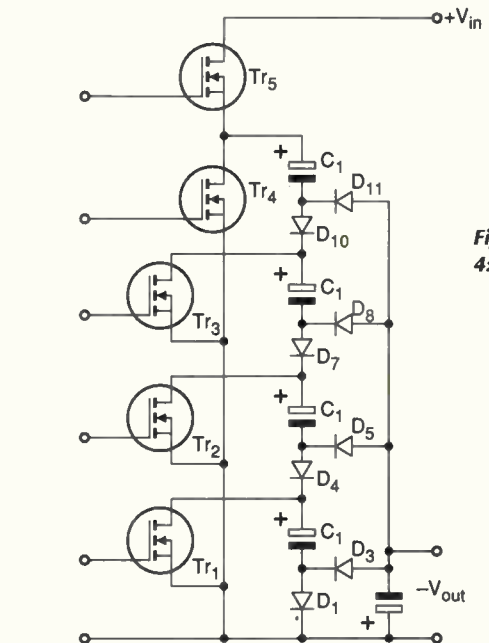


Fig. 8. Allows variable ratios of 4:1 to 1:1 in 4 steps.

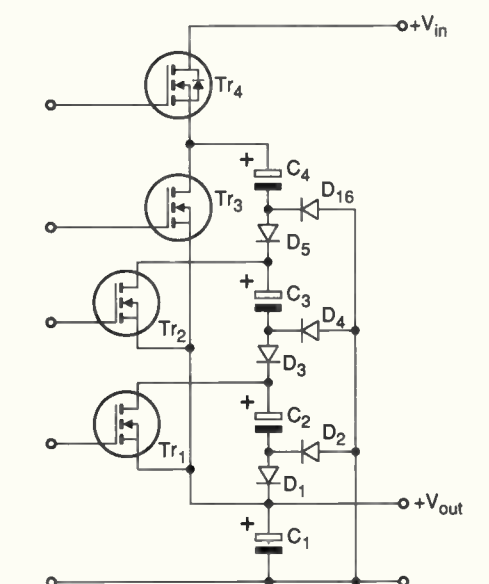


Fig. 9. Converts V_{in} to positive $\frac{1}{4} V_{in}$ with 4 steps.

If a low drop series regulator is added after the converter, the ripple can be removed and regulation over a wide range of input voltages is possible with high efficiency.

Figure 9 shows a non-inverting version. It uses two fewer diodes, one fewer transistor and one fewer capacitor. This makes it slightly more efficient. However, the transistors in a selectable ratio converter requires individual high side drive making driving more difficult.

So can the Cockcroft Walton multiplier be reversed for step down to give ratios higher than 2:1? Figure 10 shows how it can using mosfets on the improved version.¹² This allows the number of diodes to be reduced, improving efficiency.

Paralleling two dividers as in Fig. 11 reduces the ripple in the input current and allows much smaller input and output capacitors. Minimal dead time is required for best results.

Equations for switching converters

Neglecting ac ripple component on C_1 and the effect of energy loss from capacitor charge redistribution, the equations for steady state output are as follows. In all cases the output voltage is slightly lower due to charge redistribution losses⁴ but appears to contribute only a few percent of losses since ripple is usually less than 10% of the dc voltage.

Synchronous converter, Fig. 2. All switches are mosfets with equal $R_{DS(on)}$ since they carry the same peak current.

Charge phase,

$$V_C = V_{in} - I_O(ESR + 2R_{DS(on)}) - V_{out} \quad (1)$$

Discharge phase,

$$V_{out} = V_C - (ESR + 2R_{DS(on)})I_O \quad (2)$$

Substituting (2) into (1),

$$V_C = V_{in} - I_O(ESR + 2R_{DS(on)}) - V_C - (ESR + 2R_{DS(on)})I_O$$

So,

$$V_C = \frac{V_{in}}{2}$$

giving,

$$V_{out} = \frac{V_{in}}{2} - (ESR + 2R_{DS(on)})I_O$$

Single ended converter using diodes, Fig. 3. Each diode has a forward drop V_D and ohmic resistance R_D .

Charge phase,

$$V_C = V_{in} - I_O(ESR + R_{DS(on)} + R_D) - V_D - V_{out} \quad (3)$$

Discharge phase,

$$V_{out} = V_C - I_O(ESR + R_{DS(on)} + R_D) - V_D \quad (4)$$

Substituting (4) into (3) also gives,

$$V_C = \frac{V_{in}}{2}$$

hence,

$$V_{out} = \frac{V_{in}}{2} - V_D - (ESR + R_{DS(on)})I_O$$

From this, the equivalent circuit of Fig. 4 can be drawn.

Parallel converter, Fig. 11. This circuit shares the output current with $I_O/2$ through each stage giving,

$$V_{out} = \frac{V_{in}}{2} - (ESR + R_{DS(on)})I_O$$

Converting from 30V down to 3V

This 30V to 15V converter gives valuable insights into the operation of a divide-by-two converter. At the time of writing, I had not tested the 30V to 3V converter, although a 24V to 12V synchronous rectifier version, as in Fig. 2, has been run, giving the target of 95% efficiency. To get this efficiency the output current is only a fraction of the mosfets current rating. The latest mosfets will improve this.

Philips now offers a 55V device in a TO220 package with an 8mΩ on resistance. Even lower resistance devices in smaller packages are likely soon.

Conversion from 30V to 3V requires a ratio of 10:1. This can be achieved a number of ways with dividers, either two divide-by-threes or three divide by twos. It appears that the $V \times I$ capacity is about the same in both cases.

A practical converter requires regulation of the output voltage. If the input varies over a wide range it is not practical to use pulse modulation as mentioned.

Recent tests using a small inductor within a divider demonstrated efficient regulation over a 2:1 input voltage range. This allows the 30V input on the low voltage converter to

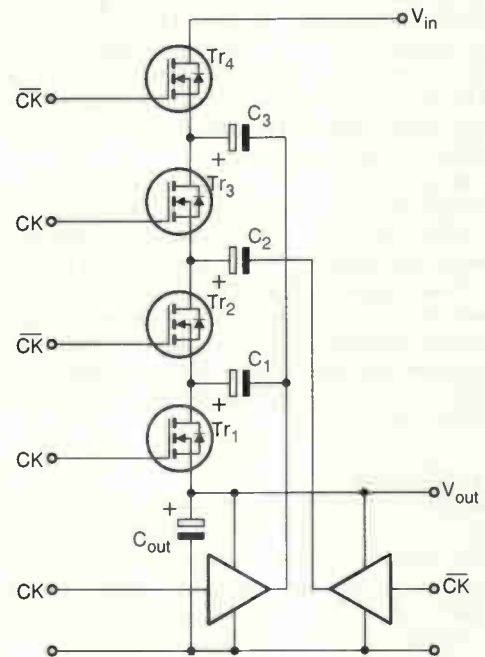


Fig. 10. Improved Cockcroft Walton multiplier can be reversed if diodes are swapped for mosfets.

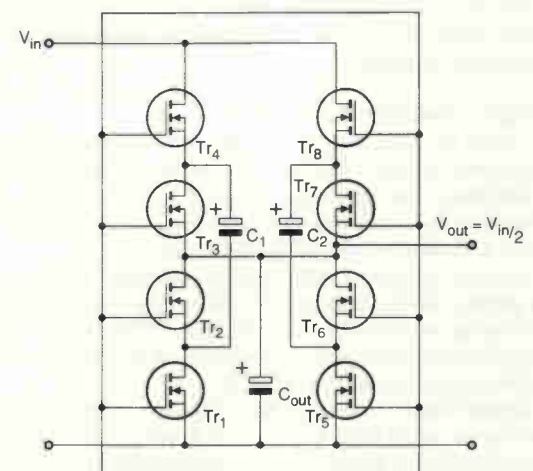


Fig. 11. Paralleling two dividers reduces the ripple in the input current and allows much smaller input and output capacitors. Minimal dead time is required for best results.

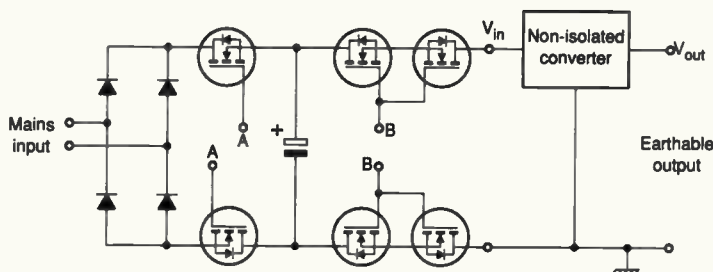


Fig. 12. The flying capacitor technique allows the normally floating output of a bridge rectifier to be connected to earth without damaging the circuit.

*Safety warning

When Ian speaks of mains isolation, this does not mean safety isolation. Device failure could result in a direct path between the mains live side and the converter's output. As a result, all parts of any such converter should be considered to be lethal, and never touched. Wiring regulations in your country should also be consulted before such a circuit is connected – Ed.

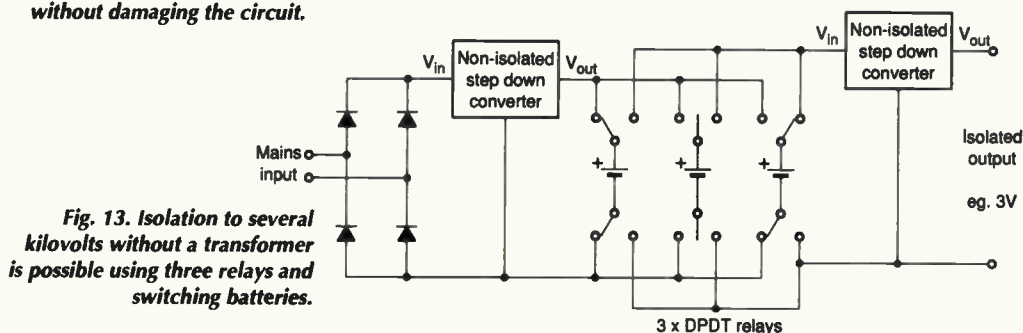


Fig. 13. Isolation to several kilovolts without a transformer is possible using three relays and switching batteries.

rise to 60V plus ripple filtering of the reservoir capacitor on this bus. I hope to present design details in a later article.

Mains to 50V conversion

The preferred arrangement for the mains converter is the circuit in Fig. 9, but with eight stages.

This arrangement uses fewer components and it allows the ratio to be varied in small increments for voltage pre-regulation and power factor improvement. It does this by varying the ratio over the mains half cycle. Current flows over most of the cycle in a sinewave like fashion.

At 50V output, this converter can use standard diodes giving about 2V in 50V loss and an efficiency above 95%. This is well above the target of 85% for the mains converter discussed earlier. It should be possible to get 80% overall for mains to 3V without using unrealistic amounts of silicon.

Isolating the output

The flying capacitor technique has been proposed as a way of 'isolating' the converter common from the mains¹³. Although this does not provide the same degree of isolation from the mains as a transformer it does allow the converter's low-voltage output common to be connected to an earth and it allows the mains to be rectified using a full-wave bridge rectifier.

Normally, the output of a bridge rectifier must be floating relative to the ac input terminals. The flying capacitor technique, Fig. 12, can be implemented with six mosfets or igbts switched at a high frequency.

Although this technique may be acceptable in some installations, it has safety limitations where people can touch the equipment being supplied. Even with a reliable earth leakage relay and the usual output over-voltage crowbar there are some people such as those with a pre-existing heart problem are at risk if exposed to a short duration mains shock while the earth leakage relay trips.

Using three batteries and three relays, Fig. 13, the output can be isolated to several kilovolts without a transformer,* with uninterruptible power supply as a bonus. With a 30V intermediate bus, three 30V batteries can be rotated in sequence, one being charged from the mains converter while the second supplies the load. The third ensures no-break changeover. A cycle life of around a second allows small batteries to be used, while giving an acceptable relay life.

This can match transformer isolation given suitable relays and sufficient tracking clearance of circuit board tracks. The

batteries and their connections need to be suitably isolated from each other and the output side. Where the relays are exposed to humidity etc they must be protected or sealed.

In summary

Hopefully I have demonstrated that it is not impracticable to use switched capacitor dividers to convert mains to 3V without a transformer – and do it efficiently without huge amounts of silicon.

Certainly the number of components is greater than a conventional switch-mode power supplies, but when power factor correction and distributed converters are added to a switch-mode psu, the component difference reduces. ■

Anyone interested in communicating with the author regarding the concepts described here can do so by contacting Electronics World's editorial offices.

References

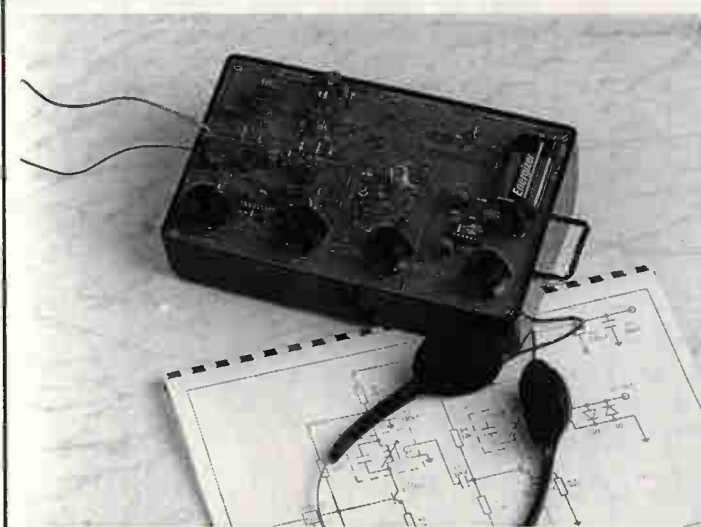
- Hegglin, I, 'Stepping out', *Electronics World* October 1996, pp. 759-806.
- Small, CH, 'Distributed Power,' *EDN* April 28, 1994, pp. 54-64.
- 'Switch-mode psu technology runs at 1MHz,' *Electronics World+Wireless World*, January 1993, pp. 58-60.
- <http://www.maxim-ic.com>
- LMC7660/7669, National Semiconductor Linear Databook 1, 1988, pp. 1-271 to 1-279.
- High current inductorless switching regulator, Linear Application Handbook, 1987, p. AN3-15.
- Gattavari, G., 'Designing with the L296 monolithic power switching regulator,' AN244, SGS-Thompson Power Supply Application Manual, July 1985, pp. 93-128.
- Electrolytic capacitors solid and non-solid, Philips Data Handbook PA01, September 1988, p22.
- EDN Spotlight 'Diodes and capacitors imitate transformers' *Electronics World+Wireless World*, Sept 1991, p. 749.
- Petkov, P., 'Bridge Rectification Enhanced,' *Everyday with Practical Electronics*, July 1995, pp. 566-568.
- Donaldson, P. E. K., 'The Mosmarx Voltage Multiplier,' *Electronics & Wireless World*, August 1988, pp. 748-750.
- Ian Hickman, 'Multiplier lowers impedance,' *EDN*, 6 June 1991, p. 173.
- Novel Power Supply, *Electronics & Wireless World*, September 1988, p. 885.



Radio Receiver Trainer



An Invaluable Learning and Design Tool for all Experimenters



The manual contains complete schematics and theory of operation of all the building blocks. Use this trainer to receive frequencies from 500KHz to 110MHz!

A set of proven alternate building block designs are included in the manual for you to get started with your own designs. There is no need to get your complete receiver design working all at once. Build and test each block one at a time.

The Radio Receiver Trainer contains nine receiver building blocks and a comprehensive training manual.

Simply connect the building blocks to build AM, SW, Superhet and Direct Conversion receivers. Decode SSB, CW & FM! Use proven building blocks to develop and test your own designs.

Full technical support and advice given.

Pricing: Complete £129.00
Kit £89.00
(Kit excludes case & headphones)

P&P is £5 (UK), £8 (EC), £12 (World)
Add 17.5% Vat to Total Price

- Building Blocks:**
- RF Input Tuner
 - RF Oscillator
 - Mixer
 - IF Filter
 - IF Amplifier
 - AM Detector
 - Beat Frequency Oscillator
 - Audio Filter
 - Audio Amplifier

Mail Order To: Pyramid Electronics Ltd.

204 Ferndale Road, Brixton, London SW9 8AG

Phone (0171) 738-4044

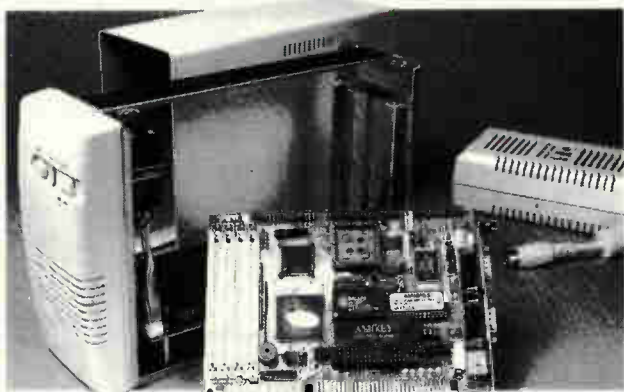
Fax (0171) 274-7997

Out of office ordering by answering machine.



CIRCLE NO. 121 ON REPLY CARD

COMPONENTS & SYSTEMS FROM IOSIS



System Components from ISO9001 Source
 Half Size Single Board Computers
 386SX to Pentium with ISA and PC/104 Bus
 2 Serial Ports, IDE, FDD & Printer Port
 Flash/ROM Disc, Cache, SVGA CRT/Flat Panel Controller
 PC/104 Modules
 386 & 486 CPUs, Solid State Disc, Isolated RS232/485
 VGA CRT/Flat Panel Display & SVGA Controllers
 PCMCIA types I, II & III
 Fast SCSI, Ethernet, Fax/Modem
 System Enclosures with Passive Backplanes
 System Integration and Support
 All-In-One Standard Motherboards & Cases
 486/586 to 200MHz Pentium

1 Somerville Rd, St Andrews
 Bristol, BS7 9AA
 Tel 0117 924 9231
 Fax 0117 924 9233
 Email: sales@iosis.co.uk



Details on our website <http://www.iosis.co.uk>

CIRCLE NO. 122 ON REPLY CARD

COLOMOR (ELECTRONICS) LTD.

Celebrating 30 years 1967 – 1997

Over 6,000 types of valves in stock. We also sell oil filled transformers, chokes, block filled capacitors, diodes, ICs, transistors, etc.

- Set of RA17 Valves **£29.50**
- Set of RA17L Valves **£31.80**
- Set of AR88 Valves **£32.25**
- AR88 and RA17L Spares—please send sae for list
- Hewlett Packard Microwave Counter 5342A **£1,292.50**

Racal Counters

- 9904 Timer Counter 10HZ to 50MHZ **£70.50**
- 9913 Timer Counter 10HZ to 200MHZ **£94.00**
- 9914 Timer Counter 10HZ to 200MHZ **£99.90**
- 9915 Timer Counter 10HZ to 520MHZ **£141.50**
- 9916 Timer Counter 10HZ to 560MHZ **£164.50**
- Philips Oscilloscope 3217, 50MHZ **£352.50**
- Vartra Nicad Charger Type CC 306C, 14 hour timer, charge current 0-600mA **£47.00**

Tubes

- DG732 - Mullard **£11.75**
- DBM911 - GEC **£23.50**
- Hewlett Packard CRT Stock No. 5083-1952, 4" x 5" rectangle **£235**
- Magnetron M5028 **£POA**
- Litton T.W.T. Type L3769 **£POA**
- Oscilloscope Probe Kit X1 X10 switchable 15 & 60MHZ **£14.10**

All prices include VAT. Carriage extra - on application

170 Goldhawk Rd., London W12 8HJ
 Tel: 0181 743 0899 Fax: 0181 749 3934
 Email - giacomelli@colomor.demon.co.uk

CIRCLE NO. 123 ON REPLY CARD

ELECTRONICS WORLD

INCORPORATING WIRELESS WORLD

Money back Guarantee.

Receive a full refund on your subscription within the first 90 days if you are not completely satisfied. Thereafter, we'll refund the unused portion of your subscription should you wish to cancel.

Electronics World incorporating Wireless World is applied electronic design. We'll show you how to use the latest silicon technology plus...

- ✓ CAE software
- ✓ New product reviews
- ✓ Technology reports
- ✓ Detailed circuit diagrams
- ✓ Innovations
- ✓ Explanations of complex technology
- ✓ Comment and much more in your issue.



So whether you are designing your own system or you're curious about your competitors, *Electronics World* will help you keep the leading edge.

SAVE UP TO 10%

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
- 146 147 148 149 150 151 152 153 154
- 155 156 157 158 159 160 161 162 163
- 164 165 166 167 168 169 170 171 172
- 173 174 175 176 177 178 179 180 181

Name	
Job title	
Company Address	
Telephone	
Only tick here if you do not wish to receive direct marketing promotions from other companies.	SEPTEMBER 1997 <input type="checkbox"/>

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 October issue of *Electronics World* - on sale 4th September - 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

Subscribe today!

Guarantee your own personal copy each month

Save on a 2 year subscription

CIRCUIT IDEAS

Over £600 for a circuit idea?

New awards scheme for circuit ideas

- Every circuit idea published in *Electronics World* receives £35.
- The pick of the month circuit idea receives a Pico Technology ADC42 – worth over £90 – in addition to £35.
- Once every six months, Pico Technology and *Electronics World* will select the best circuit idea published during the period and award the winner a Pico Technology ADC200-50 – worth £586.

How to submit your ideas

The best ideas are the ones that save readers time or money, or that solve a problem in a better or more elegant way than existing circuits. We will also consider the odd solution looking for a problem – if it has a degree of ingenuity.

Your submission will be judged on its originality. This means that the idea should certainly not have been published before. Useful modifications to existing circuits will be considered though – provided that they are original.

Don't forget to say why you think your idea is worthy. We can accept anything from clear hand writing and hand-draw circuits on the back of an envelope. Type written text is better. But it helps us if the idea is on disk in a popular pc or Mac format. Include an ascii file and hard-copy drawing as a safety net and please label the disk with as much information as you can.



Turn your PC into a high-performance virtual instrument in return for a circuit idea.

The ADC200-50 is a dual-channel 50MHz digital storage oscilloscope, a 25MHz spectrum analyser and a multimeter. Interfacing to a pc via its parallel port, ADC200-50 also offers non-volatile storage and hard-copy facilities. Windows and DOS virtual instrument software is included.

ADC42 is a low-cost, high-resolution a-to-d converter sampling to 12 bits at 20ksample/s. This single-channel converter benefits from all the instrumentation features of the ADC200-50.

Three-phase over/under voltage detector

When the voltage of each phase of a three-phase supply is within limits set by the user, the supply is connected to the output; otherwise the output remains off. No relays or contactors are used; zero-crossing, optoisolated triac drivers control each phase.

Each phase is stepped down by an ordinary 12V, 100mA transformer, whose output is rectified, filtered and passed to a BB4115 window detector via the 5kΩ adjustment trimmer. Upper and lower limits V_{ut} and V_{lt} are set by the two trimmers on the output of the 7812 regulator. Depending on the outputs of the three window detectors and the following MOC 3012 optocouplers, the MOC3083 zero-crossing, optoisolated, triac drivers, the leds of which are in series, remain off or switch on. Switching logic is shown in the table.

The power circuit consists of three power triacs with optional snubbers, each driven by one of the MOC3083s.

At start-up, the two triac drivers that see zero voltage difference between two of the

phases switch on, followed by the third when its voltage approaches the sum of that in the phases already on. This ensures zero-current turn-on of all three load branches, whether arranged as star, Y or delta.

When all leds in the 3083 switch off, all three phases switch off when current in two of them falls below triac holding current, creating zero current; the third phase then switches off. Switch S_1 controls the power circuit and an additional switch at the three-phase input might also be used. It might be useful to replace S_1 by an optocoupler, driven by an external circuit such as a temperature controller.

Triacs used in this circuit are MAC223 10FP, rated for an off-state voltage of 800V, rms current 25A and peak surge 250A.

Fuse indicators shown illuminate red to show a blown fuse and green to indicate an intact one.

Porus M Mehta
Maharashtra
India

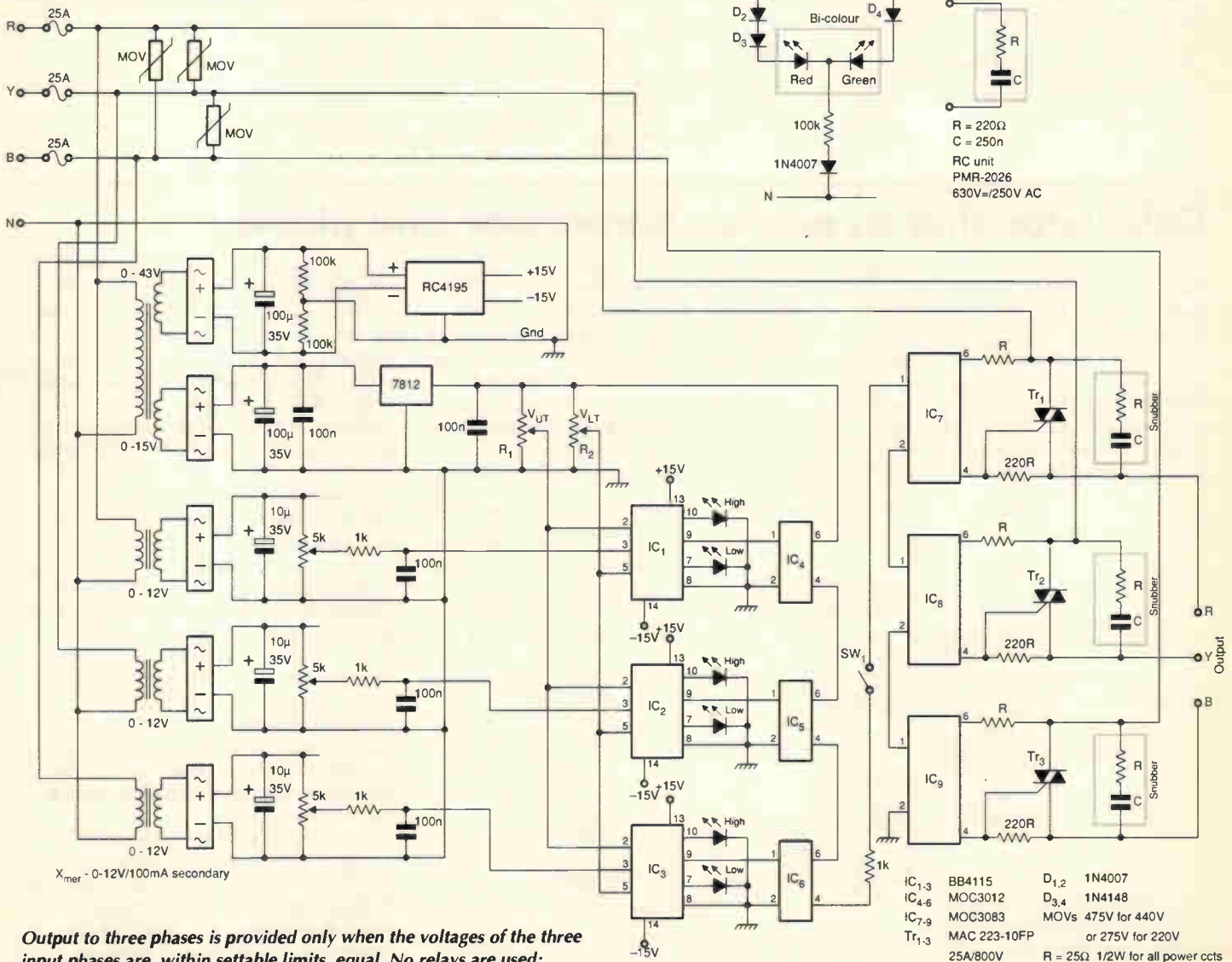
Logic table for the window comparator.

	$V_{in} > V_{ut}$	$V_{lt} < V_{in} < V_{ut}$	$V_{in} < V_{lt}$
High (red led)	on	off	off
Opto drive	off	on	off
Low (green)	off	off	on

V_{ut} =upper threshold, V_{lt} =lower threshold.

BB4115 is obsolete

Please note that although the idea is expressed here is sound, the Burr Brown BB4115 is obsolete. I could not find a direct equivalent, but the AD1317 window comparator might be suitable, with circuit modifications. Alternatively, it may be possible to duplicate the function using two AD790 comparators. If any of you know of a more direct replacement, would you mind letting us know please? Ed.



Eprom programmer/copier

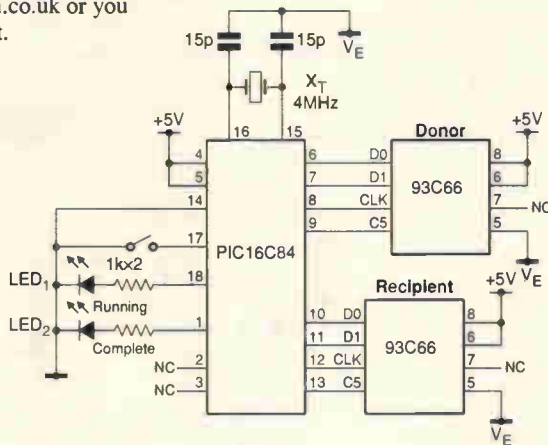
Having previously used a pc-based method of programming eeproms, I produced this device to free the pc for other work.

A donor microwire memory device is read by the circuit one byte at a time, the information then being programmed into a recipient, which is automatically erased when the process starts; all locations are written. Furthermore, instead of the manual input needed by the pc programmer, this only needs one four-second switch operation. You do, of course, have to make one donor using the pc or some other method; donors can be kept to guard against hiccups of the hard disk. Pressing the switch starts the programming operation, which halts on completion; led 1 flashes while programming is in operation and led 2 glows on completion; opening the switch primes the PIC16C84 for another run, but switch the power off when changing the recipient chip.

Opcode is shown here, but I can supply a 3.5in disk; my e-mail address is brian@briano.demon.co.uk or you can use ordinary post.

Brian Olliver
12, Fountain Drive
St Georges
Telford TF2 9DP

Instead of tying up a pc, use this programmer with donor and recipient devices to program eeproms.



```

:100000004A280028861086110611000086158614DD
:10001000000006150000000061100348612861349
:100020000613000086178616000006170000000061
:10003000061300348A1406150000061C8A100611E7
:100040000348D010830910003108D0D1A200D1021
:100050008A180D14910B252800348A1E3128861623
:100060003228861206170000061300341208910089
:100070008A12901B8A162D20900D910B382800347F
:10008000120891000A10901B0A142D20900D910B5C
:100090004228003401306500850111306600860178
:1000A0000518502885140E20023092000030900070
:1000B000362008309200C0309000362086130000B1
:1000C000B52000308C000220023092008030900079
:1000D0004020083092000C089000402021200D089C
:1000E000970021200D089800861183286E30960015
:1000F000000000000000000000000000000960B7828BF
:10010000950B762800340E2002309200403090008B
:100110003620083092000C08900036201708900016
:10012000362018089000362086130A309500762075
:100130008C0F6328A728851005156430950076205C
:100140000511643095007620051850289C280E2053
:1001500002309200003090003620083092000030CB
:1001600090003620861300009B280E20023092005B
:100170000030900036200830920080309000362009
:0C018000861300003C309500762008003B
:00000001FF
    
```

Calculator chip as maths coprocessor and display

Using a cheap microcontroller can make digital instruments cost-effective in small numbers, but the cost of displays and their demands on the processor pose a problem.

One solution to both problems is to use the ic and display from a cheap calculator as a combined coprocessor and display controller, all calculation and display functions then being carried out by this purpose-designed processor; the main microcontroller is then

left to pursue its own affairs.

Calculator keypads are normally multiplexed and may be emulated from the microcontroller by monitoring column outputs and pulling the appropriate row input line high or low, depending on the calculator used.

The diagram shows an alternative: two cmos analogue multiplexers, IC_{3,4}, will simulate the keypad directly, simplifying the software interface and reducing the number of port

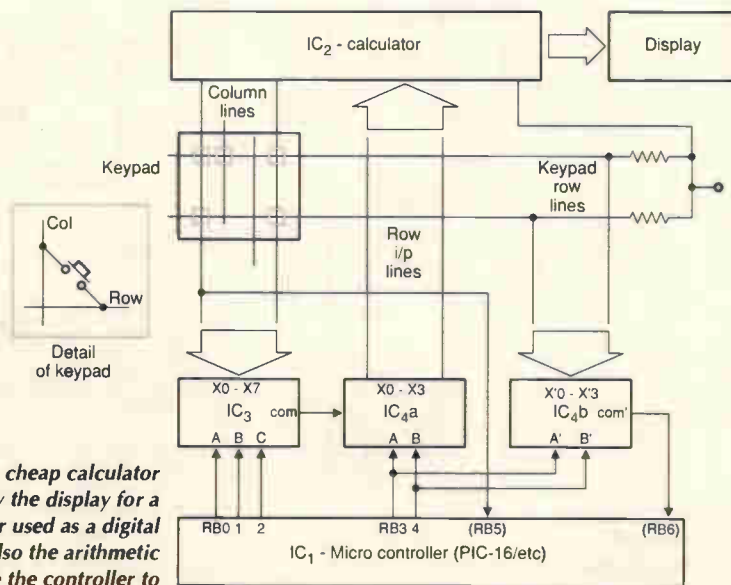
lines used. Only five lines, RB₀₋₄, are needed for calculators using the 6 by 4 or 7 by 4 matrix. Since these lines are only used when writing to the coprocessor, they can be multiplexed for other purposes – possibly using the enable pin on IC₃ to disable display writes. An unused column address in IC₃ is otherwise used as a No-op command and each digit or operand entry is achieved by writing one five-byte to the display controller.

As you can see from the diagram, the calculator keypad can be kept as a free control panel by using the spare 4:1 multiplexer in IC₄ and the extra port lines RB_{5,6}. Selecting No-op on RB_{0,2} and the row address on RB_{3,4} allows RB₆ to be monitored for a pulse. If columns rise in sequence, the active key column can be determined from the time delay from the first column at RB₅, or a priority encoder could be used to indicate a keystroke directly.

A variety of arithmetic functions is possible with eight-digit precision, even from cheap calculators; not only the basic functions, but with a little ingenuity, accumulation, average, delta and many others.

You can measure the mains frequency accurately without long gate times by using a PIC16X in timer mode and the calculator to find the reciprocal. Functions not normally found in commercial counter-timers are percentage or frequency change; these can be performed easily using this method.

Anthony New Bristol



Innards of a cheap calculator provide not only the display for a microcontroller used as a digital instrument, but also the arithmetic functions to free the controller to

High-current variable lipstick

If you remove all the metallic parts – and the red part – of a lipstick applicator and substitute a ferrite rod for the lipstick, the result is the core of a variable inductor capable of carrying an alternating current of several amps.

Maximum inductance is given by the standard formula:

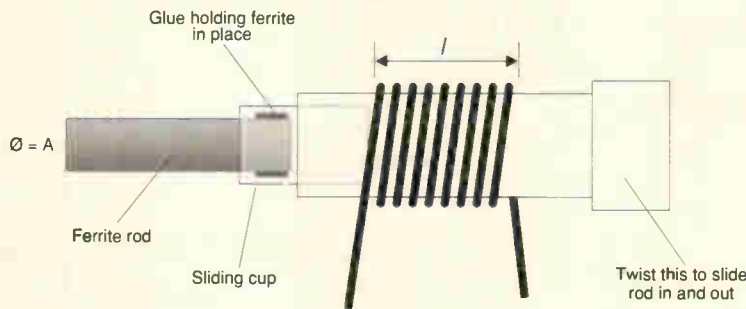
$$L = \frac{n^2 A \mu_0 \mu_r}{l} \text{ henries}$$

and the minimum inductance approaches the value given when the relative permeability $\mu_r=1$.

Using the layout shown in the diagram with about 20 turns, inductance ranged from 4-20 μ H with my prototype.

Name not supplied

Edinburgh



Mechanics of a lipstick make a low-value variable inductor.

Monitor RS-232 activity

Using only a moving-coil voltmeter, you can observe the average activity on an RS-232 link and easily detect oddities.

A centre-zero meter in voltmeter configuration with a suitable series resistor is simply connected between common and the line to be watched.

Since RS-232 transmission is in the form of two voltages with opposite polarity to indicate binary 0 or 1. If you assume one start and one stop bit, maximum usage will show on the meter, scaled for $\pm 100\%$, as zero. Idling shows up as -90% to -100% , fairly busy as -50% to -20% and flat out as -20% to $+20\%$. The region $+20\%$ to $+50\%$ means that something is not quite right. Anything over $+50\%$ indicates a probable fault.

Trim the series resistor to obtain a -100% reading for zero traffic.

Keith Wootten
Reading

Transconductance square rooter

In the simple circuit of Fig. 1, output signal V_o is the square root of input voltage V_i . The circuit is based on the quadratic law connecting I_D and V_{GS} in an enhancement mode mosfet, $I_D = K(V_{GS} - V_T)^2$. This may also be written $V_{GS} = V_T + \sqrt{I_D/K}$, where V_T is the threshold voltage and K is a constant depending on the physical parameters of the mosfet.

Together with Tr_1 , op-amp A_1 forms a voltage follower, so $V_{R2} = V_i$, $I_D = V_i/R_2$ and V_{GS} , which is buffered and referred to ground by a difference amplifier, is then $V_T + \sqrt{(V_i/KR_2)}$.

The second stage allows V_T to be subtracted, through RV_1 , and it allows total gain to be adjusted through RV_2 , in order to obtain $V_o = \sqrt{V_i}$.

To avoid thermal drift problems, the mosfet works close to the threshold voltage, with low values of I_D , where $I_D = f(V_{GS})$ is exponential rather than quadratic. However, a good adherence to the root law can be obtained by iteratively adjusting RV_1 and RV_2 .

Figure 2 shows V_o versus V_i with an input range of 0 to 1V with a root function.

Giorgio Delfino

University of Padova
Department of Physics
Istituto Nazionale per la Fisica della Materia
Italy

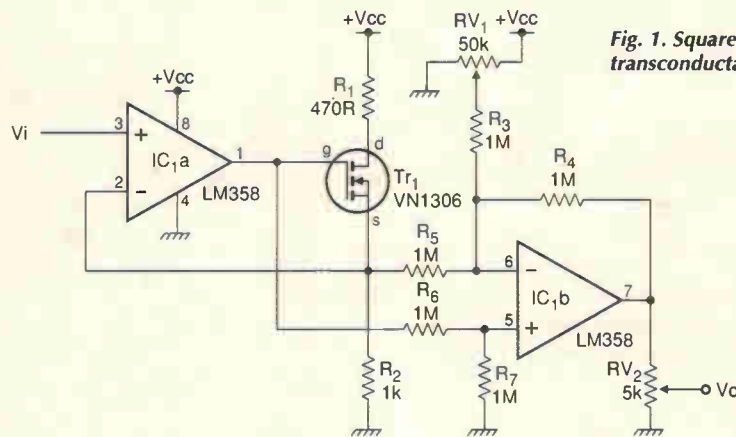


Fig. 1. Square rooting circuit based on transconductance.

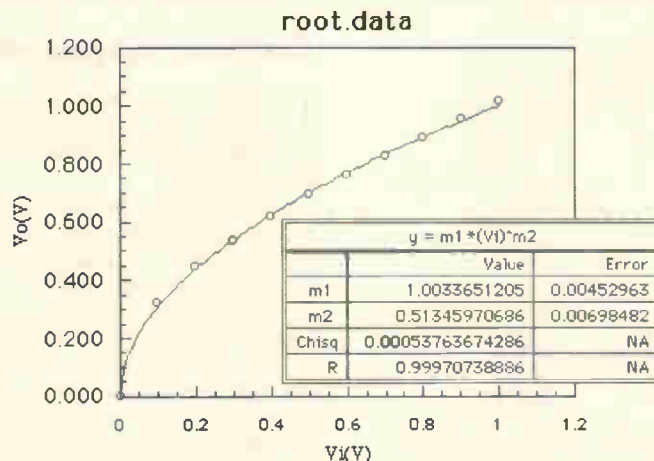


Fig. 2. Graph showing how voltage V_o closely approximates the square root of V_i .

Higher-order elliptic filter design

High-speed, current-feedback op-amps such as the *Burr-Brown OPA603* make it possible to design active filters working in the megahertz range of frequencies. Presented here is a quick method of calculating elliptic filters of any order, the example shown being a fifth-order type which is considered as being in two sections, as shown in Fig. 1.

Assume the poles $s = \alpha + j\beta$ and zeros Ω are given for a filter having the reflection factor of ρ and modulus α_0 .

Design can proceed in three steps. Assume $\rho = 20\%$ and $\alpha_0 = 20^\circ$:

$$\begin{aligned} \Omega_1 &= 3.0653 & s_{1,2} &= 0.382271 \pm j0.67123 \\ \Omega_4 &= 4.8753 & s_3 &= \gamma = 0.49308 \\ & & s_{4,5} &= 0.13647 \pm j1.05129. \end{aligned}$$

1. If you calculate the constants A_1 and A_2 using the expressions,

$$A_1 = 2\alpha A_2 \text{ and } A_2 = 1/(\alpha^2 + \beta^2), \text{ then for a third-order filter,}$$

$$A_2 = 1.6759379 \text{ and } A_1 = 1.2813249$$

and for a second-order filter,

$$A_2 = 0.88918 \text{ and } A_1 = 0.242865.$$

2. Calculate normalised capacitances using the expressions in Fig. 1.

3rd-order

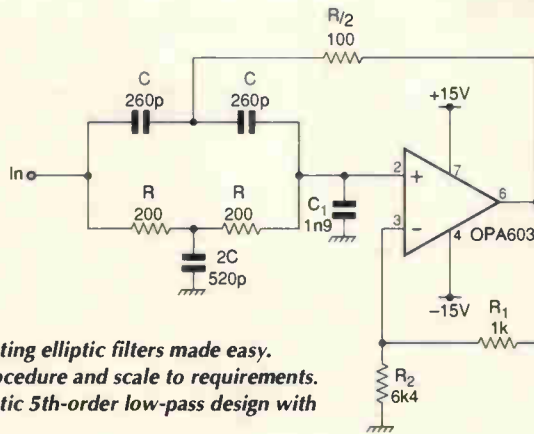


Fig. 2. Calculating elliptic filters made easy. Follow the procedure and scale to requirements. This is an elliptic 5th-order low-pass design with 1MHz cut-off.

$$\begin{aligned} c &= 1/\Omega_2 = 0.326232 \\ c_1 &= 2.40551 \\ c_2 &= 2.02807 \\ k &= 0.134956 \end{aligned}$$

and for a second-order filter,

$$\begin{aligned} c' &= 1/\Omega_4 = 0.205116 \\ c'_1 &= 2.06648 \\ k' &= 0.087087. \end{aligned}$$

3. For physical capacitance values, multiply the above c values by a factor of $1/2\pi f_0 R$, where f_0 is the cut-off frequency and R the reference resistance. In the case shown here, $f_0 = 1\text{MHz}$ and $R = 200\Omega$.

Kamil Kraus
Rokycany
Czech Republic

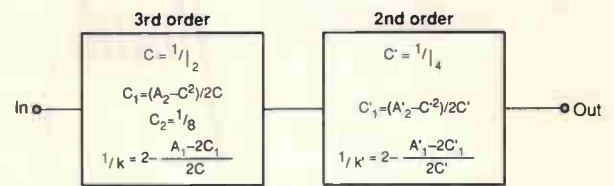
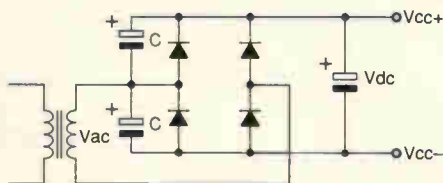
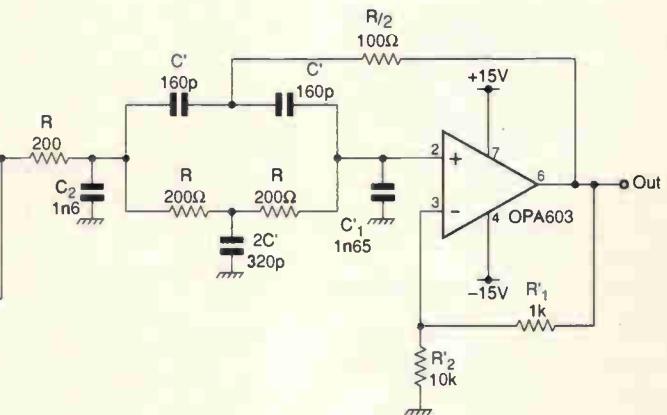
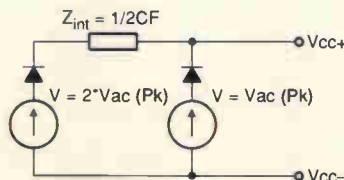


Fig. 1. Decomposition into third and second-order sections and formulas.



Bridge rectifier turns into a voltage doubler at low currents, its output falling linearly with increasing current.



Current-dependent rectifier or doubler

This bridge rectifier becomes a voltage doubler at low currents, reverting to normality when current drain increases.

It is essentially a bridge rectifier with the extra capacitors C . When no current is taken, output voltage is twice that at the input and, as current increases, internal impedance causes the output to fall linearly according to $Z_{int} = 1/(2Cf)$, assuming ideal components, until the output voltage equals the peak ac, when the circuit becomes an

ordinary bridge rectifier.

An application is as a rectifier for lead-acid battery charging, in which a high voltage (25-30V) is needed to drive a small current into a 12V battery that has been discharged for a period and has an isolating layer on the electrodes. As current increases, a lower output from the rectifier reduces dissipation in the charger's output transistor.

Albert Pijuan
Girona
Catalonia

Frugal buzzer

Four components make this very simple buzzer. Some n-p-n transistors oscillate at audio and low ultrasonic frequencies when polarity is reversed. Lowest working voltage depends on power rating, but it is about 7-8V for devices such as the BC109, BC337 and BC238, 12V for the BD139 and around 16V for power transistors 2N6543 and BUX22.

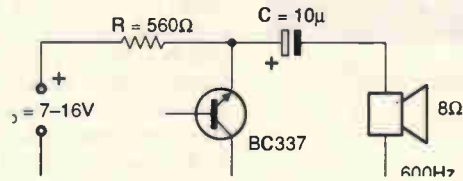
Oscillation frequency for the circuit shown is given by the empirical

equation

$$f = (V_b - 5.5) / RC$$

and is constant for devices of the same type. Power requirements are 5mA at 9V, 10mA at 12V; increasing R and decreasing C reduces power drain and also sound output. Higher voltage supplies can be used with increased values of R.

D Di Mario
Milan
Italy



Buzzer using reversed-polarity transistor as oscillator. Since the base is left open, it could be used to gate the buzzer.

10pF-10μF capacitance meter

A very simple circuit using a 555 timer and a few passive components forms a capacitance meter measuring full-scale ranges of 100pF-10μF.

Figure 1 shows the meter circuit, in which the 555 is connected as a free-running multivibrator, the frequency of the output rectangular wave being determined by

$$f = 1/T = 1.44 / (R_A + 2R_B)C$$

and

$$D = R_B / R_A + 2R_B$$

T being the period and D the duty cycle, which is made asymmetrical by setting $R_A = R_B$, since charging through the meter takes longer than discharging via the diode.

Unknown capacitors connect points A and B and C takes the form of six components selected by the switch in Fig. 2. If V is the amplitude of the 555 output, current through the meter is $I = VCf$, capacitance being therefore proportional to current for a constant

frequency. The table shows the ranges and frequencies for a 10V supply. Without the damping components $R_{1,2}, C_1$, the meter bounces a little on the highest range, since the frequency is 1Hz; at higher frequencies it is steady.

The charge-pump power supply shown in Fig. 3 also uses a 555 to double the input voltage and produce a 10V output, filtered sufficiently by C_3 . A regulated supply would give better stability.

Calibration in the original was by the use of known capacitors, adjustment being by the trimmer for one range.

Raj K Gorkhali
Kathmandu
Nepal

Fig. 3. Another 555 forms the power supply, a charge-pump voltage doubler to give 10V from the 6V supply.

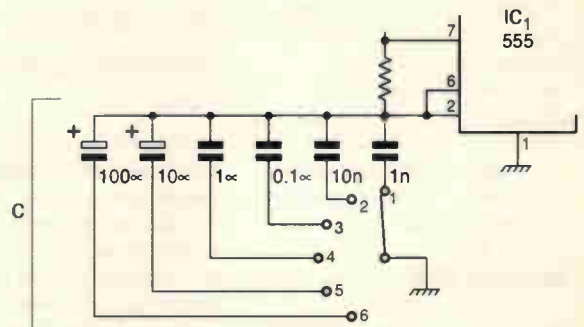


Fig. 2. Range-selection switch.

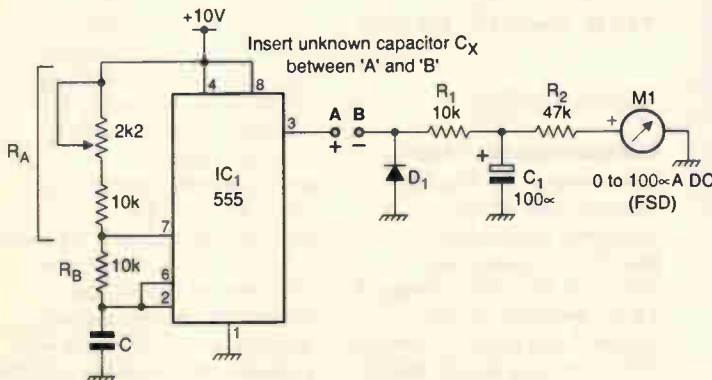
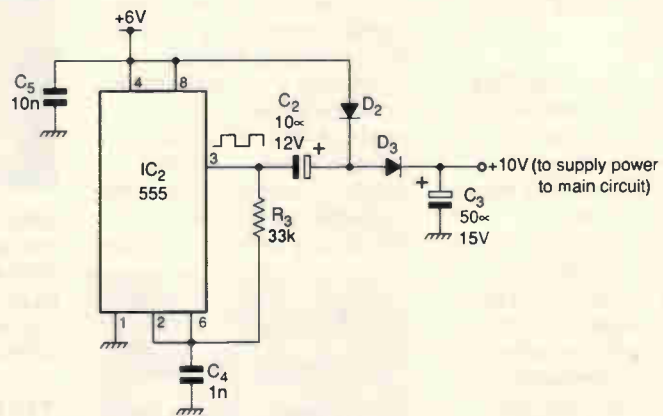
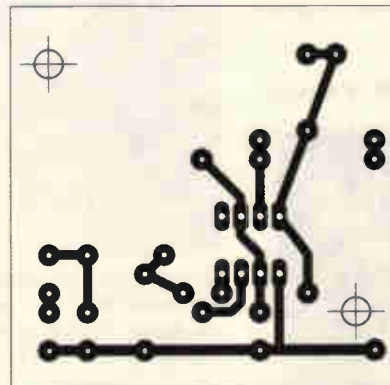
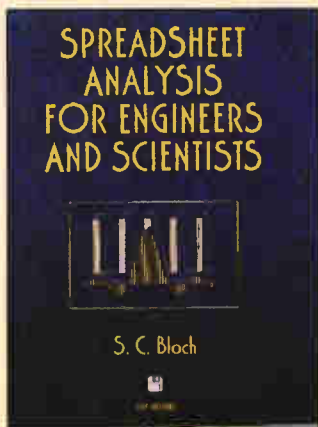


Fig. 1. Linear, direct-reading capacitance meter for values of 10pF-10μF.



BOOKS TO BUY BOOKS TO BUY



Spreadsheet Analysis for Engineers and Scientists

With this practical, hands-on guide, engineers and researchers learn, quickly and easily, the latest and most useful electronic spreadsheet methods. Using a variety of interactive techniques, including worksheets, self-test and practical programs on the included disk, *Spreadsheet Analysis for Engineers and Scientists* show you how to harness the power and versatility of spreadsheet programs, including those that contain the fast Fourier transform, complex operations and Bessel functions, and how to customise your own applications.

Includes disk

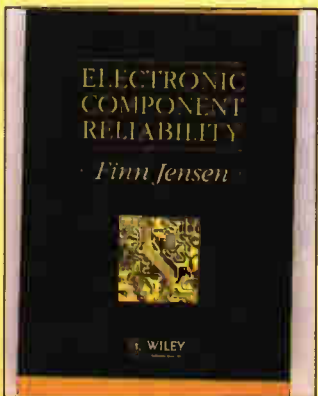
0471 126837, 336pp
UK £37.50, Europe £39.50, ROW £49.50

Electronic Component Reliability

Fundamentals, Modelling, Evaluation and Assurance

This text approaches the quality and reliability of electronic components from a unique standpoint. Traditionally the twin subjects of reliability physics and reliability statistics have been treated as separate entities. Here, the author examines both areas and reveals how components fail and how failures develop over a period of time.

0471 952966, 374pp
UK £50.50, Europe £53.50, ROW £66.50



Fuzzy Logic

Implementations and Applications

Offering a new perspective on a growing field, this text explores the many hardware implications of fuzzy logic based circuits. As use of AI increases, so the VLSI area of circuits is becoming a growth subject. Opening with an overview of fuzzy sets and fuzzy logic the book moves on to cover a range of non-standard solutions for fuzzy logic VLSI circuits. Future trends, new concepts and ideas are all examined and supported with practical examples from the author's research.

ISBN 0471 950599, approx 346pp,
UK £50.50, Europe £53.50, ROW £66.50

Microelectronic Switched-Capacitor Filters

Switched-capacitor filters and associated MOS integrated circuits are now an established technology finding applications in the telecommunications and instrumentation fields. With unrivalled breadth of coverage, this book surveys the design techniques of an important class of analogue signal processing systems. An accompanying diskette containing a comprehensive computer-aided design package (ISICAP) enables readers to gain a greater depth of understanding of the described techniques. Containing both source code



files and an executable version of the main design package, this alone will be an indispensable tool for many circuit designers.

Includes disk

0471 954047 384pp
UK £75.50, Europe £79.00, ROW £92.00

The I²C Bus

From theory to Practice

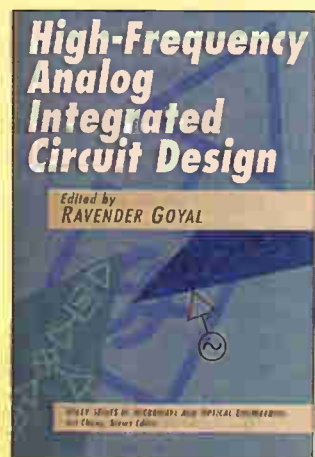
With a special emphasis on the I²C Bus, this guidebook through the world of micro controller-managed serial buses presents comprehensive coverage of the theory necessary to design the best possible communications bus for any particular application. The book examines typical industrial and consumer applications and enables the reader to design effectively in a real-world environment. A disk containing software for the I²C bus is also included.

Includes disk

0471 96268 6, 314pp
UK £54.50, Europe £56.50, ROW £65.00

High Frequency Analog Integrated Circuits

As one of the first textbooks to discuss integrated circuit design considerations and



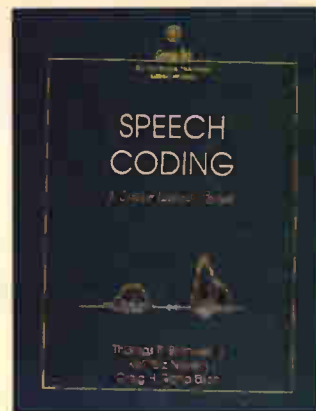
actual designs from the basic concepts, this title provides a solid background in designing basic circuits, advanced circuits and synthesis techniques.

0471 530433 424pp
UK £80.00, Europe £83.00, ROW £95.00

Speech Coding

A Computing Laboratory Textbook

This is one of the first lab manuals with software dedicated exclusively to speech processing and coding. It takes advantage of the development of the personal computer by making this technology accessible to a wider audience. The manual and Dos based software together create a user-friendly digital signal processing lab which allows the user to



perform a wide variety of speech coding and speech processing experiments. The text presents and explains a set of basic speech coders analytically and in terms of the specific parameters controlling each coder. The manual leads the student through the experimental process of understanding how speech coders work and sound via over 70 exercises and projects. The class-tested menu-driven, Dos-based software can be operated by students with little or no training.

Includes disks

0471 516929, 194pp,
UK £28.95, Europe £30.95, ROW £36.95

Solar Cells and their Applications

The past decade has witnessed numerous important breakthroughs in solar cell technology, many of which have occurred in just the past few years. Far cheaper to produce and maintain, exhibiting a longer lifetime, and considerably more efficient than ever before, solar cells are, at last, in a position to compete with traditional technologies for both small and large-scale energy conversion applications. Including contributions from some of the world's leading experts in the field, this book reports the most important recent advances in solar cell technology. From in-depth discussions of breakthroughs in cell, module, and system technologies to a probing look at important environmental, health, and safety issues in the photovoltaic industry, it covers a broad range of topics of vital interest to solar cell researchers, power systems designers, and all those with professional interest in current and future capabilities of this important technology. Offers a detailed look at cutting-edge solar technology from an international team

SOLAR CELLS AND THEIR APPLICATIONS



Edited by
LARRY D. PARTAIN

of researchers.

Covers silicon, GaAs, InP, CdTe, a-Si:H, CuInSe₂₉ and GaSb solar cells, cells, concentrators, multijunction cell configurations, space cells, and more.

Describes a wide range of applications - from space cells to terrestrial systems Provides an informal look ahead at the future of solar cell technology.

0471 574201, 596pp,
UK £71.50, Europe £75.00, ROW £92.00

Introduction to High-Speed Electronics and Optoelectronics

Lasers, fibre optics, and high-speed optical systems share many concepts with microwave devices. Furthermore, semiconductor-based optoelectronics and microwave integrated circuits share evolving process technologies. It is only natural, therefore, that students of optoelectronics be introduced to high-speed concepts in a unified manner. This highly practical intensive introduction enables electrical engineers, applied physicists, and students to develop and identify tools for understanding, analysis, design, and characterisation of high speed components. Broad in scope, this unique

text/reference examines the complementary nature of electronics and optics and emphasizes high-speed technology in which the two fields are less differentiated. Beginning with an overview that develops a perspective and appreciation of analog high-speed technology in general, the book goes on to cover devices and circuits used at microwave and millimeter-wave frequencies, optical components, and optoelectronic integrated circuits and subsystems. Particular attention is paid to applications in the area of high levels of interest in this area and because many of the concepts are applicable in other fields. The book concludes with important coverage of the often-overlooked area of measurement and characterization of high-speed devices. Fully referenced and supplemented with hundreds of helpful illustrations, *Introduction to High-Speed Electronics and Optoelectronics* is equally useful as a professional reference or a textbook for senior undergraduate and first-year graduate courses. 0471 015822, 312pp,
UK £65.00, Europe £67.00, ROW £77.00

Risc Systems and Applications

Professor Daniel Tabak has completely revised and updated his two previous books on Reduced Instruction Set Computer architecture to produce this new book, RISC Systems and Applications. The text is a unique, concentrated, detailed description of the architecture and implementation of most recent high-performance RISC systems, such as DEC Alpha AXP21164, IBM/Motorola/Apple PowerPC 620, Sun Microsystems and Texas Instruments UltraSPARC and SuperSPARC, MIPS technologies R10000, Intel i860 XP, Motorola MC88110, Hewlett-Packard PA-7100/8000 and the transputer. It also includes details of pioneering devices such as Berkley's RISC II and Stanford's MIPS and multiprocessor, real-time and workstation systems. ISBN 0863 801889, 452pp,
UK £50.50, Europe £54.00, ROW £67.00

All prices are fully inclusive of packing and delivery

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

Please supply the following titles:

Qty	Title or ISBN	Price

** All prices on these pages include delivery and package **

Total _____

Name _____

Address _____

Postcode _____

Telephone _____

Method of payment (please circle)

Access/Mastercard/Visa/Cheque/PO

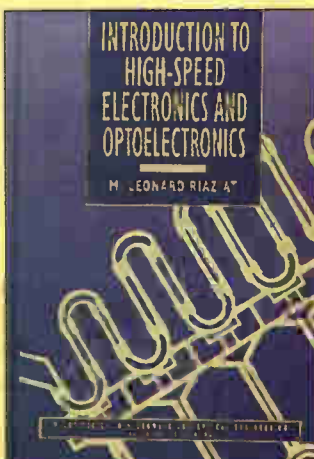
**Cheques should be made payable to
Reed Business Publishing**

Credit card no _____

Card expiry date _____

Signed _____

Please allow up to 28 days for delivery



M&B RADIO (LEEDS)

THE NORTH'S LEADING USED TEST EQUIPMENT DEALER

OSCILLOSCOPES

HP 3411TD 500 MHz digitizing scope (colour display)	£2350
HP 3411D 100 MHz 4 channel digitizing scope (colour display)	£1750
HP 5420D 300 MHz 2 channel digitizing (27 channels logic state triggering)	£1750
HP 5420A 50 MHz 2 channel digitizing scope	£600
HP 1740A 100 MHz 2 channel	£185
HP 1727A 275 MHz 2 channel storage	£500
TEKTRONIX 2465ADH 350 MHz 4 channel (digital multimeter, GP-IB/opt 09)	£2500
TEKTRONIX 2230 100 MHz 2 channel digital storage	£1750
TEKTRONIX 2220 60 MHz 2 channel digital storage	£1500
TEKTRONIX 2235 100 MHz 4 channel GP-IB	£1750
TEKTRONIX 2445 150 MHz 4 channel opt 05	£1500
TEKTRONIX 2246 100 MHz 4 channel auto cal	£1200
TEKTRONIX 79037A/82A/278B/300 MHz 4 channel	£450
TEKTRONIX 74037A/18A/27853A 4 channel	£350
TEKTRONIX 475A 350 MHz 2 channel scope	£600
TEKTRONIX 475 200 MHz 2 channel	£400
TEKTRONIX 466 100 MHz 2 channel	£450
TEKTRONIX 465B 100 MHz 2 channel	£500
TEKTRONIX 465 100 MHz 2 channel opt 05	£450
TEKTRONIX 434 25 MHz 2 channel storage	£300
TEKTRONIX 2215 60 MHz 2 channel	£325
TEKTRONIX 2225 50 MHz 2 channel	£450
TEKTRONIX 2235 100 MHz 2 channel	£700
TEKTRONIX TM 504 4 slot mainframe	£150
PHILIPS PM 3217 50 MHz 2 channel	£400
PHILIPS PM 3055 50 MHz 2 channel	£425
PHILIPS PM 3057 50 MHz 2 channel	£475
PHILIPS PM 3134 50 MHz 4 channel	£300
PHILIPS PM 3263X 100 MHz delay/trigger	£400
PHILIPS PM 3310 60 MHz digital (BOXXED NEW)	£600
PHILIPS PM95 50 MHz oscilloscope (BOXXED NEW)	£850
IWATSU SS 4122 100 MHz 4 channel with cursors	£800
IWATSU SS 5710 60 MHz 4 channel	£400
IWATSU SS 5705 40 MHz 2 channel	£300
IWATSU SS 5416A 40 MHz 2 channel	£250
FARNELL DTY100 100 MHz 3 channel (NEW)	£350
KIKUSI COS 4100 100 MHz 3 channel	£375
HITACHI V1100 100 MHz 4 channel with cursors	£750
HITACHI V114 40 MHz digital storage	£245
GOULD 420 20 MHz digital storage 2 channel 4 colour hardcopy	£1250
GOULD 1401 20 MHz digital storage 2 channel	£400
GOULD OS300 20 MHz 2 channel	£200
GOULD OS4000 10 MHz digital storage 2 channel	£190

SPECTRUM ANALYSERS

TEKTRONIX 479F 10 MHz-21 GHz (1 year cal & warranty)	£9000
TEKTRONIX 7L12 10 MHz-1800 MHz 4 channel mainframe	£1000
TEKTRONIX 7L5 L3 OPT 75 tracking gen. + mainframe	£1000
TAKEEDA RIKEN TR4172 400 Hz-1800 MHz spectrum/network analyser	£4000
HP 8754A 4 MHz-1300 MHz network analyser	£2000
HP 8407A/8412B network analyser 0.1-110 MHz	£400
HP 8558B 100 kHz-1500 MHz + mainframe	£1500
HP 8549B 10 MHz-22 GHz OPT 003/400/443	£4950
HP 3582A 0.02 Hz-25.5 MHz dual channel signal analyser	£1800
HP 3585A 30 Hz-40 MHz baseband spectrum analyser	£4000
HP 3462A 64 MHz-100 MHz dynamic signal analyser (1 year cal & warranty)	£4000
HP 1417/8552B/8555B 10 MHz-110 MHz	£450
HP 1417/8552B/8555B 100 kHz-1250 MHz	£1200
HP 1417/8552B/8555A 10 MHz-18 GHz	£1500
MARCONI TF2370 30 Hz-110 MHz digital storage	£850
BRUEL & KJAER 2033 20 Hz-20 KHz audio	£750

SIGNAL GENERATORS

HP 8904A DC-600 KHz multifunction synthesizer	£2500
HP 3314A 0.01 Hz-1800 MHz function/waveform monitor	£2750
HP 3586C 50 Hz-325 MHz selective level meter	£1500
HP 8683D 2.3 GHz-13 GHz OPT 001003 solid state generator (as new)	£2950
HP 8654A 100 kHz-900 MHz signal generator	£2500
HP 8620C/8620A 10-1300 MHz sweep	£600
HP 8620C/8620B 1.8 GHz-4.2 GHz sweeper	£1000
HP 8620C/8620A 3.2-5 GHz sweeper	£1000
HP 8620C/8620D 5.9-9 GHz sweeper	£1200

HP 8620C sweeper mainframes (as new)	£250
HP 8648B 500 kHz-512 MHz signal generator	£450
HP 8654B 10 MHz-520 MHz RF generator	£400
HP 3200B 10 MHz-500 MHz oscillator	£200
HP 3334B 10 Hz-21 MHz synthesizer/level meter	£400
HP 3320A frequency synthesizer 0.1 Hz-13 MHz	£450
HP 3312A 0.1 Hz-13 MHz function generator	£400
ADREY T100D 300 Hz-1300 MHz signal generator	£275
HP 8005B 0.3 Hz-20 MHz pulse generator	£200
TEKTRONIX 2901 tone mark generator	£450
MARCONI TF2017 10 KHz-520 MHz signal generator	£2000
MARCONI TF2018 80 KHz-520 MHz signal generator	£450
HP 3310B 0.0005 Hz-5 MHz function generator	£450
MARCONI TF2017 10 KHz-1024 MHz signal generator	£300
MARCONI TF2018 10 KHz-512 MHz RF generator	£295
GIGA 6011A 10 Hz-11 MHz synthesized signal generator	£1000
MARCONI TF2016 10 KHz-120 MHz with synchronizer	£295
MARCONI TF2016/2173 10 KHz-120 MHz with synchronizer	£300
MARCONI TF2008 10 KHz-512 MHz RF generator	£300
FARNELL PS6320 100 KHz-125 MHz synthesized	£1000
FLUKE 6011A 10 Hz-11 MHz synthesized signal generator	£1000
ROHDE & SCHWARTZ APN42 0.1 Hz-260 KHz LF gen (new)	£2000
WILTRON 610D501 1 MHz-1500 MHz sweeper + log meter	£500
GIGA GR1101A 13 GHz-18 GHz pulse generator	£600
GIGA 900 2-8 GHz RF sweep generator	£750
PHILIPS PM5326 100 KHz-125 MHz RF generator	£400
ADREY T210A 200 KHz-11 MHz synthesized source	£185
WAVETEK 193 20 MHz sweep modulation generator	£400
WAVETEK 171 2 MHz synthesized function generator	£450
WAVETEK 181 0.002 Hz-2 MHz function generator	£175
THANDAR TG503 0.005 Hz-5 MHz pulse/function generator	£225
SAVROSA MA 30 10 Hz-100 KHz	£175

TEST EQUIPMENT

ELECTECS EMT-25 MKIII interference analyser 10 KHz-1 GHz	£995
BALL EFNATROM PRT-T1 rubidium frequency standard	£4000
WAVETEK 1018A log in RF peak power meter DC-26 GHz	£1000
ANRITSU M545A 2 GHz error detector	£950
TEKTRONIX 1141/SPG11/TSJ11 pal video generator	£1500
TEKTRONIX 145 pal gen lock test signal generator	£200
TEKTRONIX 5217 100 MHz-1 GHz level meter	£450
TEKTRONIX A6102A isolator	£450
TEKTRONIX 1502 TDR cable tester	£500
SCHLUMBERGER T703 digital transmission analyser (new)	£500
SCHLUMBERGER 4900 A/P/F measuring unit	£400
SCHLUMBERGER AF405 3 tone generator/modulator	£150
FERRORAPHI RTS 2 audio test set	£2000
MARCONI TF2305 mod meter 50 KHz-2.3 GHz	£695
MARCONI TF2610 true RMS voltmeter	£250
MARCONI AF504R10 10 MHz-20 GHz RF power meter	£250
MARCONI 6593A VSWR indicator	£250
MARCONI 4460/4211 10 MHz-12.4 GHz RF power meter	£250
MARCONI TF2306 programmable interface unit	£250
MARCONI TF1432A 10 Hz-560 MHz frequency counter	£125
HP 4954A protocol analyser + HP 18155A pod	£2000
HP 8701A noise figure meter	£3500
HP 37711A TI-datarcom test set	£1500
HP 3342A 300 MHz-18 GHz microwave frequency meter	£900
HP 3343A universal systems counter	£750
HP 5335A universal systems counter	£1000
HP 5345A 1.5 MHz-26.5 GHz counter/5355A/5356A+B sensors	£3000
HP 435B 0.01/0.08/0.4/1/10/80 MHz-18 GHz (new/HP case/manuals)	£1000
HP 435B/481A 10 MHz-18 GHz RF power meter	£800
HP 435A/481A 100 kHz-4.2 GHz RF power meter	£600
HP 42A/478A 10 MHz-10 GHz RF power meter	£275
HP 435A RF power meter calibrator	£450
HP 8477A RF power meters	£225
HP 5087A distribution amplifier (new)	£750
HP 3488A switch controller	£550
HP 3581C 15 Hz-50 KHz selective voltmeters as new	£400
HP 333A distortion analyser	£295
HP 11710A down converter	£200
HP 59401A bus system analyser	£200

HP 400E 10 Hz-10 MHz AC voltmeter	£125
HP 3403C true RMS voltmeter (digital)	£195
HP 3406A 10 KHz-1200 MHz RF sampling voltmeter with probes	£200
HP 3465A 4.5 digit multimeter	£125
HP 3466B 5 digit autorange multimeter	£200
HP 3437A 3.5 digit high speed system voltmeter	£200
HP 3455A 6.5 digit bench multimeter	£495
HP 3468A 5.5 digit multimeter/auto cal (LCD)	£400
HP 5044A signature analyser	£1500
HP 5005A signature multimeter	£200
HP 4648A DC power supply 0-600V/0-1.5 amp	£750
HP 6825A power supply/amplifier -20v to +20v/0-3 amp	£250
HP 11665B 150 MHz-18 GHz modulator	£350
HP 11582A attenuator set DC-18 GHz	£500
HP 355C RF step attenuators 0-12 dB DC-1 GHz (NEW)	£195
HP 355D RF step attenuators 0-120 dB DC-1 GHz (NEW)	£195
BIRD 8323 30 db coaxial attenuator 100W	£200
BRADLEY 192 oscilloscope calibrator	£500
RESIO DP1 1 Hz-100 KHz phase meter (new)	£150
WAYNE KERR CT496 LCR meter battery portable	£75
WAYNE KERR 4235 LCR meter	£400
AVO 315-LJ AC/DC breakdown/insulation tester	£400
FARNELL RB10315 electronic load	£400
FARNELL TM8 10 KHz-1000 MHz true RMS sampling voltmeter	£350
FARNELL PDD352 dual power supply 0-35v 2 amp	£250
FARNELL TSV70 power supply 0-70v 0-10 amp	£300
FARNELL AP40-50 power supply 0-60v 0-50 amp	£600
SIEMENS D218 2235 oscilloscope (new)	£350
SIEMENS D218 100 KHz-30 MHz level meter	£350
SIEMENS W3108 200 KHz-30 MHz level oscillator	£350
NARDA 3011-20 500 MHz-1000 MHz directional coupler 20db	£125
NARDA 3044B-20 3.7 GHz-8.3 GHz 20db directional coupler	£200
NARDA 40132 solid state amplifier 8 GHz-12 GHz	£100
SAVROSA AMH 1.5 MHz-2 GHz automatic modulation meters	£175
ROHDE & SCHWARTZ NKS RF power meter	£600
SPECTRASCOPE SD330A real time analyser	£350
REDIFON RA500 100 Hz-30 MHz receivers	£450
RACAL RA17 30 MHz valve receiver	£200
RACAL RA1218 30 MHz receiver	£350
RACAL RA1772 30 MHz receiver	£650
RACAL 31092/4/2/28/2296 20 MHz-1000 MHz receivers	£100
RACAL RA6793A 30 MHz receiver (as new)	£1500
RACAL RA1779/MA 1107 30 MHz receiver	£1500
RACAL 9003 2 tone tone oscillator	£200
RACAL 9008 1.5 MHz-2000 MHz automatic modulation meter	£300
RACAL DANA 9904M 50 MHz universal counter timer	£95
RACAL DANA 9914 10 Hz-200 MHz frequency counter	£95
RACAL DANA 9915 10 Hz-520 MHz frequency counter	£95
RACAL DANA 9916 10 Hz-520 MHz frequency counter	£150
RACAL DANA 9918 10 Hz-1100 MHz frequency counter	£295
RACAL DANA 9908 10 Hz-1100 MHz universal counter timer	£400
RACAL DANA 9921 10 Hz-3000 MHz frequency counter	£400
RACAL DANA 9919 10 Hz-160 MHz universal counter timer 9 digit	£295
RACAL DANA 1992 10 Hz-1300 MHz nanosecond counter	£600
RACAL DANA 9300 RMS voltmeter	£350
RACAL DANA 9301A true RMS RF millivoltmeter	£400
RACAL DANA 6000 microprocessing digital voltmeter	£250
BRUEL & KJAER 2971 phase meter	£300
DATRON 8050A digital multimeter	£400
DATRON 1071 autocall digital multimeters	£400
FLUKE 8505A digital multimeter	£750
FLUKE 3488B universal RMS multimeter	£100
FLUKE 103A frequency comparator	£250
ESI SR 104 standard resistor 10,000 ohm	£400
FLUKE 32400 current/voltage calibrator	£450
FLUKE 5200A AC calibrator	£2000
FLUKE 5205A precision power amp	£2750
FLUKE 54000 5 digit calibrator	£495
RF MICROSYSTEMS INC. AN/TRC-176 VHF/UHF KAL filters	£400

ALL PRICES PLUS VAT AND CARRIAGE • ALL EQUIPMENT SUPPLIED WITH 30 DAYS WARRANTY

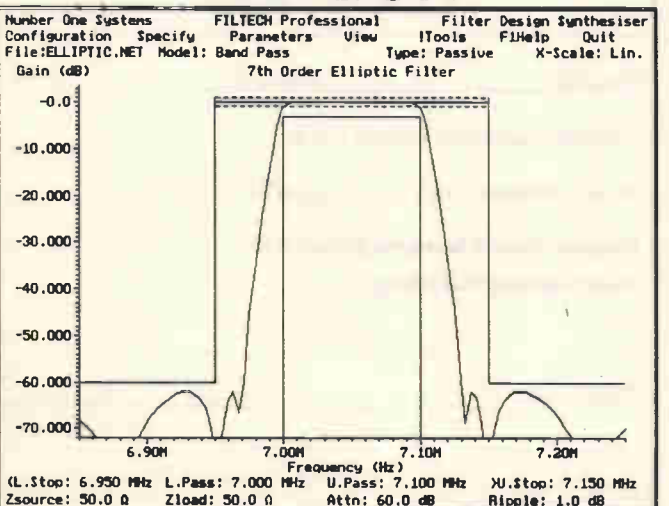
86 Bishopsgate Street, Leeds LS1 4BB
Tel: (0113) 2435649 Fax: (0113) 2426881

Visit our Web site
<http://www.mb-radio.co.uk>
e-mail info@mb-radio.co.uk

CIRCLE NO. 124 ON REPLY CARD

Electronic Designs Right First Time?

Active and Passive Filter Design - FILTECH -



From only £145!

For Full Information Please Write, Phone or Fax.

<http://www.numberone.com>

Tel: +44 (0) 1480 461778, Fax: +44 (0) 1480 494042



EASY-PC Professional: Schematic Capture and PCB CAD. Links directly to ANALYSER III, LAYAN and PULSAR.	\$375.00	£195.00
Prices From:		
ANALYSER III: Linear Analogue Circuit Simulator	\$195.00	£98.00
Prices From:		
LAYAN: Electro-magnetic layout Simulator. Include board parasitics in your Analogue simulations.	\$950.00	£495.00
Prices From:		
PULSAR: Digital Circuit Simulator	\$195.00	£98.00
Prices From:		
Z-MATCH: Windows based Smith-Chart program for RF Engineers.	\$275.00	£145.00
Prices From:		
FILTECH: Active and Passive Filter Design	\$275.00	£145.00
Prices From:		
We operate a no penalty upgrade policy. Technical support is FREE FOR LIFE. Special prices for Education		
US\$ prices include Post and Packing		Sterling Prices exclude P&P and VAT.

Number One Systems
Ref: WW, Harding Way, St. Ives, Cambridgeshire, PE17 4WR, UK.

CIRCLE NO. 125 ON REPLY CARD

Measuring microamps

Not happy with the current measuring performance of today's digital multimeters, Robert Pearson has designed his own digital ammeter, which features a 20 μ A range and 0.1 Ω shunt resistance.

There have been tremendous advances in the design and construction of portable digital multimeters. But although such instruments perform excellently on voltage ranges, most leave something to be desired when it comes to current measurement.

Before there were such things as digital instruments, it was easy to obtain a moving-coil instrument with a full-scale deflection as low as 50 μ A and with a full-scale volt-drop of as little as 50 or 75mV. Even lower figures were not uncommon.

In thermionic valve circuits, supply voltages were usually so large that milliammeter voltage drops could almost always be ignored. But modern semiconductor circuits are designed with very much lower supply line voltage requirements. A recent *Electronics World* news story concerned an op-amp that works with a supply of just one volt.

Many digital milliammeters produce a drop of 0.2V or more, at full-scale indication. This figure causes measurement errors that are often unacceptable. Another disappointment with modern digital multimeters is the almost universal common choice of 200 μ A as the most sensitive current range.

The meter's design

There are still many occasions when a separate voltmeter and an ammeter are desirable,

which is why I designed this dc digital milliammeter. Its characteristics are at least as good as those available in common analogue meters 50 years ago.

The main trigger for designing the instrument was the offer, in *Electronics World*, of PM128 digital panel meters from Vann Draper Ltd. These compact and affordable basic meters have a 200mV range and very high input resistance. They also have a liquid crystal 3.5-digit display and require only about a milliamp from a 9 to 12V battery.

A factor that simplified the design was that integrated-circuit amplifiers with sufficiently low offset voltages and currents are now become cheap and readily available. There is no longer a need to resort to chopper configurations.

Circuit notes

Adding an amplifier like the OPA177PG to such a panel meter makes it easy to reduce the voltage drop of a digital milliammeter by at least one order, to only 20mV. Simultaneously, the op-amp makes it possible to reduce the lowest current range by the same factor of ten - i.e. to 20 μ A, Fig. 1.

For a 20mV drop on the 200mA range, a 0.1 Ω shunt is required. With such a low resistance, the uncertainty of switch contact resistance becomes significant. An extra switch

bank is added to ensure that the measured potential difference is solely that across the shunt resistor, and not across the contact resistance of the switch carrying the current to be measured, Fig. 2.

Including a higher current range or a lower voltage drop would require expensive four-terminal shunts and more complex switching. A wire fuse was not included due to its voltage drop. In any event, there is no need to protect the shunts since they are not expensive.

Some protection for the amplifier input is provided by a series resistor and a pair of back-to-back diodes. A similar arrangement following the amplifier offers protection to the panel meter. Negligible loss is caused by this extra circuitry since the meter has an input resistance exceeding 100M Ω .

Removing the unwanted

It is not easy to filter out low-frequency alternating current components that may exist simultaneously with the direct current being measured.

The main filtering is achieved by the a-to-d converter in the digital voltmeter section, by integrating over one or more complete cycles of the mains waveform. This technique provides rejection only near that one frequency, which needs to be 50Hz in Europe. It works adequately only if the a-to-d converter is not

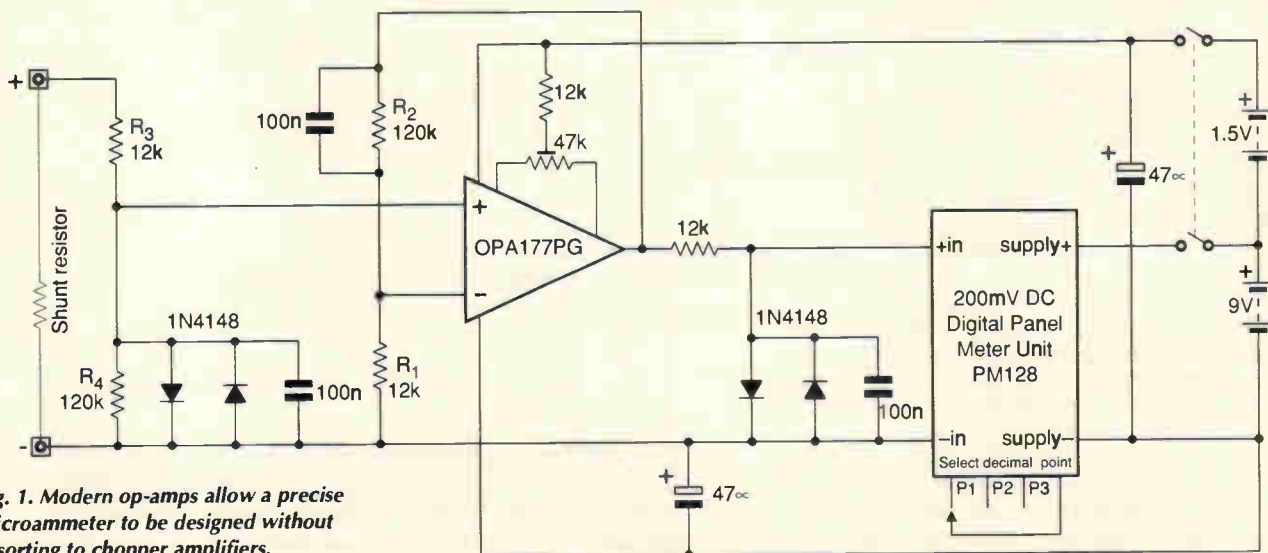


Fig. 1. Modern op-amps allow a precise microammeter to be designed without resorting to chopper amplifiers.

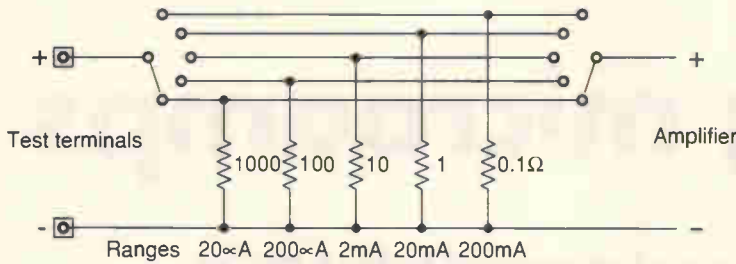


Fig. 2. Milliammeter shunt switching involves doubling up on the contacts to minimise effects of contact resistance.

pushed beyond its maximum input limits by the unwanted alternating signal. This is an important reason for including some signal amplitude limitation. The 100nF capacitors provide useful rejection of higher frequencies.

In Fig. 1, there appears to be no circuitry defining the vital 'common' rail potential for the amplifier input circuit. Since the panel meter section is completely inside the same box as the amplifier and uses the same battery supply, the meter must be allowed to set the level of its own input reference potential. This then becomes the common reference potential for the amplifier and the whole instrument. The reference potential is about 60% of the meter's positive supply voltage – a little too high to allow the very best performance from the op-amp. So although not absolutely necessary, the addition of one cheap AA dry cell, to raise the amplifier supply voltage above that for the meter, is a refinement worth the extra inconvenience.

Details and options

If the amplifier circuit is used to drive the 200mV range of a separate multimeter with its own battery, instead of the built in panel meter, then some changes should be made. The 1.5V cell is no longer necessary, but the remaining 9V supply for the amplifier requires splitting in half to provide a reference potential. Use two equal resistors, 47kΩ, one across each of the 47µF capacitors for example.

Also, some existing multimeters have an input resistance as low as 100kΩ on the 200mV range. If such an external instrument is used instead of the internal panel meter, the protection circuit between the amplifier output and the multimeter would cause an unacceptable loss in output voltage. As a result, the protection circuitry should be omitted.

Shunt switching for the five current ranges: 20µA, 200µA, 2mA, 20mA, 200mA, involves two switch wafers, each an 11-way make-before-break rotary switch. The six spare positions are wired with a short circuit in place of a shunt. This option of 11, rather than 5 switch positions is not shown in Fig. 2 but is strongly recommended. It conveniently enables the meter to be switched safely and quickly away from any sudden or unexpected large current, without interrupting the circuit under test.

A third switch wafer can be added to select the decimal point display of the internal panel meter. This merely completes a connection to one of three points, labelled P1, P2, P3. Note that in the samples I tried, these were in the

opposite sequence to that suggested in the accompanying leaflet.

If the 11-way option is chosen then this third switch wafer can also be of the same kind as the others, but if only a 5-way switch is used, the decimal point wafer alone, should be break-before-make.

Useful additional protection would be a further pair of back-to-back diodes, wired across the feedback resistor R_2 . I tried this, but rejected it because in a very warm room, the diode forward current was just beginning to upset indications near full scale. To make such a scheme satisfactory would need four diodes, two in series in each direction.

To keep the overall cost very low, all resistors used were metal film types with 1% tolerance. Thus the overall uncertainty limit could, at worst, reach just over 3% plus 0.5% for the meter. The shunts contribute only 1% to the overall uncertainty limit and are cheap enough to be expendable in an accident.

A further 2% depends upon the resistors R_1 to R_4 . If these four resistors are upgraded to 0.1% tolerance, their overall contribution to uncertainty will fall to 0.2% and this is certainly worth considering. ■

Digital panel meter for just £8.95

Incorporating the ICL7106 a-to-d converter, the PM128 digital panel meter has a full-scale input sensitivity of 200mV and a high input impedance of >100MΩ.

Its normal selling price is £12.95 – excluding VAT and postage. Vann Draper has decided to repeat the special offer price for this meter of £8.95 – fully inclusive of postage, packing and VAT – or even less in quantities above four off until 28 November (see January 1997 issue for full details of the meter).

Simply send the coupon below Vann Draper Electronics at Unit 5, Premier Works, Canal Street, South Wigston, Leicester LE18 2PL, fax 0116 2773945 or tel. 0116 2771400.



Please send me

..... PM-128 digital panel meter(s)

at the fully inclusive special offer price of
 £8.95 each for quantities up to 4 off
 £8.65 each for quantities of 5 or more or
 £8.35 each for 10 or more quantities

for which I enclose a total of £.....

Name

Company (if any)

Address

Phone number/fax

Make cheques payable to Vann Draper Electronics Ltd
 Or, please debit my Master, Visa or Access card.

Card type (Access/Visa)

Card No

Expiry date

Please mail this coupon to Vann Draper Electronics, together with payment. Alternatively fax credit card details with order on 0116 2773945 or telephone on 0116 2771400. Address orders and all correspondence relating to this order to Vann Draper Electronics at Unit 5, Premier Works, Canal Street, South Wigston, Leicester LE18 2PL. Overseas readers can also obtain this discount but details vary according to country. Please ring, write or fax to Vann Draper Electronics.

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

- HP New Colour Spectrum Analysers
HP141T+8552B IF + 8553B RF - 1KHz-110Mc/s - £700.
HP141T+8552B IF + 8554B RF - 100KHz-1250Mc/s - £900.
HP141T+8552B IF + 8556A RF - 20Hz-300KHz - £700.
Special Offer just in from MOD Qty 40 HP8555A RF Units 10Mc/s - 18GHz.
HP141T+8552B IF + 8555A 10Mc/s-18GHzS - £1200.
HP ANZ Units Available separately - New Colours - Tested
HP141T Mainframe - £350.
HP8552B IF - £300.
HP8553B RF 1KHz to 110Mc/s - £200.
HP8554B RF 100KHz to 1250Mc/s - £500.
HP8555A RF 10Mc/s to 18GHzS - £800.
HP8556A RF 20Hz to 300KHzS - £250.
HP8443A Tracking Generator Counter 100KHz-110Mc/s - £300.
HP8445B Tracking Preselector DC to 18GHz - £350.
HP3580A 5Hz - 50KHz ANZ - £750 - £1000.
HP3582A .02Hz to 25.6KHz - £2k.
HP8568A 100Hz-1500Mc/s ANZ - £6k.
HP8569B 10Mc/s-22GHz ANZ - £6k.
HP Mixers are available for the above ANZ's to 40GHz
TEK 492 - 50KHz - 18GHz Opt 1 + 2 - £4k-£4.2k.
TEK 492 - 50KHz - 18GHz Opt 1 + 2 + 3 - £4.5k.
TEK 492P - 50KHz - 21 GHz Opt 1 + 2 + 3 - £5k.
TEK 494AP 1Kc/s - 21 GHz - £7k.
TEK 496P 1KHz-1.8GHz - £4k.
TEK 5L4N 0-100KHz - £400.
TEK 7L5 + L1 - 20Hz-5Mc/s - £700.
TEK 7L5 + L3 - Opt 25 Tracking Gen - £900.
TEK 7L12 - 100KHz-1800Mc/s - £1000.
TEK 7L18 - 1.5-60GHzS - £1500.
TEK 491 10Mc/s-12.4GHz-40GHzS - £750. 12.4GHz-40GHz with Mixers.
Tektronix Mixers are available for above ANZ's to 60GHz
Systron Donner 763 Spectrum ANZ + 4745B Preselector .01-18GHz + Two Mixers 18-40GHz in Transit Case - £3k.
HP8673D Signal Generator .05-26.5GHz - £20k.
Systron Donner 1618B Microwave AM FM Synthesizer 50Mc/s 2-18GHz
R&S SWP Sweep Generator Synthesizer AM FM 4-2500Mc/s - £3.5k.
ADDET 3310A FX Synthesizer 300Hz - 60Mc/s - £300.
HP8640A Signal Generators - 1024Mc/s - AM FM - £800.
HP3717A 70Mc/s Modulator - Demodulator - £500.
HP8651A RF Oscillator 22Kc/s - 22Mc/s.
HP5316B Universal Counter A+B.
HP6002A Power Unit 0-5V 0-10A 200W.
HP6825A Bipolar Power Supply Amplifier.
HP461A-465A-467A Amplifiers.
HP81519A Optical Receiver DC-400Mc/s.
HP Plotters 7470A-7475A.
HP3770A Amplitude Delay Distortion ANZ.
HP3770B Telephone Line Analyser.
HP8182A Data Analyser.
HP59401A Bus System Analyser.
HP6260B Power Unit 0-10V 0-100 Amps.
HP3782A Error Detector.
HP3781A Pattern Generator.
HP3730A+3737A Down Converter Oscillator 3.5-6.5GHz.
HP Microwave Amps 491-492-493-494-495-1GHz-12.4GHz - £250.
HP105B Quartz Oscillator - £400.
HP5087A Distribution Amplifier.
HP6034A System Power Supply 0-60V 0-10A-200W - £500.
HP6131C Digital Voltage Source + 100V 1/2 Amp.
HP4275A Multi Frequency L.C.R. Meter.
HP3779A Primary Multiplex Analyser.
HP3779C Primary Multiplex Analyser.
HP150A Optical Signal Source.
HP1630G Logic Analyser.
HP5316A Universal Counter A+B.
HP5335A Universal Counter A+B+C.
HP59501B Isolated Power Supply Programmer.
HP8901A Modulation Meter AM - FM - also 8901B.
HP5370A Universal Time Interval Counter.
Marconi TF2370 - 30Hz-110Mc/s 750HM Output (2 BNC Sockets+Resistor for 500HM MOD with Marconi MOD Sheet supplied - £650.
Marconi TF2370 30Hz-110Mc/s 50 ohm Output - £750.
Marconi TF2370 as above but late type - £850.
Marconi TF2370 as above but late type Brown Case - £1000.
Marconi TF2374 Zero Loss Probe - £200.
Marconi TF2440 Microwave Counter - 20GHz - £1500.
Marconi TF2442 Microwave Counter - 26.5GHz - £2k.
Marconi TF2305 Modulation Meter - £2.3k.
Racal/Dana 2101 Microwave Counter - 10Hz-20GHz - £2k.
Racal/Dana 1250-1261 Universal Switch Controller + 200Mc/s PI Cards.
Racal/Dana 9303 True RMS Levelmeter + Head - £450. IFFE - £500.
TEKA6902A also A6902B Isolator - £300-£400.
TEK 1240 Logic Analyser - £400.
TEK FG5010 Programmable Function Generator 20Mc/s - £600.
TEK2465A 350Mc/s Oscilloscope - £2.5k + probes - £150 each.
TEK CT-5 High Current Transformer Probe - £250.
TEK J16 Digital Photometer + J6523-2 Luminance Probe - £300.
TEK J16 Digital Photometer + J6503 Luminance Probe - £250.
ROTEK 320 Calibrator - 350 High Current Adaptor AC-DC - £500.
FLUKE 5102B AC-DC Calibrator - £4k.
FLUKE 1120A IEEF - 488 Translator - £250.
Tinsley Standard Cell Battery 5644B - £500.
Tinsley Transportable Voltage Reference - £500.
FLUKE Y5020 Current Shunt - £150.
HP745A+746A AC Calibrator - £600.
HP8080A MF + 8091A 1GHz Rate Generator + 8092A Delay Generator + Two 8093A 1GHz Amps + 15400A - £800.
HP54200A Digitizing Oscilloscope.
HP11729B Carrier Noise Test Set .01-18GHz - LEF - £2000.
HP3311A Function Generator - £300.
Marconi TF2008 - AM-FM signal generator - also sweeper - 10Kc/s - 510Mc/s - from £250 - tested to £400 as new with manual - probe kit in wooden carrying box.
HP Frequency comb generator type 8406 - £400.
HP Vector Voltmeter type 8405A - £400 new colour.
HP Sweep Oscillators type 8690 A & B + plug-ins from 10Mc/s to 18GHz also 18-40GHz. P.O.R.
HP Network Analyzer type 8407A + 8412A + 8501A - 100Kc/s - 110Mc/s - £500 - £1000.
HP Amplifier type 8447A - 1.400Mc/s £200 - HP8447A Dual - £300.
HP Frequency Counter type 5340A - 18GHz £1000 - rear output £800.
HP 8410 - A - B - C Network Analyzer 110Mc/s to 12GHz or 18GHz - plus most other units and displays used in this set-up - 8411a - 8412 - 8413 - 8414 - 8418 - 8740 - 8741 - 8742 - 8743 - 8746 - 8950. from £1000.
Racal/Dana 9301A - 9302 RF Millivoltmeter - 1.5-2GHz - £250-£400.
Racal/Dana Modulation Meter type 9009 - 8Mc/s - 1.5GHz - £250.
Marconi RCL Bridge type TF2700 - £150.
Marconi/Saunders Signal Sources type - 6058B - 6070A - 6055A - 6059A - 6057A - 6056 - £250-£350. 400Mc/s to 18GHz.
Marconi TF1245 Circuit Magnification meter + 1246 & 1247 Oscillators - £100-£300.
Marconi microwave 6600A sweep osc., mainframe with 6650 PI - 18-26.5GHz or 6651 PI - 26.5-40GHz - £1000 or PI only £600. MF only £250.
Marconi distortion meter type TF2331 - £150. TF2331A - £200.
Tektronix Plug-ins 7A13 - 7A14 - 7A18 - 7A24 - 7A26 - 7A11 - 7M11 - 7S11 - 7D10 - 7S12 - S1 - S2 - S6 - S52 - PG506 - SC504 - SG502 - SG503 - SG504 - DC503 - DC508 - DD501 - WR501 - DM501A - FG501A - TG501 - PG502 - DC505A - FG504 - 7B80 + 85-7B92A
Gould J3B test oscillator + manual - £150.
Tektronix Mainframes - 7603 - 7623A - 7613 - 7704A - 7844 - 7904 - TM501 - TM503 - TM506 - 7904A - 7834 - 7623 - 7633.
Marconi 6155A Signal Source - 1 to 2GHz - LED readout - £400.
Barr & Stroud Variable filter EF3.01Hz - 100kc/s + high pass + low pass - £150.
Marconi TF2163S attenuator - 1GHz. £200.
Farnell power unit H60/50 - £400 tested. H60/25 - £250.
Racal/Dana 9300 RMS voltmeter - £250.
HP 8750A storage normalizer - £400 with lead + S.A or N.A Interface.
Marconi TF2330 - or TF2330A wave analysers - £100-£150.
Tektronix - 7S14 - 7T11 - 7S11 - 7S12 - S1 - S2 - S39 - S47 - S51 - S52 - S53 - 7M11.
Marconi mod meters type TF2304 - £250.
HP 5065A rubidium vapour FX standard - £1.5k.
Systron Donner counter type 6054B - 20Mc/s - 24GHz - LED readout - £1k.
Racal/Dana 9083 signal source - two tone - £250.
Systron Donner - signal generator 1702 - synthesized to 1GHz - AM/FM - £600.
Tektronix TM515 mainframe + TM5006 mainframe - £450 - £850.
Farnell electronic load type RB1030-35 - £350.
Racal/Dana counters - 9904 - 9905 - 9906 - 9915 - 9916 - 9917 - 9921 - 50Mc/s - 3GHz - £100-£450 - all fitted with FX standards.
HP4815A RF vector impedance meter c/w probe - £500-£600.
Marconi TF2092 noise receiver. A, B or C plus filters - £100-£350.
Marconi TF2091 noise generator. A, B or C plus filters - £100-£350.
Marconi 2017 S/G 10KHz - 1024MHz.
HP180TR, HP182T mainframes £300-£500.
Philips panoramic receiver type PM7900 - 1 to 20GHz - £400.
Marconi 6700A sweep oscillator + 18GHz PI's available.
HP8505A network ANZ + 8503A S parameter test set + 8501A normalizer - £4k.
HP8505 network ANZ 8505 + 8501A + 8503A.
Racal/Dana VLF frequency standard equipment. Tracer receiver type 900A + difference meter type 527E + rubidium standard type 9475 - £2750.
HP signal generators type 626 - 628 - frequency 10GHz - 21GHz.
HP 432A - 435A or B - 436A - power meters + powerheads - Mc/s - 40GHz - £200-£1000.
Bradley oscilloscope calibrator type 192 - £600.
HP8614A signal generator 800Mc/s - 2.4GHz, new colour £400.
HP8616A signal gen 1.8GHz - 4.5GHz, new colour £400.
HP 3325A syn function gen 20Mc/s - £1500.
HP 3336A or B syn level generator - £500-£600.
HP 3586B or C selective level meter - £750-£1000.
HP 3575A gain phase meter 1Hz - 13Mc/s - £400.
HP 8683D S/G microwave 2.3 - 13GHz - opt 001 - 003 - £4.5k.
HP 8660 A-B-C syn S/G. AM + FM + 10Kc/s to 110Mc/s PI - 1Mc/s to 1300Mc/s - 1Mc/s to 2600Mc/s - £500-£2000.
HP 8640B S/G AM-FM 512Mc/s or 1024Mc/s. Opt 001 or 002 or 003 - £800-£1250.
HP 86222BX Sweep PI - 01 - 2.4GHz + ATT - £1750.
HP 8629A Sweep PI - 2 - 18GHz - £1000.
HP 86290B Sweep PI - 2 - 18GHz - £1250.
HP 86 Series PI's in stock - splitband from 10Mc/s - 18.6GHz - £250-£1k.
HP 8620C Mainframe - £250. IEEE - £500.
HP 8615A Programmable signal source - 1MHz - 50Mc/s - opt 002 - £1k.
HP 8601A Sweep generator .1 - 110Mc/s - £300.
HP 3488A HP - IB switch control unit - £500 + control modules various - £175 each.
HP 8160A 50Mc/s programmable pulse generator - £1000.
HP 853A MF ANZ - £1.5k.
HP 8349A Microwave Amp 2 - 20GHz Solid state - £1500
HP 3585A Analyser 20Hz - 40Mc/s - £4k.
HP 8569B Analyser .01 - 22GHz - £5k.
HP 9590A Analyser 5Hz - 50kHz - £1k.
HP 1908B Oscilloscope measurement system - £600.
HP 3455A Digital voltmeter - £500.
HP 3437A System voltmeter - £300.
HP 3581C Selective voltmeter - £250.
HP 5370A Universal time interval counter - £450.
HP 5335A Universal counter - 200Mc/s - £500.
HP 5328A Universal counter - 500Mc/s - £250.
HP 6034A System power supply - 0 - 60V - 0 - 10 amps - £500.
HP 5150A Thermal printer - £250.
HP 1645A Data error analyser - £150.
HP 4437A Attenuator - £150.
HP 3717A 70Mc/s modulator - £400.
HP 3710A - 3715A - 3716A - 3702B - 3703B - 3705A - 3711A - 3791B - 3712A - 3793B microwave link analyser - P.O.R.
HP 3730A + B RF down converter - P.O.R.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.
HP 3781B Pattern generator (bell) - £300.
HP 3782A Error detector - £400.
HP 3782B Error detector (bell) - £300.
HP 3785A Jitter generator + receiver - £750-£1k.
HP 8006A Word generator - £100-£150.
HP 8016A Word generator - £250.
HP 3552A Transmission test set - £400.
HP 3763A Error detector - £500.
HP 3764A Digital transmission analyser - £600.
HP 3770A Amp delay distortion analyser - £400.
HP 3780A Pattern generator detector - £400.
HP 3781A Pattern generator - £400.

GAS HOBS Standard domestic units, new and boxed, 3 burner, household gas, brown. Bargain at just £12.95 ref BAR316

INFRA RED FILM 6" square piece of flexible infra red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infra red output only using standard light bulbs Easily cut to shape, 8" square £15 ref IRF2

HYDROGEN FUEL CELL PLANS Loads of Information on hydrogen storage and production. Practical plans to build a Hydrogen fuel cell (good workshop facilities required) £8 set ref FCP1

STIRLING ENGINE PLANS Interesting information pack covering all aspects of Stirling engines, pictures of home made engines made from an aerosol can running on a candle! £12 ref STIR2

12V OPERATED SMOKE BOMBS Type 3 is a 12v trigger and 3 smoke cannisters, each cannister will fill a room in a very short space of time! £14.99 ref SB3. Type 2 is 20 smaller cannisters (suitable for simulated equipment fires etc) and 1 trigger module for £29 ref SB2

Type 1 is a 12v trigger and 20 large cannisters £49 ref SB1

HI POWER ZENON VARIABLE STROBES Useful 12v PCB fitted with hi power strobe tube and control electronics and speed control potentiometer. Perfect for interesting projects etc 70x55mm 12vdc output. £8 ea ref FLS1, pack of 10 £49 ref FLS2

NEW GEIGER COUNTERS IN STOCK Hand held unit with LCD screen, auto ranging, low battery alarm, audible 'click' output. New and guaranteed. £129 ref GE1

RUSSIAN BORDER GUARD BINOCULARS £1799

Probably the best binoculars in the world! ring for colour brochure.

RUSSIAN MULTIBAND WORLD COMMUNICATIONS RECEIVER, Exceptional coverage of 9 wave bands, (5 short, 1 LW, 1 FM, 1 MW) internal ferrite and external telescopic aerials, mains/battery. £45 ref VEGA

NEW LASER POINTERS 4.5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 870nm. £29 ref DCK49

HOW TO PRODUCE 35 BOTTLES OF WHISKY FROM A SACK OF POTATOES Comprehensive 270 page book covers all aspects of spirit production from everyday materials. Includes construction details of simple stills etc. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of up to 800 metres and a 3 days use from a PP3 this is our top selling bug! less than 1" square and a 10m voice pickup range. £28 Ref LOT102.

BUILD YOUR OWN WINDFARM FROM SCRAP New publication gives step by step guide to building wind generators and propellers. Armed with this publication and a good local scrap yard could make you self sufficient in electricity! £12 ref LOT81

PC KEYBOARDS PS2 connector, top quality suitable for all 286/386/486 etc £10 ref PCKB, 10 for £85.

NEW LOW COST VEHICLE TRACKING TRANSMITTER KIT £29 range 1.5-5 miles, 5,000 hours on AA batteries, transmits info on car direction, left and right turns, start and stop information. Works with any good FM radio. £29 ref LOT101a

HIGH SECURITY ELECTRIC DOOR LOCKS Complete brand new Italian lock and latch assembly with both Yale type lock (keys inc) and 12v operated deadlock. £10 ref LOT99

***NEW HIGH POWER WIRELESS VIDEO AND AUDIO BUG KIT 1/2 MILE RANGE** Transmits video and audio signals from a miniature CCTV camera (included) to any standard television! Supplied with telescopic aerial. £169

CCTV PAN AND TILT KIT Motorize your CCTV camera with this simple 12vdc kit. 2 hermetically sealed DC linear servo motors 5mm threaded output 5secs stop to stop, can be stopped anywhere, 10mm travel, powerful. £12 ref LOT125

CCTV CAMERA MODULES 46X70X29mm, 30 grams, 12v 100mA, auto electronic shutter, 3.6mm F2 lens, CCIR, 512x492 pixels, video output is 1v p-p (75 ohm). Works directly into a scart or video input on a tv or video. IR sensitive. £79.95 ref EF137.

IR LAMP KIT Suitable for the above camera, enables the camera to be used in total darkness! £6 ref EF138

UK SCANNING DIRECTORY As supplied to Police, MOD, M15 and GCHQ! covers everything from secret government frequencies, eye in the sky, prisons, military aviation etc £18.50 ref SCANB

INFRA RED POWERBEAM Handheld battery powered lamp, 4 inch reflector, gives out powerful pure infrared light perfect for CCTV use, nightsights etc. £29 ref PB1.

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser, X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front & earwave guides, 1.1"x2.7"x4.8" fits on sun visor or dash £149 ref

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS

Could be adapted for laser listener, long range communications etc Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignment. 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. £199 for one. Ref LOT4.

NEW LOW PRICED COMPUTER/WORKSHOP/HI-FI PCB UNITS Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends fit by 750mm), fitted in less than 10 seconds, reset/test button, 10A rating, £6.99 each ref LOT5. Or a pack of 10 at £49.90 ref LOT6. If you want a box of 100 you can have one for £250!

TWO CHANNEL FULL FUNCTION B GRADE RADIO CONTROLLED CARS From World famous manufacturer these are returns so they will need attention (usually physical damage) cheap way of buying TX and RX plus servos etc for new projects etc. £12 each sold as seen ref LOT2

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleaves, designed to read standard credit cards! complete with control electronics PCB and manual covering everything you could want to know about what's hidden in that magnetic strip on your card! just £9.95 ref BAR31

WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at

your leisure using the text editor on your PC. Also included is the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74



HIGH POWER DC MOTORS, PERMANENT MAGNET 12 - 24v operation, probably about 1/4 horse power, body measures 100m x 75mm with a 60mm x 5mm output shaft with a machined flat on it. Firing is simple using the two threaded bolts protruding from the front of the motor (4mm x 12mm). These motors are perfect for model engineering etc they may even be suitable as a cycle motor? We expect high demand so if you would like one or think you may require one in the future place your order today! £22 ref MOT4 10 pack £185 ref MOT5B

ELECTRONIC SPEED CONTROLLER KIT For the above motor is £19 ref MAG17. Save £5 if you buy them both together, 1 motor plus speed controller rrp is £41, offer price £36 ref MOT5A

RUSSIAN 900X MAGNIFICATION ZOOM MICROSCOPE metal construction, built in light, mirror etc. Russian shmp farm, group viewing screen, lots of accessories. £29 ref ANAYLT.

AA NICAD PACK Pack of 4 tagged AA nicads £2.99 ref BAR34

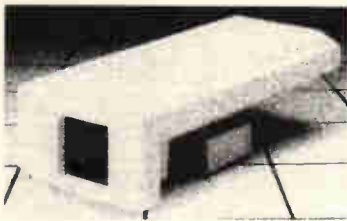
RUSSIAN NIGHTSIGHTS Model TZS4 with infra red illuminator, views up to 75 metres in full darkness in infrared mode, 150m range, 45mm lens, 13 deg angle of view, focussing range 1.5m to infinity, 2 AA batteries required. 950g weight. £199 ref BAR61. 1 years warranty

LIQUID CRYSTAL DISPLAYS Bargain prices, 20 character 2 line, 83x19mm £3.99 ref SMC2024A

16 character 4 line, 62x25mm £5.99 ref SMC1640A

TAL-1, 110MM NEWTONIAN REFLECTOR TELESCOPE Russian. Superb astronomical scope, everything you need for some serious star gazing! up to 169x magnification. Send or fax for further information. 20kg, 885x800x1650mm ref TAL-1. £249

YOUR HOME COULD BE SELF SUFFICIENT IN ELECTRICITY Comprehensive plans with loads of info on designing systems, panels, control electronics etc £7 ref PV1



COLOUR CCTV VIDEO CAMERAS, BRAND NEW AND, CASED, FROM £99.

Works with most modern video's, TV's, Composite monitors, video grabber cards etc Pal, 1v P-P, composite, 75ohm, 1/3" CCD, 4mm F2.8, 500x582, 12vdc, mounting bracket, auto shutter, 100x50x180mm, 3 months warranty, 1 off price £119 ref XEF150, 10 or more £99 ea 100+ £89

YUASHA SEALED LEAD ACIDS FROM £2.50 12v 6.5Ah ex equipment batteries to clear at just £9.99 for a pack of four! ref XX1

A MAGNET THAT LIFTS 33 KILO'S!

Just in this week are these incredible magnets that lift 33 kilo's! Price is £14.99 ref MAG33

25 SQUARE FOOT SOLAR ENERGY BANK KIT 100 6"x6" 6v Amorphous 100mA panels, 100 diodes, connection details etc to build a 25 square foot solar cell for just £99 ref EF112.

CONVERT YOUR TV INTO A VGA MONITOR FOR £25! Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware. Ideal for laptops or a cheap upgrade. Supplied in kit form for home assembly. SALE PRICE £28 REF SA34

***15 WATT FM TRANSMITTER** Already assembled but some RF knowledge will be useful for setting up. Preamp req'd, 4 stage 80-108mhz, 12-18vdc, can use ground plane, yagi or dipole £69 ref 1021

***4 WATT FM TRANSMITTER KIT** Small but powerful FM transmitter kit. 3 RF stages, mic & audio preamp included £24 ref 1028

YUASHA SEALED LEAD ACID BATTERIES 12v 15AH at £18 ref LOT8 and below spec 6v 10AH at £5 a pair

ELECTRIC CAR WINDOW DE-ICERS Complete with cable, plug etc SALE PRICE JUST £4.99 REF SA28

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. £12.99 REF AUG10P3.

SOLAR POWER LAB SPECIAL You get 2 6"x6" 6v 130mA cells, 4 LED's, wire, buzzer, switch + 1 relay or motor. £7.99 REF SA27

SOLAR NICAD CHARGERS 4 x AA size £9.99 ref 6P478, 2 x

BULL ELECTRICAL

250 PORTLAND ROAD, HOVE, SUSSEX. BN3 5QT. (ESTABLISHED 50 YEARS).

MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £3.50 P&P PLUS VAT.

24 HOUR SERVICE £4.50 PLUS VAT. OVERSEAS ORDERS AT COST PLUS £3.50

'phone orders: 01273 203500

(ACCESS, VISA, SWITCH, AMERICAN EXPRESS)

FAX 01273 323077

E-mail bull@pavilion.co.uk

C size £9.99 ref 6P477

GIANT HOT AIR BALLOON KIT Build a 4.5m circumference, fully functioning balloon, can be launched with home made burner etc. Reusable (until you loose it!) £12.50 ref HA1

AIR RIFLES. 22 As used by the Chinese army for training purposes, so there is a lot about! £39.95 Ref EF78. 500 pellets £4.50 ref EF80.

***NEW MEGA POWER VIDEO AND AUDIO SENDER UNIT.**

Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 500m range! (tune TV to channel 31) 12v DC

op. Price is £85 REF: MAG15 12v psu is £5 extra REF: MAG6P2

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range up to 2 km in open country. Units measure 22x52x155mm. Including cases and earpieces. 2xPP3 req'd. £37.00 pr. REF: MAG30

***FM TRANSMITTER KIT** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £18 REF: EF62 (Kit) Transmits to any FM radio. Built and tested version now available at £45 ref EXM34

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £14.95 Ref EF82B extra pellets (500) £4.50 ref EF80.

HEAT PUMPS These are mains operated air to air units that consist of a aluminium plate (cooling side) and a radiator (warming side) connected together with a compressor. The plate if inserted into water will freeze it. Probably about 3-400 watts so could produce 1kw in ideal conditions. £30 ref HP1

3 FOOT SOLAR PANEL Amorphous silicon, 3' x 1' housed in an aluminium frame, 13v 700mA output. £55 ref MAG45

SOLAR/WIND REGULATOR Prevents batteries from over charging. On reaching capacity the regulator diverts excess power into heat avoiding damage. Max power is 60 watts. £27.99 ref S/C11-1/05

4X28 TELESCOPIC SIGHTS Suitable for all air rifles, ground lenses, good light gathering properties. £24.95 ref R7.

NICAD CHARGERS AND BATTERIES Standard universal mains operated charger, takes 4 batts + 1 PP3, £10 ref PO11D. Nicads- AA size (4 pack) £4 ref 4P44, C size (2 pack) £4 ref 4P73, D size (4 pack) £9 ref 9P12.

PHOTOGRAPHIC RADAR TRAPS CAN COST YOU YOUR LICENCE! The new multiband 2000 radar detector can prevent even the most responsible of drivers from losing their licence!

Adjustable audible alarm with 8 flashing leds gives instant warning of radar zones. Detects X, K, and Ka bands, 3 mile range, 'over the hill' 'around bends' and 'rear trap' facilities. micro size just 4.25"x2.5"x.75". Can pay for itself in just one day! £89 ref EP3.

STEREO MICROSCOPES BACK IN STOCK Russian, 200x complete with lenses, lights, filters etc very comprehensive microscope that would normally be around the £700 mark, our price is just £299 (full money back guarantee) full details in catalogue.

SECOND GENERATION NIGHT SIGHTS FROM £748

RETRO N Russian night sight, 1.8x, infra red lamp, 10m-inf, standard M42 lens, 1.1kg. £349 ref RET1

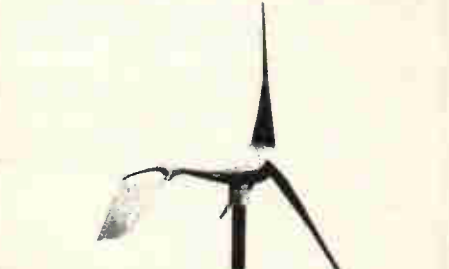
MAINS MOTORS 180 RPM 90X70mm, 50X55mm 50x55mm output shaft, start cap included. £22 ref MGM1

PC POWER SUPPLIES, CUSTOMER RETURNS, ALL FAN COOLED, OUR CHOICE, BARGAIN AT 8 PSU'S FOR £9.99 REF XX16

LOW COST CORDLESS MIC 500' range, 90 - 105mhz, 115g, 193 x 28 x 39mm, 9v PP3 battery required. £17 ref MAG15P1

JUMBO LED PACK 15 10mm bicolor leds, plus 5 giant (55mm) seven segment displays all on a pcb £8 ref JUM1. Pack of 30 55mm seven seg displays on pcbs is £19 ref LED4, pack of 50 £31 ref LED50

12VDC 40MM FANS MADE BY PANAFLO, NEW. £4. REF FAN12



WIND GENERATORS 380 WATT

1.14 metre dia blades, carbon matrix blades, 3 year warranty, 12vdc output, 24v version available, control electronics included, brushless neodymium cubic curve alternator, only two moving parts, maintenance free, simple roof top installation, start up speed 7mph, max output (30mph) 380w. £499 ref AIR1

Check out our **WEB SITE**
full colour interactive
1997 catalogue
<http://www.pavilion.co.uk/bull-electrical>

FREE COLOUR CATALOGUE WITH EVERY ORDER

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

WE BUY SURPLUS STOCK FOR CASH
SURPLUS STOCK LINE 0802 660335

NEW PRODUCTS CLASSIFIED

Please quote "Electronics World" when seeking further information

ACTIVE

Discrete active devices

Power darlings. *FMMT634* power darlings from Zetex in the surface-mount 'SuperSOT' package cope with twice the current of SOT23 alternatives, replacing darlings in SOT89, SOT223 and TO126 packages. Peak pulse current is 5A and power dissipation 625mW. At a collector current of 2A, minimum device gain is 5000, $V_{CE(sat)}$ at 1A being 960mV maximum. In automotive use, the collector/emitter voltage rating of 100V will help with the transients normally found. Zetex plc. Tel., 0161-627 5105; fax, 0161-627 5467.

Linear integrated circuits

G-p op-amp. Micrel has introduced the *MIC6211*, which is said to be the first general-purpose op-amp in an SOT-23-5 package, whimsically known to some as an *IttyBitty*. It is similar to one of the devices in the quad *LM324*, the miniature package allowing four single op-amp *6211s* to occupy less space than in the *324*. Operating from either single 4 to 32V or $\pm 2V$ to $\pm 16V$ supplies, the *6211* provides high gain and is frequency compensated. Current drawn is 2mA, unity-gain bandwidth 2.5MHz and slew rate 7V/ μ s. Micrel Semiconductor Europe. Tel., 01635 524455; fax, 01635 524466.

Microprocessors and controllers

New PICs. New 8-bit microcontrollers from Microchip, the *PIC16C66/7* feature extensive communications and a 5Mips performance. They are eeprom-based and the usart operates at up to 5Mb/s, have 35 single-cycle 200ns instructions, 8K by 14 words of program memory and 368byte of data ram. Current taken from a 33kHz 3V supply is under 15 μ A and 1 μ A in sleep mode. Of the 40 pins, 33 are for communications, which include an 8-bit asynchronous slave port, a synchronous serial port for DPI or I²C protocols, two pwm outputs at 80kHz and 8-bit resolution and a 16-bit capture/compare facility with 200ns resolution. The chips also drive leds

and triacs directly. Arizona Microchip Technology Ltd. Tel., 01628 851077; fax, 01628 850259.

Mixed-signal ICs

Digital video demodulator. Siemens' *TDA6180X* amplifier and demodulator ic handles qpsk modulation in digital video broadcast signals, converting signals at 300-600MHz to I and Q analogue levels. Functionally, the device is a qpsk-input amplifier, an agc oscillator which generates the 0° and 90° signals for demodulation and a qpsk demodulator. Filtered if goes to a variable-gain amplifier and is then demodulated to baseband. It is the split and passed to two low-level detectors, from which it is amplified and output as Q and I. Siemens plc. Tel., 0990 550500; fax, 01344 396721.

Optical devices

High-voltage Isolators. Isocom has a 300V optoisolator, the *IS7000*, that withstands 300V across its output transistor; it is meant for use in positions such as fax modems and power supply interfaces. Input/output isolation is to 5kV and the darlington output stage produces a current output of up to 150mA on inputs down to 1mA, or much more with pulse inputs. Turn-on and turn-off times are 50 μ s and 15 μ s and performance is held over the -30°C to 100°C range. Isocom Components Ltd. Tel., 01429 863609; fax, 01429 863581.

DII clocks. Dual-in-line clock oscillators from Total Frequency Control can be specified, made and delivered within seven working days. Frequency range is 4-30MHz to within $\pm 5\%$, ageing rate ± 1 ppm/year and output is hcmos/ttl-compatible. Total Frequency Control Ltd. Tel., 01903 745513; fax, 01903 742208; e-mail, eddie @ tfc.co.uk.

PASSIVE

Cameras

Conference camera. *QuartzSight*, developed by Vision and Rockwell, is a digital colour camera, made to international standards, for use in pc-based videoconferencing. The camera itself is simply the lens and



cmos single-chip colour sensor, while the *QuartzCapture* chip set contains many of the camera dsp functions. Digitised video signals, power and control are all carried by a 9-wire cable. Colour balance and exposure control are automatic, while the user controls focus, colour saturation, contrast, brightness, frame rate and resolution. An anti-flicker mode reduces the effects of fluorescent tubes. VLSI Vision Ltd. Tel., 0131-539 7111; fax, 0131-539 7141.

Communications equipment

Ring generator. The *PowerDsine PCR-SIN01* is a 1W sine generator for telephony, putting out selectable 17, 20 and 25Hz frequencies for different countries. Current taken from 12V or 24V dc is 90mA and r filtering is included. It is for use in single or dual line applications and an external inhibit control reduces idle power, the control also being used to generate the ringing signal intervals, so doing away with relays. Overload protection is provided. DIP International Ltd. Tel., 01223 462244; fax, 01223 467316.

Crystals

Surface-mount crystals. New crystals from Total Frequency Control are packaged in resistance-welded metal cases with preformed leads for automatic surface-mounting, special mounts inside the package conferring resistance to shock and vibration. Frequency tolerance over the -10°C to 60°C range is ± 3 ppm and ageing is 0.5ppm/year maximum; the company points out that this level of performance is not available in conventional s-m packages. Total

Memory

Compact flash. New range of compact flash cards by *Kingmax* is intended to increase the number of pictures stored in digital cameras and the data available to mobile telephone users. Used with a camera, it avoids the need to download the data straight from the camera; many cards may be filled with data at high definition and interfaced to a pc. The range of capacities is 2-16Mbyte and a high-speed buffer allows transfer rates to and from memory at up to 8Mbyte/s, a speed compatible with the fastest digital cameras. Cards are compatible with PC Card services and Socket Services and, by the use of an adaptor, can be plugged into PCMCIA sockets. Premier Electronics Ltd. Tel., 01922 634652; fax, 01922 634616.

Frequency Control Ltd. Tel., 01903 745513; fax, 01903 742208; e-mail, eddie @ tfc.co.uk.

Displays

Small graphics panel. From Nan Ya, the *LMCDB078* liquid-crystal display panel provides 320 by 240 resolution and measures 134.5 by 117 by 14mm. It uses a transreflective technique and can be used with no backlight, so saving power. Neither does it need inverting circuitry and therefore also saves space. Mono displays in the range include types with an integral matrix touch screen in which, since no controller is needed, a simple buffer like those in

Please quote "Electronics World" when seeking further information

membrane keypads can be used. These are transreflective or transmissive versions in blue and white or black and white. Anders Electronics plc. Tel., 0171-388 7171; fax, 0171-387 2951.

Filters

GSM saw filters. Surface acoustic wave filters in Fujitsu's F4 range are meant for applications in the 200-600MHz band, GSM filters being available at 246MHz and 400MHz. Inputs and outputs are balanced and attenuation in the stop band is better than 50dB. Surface-mounting packages measure 5 by 5 by 1.6mm for the 246MHz filter and slightly larger for the 200MHz device. Fujitsu Microelectronics Ltd. Tel., 01628 76100; fax, 01628 781484.

Hardware

Joysticks. Sakae joysticks, meant for plant control, robotics, wheelchairs and games, use conductive plastic tracks and have a life expectancy of up to five million operations. Models cover the range of sizes from minute to huge and can be had in 1, 2 or

RCA jacks. Shiuia Chyuan of Taiwan supply RCA jacks in a number of forms and they are now available in the UK. The jacks come in single units or with 2-8-way types, with optional emc screening. They are meant for high-volume use where fast installation is needed. Plating options are gold, half-gold and silver, resulting in a minimum contact resistance of 30mΩ and reliability sufficient for 5000 cycles. Colours can be specified and both horizontal and vertical barrels are available. TW Electronics Ltd. Tel., 01635 278585; fax, 01635 278122.



3-dimensional form with optional switches, being built to ISO9001 standard. They withstand vibration to 10g and shock to 30g and may be supplied with fittings and a choice of knobs. Dust gaiters are available. Techni Measure. Tel., 01527 854103; fax, 01527 853267.

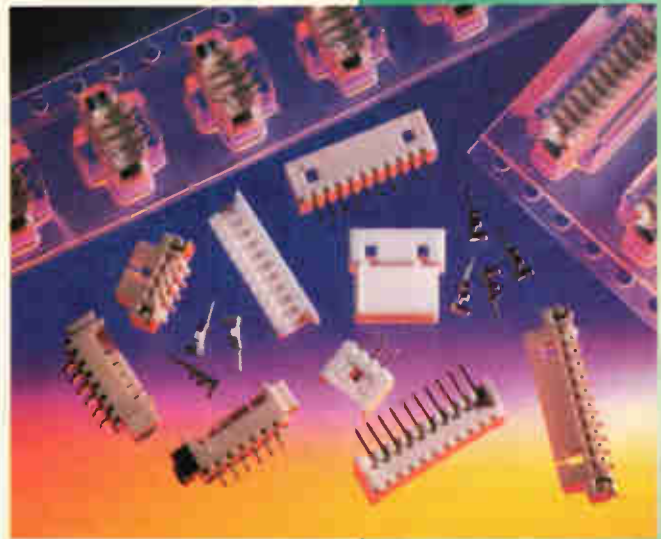
Ceramic adjusters. Torayceram tools, now available from Toolworld, are for the adjustment of trimmers and inductors, ceramic business ends avoiding any interference with component characteristics even at high frequencies. A manufacturing process confers resistance to bending forces and the chipping that can occur in zirconia ceramics. The tools come in a range of sizes, with interchangeable bits and with long thin handles for awkward positions. Also available are ceramic tweezers, which provide the same advantages of long life (ten times longer than metal and 100 times longer than plastic) and no magnetic materials. Toolworld Ltd. Tel., 01249 821234; fax, 01249 816723.

Cable tidy. Richco International's latest offering is a little plastic bit that clips into a 5mm hole on the edge of a pcb and holds any odd wires coming off the board in a 'saddle'. It is known as an edge holding wire saddle and is made in nylon 6/6, RMS-01 or flame-retardant nylon 6/6 and RMS-19. Richco International Co., Ltd. Tel., 01474 327527; fax, 01474 327455.

Chip coolers. Sanyo Denki San Ace MC coolers for Pentium and Alpha microprocessors are now available in the UK. They consist of miniature fans with integral heatsinks and come in four sizes from 45mm square by 18mm to 66 by 62 by 30mm, each being made in 5V or 12V versions. A silicone compound is used as a thermal interface. Noise level is low at about 28dB(A), there is locked-rotor protection and an alarm output is optional. EAO-Highland Electronics Ltd. Tel., 01444 236000; fax, 01444 236641.

Test and measurement

Acoustics and vibration. Developed by Müller-BBM GmbH, the PAK multi-channel acoustic and vibration measurement and analysis system is based on a Hewlett-Packard VXI front end with an HP9000 Series 700 workstation to run the PAK software under the HP-UX os. Analysis software handles time and frequency domains, octave analysis, order tracking and psychoacoustic analysis; additional parameters for engine analysis can also be captured. Both Yard and Oracle databases are supported and a report generator is provided. Strategic Test and Measurement Systems Ltd. Tel., 01734 795950; fax, 01734 795951.



Exotic multimeter. Capable of capturing data 3.3 times per second and of true-rms measurement, the Escort EDM89S handheld multimeter measures 500mV-1000V dc and true-rms alternating voltage, 5mA-10A direct and alternating current, 500Ω-50MΩ resistance, frequency, 5nF-50μF capacitance and dBm with selectable reference impedance. A range of features includes automatic or manual dynamic recording, 5000-count digital readout and an analogue bar graph. Bandwidth on ac measurements is 20kHz and there is dual-tone, dual-display logic detection, a relative mode for deviation, audible and visible input warnings and power-saving modes. Feedback Test and Measurement. Tel., 01892 653322; fax, 01892 663719.

2.4GHz counter/timer. Available from TTI, the Tabor 6000 range of GPIB-interfaced counter/timers consists of three models: the 6010, measuring up to 125MHz, extendable to 1.3GHz; the 6020 to measure to 225MHz and extendable to 1.3GHz; and the 6030 for 225MHz and 2.4GHz. The latter has two independent inputs for frequency measurements up to 300MHz, below which reciprocal measurement is automatically selected. Optionally, a third channel will measure up to 2.4GHz on an input of 15mV. Period and pulse measurements (5ns-2000s) and time interval A to B (0-2000s) can be made, with the provision for up to 500 programmed delay intervals to be inserted between start and stop of the time interval A to B. Stability with an optional oven-controlled time base is 0.15ppm/year. Thurlby Thandar Instruments Ltd. Tel., 01480 412451; fax, 01480 450409.

Interfaces

GPIB interfaces. ComputerBoards Inc. announces a range of GPIB interfaces for ISA, PCI and PCMCIA, all significantly cheaper

Connectors and cabling

"Smallest" connectors. Molex 1.25 connectors are said to be the smallest available. There are wire-to-board types and wires-to-other-wires versions, all with flat, twin-contact pins pitched 1.25mm, taking 1A maximum and in detachable through-hole form and for surface mounting. With 2-15 connections, the pins have a maximum contact resistance of 20mΩ and insulation resistance of 1GΩ. Connectors are polarised, the headers having friction locks. Hawnt Electronics Ltd. Tel., 0121 784 3355; fax, 0121 783 1657.

than competitors, the PCMCIA board being about half the common price. These GPIB IEEE-488.2 interfaces let any pc function as instrumentation control and data acquisition system. They use the standard CB7210.2 GPIB chip for full talker/listener/controller functions and allow up to 14 instruments to be connected to the pc. Supplied software supports programming under dos, Windows 3.1x and '95. Data transfer rates are up to 1Mbyte/s and the PCMCIA and PCI models are of the plug-and-play type. Adept Scientific Micro Systems Ltd. Tel., 01462 480055; fax, 01462 480213.

Literature

Optoelectronics. Onboard Electronics offers a 100-page catalogue of optoelectronic components from Kingbright, including super-bright led lamps and bright blue leds. Also described are surface-mounted, shaped and large-sized lamps, led clusters, seven-segment and dot-matrix displays. Onboard Electronics Ltd. Tel., 01256 818222; fax, 01256 840610.

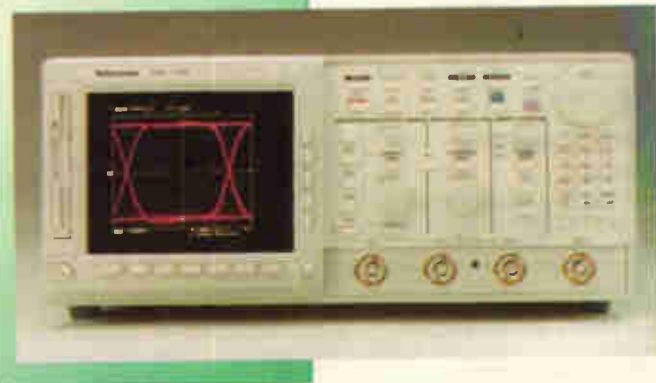
Please quote "Electronics World" when seeking further information

Relays. Free from Ashwell Electronics, the 24-page *Teledyne Gentron* data book of solid-state relays, which covers devices from 10A board-mounted types to three-phase, 1000A devices. Ashwell Electronics Ltd. Tel., 01438 364194; fax, 01438 313461.

Servo amplifiers. Ninety brush and brushless servo amplifiers for motion control are described in Copley Controls' eight-page short catalogue. Power ratings from a few watts to 20kW, and single-axis and multi-axis types and sub-systems are all included, as are dc psus, transformers and amplifier mounting hardware. Most Copley pwm amplifiers can be made to match specific motors by plugging resistors and capacitors into a no-soldering header. Amplifier features include built-in power filtering or edge filters to reduce output rise rate to prevent rfi coupling to other circuits. Copley Controls. Tel., 001 617 329 8200; fax, 001 617 329 4055.

Scope for communications.

Newly introduced by Tektronix, the *TDS 700C* and *TDS 500C* family of *InstaVu* acquisition digital storage oscilloscopes for use on communications equipment such as switches, routers and videoconferencing equipment, together with a set of accessories to enable connection of optical and electrical signals to the instruments. A feature of the oscilloscopes is the facility for mask testing of communications signals; there are 39 automatic telecomms and datacomms masks and custom masks can be built by the user. In compliance test, the mask for a particular standard is displayed, the signal being scaled and correctly offset for comparison. Statistical tools are included for analysis in the form of statistics and histograms. The two series are available in two and four channel models with sampling rates to 4Gsample/s, up to 8Mbyte of record length and 1GHz bandwidth. Tektronix UK Ltd. Tel., 01628 403300; fax, 01628 403301.



Emc gaskets

Holland Shielding Systems has a new engineering handbook on its range of emc gaskets for electronic enclosures. Most of the gaskets, which are in the 0.8-60mm range of sizes, can be used in existing equipment without design changes by virtue of the self-adhesive backing and low closure force required. The gaskets are in strip form or as ready-made gaskets, are in flame-retardant or high-temperature versions and are also available with an environmental seal. Holland Shielding Systems bv. Tel., 0031 78 6131366; fax, 0031 78 6149585.

Materials

Shielding tape kit. 3M supply an engineering kit for foil shielding tapes to allow engineers to obtain small quantities. The tape provides reliable point-to-point electrical contact for emi/RFI shielding and static draining and is provided with a range of backings and adhesive compounds. Tapes are 0.75in wide and 144in long, replacement rolls being available. Each of the nine tapes in a box is fully described on the box. 3M United Kingdom plc. Tel., 01344 858739; fax, 01344 858758.

Anti-emi coating. Chomerics *Cho-Shield 2052* is a conductive coating to give a high level of emi shielding on plastic materials such as polycarbonate, ABS, PC-ABS, Noryl and pvc. It consists of silver-plated copper particles dispersed in a one-component acrylic resin, which works with all available material application methods including high-volume, low-pressure sprays and propeller-agitated pressure pots. The material is abrasion-resistant, stable at high and low temperatures and withstands high humidity and moderately saline fog environments. Parker Hannifin plc, Chomerics Division. Tel., 01628 486030; fax, 01628 476303.

Thermal grease. *Easy-Ply* from Redpoint Thermalloy can improve heatsink performance by thirty times. It is applied to the heatsink at the factory and protected by a pull-off



cover until needed, whereupon the whole heatsink with the grease in place is put into position with the size and shape of grease interface tailored to the application. *Easy-Ply* is non-toxic and stable and works over the -40°C to 204°C range, with an indefinite shelf life. Redpoint Thermalloy Ltd. Tel., 01793 537861; fax, 01793 615396.

Printers and controllers

Thermal print heads. Rohm's new series of thermal print heads come in printing widths of 2, 3, 4, 8 or 10in and with 8-dot/mm resolution. All models have Rohm's own drive ics. The *GC20* is a label printer and replaces the *C1S* series; it has superglass protection on the dot line, epoxy ic coating and a shrouded, polarised connector. *GC10* is similar, but smaller. Lowest cost model is the *GH1*, which is a small fax head, meant for epos printers or machines giving receipts. Kestronics Ltd. Tel., 01727 812222; fax, 01727 811920.

Production equipment

Metal wrist band. For static control, TBA ECP has a new metal wrist band that is more comfortable than elasticated types since it can be worn looser and is said to be safer than other metal ones on the market. It is fully adjustable and has a stainless steel linked inner layer with a plastic moulded outer cover, which is immune to scratching and cannot expose the metal, so preserving the wearer from possible contact with live parts. There is a 10mm stud to receive a standard coiled cable. TBA Industrial Products Ltd. Tel., 01706 47718; fax, 01706 46170.

Piezoelectric pump. Densitron's *Crystal pump* uses a piezoelectric stack element to give precise control of fluid flow. Metering of the fluid is obtained by varying crystal drive amplitude and frequency to give flows at rates between 0.05µl/min to

Low-level switching.

EAO-Highland's *84 Series* is a modular system of pushbuttons and indicators that can be assembled to make a wide range of switches by combining lenses, actuators, switches and mountings. The units are suited to low-voltage switching in industrial positions, for example in computer-based controls. Switch ratings are from 50mV to 42V and 10µA to 100mA ac or dc, maximum power rating being 2W and typical rebound time under 1ms. They can be had in aluminium or plastic and flush mount in a standard 22.5mm diameter cutout. Depth behind the panel is 18-31mm and the switches are sealed to IP67, resistance to vibration and shock is high and the metal fronts make them proof against electrostatic discharge. EAO-Highland Electronics Ltd. Tel., 01444 236000; fax, 01444 236641.

380ml/min; frequency can be at frequencies as low as 20Hz when noise might be a problem, although the noise at any frequency is small. Response is virtually instantaneous for the precise metering of small quantities of fluid. The pump body is available in Teflon, polyacetal, stainless steel or other materials to suit different fluids. Densitron Europe Ltd., 01959 700100; fax, 01959 700300.

Fluid dispenser. From Camelot Systems Inc., the *CAM/ALOT 680 Series* rotary positive displacement pump or glop dispenser accurately provides encapsulation and flip-chip underfill in precise quantities with no drips; it will pump 10-200mg of fluid to within ±2% by volume. It has a positive needle shut-off and the material is under constant low pressure to prevent cavitation. There

Please quote "Electronics World" when seeking further information

is a micrometer built in to help adjust the gap between the dispensing auger and its seat and the interchangeable cartridge assembly can be cleaned in minutes. A heating cartridge brings the material to the required temperature. Dage Precision Industries Ltd. Tel., 01296 393200; fax, 01296 331585.

Power supplies

Micro-controlled 600W psu. Vicor's *FlatPAC* family of 50-600W supplies has a microprocessor-controlled front end and now has industry-standard input terminals and high-current output connectors. Input is autoranging. Thousands of configurations are possible from systems with one to three outputs at various powers, the *FlatPAC* family being modular in design; units contain up to three dc-to-dc converters, each providing up to 200mW, in a choice of chassis-mounted enclosures measuring 35mm high, 219mm long and 64, 125 or 186mm wide. Regulation is 0.05%, ripple 1% pk-pk, efficiency 80-90% and total remote sense compensation 0.5V. XP plc. Tel., 01734 845515; fax, 01734 843423.

Low-profile 150W supplies. First arrivals in a new series of low to medium-power supplies from Power-One single and multi-output switched-mode supplies are making an appearance. *MPU150 Series* units are in 1.5in 1U U-channel cases with optional covers and have power-factor correction to IEC61000-3-2 with a 85-264V ac input range. With air cooling given by the user's system or by an optional fan, each unit will produce 150W and other features include mains fail, current sharing, thermal shutdown, remote sensing and optional remote inhibit. The *MPU* series meets a truly impressive number of emi, rfi and safety standards. Power-One Europe. Tel., 01769 540744; fax, 01769 540756.

Compact 25W dc-to-dc. In a package measuring 2 by 2 by 0.375in, the *OB Series* of dc-to-dc converters by Ampicon give up to 25W, pin-out being to industry standard. Input is 12-48V dc, efficiency up to 86% and outputs 5/12/15V dc and $\pm 5/\pm 12$ and ± 15 V dc, outputs being trimmable by $\pm 10\%$. Regulation and stabilisation are both 0.2%, temperature coefficient $\pm 0.02\%/^{\circ}\text{C}$ and ripple 150mV maximum. Cased or open models are available. Ampicon Liveline Ltd. Tel., 0800 525 335 (free); fax, 01273 570215.

Charger controllers. *ADP3810/1* by Analog Devices are battery charger controllers offering programmable current limiting and precise voltage limiting for the constant-current, constant-voltage charging of lithium

ion, nickel cadmium and nickel metal hydride cells. The *3810* has its own precision resistors for 1% accuracy on Li-ion cells, while the *3811* uses external resistors for a wide range of output voltages. Control voltage input, which is buffered, takes either an RC-filtered pwm microcontroller output or the divided reference voltage. Analog Devices Ltd. Tel., 01932 266000; fax, 01932 247401.

Charge-pump converters. National Semiconductor's *LM2660/1* are cmos charge-pump voltage converters for battery-powered equipment, PCMCIA cards and hard-disk drives. Conversion is 1.5V-5.5V at 90% efficiency, operating current being 120 μ A for most loads. Output impedance is 6 Ω , giving a droop of 0.6V at 100mA. The *LM2661* also has a low-current shutdown mode of operation, in which it draws less than 1 μ A. National Semiconductor GmbH. Tel., 0049 1805 32 7832; fax, 0049 814103515.

3W dc-to-dc converter. Coutant's *PP3* low-profile converters have been reduced in price, due to new methods of manufacture and a move to another factory. The *PP3-48-12* is the first in the cheaper series and is suited to distributed and modular systems. Input is 32-63V dc, input current at 48V being 90mA. A single 12V, 120mA output is accurate to within $\pm 5\%$, ripple is 150mV and efficiency is 75%, with stabilisation and regulation at 0.4% and 5% respectively. Coutant Lambda Ltd. Tel., 01271 865656; fax, 01271 864894.

Radio communications products

Receiver chip set. RF Monolithics' chip-set for its amplifier-sequenced receiver, which needs no frequency changing, for remote-control and security use is available from Acal. *ASH* chips include a low-loss surface acoustic wave filter for front-end selectivity, a saw delay line and rf circuitry to form the amplifier-sequenced gain and detector stages. Typically, sensitivity is -100dB without the use of heterodyning or regenerative circuits; virtually no rf emissions are produced. Chip-sets for frequencies between 303.825 and 433.92MHz are available, all running on 3V lithium batteries and drawing 1.1mA. Acal Electronics Ltd. Tel., 01344 727272; fax, 01344 424262.

40GHz up/down converters. Transmission up-converters and receiver down-converters from Anglia Microwaves are for 40GHz video distribution. The *DUC-4042N810* and *DDC-4042N610* cost less than travelling-wave tubes and are more reliable, life-expectancy being ten years of full-power operation.



Intermediate frequencies of 1.85-2.15GHz and rf at 40.5-42.5GHz are converted, local oscillator costs being reduced by the use of a multiplier before the mixer stage, which allows the use of X-band instead of K-band components. If/rf conversion gain in the *DUC* is 20dB to give an rf power output of 1mW, or 200mW with an optional amplifier. Oscillator leakage and sideband noise are a minimum of 20dB below signal. Down-conversion gain in the *DDC* is 30dB and noise 8dB in ssb operation. Anglia Microwaves Ltd. Tel., 01277 630000; fax, 01277 631111.

Switches and relays

S-m fuses. Three new surface-mounted *PolySwitch* resettable fuses by Raychem are intended for use with Universal Serial Bus ports, protecting against shorts and overcurrent conditions when plug-and-play boards are used. In the presence of a fault, the fuses switch to a high-resistance state, reverting to normal when the fault is cleared. *SMD20* satisfies a demand for low resistance (50m Ω) and voltage drop on USB ports; *miniSMDC110* is for self-powered port protection, having a 1.1A hold current and 160m Ω resistance; and *miniSMDC075* is for bus-powered application, holding on 0.75A and showing 300m Ω resistance. Raychem Ltd. Tel., 01973 572692; fax, 01973 572209.

Transducers and sensors

Level and flow sensors. Crydom has ranges of liquid level and flow sensors with a large number of options to meet most applications; if a requirement is not available, there is a design service to produce it quickly. Level sensors use float switches operated by reed-switch and magnet in vertical and horizontal

"Lowest-cost" PIC Ice. Jointly developed by Neosoft and RF Solutions, *ICEPIC Junior-16* is a modular unit that reduces development time and cost by working with all *PIC 16C6/7/8/9X* processors. It runs in a Windows environment, using the same gui as others in the *ICEPIC* family, and is non-intrusive, being capable of source-level debugging in assembler or C at the maximum processor speed. It has a standard Microchip emulation chip, 8K of 16Cxx emulation memory and a fast RS-232 interface for communications with the host at 57.6kb/s. The basic emulator costs £299 and additional modules for other processors £99. RF Solutions Ltd. Tel., 01273 498880; fax, 01273 480661.

configuration and internal or external mounting; materials used for manufacture are specified for the liquid in use, from boiling water to acids. The flow detectors use double-isolated reed switches and are housed in Hoechst Hostaform, which is acetal copolymer. Models in the range work in hot or cold water low-pressure systems and in alcohol or dilute acids and there are variants with triac buffers for improved switching, particularly with inductive loads. Crydom. Tel., 01202 897 964; fax, 01202 891 918

COMPUTER

Computer board-level products

Network controller for cards. *TDS2020* 16-bit and *TDS9092* 8-bit embedded computers by Triangle Digital Services can now be

networked using the *TDS2020CAN* board, which fits under one of the *TDS* cards to connect it to a multi-drop RS485 CAN network. Users are then able to, for example, display messages on a remote lcd, toggle relays and lamps in remote equipment, acquire data and control remote equipment. CAN networking is over two twisted pairs over distances of up to 1km, with up to 110 nodes, each optically isolated. Triangle Digital Services Ltd. Tel., 0181-539 0285; fax, 0181-558 8110.

Computers

200MHz single-board computer. Eltech Solutions announces *Eurocom 128*, a VMEbus single-board computer using the 200MHz Pentium processor, with options of IDE or SCSI hard disk support by way of the P2 connector and a choice of operating software including *VxWorks*. Its 64-bit wide memory allows the use of 8Mb to 128Mb ram using standard 8Mb PS/2 simms, memory size being automatically detected; memory can be optionally boosted by 256Kb second-level cache and EDO rams with hyper-page mode. Bios is in updateable boot-block flash eprom and there is a 2K serial eprom for user's data. A variety of monitors,

both crt and flat-panel displays, is on offer and the PCI-based graphic interface is compatible with the IBM VGA standard as well as backward to the EGA and CGA standards. The board has two asynchronous 16550 compatible serial channels with hardware handshaking and a bidirectional Centronics port supporting the IEEE1284 enhanced mode. Standard pc software is supported. Eltech Solutions UK Ltd. Tel., 01908 260044; fax, 01908 260012.

Workstation for clean rooms. Deeco, part of LucasVarity, has produced the *Sealtouch* clean room computer, which has virtually no effect whatever on its surroundings; it is completely sealed and has no need for a keyboard or separate mouse. No fans or filters are needed for cooling, since the computer is housed in a cast aluminium case that acts as a heat sink, and the infrared touch screen and flat-panel electroluminescent or active-matrix lcd colour display are sealed to prevent air entering or leaving. The touch mouse and on-screen keys can be used precisely even when wearing gloves. Lucas Control Systems Products. Tel., 0049 7024 971214; fax, 0049 7024 971240.

Data communications

Wireless RS-232. Radio Data Technology claims its *LPRS232* is the first reliable application of radio to data communication using RS-232 protocols. The transceiver is available in 428MHz and 433.92MHz with a range of 120m line-of sight or 30m in buildings, with a longer-range version, the -300 type, providing a range of over 1km. Transmission speed is selectable between 4.8kb/s and 19.2kb/s. Normally, the unit remains in receive mode until data arrives at its RS-232 input or an rf carrier is detected, whereupon the data is transmitted in packets with a header block containing a sync. word, the number of bytes in the packet and a checksum. The unit is compact, measuring 114 by 63 by 17mm, uses a single 8-12V supply and draws 45mA unloaded. Low Power Radio Solutions Ltd. Tel., 01993 709418; fax, 01993 708575.

Development and evaluation

Low-cost 68HC(7)05 development. Motorola has announced *JICS*, which is a £30 development kit for the 8-bit *MC68HC(7)05J1A* microcontroller. It contains everything needed for development and debugging,

including assembly programming, editing, software simulation and in-circuit simulation. The kit provides a sample device, cabling, power supply and full documentation. Motorola. Fax, 01354 688248.

Software

Power analysis. Voltech has Windows software for visual power analysis to assist in the remote configuration, control and monitoring of single and three-phase power measurements. The software is designed for use with the company's low-cost *PM100/300* power analysers and eliminates the need to program the analyser's front panel, enabling remote set-up, running and recording of measurements including real and apparent power, crest factor, efficiency, harmonic distortion and inrush current. Results are shown graphically or numerically and both ASCII and CSV formats are used for transfer to word processors and spreadsheets. New capabilities conferred by the software include modification of the thd formula, adjustment of averaging depth and the setting of fixed ranges for all power measurements. Voltech Instruments Ltd. tel., 01235 861173; fax, 01235 861174. ■

ADVERTISE FREE OF CHARGE

Subscribers* to *Electronics World* can advertise their electronics and electrical equipment completely free of charge

Simply write your ad in the form below, using one word per box, up to a maximum of twenty words. Remember to include your telephone number as one word. You must include your latest mailing label with your form.

* This free offer applies to private subscribers only. Your ad will be placed in the first available issue.

This offer applies to private sales of electrical and electronic equipment only.

Trade advertisers - call Joannah Cox on 0181-652 3620

All adverts will be placed as soon as possible. However, we are unable to guarantee insertion dates. We regret that we are unable to enter into correspondence with readers using this service, we also reserve the right to reject adverts which do not fulfil the terms of this offer.

Please send your completed forms to:

Free Classified Offer: Electronics World, L333, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS

Skin effect

Nick Wheeler outlines skin effect and describes why it is irrelevant at audio frequencies.

Table 1. Effect of frequency on rf resistance in two wires with different diameters.

Frequency (Hz)	Wire diameter	
	2mm	0.2mm
10	1	1
100	1	1
1k	1	1
10k	1.095	1
100k	2.626	1
1M	7.7	1.095
10M	23.8	2.626
100M	74.7	7.7

Everyone involved with electronics will have heard of skin effect. And most will know that it has the effect of increasing the effective resistance of a conductor as signal frequency increases. This is due to the current flow being increasingly concentrated on the outer surface of the conductor.

The effect can be so pronounced that in some cases a thin-walled tube is as effective as a solid conductor. Silver plating and the use of oxygen-free copper are commonly used to reduce the effects of skin effect.

Silver plating reduces resistance of the conductor skin while oxygen-free wire has a fractionally lower resistance than the standard-quality option. Oxygen-free cable can be simulated by simply increasing conductor cross section. The diameter increase necessary to do this is so small as to be negligible.

Note that effective resistance, as referred to above, is also known as 'rf resistance'. It is an ohmic effect, and nothing to do with reactance. It's operation can be detected thermally.

What causes skin effect?

Consider a conductor made up of many strands of thin uninsulated wire, and carrying an alternating current. Current flowing through any single strand produces a field which cuts through the bulk of the surrounding conduc-

tors. In effect, these conductors form shorted turns as they are in intimate contact.

Currents flowing in the shorted turns oppose that flowing in the specimen strand, but those currents have to go somewhere. It is easy to show that they concentrate on the outer surface of the conductor bundle, or in the case of a single large conductor, on the surface.

Fields associated with the outside surface intersect less conductor material. As a result, the opposition to current flow is less on the surface, which is where it then flows. This effect depends strongly on increasing frequency and – because of the larger cross-sections involved – with increasing sizes of solid or uninsulated stranded conductors.

Stranded versus solid conductors

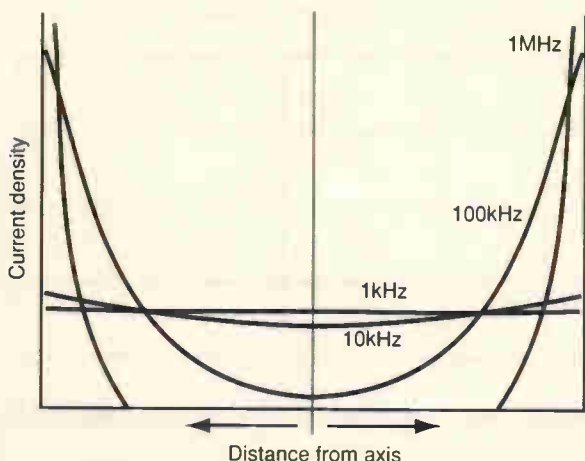
Imagine a conductor comprising 55 uninsulated strands of 0.1mm diameter copper, such as RS356-167. This has a copper cross-section of 0.43mm² and an equivalent solid diameter of 0.74mm.

At high kilohertz and megahertz frequencies, this cable performs very much the same as 22SWG solid, with a diameter of 0.71mm which has, as predictable from theory, fractionally less rf resistance. A conductor made up of 15 strands of enamelled 36SWG, amounting to a cross-sectional area of 0.425mm², as opposed to the 0.43mm² of the 55 uninsulated-strand wire, has about half the rf resistance at frequencies in the 1 to 2MHz region. This is, I think, as high as you need to consider if you are interested in audio.

Note that these principles are not new. They have been known and applied since the earliest days of radio, in the form of Litz wire.

The facts

It is a matter of simple scientific fact that – to three decimal places – a conductor of 0.2mm outside diameter has negligibly more rf resistance at 100kHz than its dc resistance. What this means is that, up to this frequency, the current distribution is uniform across the conductor cross-section, thereby making oxygen-free copper and silver plating irrelevant for



Current distribution across a 2mm conductor at various frequencies demonstrates skin effect.

audio work.

At 1MHz the rf resistance is up by 9.5%, where silver plating and so on really do start to be useful. On the other hand a conductor of 2mm outside diameter has 2.625 times the rf resistance, compared with dc resistance, at the significantly low frequency of 10kHz.

Figure 1 from reference 2, illustrates this, and Table 1, from the same source, summarises some experimentally determined data. Of course, if a conductor of very large cross-section is used, the dc resistance, and consequently the rf resistance, will be low in comparison with the highly variable impedance of the loudspeaker load.

Domestic twin-and-earth cable of adequate cross-section may well be the most cost-effective route¹. In terms of power loss, rf resistance is irrelevant in audio applications. What matters is that the low output impedance of a good amplifier may not be seen as effectively damping hf loudspeaker transients.

In summary

What this boils down to is that cables made up of many strands of thin uninsulated wire offer no advantages over the same cross-section of solid wire, except mechanical flexibility. Separately insulated multistrand cable can offer genuinely superior performance.

It would be prohibitively expensive to make up a coaxial cable of which the outer braid was composed of insulated wires, commoned at each end, and with an insulated multi-strand inner, but this must be the ultimate cable. ■

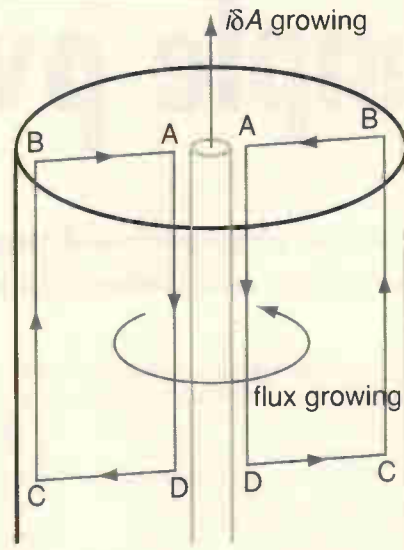
Reference

1. Speaker Cables, C. Bateman, EW Feb 1997
2. Services Textbook of Radio Volume I HMSO 1956.

Skin deeper

The following is an extract from reference 2.

Current density in this wire is iA/cm^2 . Current $i\delta A$ flows through an area δA on the axis of the wire and grows, creating magnetic field H . Through any radial section of the wire, such as ABCD, flux due to H is growing, resulting in an emf between A and D along the axis, and from C to B on the outer side. This emf tends to reduce current flowing along the axis and increase that flowing along the outside of the wire.



Skin effect. Any change in current along the axis causes induced voltages which oppose this change along the axis and promote it in the outer regions.

Halcyon Electronics Off-Air Frequency Products



We manufacture a range of Off-Air Frequency products including frequency standards, sources and disciplined standards including GPS, Customised units also available

Precision Frequency Source
1kHz to 16MHz sinewave output, 0.0001Hz resolution,
Easily settable via decade switches,
VCXO backup as standard

Off-Air Frequency Standard
1MHz, 5MHz and 10MHz, outputs,
Options include Sinewave, Signal inhibit and Audio Warning

CIRCLE NO. 128 ON REPLY CARD

We are well known for our quality new and used test equipment. Our list is extensive, ranging through most disciplines. Call for details

CIRCLE NO. 129 ON REPLY CARD

Halcyon Electronics

423 Kingston Road, Wimbledon Chase, London SW20 8JR
Phone: 0181 542 6383 Fax: 0181 542 0340

CIRCLE NO. 130 ON REPLY CARD

WE HAVE AN EXCELLENT CHOICE OF QUALITY, FULLY GUARANTEED USED TEST EQUIPMENT

OSCILLOSCOPES

TEKTRONIX 465 Real-Time Scope.....	£300
TEKTRONIX 475 Real-Time Scope.....	£425
TEKTRONIX 475A Real-Time Scope.....	£475
H.P.1725A 275MHz Real-Time Scope.....	£450
MEGURO MO 1254A 50MHz Real-Time Scope.....	£200
HAMEG HM605 60MHz Real-Time Scope.....	£250

DIGITAL OSCILLOSCOPES & DSO ADAPTORS

H.P.54501A 100MHz Digitising Scope.....	£1400
YOKOGAWA DL1200 4 Channel 100MHz, Digitising Scope.....	£1000
THURLBY Digital Storage Adaptor DSA524	£250

SIGNAL GENERATORS

TEKTRONIX SG503 Levelled Sine Wave Generator.....	£700
TEKTRONIX PG506 Calibration Generator.....	£850
FARNELL LFM4 Sine/Square Wave.....	£50

GENERAL TESTERS

POLAR TONEOHM 700.....	£40
------------------------	-----

MULTIMETERS

SELECT TEST AVO.....	£35
TAYLOR AVO.....	£35
AVO Fei Tester TT167.....	£85

OSCILLOSCOPE CALIBRATORS

BRADLEY 192 Volts/Time/Pulse Edge.....	£400
--	------

POWER SUPPLIES

BRANDENBURG 5kv Supply.....	£300
VARECO 2A 30v Variable PSU.....	£40

TEST BRIDGES

MARCONI Universal Bridge TF2700.....	£100
--------------------------------------	------

EX-DEMO STOCK, (12 MONTHS GUARANTEED), EXCELLENT CONDITION ACTIVE PROBES

ARMEX FSP 500 500MHz Switchable, (x1)x10.....	£350
ARMEX FP 500 500MHz (x10).....	£250

BRAND NEW AND BOXED DIFFERENTIAL PROBES, (WITH 12 MONTHS GUARANTEE)

GOULD PB57 100MHz, 400v, x10/x100.....	£450
GOULD PB54 300MHz, 6v, x1/x10.....	£450

BARGAIN BASEMENT

SANGAMO S82 Current Meter.....	£20
TEKTRONIX 106 Square Wave, Signal Generator.....	£50
TEKTRONIX 191 Constant Amplitude, Signal Generator.....	£50
VARIOUS DVM'S.....	£25

Please call for stock availability and details. Carriage for units over £200 is £12. Carriage for units under £200 is £8. VAT to be added to the total value of the order. User manuals are supplied if possible. Used equipment guaranteed.

ARMEX ELECTRONICS LTD.

TELEPHONE: 01492 580080 FAX: 01492 580081
19, Ffordd Sam Pari, Conwy Morfa Industrial Estate,
Conwy, N. WALES LL32 8HH.

CIRCLE NO. 131 ON REPLY CARD

Simple pwm power amp

Designed for efficient low-frequency and dc power driving, Richard Lines' pwm amplifier can deliver up to 5A at 25V.

This note describes a pulse-width modulated amplifier capable of producing a unipolar output of up to 25V at 5A.

Designed for simplicity, the circuit is based on an *LT1074CT* switch-mode power supply IC from Linear Technology. It is suitable for use in servo systems, or as a heater driver or thermoelectric cooler, where power conversion efficiency is a priority and the control signal is a few hertz or less.

The design is especially useful in low-voltage high-current applications, where a standard linear regulator would waste a lot of power.

Circuit operation

The chip has an internal oscillator running at 100kHz. The square wave generated is pulse width modulated with a duty cycle controlled by the voltage on pin 2 (out). The chip's main output appears at pin 4 (switch); this is the dc input chopped according to the duty cycle.

Components D_1 , L_2 , C_4 form the conventional flyback circuit and low pass filter. Inductor L_2 needs some consideration: the magnetic core needs to be large enough not to saturate at peak currents.

My prototype consisted of 32 turns of 1mm

wire on an *RM400* pot core. If the full 5A output is needed then the inductance should be dropped to 50 μ H in accordance with the device data sheet. Capacitor C_4 needs to be rated at the power supply voltage since the output voltage will rise to this level if the load is accidentally connected.

The feedback pin connects internally to the error amplifier input. In the usual power supply circuit, it samples the output voltage via a potential divider. Also, the output pin connects internally to the error amplifier output. This makes it possible to build an inverting amplifier from the error amp with gain set by R_1/R_3 .

I found a swing of something less than 1V at pin 2 enough to sweep the duty cycle from 0% to the chip's maximum of about 90%. In the prototype application, an offset current was required into the summing junction. This is provided by R_2 from a regulated 5V source.

Components R_4 and C_3 are recommended by the manufacturers for circuit stability. Capacitor C_2 was found necessary for the same reason.

It is important that D_1 is a high current Schottky barrier type. Resistor R_5 and C_5 were fitted to reduce ringing; they are not necessary and are not recommended by the chip manufacturer on the grounds of slightly reduced

efficiency. However the output was less noisy with them fitted and this was an important consideration. An obvious alternative is to fit an extra low pass section in the output lead.

The chip contains an analogue multiplier. This is used to reduce the duty cycle with increasing supply voltage thus keeping the output voltage approximately constant – depending only on the control input. Without this circuit element, any power supply variations would be seen in the output in proportion to the duty cycle. The presence of the analogue multiplier gives a useful degree of ripple rejection.

Input filter L_1/C_1 is recommended to stop switching transients getting back into the general power supply. Capacitor C_1 should be close to the IC.

Setting up

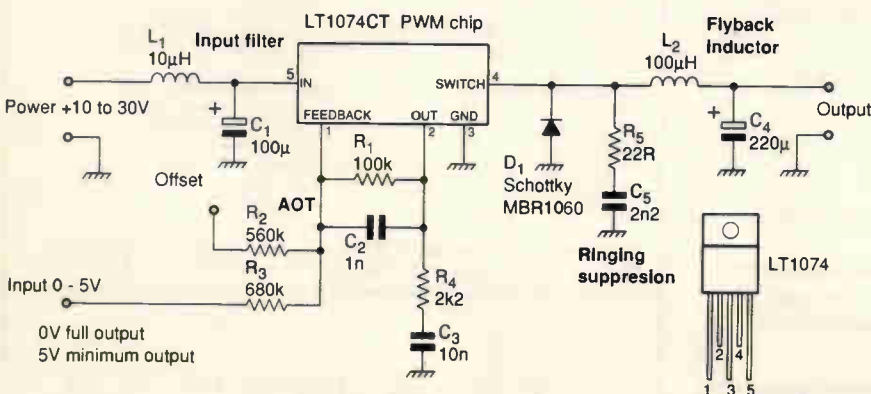
First consider the maximum duty cycle required. This will depend on the ratio of output voltage to power supply voltage and don't forget to allow about 1.5V lost in the switching transistors.

With the input open circuit resistor R_2 should be adjusted so as the output voltage is about half the expected maximum with a suitable dummy load connected. Check the waveform on pin 4 and see if the duty cycle is as expected.

Now adjust R_3 if necessary to ensure that the output goes from nearly 0V to the expected maximum as the input control voltage goes from 5V to 0V. Pin 1, feedback, will always be at 2.21V with respect to ground if the circuit is operating correctly.

I used this circuit as part of a temperature controller servo loop. With a power supply of 15V, the prototype produced 0 to 11V with the component values shown. This was used to run a small heater of 10 Ω resistance.

Efficiency was measured at over 80%, except for very low outputs. The circuit is quite linear over the middle 80% of the range but deviates at both extremes. This was not of significant for me since the circuit was inside a temperature controller loop. ■



Designed as part of a temperature controller servo loop, this circuit produced 0 to 11V with the component values shown using a 15V supply. The controller was used to run a small 10 Ω heater. Zero volts at the input gives full output while 5V gives minimum output.

The Headphone Amplifier Box
Balanced or unbalanced microphone or line input
to headphone output
Professional portable units operating from an internal PP3
battery or external mains adaptor



- * Precision transformerless balanced input * Bridged headphones output drive * Sensitivity selectable over a wide range of input levels * Low noise and distortion
- * High common mode rejection * Loop through facility
- * Extensive RFI protection

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

Conford Electronics Conford Liphook Hants GU30 7QW
Information line 01428 751469 Fax 751223
E-mail contact@confordelec.co.uk
Web <http://www.confordelec.co.uk/catalogue/>

CIRCLE NO. 132 ON REPLY CARD



- ✓ 100% Transparent Cable Replacement!
- ✓ No Special Software Drivers Required!
- ✓ Typically Only 10ms System Latency!
- ✓ Handles Single Bytes or Complete Files!
- ✓ Dual RS232 + RS422/RS485 Interfaces!



RTcom-Global RF Modem:
2400bps to 115200bps AS/4 Data Rates
Between 200m to 1.2km Range
UK: 01273 796226 FAX: 01273 796226
USA and Australia: 0734411111
Dual RS232 + RS422/RS485 Interface
Wall Mount or DIN Rail Mount
Up to 4 Cables (Attenuating & Factory preset)



RTcom-Universal RF Modem:
2400bps to 115200bps AS/4 Data Rates
Between 100m to 100m Range
UK and USA: 01273 796226
Dual RS232 + RS422/RS485 Interface
Wall Mount or DIN Rail Mount
Up to 4 Cables (Attenuating & Factory preset)

New from Radio-Tech the RTcom Radio Modems offer industry a competitive alternative to cables. Fully customised versions are available to suit customer needs at little or no additional costs.



Radio - Tech Limited, Overbridge House, Weald Hall Lane
Thornwood Common, Epping, Essex CM16 6NB.
Sales +44 (0) 1992 57 6107 (4-lines) Fax +44 (0) 1992 56 1994
e-mail sales@radtec.demon.co.uk
<http://www.radio-tech.co.uk>

CIRCLE NO. 133 ON REPLY CARD

WE HAVE THE WIDEST CHOICE OF USED OSCILLOSCOPES IN THE COUNTRY

PHILIPS PM3296 Dual Trace 400MHz Delay Cursors	£1750
PHILIPS PM3295 Dual Trace 350MHz Delay Cursors etc	£1500
N.P. 5420Aa Digitizing Oscilloscope 50MHz	£750
TEKTRONIX 2145 4 Channel 150MHz Delay Cursors	£1500
TEKTRONIX 1A5465 Dual Trace 100MHz Delay Cursors	£900
TEKTRONIX 475 Dual Trace 200MHz Delay Sweep	£500
TEKTRONIX 465 Dual Trace 100MHz Delay Sweep	£400
TEKTRONIX 2215 Dual Trace 60MHz Delay Sweep	£400
PHILIPS 3065 2x1 Channel 100MHz Dual Trace/Delay	£700
PHILIPS 3055 2x1 Channel 50MHz Dual Trace/Delay	£500
PHILIPS PM3217 Dual Trace 50MHz Delay Sweep	£600
COULD OS300 Dual Trace 30MHz	£200
COULD OS300 Dual Trace 20MHz	£200
BRUSH 5530A Dual Trace 35MHz	£220
PHILIPS PM3206 Dual Trace 15MHz	£400
HITACHI V209 Dual Trace 20MHz Wave/Battery	£700
PHILIPS PM57 Dual Trace 50MHz Scope/Meter Dig Storage	£700
TEKTRONIX Telemeter 194555 Trace 1945 MM/Auto-ranging	£500
LEADER LCD100 10MHz Scope 200MHz Digital Storage LCD	£300
TEKTRONIX TDS340 Digital Storage 100MHz 500 Mega Sampler	£1400
TEKTRONIX 2230 Digital Storage 100MHz Cursors	£900
TEKTRONIX 2210 Digital Storage 50MHz Cursors	£700
TEKTRONIX 468 Dual Trace 100MHz Dig Storage	£750
HITACHI H55041 Dual Trace 40MHz Dig Storage	£600
BECKMAN 9302 Dual Trace 20MHz Dig Storage	£450
COULD 1425 Dual Trace 200MHz Dig Storage Cursors etc	£600
TEKTRONIX 466 Dual Trace 100MHz Dig Storage Storage	£450
N.P. 171A Dual Trace 100MHz Analogue Storage	£400
TEKTRONIX 434 Dual Trace 25MHz Analogue Storage	£250

THIS IS JUST A SAMPLE - MANY OTHERS AVAILABLE

N.P. 8629C Sweep Osc with 8629B 2.18 GHz	£1750
N.P. 8629C Sweep Osc with 8627B 0.1 to 2.4 GHz	£1750
N.P. 8656A Synthesised Sig Gen 0.1-990MHz	£1500
MARCONI 2017FMAM Signal Generator 100Hz-1024MHz	£1800
MARCONI 2015A Synthesised FM/AM Sig Gen 800Hz-1040MHz	£1800
N.P. 8640B Phase Lock Evn Sig Gen 500Hz-5120MHz	£750
N.P. 8640A FM/AM Sig Gen 500Hz-1024MHz	£650
FARNELL PSC520 Synthesised FM/AM Sig Gen 10MHz-520MHz	£450
FARNELL TTS320 Transistor Test Set	£350
MARCONI TF2361 Sweep Generator 1-300MHz	£200
N.P. 8616A LMF Signal Gen 1.8-4 GHz	£250
N.P. 8616A LMF Signal Gen 800MHz-2 GHz	£250

SPECTRUM ANALYSERS

N.P. 8565A 0.01-22GHz	£3500
ALLTECH 727 0.01-200GHz	£2000
ARRIFUSU MSC20 100Hz-1.7GHz (Slight shadowing on storage)	£1200
N.P. 182 with 8554B 100MHz-1500MHz	from £1000
N.P. 141T with 8554A & 8552B 10MHz-18GHz	£1500
N.P. 141T with 8554A & 8552B 500MHz-1250MHz	£1200
N.P. 141T with 8554A & 8552A 10Hz-110MHz	£800
N.P. 140T with 8554A & 8552B 500MHz-1250MHz	£800
N.P. 141T with 8554A & 8552A 10Hz-110MHz	£700
N.P. 141S with 8554A & 8552A 10Hz-110MHz	£600
MARCONI TF2310 with 142373 30Hz-1.25GHz	£1750
MARCONI TF2310 30Hz-110MHz	from £700
N.P. 3580A Sig 50MHz	£800
N.P. 3582A Dual Channel 250Hz	£500
N.P. 8443A Tracking Generator/Counter	£300
N.P. 8444A Tracking Generator	£1000

Used Equipment - GUARANTEED. Manuals supplied if possible.
This is a VERY SMALL SAMPLE OF STOCK. SAE or Telephone for lists. Please check availability before ordering.
CARRIAGE all units £16. VAT to be added to Total of Goods and Carriage.

STEWART of READING
110 WYKEHAM ROAD, READING, BERKS. RG6 1PL
Telephone: (0118) 9268041. Fax: (0118) 9351696
Callers Welcome 9am-5.30pm Monday to Friday (other times by arrangement)

CIRCLE NO. 134 ON REPLY CARD

KOMPASS

Following just one year's advertising, our customer base has increased by 55% in the UK

Mr. P Hart W E Couplings & Coatings

Over 332,000 buyers are using the **UK Kompass Register** every day to find companies like yours.

Is it you they're finding or your competitors?

Call now to appear in the next edition.
0800 521393

Please quote reference UKK 1

CIRCLE NO. 135 ON REPLY CARD

electronicsWEEKLY HyperACTIVE

CONNECT WITH THE UK'S NO 1 READ
FOR ELECTRONICS PROFESSIONALS
ON THE INTERNET

- **Daily News Service** – this section is updated daily from news sources around the world. So keep coming back to keep abreast of developments in the global electronics industry.
- **Technology Updates**
- **Fully Searchable** online database to Electronics Weekly's high quality editorial
- **On-line Jobs service** and careers advice – see the latest jobs on offer
- **Instant Feedback** – your chance to speak to other engineers



CAREERS



DAILY NEWS



TOOLKIT



ARCHIVE



INSIDE VIEW



TECHNOLOGY



NEWS

Sponsored by:



Point your browser at

<http://www.electronicweeklly.co.uk/>

and register now (it's free)

LETTERS

Letters to "Electronics World" Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Charge alkaline cells

I read with interest the article on recharging of alkaline cells in the March 1997 issue of *Electronics World*. There are two points that appear to be missing. They are of a supplier of suitable pcbs and a supplier of the special value resistors R_c , R_r and R_f .

With the aid of a standard 12-segment switch unit it would be possible to configure it as a 3-pole-4-way unit so as to be able to switch between the various battery types/ratings for each charger unit and a double switch unit for a pair of chargers?

Even better would be a 4-pole-4-way switch so that the respective socket could be switched as well so ensuring that the switch position matched the cell(s) being charged.

Philip T. Bellamy
Britten
Switzerland

Rod replies

Some consideration was given to producing a pcb, but it was shelved as it was thought not to be an economic proposition at that time.

However, it is likely that I will be producing another article on recharging silver-zinc button cells using the same techniques, and I will be designing a pcb for this. If this article is published, the pcb will be designed to accommodate alkaline cell charging too.

It is possible to switch between cell types using a multi-pole mechanical switch, but the contacts needs to be good quality. I tried this with wafer switches, but the reliability of the contacts fell off rapidly with use so I did not consider it to be very safe. As you may have noticed from the article, the accent was on safety.

If this type of switching were to be attempted, I would suggest a switch with gold-plated contacts and a good wiping action, totally enclosed to exclude dust. I have yet to discover a reasonably priced switch of this specification.

You would also have to ensure that a high charge was never administered to a small cell by wrong switch selection. This is easy to avoid in practice – use individual cell holders for each cell type rather than the expendable 'universal' cell holders you often see in commercial battery chargers.

As for the 'special' resistors, no special values are needed. Need I explain the trick?

Thank you for your interest.

Noise in emc

Ann Baker's letter in the January issue, and also a recent editorial on the subject of emc prompts me to write to you.

My credentials include a major paper entitled 'Crosstalk (Noise) In Digital Systems' in *IEEE Trans Comp.* EC-16, Dec. 1967 and a major paper in *IEE/IEPE Proceedings (IERE Pub. No 60)* of the September 1984 International Conference on emc entitled 'The Fundamentals of Electromagnetic Energy Transfer'. In addition, I was employed as the 'emc expert' on sundry major British weapons projects including Stingray.

Working in the USA in 1965 on military equipment design, I knew that the emc requirements for military weapons were fraudulent – a slush-fund where US Navy admirals and the like presumably owned most of the stock in the accredited test houses.

Don White later became king of the pseudo-technical aspect of emc, and had his 'academy' suitably situated near Washington DC. Any 'engineer' appointed 'EMC Expert' on a mirror British weapons project would pay £400 for the Don White 'Bible' and copy slabs of it into his reports – duly to join the torrent of paper going into the MOD.

An attendant at a Don White seminar told me that Don was anxious to get hold of my books.

The key point is that the technical level of competence of the emc sub-culture is the lowest of any branch of electrical and electronic engineering. There will be no correlation between whether two modules have passed the emc tests, and whether they subsequently interfere with each other. This is because the theoretical basis for these tests is hopelessly flawed.

When I heard, some fifteen years ago, that Britain would join up with Europe on emc standards, I telephoned the government department responsible and could find no evidence of any technical element in our government's decision making on this matter. The whole thing was just a paper empire.

Europe EMC standards, which follow the US Don White style, will only result in products made in

Europe costing some 10-20% more, and it will also drive out small companies and stop the manufacture of customised products. Companies in the one-off business are closing down.

In 1956, when I graduated in engineering, I took up electrical engineering, not mechanical. This is because civil and mechanical engineering had nonsensical, unscientific standards and

regulations. These nonsenses – such as the fact that the architecture of a Roman Point high-rise was not culpable when it collapsed because he kept within regulations – has now taken over electronics.

The decadence of the IEE has meant that we could not work through it to protect our industry against the phoney emc nonsense.

After 30 years of emc talk and enforcement, you cannot work your

Q & A

Q This aspect of digital signal processing which puzzles me. Consider a system sampling at 40.000kHz whose input is a sinewave just below the Nyquist frequency at 19.999kHz. Initially, assume that the sampling points coincide with the peaks of the input signal; the output from the a-to-d converter will alternate between maximum and minimum values.

A quarter of a second later, the system will have taken 10 000 samples but the input signal has only completed 4,999.75 cycles. The sampling points thus now coincide with the zero-crossings of the input signal, and the output from the converter will be zero.

After another quarter-second, the system has taken 20 000 samples and the input signal has completed 9999.5 cycles. The sampling points once again coincide with the peaks of the input signal, only the other way up; the output from the converter alternates between minimum and maximum values.

After three-quarters of a second, the converter output will be zero again; and after a whole second, we are back to the starting point with maximum and minimum converter output.

When this signal is replayed, the output from the digital-to-analogue converter will not be a signal at 19.999kHz. It will be at 20.000kHz squarewave, whose sharp corners will be knocked off by the analogue filter following the d-to-a converter to give a 20kHz sinewave, whose amplitude falls to zero twice per second and whose phase reverses at the points of zero amplitude. This would be heard, by those golden-eared individuals whose hearing extends up that far, as a high-pitched whine going 'wuhwuhwuh'.

More generally you can see that, for an input signal close to the Nyquist frequency, the output signal will be a sinewave at the Nyquist frequency, whose amplitude falls to zero at a rate of twice the difference between Nyquist and signal frequencies. So when attempting to record a 20kHz signal on a cd, you would expect an output from the cd player of a 22.05kHz whine – inaudible – and 4.1kHz whine – very audible.

Now I have heard many criticisms made of cd players, some more rational than others, but a tendency to transform the high frequency content of the input signal into strange whines and buzzes further down the scale was never one of them.

I have occasionally come across writings which purport to knock down this paradox. They generally start out by describing such a signal as I have done – perform some mathematical juggling which leaves me floundering – and triumphantly announce that in some manner averaged over many cycles we do get a 19.999kHz sinewave after all. But surely any filter able to perform such magic would have to delay the signal for many cycles to 'see what's going on'?

In the example above, unless the filter had a time delay of over a second, you would surely still get a high-pitched whine going 'wuhwuhwuh'.

Could someone please explain in as non-mathematical a way as possible why we apparently, do not?

Chris Bulman
Bedford

lap-top in an aeroplane, and a car's brakes come on when you operate your mobile telephone. You cannot listen to your fm radio while your computer mouse is on.

At the same time, I cannot get any theatre in which to debate the theoretical base of these problems with the emc punkah-wallahs.

Ivor Catt
St Albans
Hertfordshire

Crossover distortion and Miller capacitance

I read Prof. Cherry's letter with great interest concerning the position of the stabilisation capacitor in an audio amplifier¹. I fully agree that the position recommended by Self² is inappropriate for reducing crossover distortion. I am sure, however, that most of your readers will realise that the position Self suggests, Fig. 1, is incapable of allowing crossover distortion to be fully suppressed.

Consider a simple output stage which has no bias applied as shown in Fig. 2. If the driver stage had to

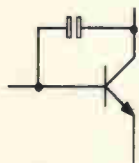


Fig. 1. Miller compensation.

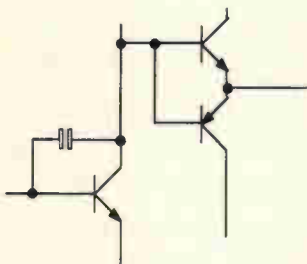


Fig. 2. Unbiased Class B amplifier.

provide a continuous signal for a given input, the collector voltage will have to move in a very short time, tending towards being infinitesimal, by, about $1.2V - \text{twice } V_{be}$ – to ensure a continuous output current. The maximum speed at which a practical circuit could respond would be limited by the current which could be dumped into or extracted from the compensation capacitor, increasing the Miller effect, according to the equation,

$$\frac{dV}{dt} = \frac{i}{C}$$

Clearly, the larger the capacitor the higher this current would be. The burden for the charging current falls on the transistors ahead of the voltage amplifier stage. This causes

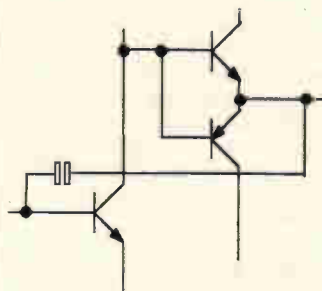


Fig. 3. Cherry's recommendation.

the concerns about the input stage overhead during fast signal peaks. In turn this endorses Prof. Cherry's view that fairly large resistors are needed in series with the input stage emitters to avoid possible transient intermodulation distortion. For example, a 1mA current source could only charge a 220pF capacitor at 4.5MV/s. Although high, this is comparable with a 60kHz signal at 20V amplitude.

In a circuit which has a bias, normally intended to avoid the 'dead-band', some considerable reduction in crossover distortion is achieved, according to Self's results, although he admitted problems with residual distortion, which as I have indicated cannot be cured by his capacitor position.

Prof. Cherry's alternative position for the feedback stabilisation capacitor is to connect it to the amplifier output stage, Fig. 3, I have seen this once before, in a publication by RCA³.

When I built a similar circuit, I did not experience any instabilities, but for other reasons the circuit was not particularly suited to high fidelity applications. Recently, I have built a fully complementary circuit using higher frequency transistors and I did observe some oscillation. However, I did not use damper capacitors across the drivers, as Cherry recommends, so there is a possibility that this will cure the problem.

My continuing concern with the capacitor is that even eliminating the effect it has on the driver transistor, it will still load the input stages. This of course is why Lohstroh and Otala developed an amplifier which explicitly did not use capacitors to roll the gain off in the Miller position⁴.

Despite some criticism by Cherry, the Lohstroh and Otala approach has not to my knowledge been shown to be incorrect in any way as a methodology.

What Cherry and Self suggest is that lower distortions are possible using the conventional feedback method; except for the concerns that I have discussed in this letter.

I accept that transient intermodulation ought to be fully suppressed provided Cherry's

observation – that the input resistors need to be high enough to prevent the input stages from ever cutting off – is met. This means that they have to drop a voltage at least as large as the input peak voltage. They will seriously reduce the open-loop gain if the input is to be as high as 1V rms – another point Cherry has made.

Another point to note is that often, designers involved with high-frequency amplifiers do not use Miller capacitors because of the degree to which they slow the design.

Many designers trying to minimise Miller capacitor effects use local feedback and low or medium impedance load resistors to define the gain of the voltage amplifier stage more precisely. Therefore, I do not accept that Self's amplifier can be given the label 'blameless' while the compensation capacitor could overload the input stages.

Perhaps if Self were to agree to increase his input resistors, and consider moving the compensation capacitor to the position Cherry advocates, Self's design would get rid of residual distortions he has been trying to eliminate recently.

If Self were to reoptimise his design, I suspect that there would be absolutely no grounds for any distortion components arising anywhere. It would then be very interesting to compare a Cherry nested differentiating feedback loop design⁵ with a re-optimised Self amplifier and a Lohstroh and Otala.

I doubt that a critical listener could discern the differences. All three aim to avoid all known distortions; but could one really tell the difference between 0.03% and .003%? The Lohstroh and Otala design does peak at 0.1% at 20kHz, but then the nested differential feedback loop approach does not minimise hf distortion.

Finally, I still urge amplifier designers to listen to the type of music that their designs are intended to amplify. Try isolating one instrument from another while listening. Can you pick out a harpsichord cleanly in a Brandenburg? Or follow the 'cellos in a Beethoven symphony?

While this introduces a degree of subjectivism into the debate I will state for the record that poor designs absolutely fail this musical test – even though single instruments may sound reasonable. Good designs will not, whether or not the listener perceives any other subjective quality. Designs which pass this test include Bailey's 30W amplifier (from 1968) and Lohstroh and Otala's.

I would be happy to see these statements quantified by perhaps analysing the output from speakers digitally, using a microphone to

record the output, and comparing the results to the original. This ought to be one way in which the amplifier designers could finally lay to rest this subjectivism – as well as being able to evaluate the effects of speaker performance on the overall result.

J.N. Ellis
Tavistock
Devon

References

- Cherry, EM, 'Ironing out Distortion', *Electronics World*, pp. 577-583, July 1997.
- Self, D, 'Distortion in Power Amplifiers', Aug. 1993 on, see e.g. part 3: 'The voltage amplifying stage', pp. 818-824, Oct. 1993.
- Solid State Power Circuits, RCA publication, 1971. See section on audio power amplifiers.
- Lohstroh, J and Otala, M, 'An Audio Power Amplifier for Ultimate Quality Requirements', *IEEE Trans. Audio and Electroacoustics*, vol. AU-21, pp. 545-551, Dec. 1973.
- Cherry, EM, 'Nested Differentiating Feedback Loops in Simple Audio Amplifiers', *J. Audio Eng. Soc.*, vol. 30, pp. 295-305, May 1982. See also 'Designing NDFL Amps', *Electronics Today International*, pp. 46-51, April 1983.

Towards a better World

In the July issue, some published circuits will disappoint without modifications.

In Frank Ogden's fluxmeter, on page 584, R_{scale} should be an unequivocal 10k Ω . This is because the meter and bridge rectifier are fed from a constant-current source in the feedback path and their resistance is immaterial.

However, this gives arithmetic-mean flux and for peak flux – assuming sinusoidal waveform – the resistor should be 6.32k Ω .

On page 586, Phil Regalia's audio preamplifier will spring to life once the lines crossing just left of the output terminal are joined together. And on page 590, Sujit Little's phase-splitter is useless until the right end of R_5 , joined to IC_{2b} , is also taken to 0V; but to get the intended gain of 10.1 from IC_{2b} , R_3 needs a further 1k Ω in series, since the formula for its negative gain is different from that for IC_{2a} 's positive gain, being compared with $(1+R_6/R_5)$.

B Jones
London

Frank Ogden replies

Mr Jones's is quiet correct. The meter resistance is immaterial. This was a moment's mental aberration, doubtless caused by the excessive magnetic flux from the computer monitor on the word processor.

A difference resolved

In reply to Steve Winder's letter in the August issue, this is essentially a matter of definition; can you define a meaningful input impedance relative to ground when a floating input voltage source has no connection to that ground?

The input impedances for a floating voltage source are the same in the sense that a given voltage must cause the same current in each input. The voltages on them are far from equal, being indeed zero for the cold input, as described in detail in my article.

On mature reflection, it seems more sensible to say that a floating source can only have one meaningful input impedance, in this case between the hot and cold inputs, and we agree that this is $20k\Omega$.

Douglas Self
London

In defence of anarchy

Referring to the August issue Letters, I won't go into Jim Adam's reasoning because he shows so little of it. Besides, I am no expert. Having just discovered the magazine, I've not even read John Watkinson's loudspeaker article (June issue) so I cannot comment on it.

But when Jim came on like a tendentious boff he annoyed me. Jim Adams vilifies trial and error. No scientist would scorn observation and experiment. Even the best design involves trial, compromise and error. Lack of reference and design formulae in an article isn't bad practice. It is daring, maybe arrogant, but good, showing healthy scepticism of received wisdom, and real wisdom in not pasting human ideas over nature – as if that alone matters.

As to active versus passive, public address firms use active filters to avoid inaccuracy, power and phase problems – and expense. As amplifier costs fall faster than those for large, exacting, passive components, the music industry is buying more active monitors; and where they go, the home listeners often follow. Variable crossovers in amplifiers will preserve their choice.

As a final note, good listening, being subjective, is more about removing vice than adding virtue. Position speakers correctly, drive them moderately, and test them with simple waveforms, noise, and good well-known recordings. That's as objective as a varied world will allow.

Mr Crow
Bristol

Music speaker

John Watkinson's article 'Loudspeakers exposed' in the June issue makes much of the bad pulse response of standard loudspeakers.

But this is surely not the point, given that the ear uses a series of transducers responding to pure frequencies?

As regards polar diagrams, the JBL speakers with 'baby's-bottom' tweeter horns have admirable polar diagrams and frequency response. In addition, they are completely transparent for rock enthusiasts in relation to live concerts originally heard through JBL speakers. You could say these are integral parts of the electric guitars used, otherwise inaudible, just as huge speaker cabinets and Leslies had to be considered integral parts of electronic cinema organs.

Bernard Jones
London

The future of hi-fi loudspeakers?

It is entirely possible that the nature of hi-fi loudspeakers will change significantly over the coming years. I am not referring to the development of flat drive units, or any other new technology, so much as the likelihood of a large proportion of them becoming active units with active crossovers.

The market for these is currently approximately nil – despite the technical advantages of such an approach. There are strong reasons, however, for thinking this will change, and soon.

The impact of multimedia

Although the market for bi-amped and tri-amped speakers is tiny, the market for active speakers is now huge, as a result of the recent explosion in the cd rom and multimedia pc market. Multimedia loudspeakers are now sold by the million – and they are all active. They have to be, because computers do not include power amplifiers.

The multimedia sound source is the compact disc, which for domestic listening is well nigh perfect. To make the very best of it, extremely high quality loudspeakers are needed. Of course, one possibility is to plug the computer's audio line output into your stereo system, but this is not always convenient. There is undoubtedly a market for top quality speakers that can be driven directly from computers without the intervening stereo system.

The advent of cd rom means that music cds will increasingly contain other data as well, an expanded 'sleeve notes'. They will also contain pictures of the artists concerned, and no doubt sales material, such as details of other titles on offer, interactive software to allow you to browse it, and something to click on if you want to place an order over the Internet. These developments seem natural and inevitable.

This means that cd-rom, multimedia, and stereo systems are moving closer together. Quality loudspeaker manufacturers will see that to gain as large a market share as possible they will need to offer products compatible with computer line outputs and existing stereo systems as well.

Computer manufacturers are not going to incorporate hefty high-quality power amplifiers into their products. But active loudspeakers can easily enough be made to work with existing stereos by bypassing the existing power amplifier – or at a pinch using the power amplifier output as the input to the active speakers.

Nasty this may be – but it works. You will no doubt be able to go down to your local hi-fi shop and buy a suitable adapter containing no more electronics than a couple of resistors to pad the level down a bit.

The upshot of all this is that there will be continued market pressure to make loudspeakers active, where in the past they have been passive.

Active versus passive crossovers

Having decided to relocate the power amplifiers into the loudspeaker boxes, the choice as to whether the crossover should be active or passive will be revisited.

A marketplace for active crossovers was always unlikely to arise when the amplifiers and loudspeakers were in separate boxes. All kinds of compatibility issues arise. In practice the most likely to emerge would have been to use a two-way active crossover between the bass and mid units, and a passive one between mid and top unit, if there is one. This has the advantage of avoiding a third amplifier section which would not always be required.

The lower frequency crossover is the more problematic one of the two and three-way passive networks, requiring bulkier and costlier reactive components which tend not to be very linear. Higher crossover frequencies are easier to implement. There are therefore also technical reasons why the bi-amp solution suggested above might have been appropriate.

But there still remain the issues of being able to adjust the crossover frequency, the balance between the low and high frequency outputs, and what happens if you want to switch between loudspeakers. By putting the power amplifiers in the loudspeaker these problems are removed.

Other problems disappear, too. The impedance of the loudspeaker drive units is no longer an external issue. The power amplifier comes with the right voltage and current capacity for the speakers. The top units will be harder to burn out

because they will be driven by a small amplifier. Clipping in the bass amplifier will not harm them.

Active crossovers and multiple power amplifiers become a much more attractive proposition when the amplifiers and drive units are in the same box. This means that the arrival of cd rom is giving the market a strong push in a direction which favours active crossovers. That this will lead to higher sound quality is a welcome bonus.

There are no doubt some hi-fi obsessives who will disagree on this, but their impact on the market will be insignificant. Large numbers of bi-amped loudspeakers will be sold with monolithic power amplifiers like the TDA2030 inside them. They will sound better than the current passive loudspeakers and passive crossover networks driven by separate power amplifiers with monolithic amplifiers like the TDA2030 inside them.

Digital signal processing

DSP chips are already available which can do the job of an active crossover, and better, too. One thing dsp chips are able to do easily, unlike analogue filters, is introduce longer delays into the high frequency components of the signals, as well as the low frequency ones. This gives far more flexibility where design of the phase response is concerned. Another thing dsp chips are better at is precision and stability, whereas analogue filters are to varying degrees sensitive to component tolerances.

The main issue, however, is cost. The input signal needs to be converted to digital first, processed, and then the results converted back to two or three output channels to be amplified. Ultimately this is no barrier to their use, since the cost of the silicon required to do this is falling continually.

Once the digital threshold has been crossed, all sorts of new possibilities open up. A dsp-based loudspeaker can be made to produce higher quality output by compensating for some of the drive unit deficiencies. In theory, it is possible to completely compensate for the bumps in their frequency and phase responses. In practice of course it isn't anywhere near that easy.

This does not mean it is not worth doing. Such compensation can operate on three levels. Level one is simply to filter the signal to compensate for the 'average' drive unit. Differences between units will mean the results are imperfect, but the improvement will be worth having.

Level two is to compensate for the failings of the units on an individual basis. The response of the loudspeaker is measured after it has been assembled, and the filter characteristics are adjusted for that

particular loudspeaker. This would of course be automated. The results might be held in eeprom.

The third level is to adjust the filter characteristics to get the best from the loudspeaker in its environment. Clearly this is only possible at the top end of the market, where the customer has his new speakers installed for him by an engineer with the necessary equipment to set the system up. This is no wild speculation – equalisation of monitor loudspeakers in their environment has been common practice in the professional recording studio market for years.

DSP chips can do far more than just implement filter algorithms. Remote control is possible. The output signals to the power amplifiers can be limited to prevent burn-out or excessive mechanical stress in the drive units. The bass drive can be limited to prevent excessive excursion of the voice coil. The heatsink temperature can be monitored and the drive levels abated if it becomes too hot.

Once the low cost dsp capacity becomes available, as it inevitably will, these extra frills will be cheap to implement. These loudspeakers will

tolerate gross abuse in a way you cannot possibly say of passive ones.

It is not difficult to predict that there will come a time when a dsp chip specifically targeted at active loudspeaker manufacturers will become available – including one a-to-d converter for the input – three d-to-a converters for the drive unit outputs, and on-board eeprom to hold the filter coefficients.

One of the three converters would be redundant in bi-amped speakers. Fallouts with one of the converters out of specification or not working properly would do for these.

Another likely development is a similar chip with pulse-width modulated outputs instead of d-to-a converters. The PWM outputs would drive switch-mode Class-D amplifiers directly. They would be very easy to implement on silicon.

Chips like this can be expected to be targeted at the lower end of the market. Use of d-to-a converters and linear amplifiers is still likely to remain the norm where the highest quality is required.

Design freedoms

The establishment of a market in active loudspeakers will give

designers more freedom. They will no longer be tied to making drive units with impedances designed to match somebody else's drive capability, or to be compatible with another unit connected to the same passive crossover network.

One obvious possibility is to design a loudspeaker so that the bass unit is driven by a bridge mode amplifier, whereas the mid and top drivers are single ended, since the power output required is lower. These would all run off the same power supply.

The top unit might be made with a higher impedance, so its amplifier operates with a sensible output voltage swing, and is more efficient.

All kinds of other possibilities can be imagined. The connections to the drive units are all separately available to the drive circuits giving more design freedom than is available today.

Incorporating more exotic drive units becomes easier. If an unusually low or high impedance needs to be driven, the traditional constraint of having to couple it to a traditional amplifier with the wrong drive capability is removed.

Beyond the horizon

In the long run, it seems almost inevitable that digital interfaces between hi-fi units will supplant the current analogue ones. Such interfaces already exist in the professional audio equipment market. When this happens the input to the loudspeaker will be a digital one, and the a-to-d converters input to the dsp chip crossover will be eliminated.

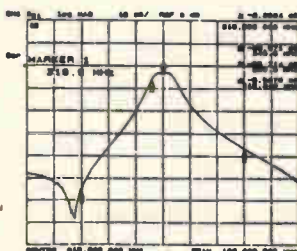
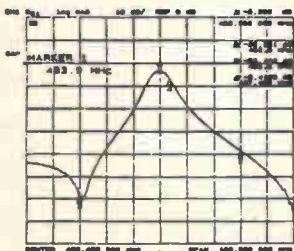
Playing digital recordings will then involve an entirely digital path from the a-to-d converter on the microphone input at the recording studio – or wherever – to the dsp crossover outputs in the loudspeakers.

These things, however, are not imminent – or at least, not as far as I am, aware. Fairly soon, though, we can expect to see more and more active loudspeakers with active crossovers. And we can expect to see more and more dsp crossovers, starting at the top end of the market and working downwards. I, for one, think this will be a welcome development. The days of the separate power amplifier and passive crossover are deservedly numbered.

Alan Robinson
Holgate York

HELICAL BPF FILTERS FOR SECURITY BAND 433.9MHZ(DIN) & 310-320MHZ(FCC), WE MAKE MASS PROD. T6711A/AA-433.9M(7H2)/T6740A/AA-310-320M(7H2). THOSE HAVE GOOD ATEN & BW. SMALL GROUP DELAY, EASY MATCHING, ATTRAC. PRICE COMPARISON WITH SAW FILTER. FREE SAMPLES FOR EVALUATION, PLS FAX US IMMEDIATELY TODAY!!

SPEC \ PARTS NAME	T6711A-433.9M(7H2)	T6740A-310-320M(7H2)
f ₀ (CENTER FREQ.)	433.9 MHZ	310-320MHZ
INSERTION LOSS	TYP. 4.5 dB	TYP. 4.0 dB
3 dB BANDWIDTH	TYP. 7.0 MHZ	TYP. 8.0 MHZ
ATTENU.		
f ₀ -30MHZ	TYP. 53.0 dBc	TYP. 50.0dBc
f ₀ +30MHZ	TYP. 32.0 dBc	TYP. 31.0dBc
RIPPLE	< 1.0 dB	< 1.0dB
RETURN LOSS	> 12.0 dB	> 8.0dB
IMPEDANCE	IN / OUT: 50Ω	IN / OUT: 50Ω



IN ADDITION, ANY FO 55M-1.6G YOU MAY DESIGN HELICAL BPF, FULL CAT. SUGGEST YOU. --- AGENT WANTED, WELCOME OEM ---.

TEMWELL CORP. WELL MADE IN TAIWAN

FAX: 886-2-5515250/5652287

CIRCLE NO. 136 ON REPLY CARD

Leading Edge Technology Ltd

Low cost Programmers for all your requirements

GAL PROGRAMMER

16V8 / 16V8A / 16V8Z 20V8 / 20V8A / 20V8Z

£79.95

- Stylish compact case with quality ZIF socket
- Easy to use software - load/save in JEDEC format
- Plugs into Centronics printer port
- Works on any IBM PC or compatible / laptops / notebooks etc
- Fast and reliable programming using manufacturers algorithms
- Program protection fuses to prevent unauthorised copying
- Supplied with PLAN Logic compiler software
- Complete system with example files, connection lead, and PSU
- Full 12 months parts and labour guarantee



128k x 8 EPROM EMULATOR

£89.95

This is the ideal way to test / change 'running' code on CPU based systems. It plugs directly to the printer lead of an IBM compatible computer. There are no internal cards so it is ideal for laptops etc. The unit emulates ALL Eproms from 24 pin 2716 (2k) to 32 pin 27C010 (128k). The memory can be configured as 128k by 8 bits or 2 x 64k by 8 bits. A CPU reset line is provided and the user can select high/low or low/high reset signals. Software supplied (DOS and Windows 3.0/1) has full screen editing and allows you to save and load code with offsets. Full 12 month guarantee.

MEGAPROM UNIVERSAL EPROM PROGRAMMER

EPROMS / EEPROMS / FLASH EEPROMS / 12C BUS EEPROMS

- Covers all types of Eprom, EEPROM, and flash up to 32 pin
- Fast programming and verification
- Easy to use software - supports Bin / Intel Hex / Motorola S and ASC file formats
- Read / Edit / Verify / reprogram etc
- Supplied with full 12 months parts and labour guarantee

Megaprom runs on any IBM PC / compatible, connects directly to the centronics printer cable and requires 12-18V AC/DC PSU. Low cost makes it ideal for hobbyists and engineers alike. £99.95



ENHANCED PIC PROGRAMMER

- Programs PIC54, 55, 57, 58A, 61, 64, 65, 71, 75, 84, 620, 621, 622, MEMORY CHIPS, 24LC01, 02, 16, 32, 65
 - Read / Write / Copy / Program fuses
 - Software supports Microchip, Intel Hex, binary format also supplied with Editor assembler for 54 series and 71/84
- Runs on IBM PC / compatible, connects to the centronics printer cable and requires 12-18V AC/DC PSU. Full guarantee. £69.95



Visit our Website at:
<http://www.angelfire.com/free/leadedge.html>
or Email us at:
johnmorr@email.keyworld.net

Postage/packing not included. No VAT or C/C surcharge

Leading Edge Technology Ltd
White Rose House, Xintill Street
Tarxien, PLA 11, Malta
Phone: (00 356) 678509
Fax: (00 356) 667484






CIRCLE NO. 137 ON REPLY CARD

CLASSIFIED


TEL 0181 652 3620

FAX 0181 652 8956

ARTICLES FOR SALE

SUPPLIER OF QUALITY USED TEST INSTRUMENTS






CONTACT

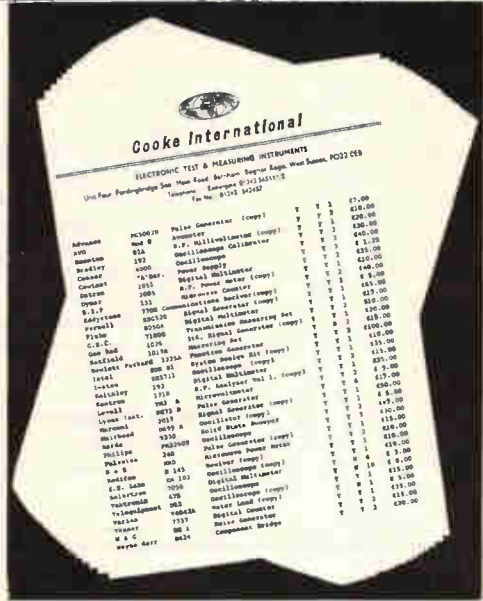
Cooke International

ELECTRONIC TEST & MEASURING INSTRUMENTS
Unit Four, Fordingbridge Site, Main Road, Barnham,
Bognor Regis, West Sussex, PO22 0HD, U.K.
Tel: (+44)01243 545111/2 Fax: (+44)01243 542457

CIRCLE NO. 138 ON REPLY CARD

OPERATING & SERVICE MANUALS



CONTACT

Cooke International

**Unit Four, Fordingbridge Site, Main Road, Barnham,
Bognor Regis, West Sussex, PO22 0HD, U.K.**
Tel: (+44)01243 545111/2 Fax: (+44)01243 542457
NOW AVAILABLE CATALOGUE ON DISC

CIRCLE NO. 139 ON REPLY CARD

ADVERTISERS INDEX

Anchor	732	Leading Edge	789
Armex	781	M & B Radio	770
Bull	712, 784	Number One	770
Card Professionals	738	Pico Technology	738
Chelmer	742	Pyramid	760
Colomar	760	Radiometrix	716
Conford	783	Radio Tech	783
Display Electronics	723	Stewart of Reading	783
Equinox	IBC	Surrey	706
Halcyon	781	Technology Sources	706
Hart	747	Telford	711
IOSIS	760	Telnet	716
John's Radio	773	Temwell	789
JPG	706	Tie Pie	711
Keytronics	724	Ultimate	IBC
Labcenter	OBC	Weir	729
Langrex	742		



INNOVISION RESEARCH & TECHNOLOGY LTD

... is a fast-growing company with a reputation to do the impossible. We design and develop new products for a host of multinational companies, using new technologies and processes. We offer a competitive advantage to our customers - and an exciting and challenging career for you.

WE ARE LOOKING FOR:

Embedded Software Engineer

Hardware Design Engineer (good analogue)

Design Technician (new graduates)

Location: Wokingham, Berkshire - M4, Junction 10.

THE RIGHT CANDIDATE MUST HAVE:

- Good HND or Degree in Electronic Engineering
- At least 3 years experience in design engineering (depending on position)
- High professional and quality standards
- Good problem solving and lateral thinking abilities

IN RETURN WE CAN OFFER YOU:

- An excellent salary
- Corporate healthcare membership
- Participation in corporate incentive scheme

NEXT STEPS ...

Fax, Email or post your CV to **Jenny Greenfield** (Project Development Manager), **Innovision R&T Ltd.**, Exa House, Alexandra Court, Wokingham, Berks RG40 2SJ
Tel: 0118 979 2000 Fax: 0118 979 1500
Email: Jenny.Greenfield@innovision-group.com

ADVERTISERS PLEASE NOTE

For all your
future enquiries
on advertising
rates

Please contact
Joannah Cox on

Tel: 0181-652 3620
Fax: 0181-652 8956

VALVES and CRTs AVAILABLE

ONE MILLION VALVES stocked for Audio, Receiving, Transmitting & RF Heating. Rare brands such as Mullard & GEC available. Also MAGENTRONS, KLYSTRONS, CRTs and SOCKETS.

Large stocks of Russian and Sovtek items.

Please ask for our free catalogues of valves or CRTs.

VALVES, etc, WANTED

Most types considered but especially KT88 (£60), PX4/PX25 (£60), KT66 (£38), KT77 (£18), EL34 (£15), EL37 (£15), ECC83 (£3). Valves must be UK manufacture to achieve prices mentioned. Also various valve-era equipment e.g. Garrard 301, (up to .£80). Ask for a free copy of our wanted List.

BILLINGTON EXPORT LTD., Billingshurst, Sussex RH14 9EZ

Tel: 01403 784961 Fax: 01403 783519

VISITORS STRICTLY BY APPOINTMENT.

MINIMUM ORDER £50 plus VAT

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

RF DESIGN SERVICES

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

WATERBEACH ELECTRONICS

TEL: 01223 862550

FAX: 01223 440853

MICRO CCD CAMERA

High definition and sensitivity

>380 lines < 0.1 Lux 92 deg. lens

1/3" b/w PCB, 12V 75mA

38*38*30mm

Standard 1 Volt 625 line video o/p.

ONLY £64.95

inc uk. p&p, and VAT

Send cheque or PO. to

ReTech Ltd., Unit 1,
Dorcan Business Village,
Swindon, SN3 5HY.

Send sac, for details and latest list of AV. and Satellite offers

PRECISION SHEET METAL SERVICES

We specialise in the manufacture of small sheet metal parts for the electronic industry; chassis, screening cans, cases etc., sizes under 30cm.

SMALL/MEDIUM QUANTITIES. QUICK TURNAROUND

Please write, fax or phone for quotation

HARRISON ELECTRONIC SERVICES

Century Way, March, Cambs. PE15 8QW

Tel/Fax: (01354) 651289

MEGGAR INSULATION TESTER. up to 2500v, hand cranked, excellent condition, leather case, accessories and leads: £300 ono. Tel: 01793 724151.

WANTED - any AVO model 8 with hopelessly damaged movement. Tel: 01326 312901.

TEKTRONIX 145 PAL Genlock Test Signal Generator, 148 Inscrption Test Signal Generator, EV4020 Vectorscope, EV4040 Waveform Monitor. All manuals. Tel: 01383 419282.

TWO TEKTRONIX 561A oscilloscopes. Trolley, manuals, plug ins. Good working order. £60 pair. Details tel: 01273 553505.

FOR SALE: complete volume of Electronics World/Wireless World from 1945-1983. Plus selection of technical books. For further information please tel: 01920 870289.

FLUKE 867B graphical multi meter, five months old, with leads and manual: £550 ono. Tel: 01482 815625.

Test & Measurement Instruments

A chance to profit
from your own ideas !

An established U.K. manufacturer of test & measurement instruments is looking for new product concepts.

They would like to hear from design engineers with innovative product ideas that could lead to joint developments on either a fee or royalty basis.

In the first instance, please write giving an outline of your product concept along with details of your own experience and capabilities.

Detailed disclosure, should the idea be pursued, would be subject to an intellectual property agreement protecting your rights.

Write to: Box 111, Electronics World, Third Floor,
Quadrant House, The Quadrant, Sutton. Surrey. SM2 5AS

ELECTRONIC UPDATE

Contact Joannah Cox on
0181-652 3620

A regular advertising feature enabling
readers to obtain more information
on companies' products or services.



Comprehensive new LCD brochure

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 products ranging from 2.9" monitors to 16.1" colour LCD screens, mono/colour STN TFTs and touch screen technology from the worlds leading manufacturers.

Phone Trident today for your free copy.

Tel.: 01737 765900
Fax: 01737 771908

CIRCLE NO. 140 ON REPLY CARD

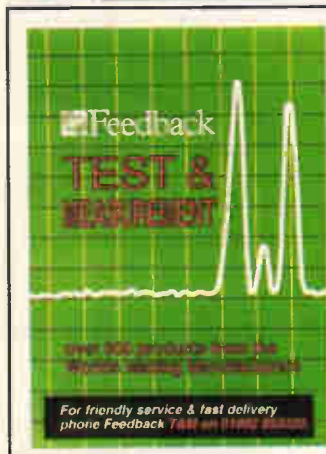


New for '97 Free Data Acquisition Software Tool

DAQ Designer 97 is a free system configuration software tool for the PC that takes you through your application step-by-step, asking you questions, and recommending all the right equipment, including: PC plug-in DAQ boards, PCMCIA DAQ cards, Signal Conditioning and Sensor Interfacing, Cabling and Software.

Call National Instruments for your free copy on (01635) 523545

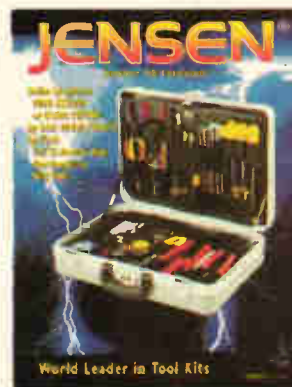
CIRCLE NO. 141 ON REPLY CARD



NEW Feedback T&M Catalogue

The latest edition of the Feedback Test & Measurement catalogue is now available. Over 60 pages packed with more than 800 products divided into over 20 sections. The catalogue is indexed for both product and manufacturer and is fully illustrated. Whether you are looking for an individual product, a complete workstation, or a solution to a particular Test & Measurement need the NEW Feedback catalogue will solve your problems, send for a copy NOW!

CIRCLE NO. 142 ON REPLY CARD



NEW JENSEN TOOLS CATALOGUE

Colourful new Catalogue, hot off the press from Jensen Tools, presents unique new tool kits for service/support of communications equipment. Also latest test equipment from many major manufacturers. Includes hard-to-find tools, PC/LAN diagnostics, bench accessories, static control, technical manuals and more.

Ring 0800 833246 or Fax 01604 785573 for a free copy.

Jensen Tools, 10-12 Ravens Way, Northampton NN3 9UD

CIRCLE NO. 143 ON REPLY CARD

All the information you need on
top UK Companies -
available on a single CD.

Kompass CD Plus -
the only business CD you'll need!

Contains: 60,000 companies • 42,000 classifications • 17 different search criteria

Used for: Cost-effective purchasing • New business lead generation • Fast, effective research
• Financial, credit and sales planning • Corporate structure data

Allows for: Downloading • Printing • Networking

Kompass CD Plus - information, not just raw data - unbelievable value for money.

Call 0800 521393 for more details and prices.

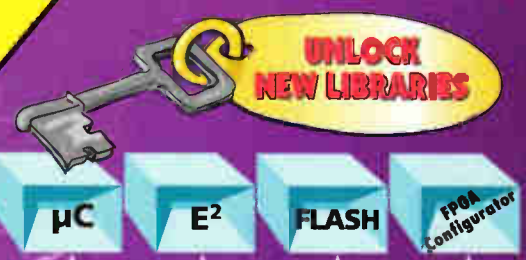
Please quote reference CDP 1.

CIRCLE NO. 144 ON REPLY CARD

MICRO-PRO THE STATE-OF-THE-ART PROGRAMMER



NOW SUPPORTS
AVR™
 MICROCONTROLLER FAMILY



UNLOCK NEW LIBRARIES

Atmel - 89C, 89S (see table below) Philips/Intel - 87C-51/52-Fx Dallas - 87C520 Comes as standard	Atmel E ² - 24C, 25C, 28C, 59C, 93C FLASH - 29C, 49F Order Code: MPW-LIB MEM AT £75.00	FPGA Serial Configurators Atmel, Xilinx, Altera etc. Order Code: MPW-LIB-CON £75.00
---	--	---

A Security Dongle is required for the above libraries Order Code: MPW-LIB-SEC **£24.00**

Features Include

- Micro-Pro for Windows™ Programmer Interface Software
- FPGA hardware ensures future device support
- Supports most DIL devices up to 40 pins without an adaptor
- Adaptors available for many other package types

Order code: MPW-SYS **£149.00** ▲

The **4001** 8051 FLASH microcontroller family

Atmel Part Code:	89C51	89C52	89C55	89S8252	89S53	89C1051	89C2051
Flash Code ROM (bytes)	4K	8K	20K	8K	12K	1K	2K
RAM (bytes)	128	256	256	256	256	64	128
EEPROM	-	-	-	2K	-	-	-
In-system re-programmable	-	-	-	YES	YES	-	-
I/O Pins	32	32	32	32	32	15	15
16-bit Timer/Counters	2	3	3	3	3	1	2
Watchdog timer	-	-	-	YES	YES	-	-
Interrupt sources	6	8	8	9	9	3	6
Serial UART (full duplex)	YES	YES	YES	YES	YES	-	YES
SPI Interface	-	-	-	YES	YES	-	-
Analogue comparator	-	-	-	-	-	YES	YES
Data pointers	1	1	1	2	2	1	1
Package Pins (DIL)	40	40	40	40	40	20	20

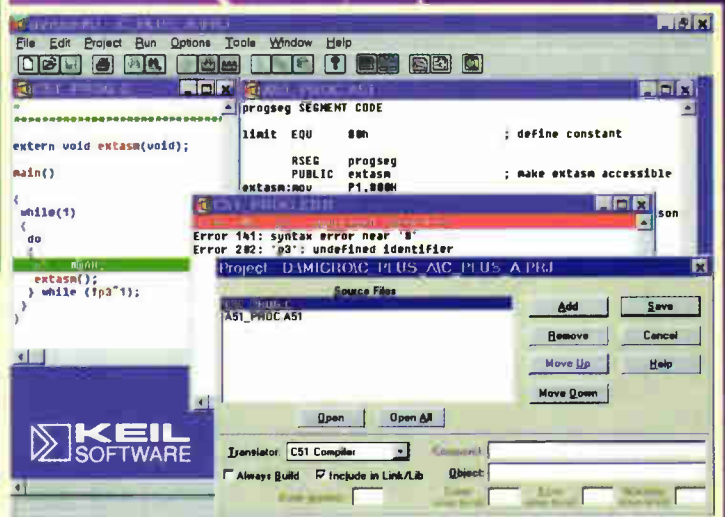
C51 Microcontroller Starter System



UPGRADE TO BE NOW AVAILABLE

- ✓ Optimising C Compiler
- ✓ Macro Assembler
- ✓ Software Simulator
- ✓ Device Programmer
- ✓ Evaluation Module
- ✓ Atmel AT89C2051
- ✓ Hardware/Software Documentation

Plus FREE Atmel CD ROM data book
 Order code: AT-89C-2K-ST **£199.00**



▲ KEIL Integrated Development Environment - C compiler + Assembler output restricted to 2K total program code.

In-Circuit Parallel Programming Adaptor



Now you can re-program the entire 80C & 89S Atmel Microcontroller families in-circuit

▲ Order code: AD-8051-ICPP **£125.00** (Requires Micro-Pro Programmer to operate)



Visit our web page at: www.equinox-tech.com
 Email: sales@equinox-tech.com
 229 Greenmount Lane, Bolton BL1 5JB UK

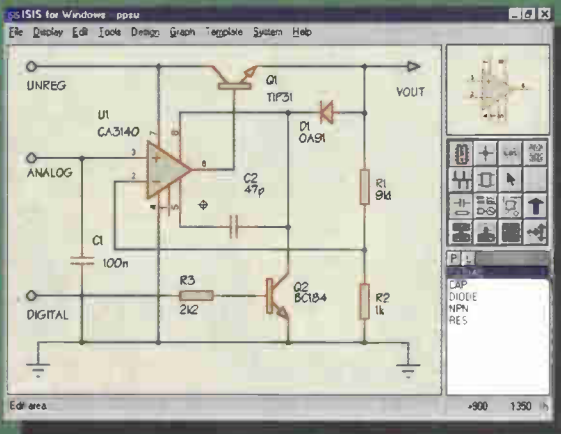


PROTEUS

The IVth Generation

Schematic Capture

NEW Version IV



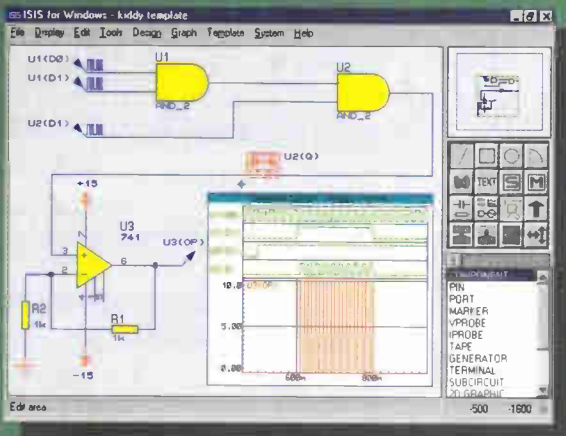
- Produces attractive schematics like you see in the magazines.
- Netlist, Parts List & ERC reports. • Hierarchical Design. • Full support for buses including bus pins. • Extensive component/model libraries. • Advanced Property Management.
- Seamless integration with simulation and PCB design.

New Features

- Component Auto-Placer
- Pinswap/Gateswap Optimizer
- Background Regeneration of Power Planes
- Enhanced Autorouting with Tidy Pass
- Full Control of Schematic Appearance
- Extensive New Component Libraries

Available in 5 levels - prices from £295 to £1875 + VAT.
Call now for further information & upgrade prices.

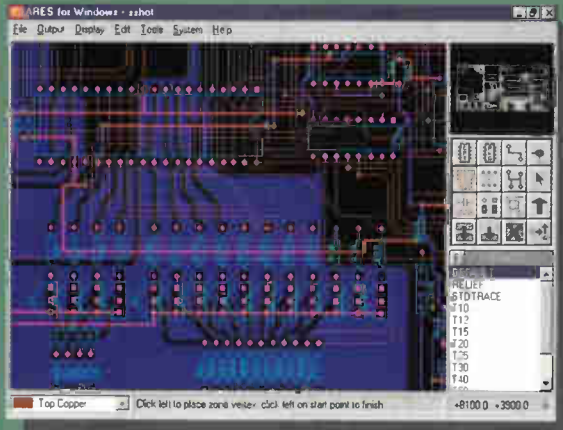
Simulation



- Non-Linear & Linear Analogue Simulation. • Event driven Digital Simulation with modelling language. • Partitioned simulation of large designs with multiple analogue & digital sections. • Graphs displayed directly on the schematic.

PCB Design

NEW Version IV



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

“PROTEUS
is particularly **good**

with its rip-up-and-retry **autorouter**”

EWV January 1997

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.