

Multi-instrument - discount and free dmm

ELECTRONICS WORLD

Austria Asch. 65.00
Denmark DKr. 66.00
Germany DM 15.00
Greece Dra. 1000.00
Holland Dfl. 11.50
Italy L. 8500.00
Malta Lm. 1.45
IR £3.30
Singapore S\$12.60
Spain Pts. 800
USA \$5.50

A REED BUSINESS PUBLICATION
SOR DISTRIBUTION

INCORPORATING WIRELESS WORLD

September 1996 £2.25

PCB CAD multi-review

**Hands-on
Internet**

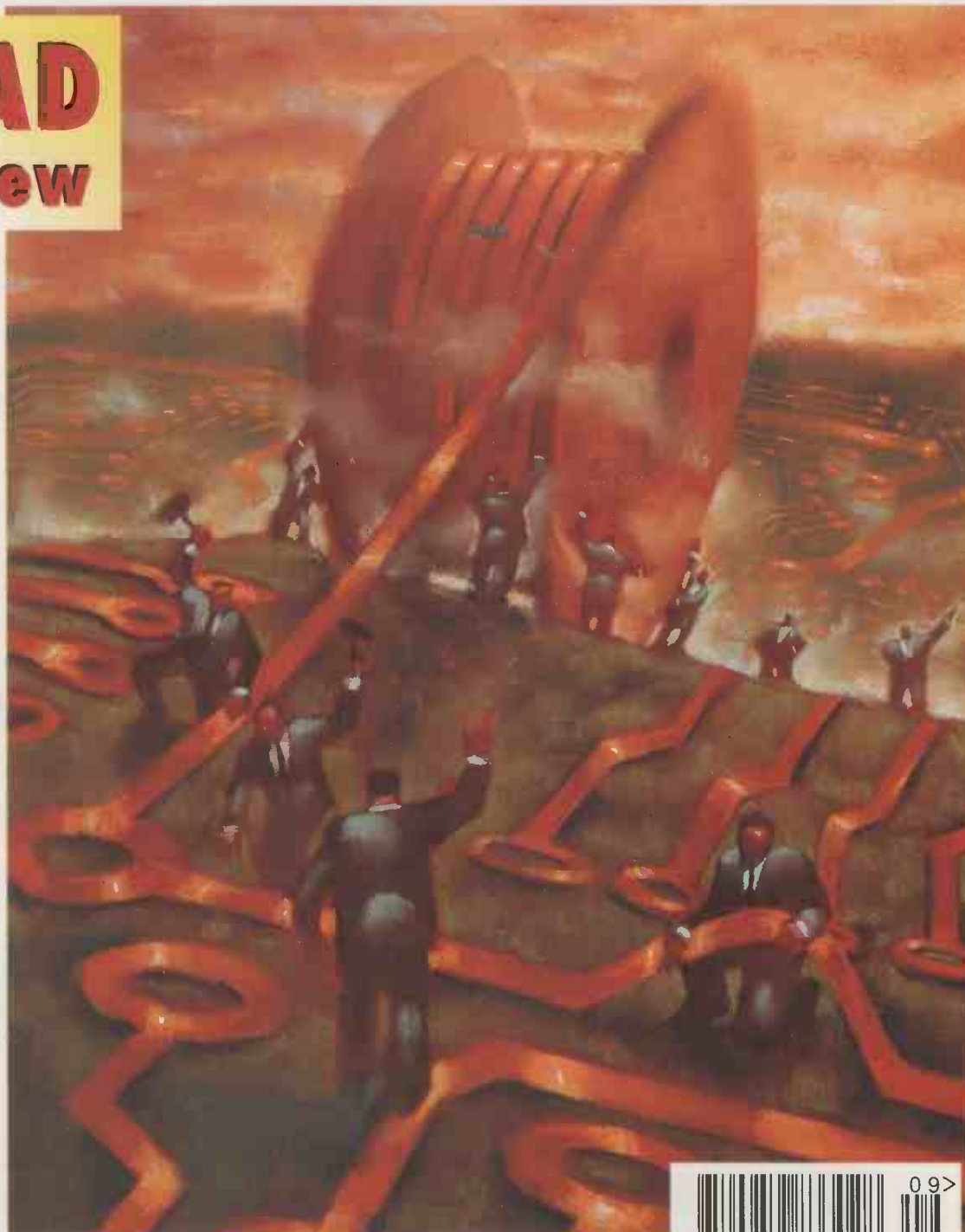
**Reliable
linear
supplies**

**Linsley-Hood
Class-A power**

**Gigahertz
prescaler**

**Intelligent
opto**

**Video
inserter**



Tina CAD - UK launch, review and reader offer



09 >

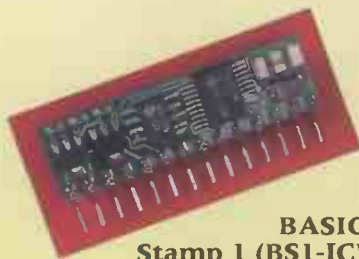
9 770959 833028

Small Awkward PROBLEMS? BIG No Time SOLUTION!

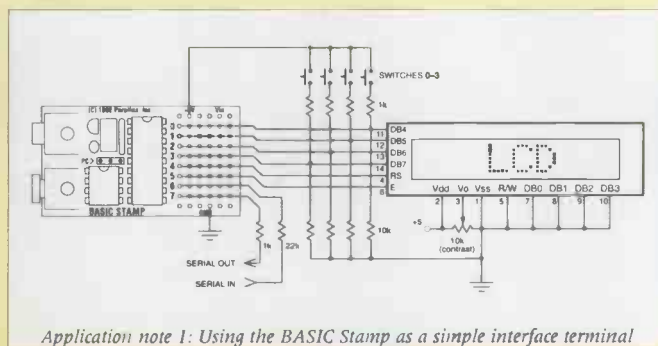
PIC based TOOLS to help you realise your project:
from single applications to full scale production

BASIC STAMPS®

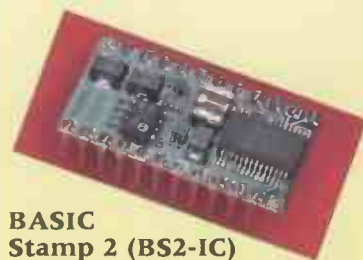
PIC based BASIC Stamps are perfect for one-off and low volume applications. Their easy to learn but powerful BASIC syntax (with familiar instructions such as GOTO, FOR ... NEXT, and IF ... THEN as well as instructions for serial I/O, pulse measurement, button debounce, DTMF, X-10 etc) will get your application up and running in hours. Once programmed, the Stamp runs independently of your PC and programs are stored in non-volatile EEPROM so they can be changed at will. Detailed manuals cover many commonly needed routines and the Stamp is well supported by a growing list of custom application kits to cut development time even further. Available in two formats:



BASIC Stamp 1 (BS1-IC)
8 I/O Lines
up to 80 program lines
Comms to 2400 baud
35x10mm size
£29 single price



Application note 1: Using the BASIC Stamp as a simple interface terminal
Typical Application



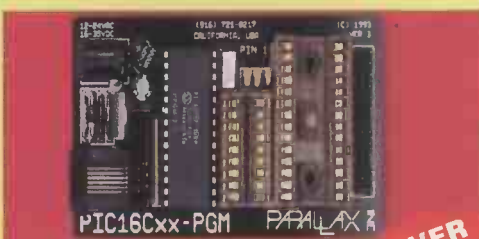
BASIC Stamp 2 (BS2-IC)
16 I/O Lines
up to 500 program lines
Comms to 50 kbaud
24pin DIP package
£49 single price

BASIC Stamp Development Kits including PC software, manuals, 24+ application notes, downloader cables, Stamp (BS1-IC or BS2-IC) and corresponding Project Board - £99 / £119

PIC16Cxx DEVELOPMENT TOOLS

For medium to large volumes and high speed requirements, the popular range of PICs is hard to beat. We offer an extensive range of programmers, emulators and associated hardware to support the following PICs: 52 54 55 56 57 58 620 621 622 61 62 63 64 65 71 72 73 74 84

PIC16Cxx Programmer

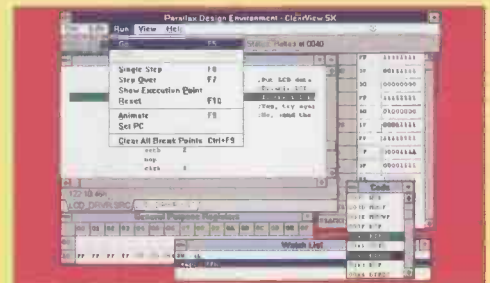


Also stocked
* ZIF sockets
* SOIC/SSOP/PLCC adapters
* Prototyping boards
* Compilers/Simulator

OVER
5000
SOLD

In Circuit Emulators

- * True hardware emulation of program memory, registers and I/O
- * Unlimited breakpoints.
- * Single stepping
- * Software-programmable oscillator
- * Windows Environment
- * Runs from 32Khz to 10Mhz ('xx) and 20Mhz ('5x)
- * Source level debugging for PASM(X), MPASM and MPC
- * Optional trace facility



Milford Instruments
Milford House, 120 High Street,
SOUTH MILFORD LS25 5AQ
01977 683665 Fax 01977 681465

Please call or fax to receive
our catalogue and price list.
All prices exclude VAT
and £3 shipping.
BASIC Stamp & the Parallax logo are
registered trademarks of Parallax, Inc.

PARALLAX
3805 Atherton Road, #102
Rocklin, CA 95765 USA
916-624-8333, Fax 916-624-8303
<http://www.parallaxinc.com>

Contents



Cover - Jamel Akib

644 THE ROUTE TO PCB CAD

Comprehensive – and possibly unique – guide to the first three of ten pcb design packages, by Rod Cooper.

650 VIDEO INSERTER

Ian Polczynski's module superimposes text – together with time and date – on composite video in any colour-standard.

654 DESIGNER WEB FILES

Useful Web sites for electronics designers.

659 A NEW VARIABLE CAPACITOR?

Martin Grove proposes a new device whose capacitance can be varied digitally. It could form the basis of a variety of transducers.

663 DESIGN LAB BYTES

Exclusive review – Tina is a new pc based circuit design lab with virtual instrumentation including a scope and spectrum analyser.

669 PRESCALE TO 1GHz

Nick Wheeler describes a low-cost prescaler designed to extend the useful range of your frequency counter to just over 1GHz.

675 LIGHT UPDATE

A look at how Texas' light sensors are evolving. Line imagers are added to the product range and there's emphasis on easier interfacing with increased performance.

681 CLASS-A POWER

John Linsley-Hood's original Class-A power amp is still rated among the best. Here he explains how to bring the design up to date.

691 DESIGNING RELIABLE RECTIFIERS

Ray Fautley's easy-to-follow procedures take the guesswork out of reliable linear power supply design.

696 HANDS-ON INTERNET

Cyril Bateman discusses new search tools and looks at hardware and software support on the World-Wide Web.

708 PRECISION PREAMPLIFIER '96

"Could this be the quietest audio preamplifier design in existence?" asks Douglas Self. Part II concludes, detailing circuits and performance. It also reveals a new concept in hi-fi tone control.

Regulars

635 COMMENT

Pricing versus rationing.

636 NEWS

Tethered satellite report, Flat satellite tv antenna, Summarising software, Police radio and emc effects, DVD, Wristphone, R&D drop in '95, Solar power for schools, Virtual Stonehenge.



641 RESEARCH NOTES

Nanotubes, Finer chip interconnects, Northern aurora from space, Smart needle for tumours, Diesel pollution, Towards better fuel cells, Aid for night drivers.



Find out how you can fly round this virtual stonehenge – see page 636.

Spectacular view of the full northern auroral oval in ultraviolet light – Research Notes, p. 641.

700 LETTERS

Strange science, Bach and the clavichord, Historical units, loudspeaker cables, loudspeaker networks, Capacitive cables, Call Waiting ID, Bipolar transistors.

703 NEW PRODUCTS

Pick of the month – classified for convenience.

EW reader discount

Obtain over 30% discount on Tina – a Windows-based circuit design lab that receives its UK debut in this issue – Review page 663, offer, page 666.



Multi-instrument with free DMM

A 1GHz frequency meter, 2MHz function generator, 3¹/₂ digit DMM and 30V, 3A power supply – all in one unit. Readers can obtain this with over 17% discount and a free hand-held DMM – p. 698.

OCTOBER ISSUE
ON SALE 5 SEPTEMBER

EDITOR

Martin Eccles
0181 652 3128

EDITORIAL ASSISTANT

Mark Hefley
0181 652 8638

CONSULTANTS

Jonathan Campbell
Philip Darrington
Frank Ogden

DESIGN

Alan Kerr

EDITORIAL

ADMINISTRATION

Jackie Lowe
0181-652 3614

E-MAIL ORDERS

jackie.lowe@rbp.co.uk

ADVERTISEMENTS

MANAGER

Richard Napier
0181-652 3620

DISPLAY SALES EXECUTIVE

Malcolm Wells
0181-652 3620

ADVERTISING

PRODUCTION

0181-652 3620

PUBLISHER

Mick Elliott

EDITORIAL FAX

0181-652 8956

CLASSIFIED FAX

0181-652 8956

SUBSCRIPTION HOTLINE

01622 721666

Quote ref INJ

SUBSCRIPTION QUERIES

01444 445566

FAX 01444 445447

ISSN 0959-8332

NEWSAGENT ENQUIRIES

Contact MarketForce
(UK) Ltd.

Telephone:

0171-261 5555

Fax: 0171-261 6106



Pricing versus rationing

Karl Marx rejected capitalism and free markets in favour of public ownership of the means of production and distribution. He did this on the premise that people would work better for the common good than for their own profit. But he – or at least his followers in the USSR – went further than that. They virtually eliminated the operation of any price mechanism and substituted the command economy, which was a euphemism for rationing by central bureaucrats.

Those two issues – private versus public ownership and pricing versus rationing – should not be confused. There is now widespread acceptance in this country that private ownership generally leads to more prosperity in peace time than public ownership, but that there are exceptions. On the other hand, the price mechanism has an engineering function which is indispensable under either kind of ownership. It does not stem from any judgment of human motivation.

For example, power station designers invest in improving their stations' thermal efficiencies because fuel is generally expensive. Where fuel is cheap, they are correspondingly less concerned. In any case, they use large quantities of excess air for combustion because air is plentiful and free. They apply that principle of balancing costs against benefits to all their decisions, and so do their consumers, fuel suppliers and so on. It has produced a web of interlocking prices which co-ordinate the efforts of engineers across the whole economy.

Prices are often disdained as a sordid necessity in a vulgar world, but in truth they are the life blood of engineering, quite apart from their role in free markets. By removing them, the communists reduced their engineers to copying – as best as they could with inadequate information – the designs of their opposite numbers in non-communist countries. That was what doomed communism and would have done so even if the people and their leaders had been altruistic beyond belief.

Within our pricing web, telecommunication engineers have invested in increasing the information transmission rates of cables because cables are expensive to manufacture and lay. But they have paid much less attention to economising with radio spectrum because the supply has seemed to be plentiful. Spectrum has been freely allocated (except for administration charges) on the principle of first come first served. But it is a finite resource and serious congestion appeared in the 1970s in the private mobile radio bands.

The Merriman Report recognised the problem in



Power station designers use large quantities of excess air for combustion because air is plentiful and free.

1983 and included a pricing scheme for the whole spectrum, proposed by the Department of Transport to reflect the scarcity values of the various bands. But the engineering function of pricing was not understood and the large established users, notably in broadcasting, civil telecommunications and defence, opposed spectrum pricing.

Some consultants proposed instead to deregulate the congested bands but *EW+WW* exposed the irrelevance and failings of that idea in September 1987. The central regulators were left to ration out spectrum in the congested bands without knowing which users could make the most cost-effective use of it. The congestion worsened.

Now a DTI white paper on 'Spectrum Management into the 21st Century' (Cm 3252) proclaims a welcome change of government policy, albeit with some reservations. It proposes legislation to introduce spectrum pricing on the lines proposed by the Department of Transport thirteen years ago. The congestion is worse now than it was then, so the cure will be correspondingly more painful but, if they really mean what they say, the DTI will extend the pricing web across that part of our economy, which badly needs to be strengthened there. The white paper and some implications of those reservations will be reviewed next month.

David Rudd, independent engineering and economics consultant.

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 Publishing Group 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 £30 UK 2 years £48.00 3 years £70.00. Surface mail 1 year £35.00 2 years £56.00 3 years £80.00 Air mail Europe/Eu 1 year

£43.00 2 years £68.00 ROW 1 year £52.00 2 years £83.00 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. 2nd class 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 Wace Publication Imaging 2-4 Powerscott Road, Sidcup, Kent DA4 4SDT. Reed Business Publishing Ltd 1995 ISSN 0959 8332

Copyright protection delays DVD

More non-technical wrangling over the digital video disk specifications is further delaying the introduction of the format. Previously, the debate was over which audio format to use with DVD video, now it is over intellectual property protection, again, predominantly with video.

Frank Carrubba, chief technical officer of Philips Electronics, said: "Some companies say they are bringing out DVD products this September. Don't believe it; they can not. There will be no products this year."

Philips is one of the companies

intending to make DVD players and also owns a record label.

Six bodies dominate the group discussing the specification. These represent: equipment makers, film makers, the computer industry, record companies, business software sellers and CD-ROM publishers.

Research and development investment fell in '95

Electronics companies' investment in research and development (r&d) in the UK fell significantly last year, a DTI report has shown. The UK r&d Scoreboard reveals that within the electronic and industrial equipment sector, the r&d expenditure as a percentage of turnover fell from 4.2% in 1994 to just 3.2% in 1995.

Although r&d expenditure worldwide also fell in the same period, the average remained higher than that of the UK.

The amount spent on r&d is far greater among foreign-owned companies than their UK rivals. The top five spenders in the global electronics industry were, in order, Siemens, Hitachi, Matsushita, IBM and Toshiba. Toshiba spent £1.89bn on r&d, while GEC, which headed the UK electronics rankings, spent just £412m.

Mike Pilbeam, managing director of Cray Communications (part of Cray Electronics), pointed out that, to compete in R&D spending with US firms, UK electronics companies must recognise Europe as their home market.

"The biggest problem is the UK home market is only a fraction of the American home market," he said. "Consequently the sales turnover spent on r&d is much less."

For the first time the scoreboard includes foreign-owned companies based in the UK.

"Much of the electronics industry in the UK is owned by international companies," said Peter Jones, seconded from Thorn EMI to the DTI's Innovations Unit. Jones explained that including UK based arms of interna-

tional companies "gives a much fairer representation of the UK electronics industry."

Richard Freeman, chief economist at ICI, said increasing r&d spending does not automatically lead to commercial success.

Jon Mainwaring
Electronics Weekly

EMC effects of Police radio

Concerns over the effects of stray electromagnetic radiation have surfaced again. Following a recent report that electromagnetic interference is causing motorists to be locked out of their cars, the latest scare is that 'police radio system can trigger bombs'.

This headline reported in a national newspaper recently, while sensationalist, does highlight an emc issue: users of radio transmitting equipment, including mobile phones, should not use them without regard to the situation and location.

There are police guidelines against transmitting from its its handsets in hospitals, computer rooms and other places with electronic equipment. In addition, a police spokeswoman said: "There is a longstanding guideline from the Association of Chief Police

Officers that radio handsets should not be used within 25m of a suspected explosive device."

The police radio handset in the report is the Motorola MTS2000 which forms part of the Metropolitan Police's new cellular Metradio system. The uhf handset produces 1W effective radiated power, less than most mobile phones and slightly more than the older vhf police handsets which radiate around 0.7W.

A spokesman for Motorola said: "There is nothing magic about our handset. The police guidelines are precautions that could easily apply to mobile phones. Indeed, airlines will not allow mobile phones to be used on their aircraft and mobile phone instructions carry similar warnings not to operate them in petrol stations."



Virtual Stonehenge

A virtual reality model of Stonehenge is available on the Internet.

Developed by Intel, Superscape and English Heritage, the model can be navigated in ten different eras from 8500BC to 2000AD by pc users. A photo realistic model has also been developed, on a 200MHz Pentium Pro processor, by VR Solutions Limited of Salford, who worked with English Heritage archaeologists to generate it. The Internet-based Stonehenge can be accessed on Intel's website: <http://www.intel.com/>

ANCHOR SURPLUS 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



Micro Video Cameras

Following last Month's Readers Offer for the 721-S Micro Camera many readers have contacted us asking about other items in our range of Micro Cameras and Security Surveillance equipment.



We are **SOLE AUTHORISED IMPORTERS** of the entire range of Cameras and Video Surveillance equipment produced by world's leading manufacturer. ALL items in the range carry a full 12 Months Guarantee. If you would like to receive our comprehensive catalogue of Cameras and associated equipment please send a large SAE with 48p postage, marked "Camera Catalogue"



Here is a sample of the available stock.

- A-721-S Micro Camera 32mm x 32mm ... £85
- A-721-P Micro PIN-HOLE Camera ... 32mm x 32mm ... £85
- A-921-S Camera with AUDIO ... 30mm x 30mm ... £95
- A-1211 C/CS Mount Camera ... 110mm x 60mm x 60mm ... £110
- A-521 Micro Cased Camera 43mm x 48mm x 58mm ... metal cased ...£120
- 6001-A High Resolution COLOUR Cameras (420 lines) ... 0.45 lux ... £210
- Outdoor Camera Housings ... Aluminium ... £45
- Camera Mounting Brackets ... Universal Mounting ... £5.95
- Camera Switchers ... for up to 8 Cameras ... £85
- Auto Record Controllers ... Allow NORMAL VHS Videos to operate like professional Time Lapse or Security Recorders ... £75
- QUAD-1 Multi Vision Processors ... Digital Freeze ... Quad Pictures etc £275

PLEASE NOTE:

AS A CONTINUED SPECIAL OFFER ALL THE ABOVE CAMERA AND ACCESSORY PRICES INCLUDE VAT AND CARRIAGE TO UK ADDRESSES

Government Surplus Electronics Equipment on Special Offer This Month

- THANDAR TC200 LCD Hand Held Digital Meters ... 0-200uF ... 0-2H ... 0-20MΩ ... ONLY £50
- THURLBY 1905a Intelligent 5 1/2 Digit MultiMeters ... 0.015% acc ... Log, Filters, Math ... ONLY £175
- TIME Electronics 404N/1021 Voltage/Current Calibrators ... 0.05% accuracy ... ONLY £275
- HOIKI 8832 HiCorder ... 4 analog/32 digital channels ... Printer ... LCD Screen ... AS NEW ... ONLY ... £750
- EATON 2075 Noise Gain Analysers + 7618 Noise Source ... 10Mhz-18Ghz ... LAST 2 Cased with paper work ... NOW ONLY £1350
- FRANKLIN Wavetek 3600 Power Line Disturbance Monitor + Printer ... LAST 2 NOW ONLY £350
- MARCONI TF9693 + TF2361 + TF9695 VHF Sig Gen / Sweeper sets ... 1Mhz-300Mhz ... 0.01-100Khz sweep rate ... 0-60db attenuators ... INCL Cased Adaptor sets ... LAST FEW NOW ONLY £125
- COMARK 2007 + 3 "K" type probes ... 0.1°res ... ±0.5%acc ... Cased As New ... ONLY ... £65
- Other Digital Thermometers always in stock ... Please Phone

OPEN SEVEN DAYS A WEEK

Mon-Fri 9am-6pm Sat 8am-4pm Sun 10am-4pm
NO APPOINTMENTS NEEDED. CALLERS ALWAYS WELCOME

All Prices are Ex VAT & Carriage

All items are Fully Tested with Verified Calibration
and carry our Unique 30 Day Un-Conditional Warranty



Tethered satellite investigation report is released

NASA and the Italian Space Agency (ASI) have released the report of the investigative board appointed to determine factors which resulted in the Feb 25 tether break and loss of the Tethered Satellite during the STS-75 Space Shuttle mission.

"The tether failed as a result of arcing and burning of the tether, leading to a tensile failure after a significant portion of the tether had burned away," the report concludes.

Arcing occurred because of either external foreign object penetration (but not orbital debris or micrometeoroids) or a defect in the tether caused a breach in the layer of insulation surrounding the tether conductor. The

insulation breach provided a path for the current to jump, or arc, from the copper wire in the tether to a nearby electrical ground.

The break occurred when approximately 12.2 miles (19.7 km) of tether was unreeled, in a period when the tether was experiencing normal stresses of approximately 15 pounds (65 newtons).

● Scientific papers recently presented at an American Geophysical Union conference reported that currents generated by the tether were three times higher than theoretical models had predicted prior to the flight.

The system was generating

3,500Vdc and up to 0.5A of current during satellite deployment. That high level of electrical energy resulted from the length of conducting tether extending from the Shuttle, coupled with the 17,500 mile/h speed at which the Shuttle and tether were cutting through Earth's magnetic field lines.

"This arcing produced significant burning of most of the tether material in the area of the arc," the board found. The tether was designed to carry up to 15,000Vdc and handle tensile forces of up to 400 pounds (1780 newtons). It used super-strong strands of Kevlar as a strength-providing member, wound around the copper and insulation.

Software that summarises

BT's research centre at Martlesham has developed a text summarising program that can reduce pages of text into paragraphs, or sentences. The program, called 'Netsumm', is currently being trialed on the Internet, but BT plans a stand-alone version, for use with Microsoft Windows, soon.

The software has come about because of the modern complaint of information bombardment. Keith Preston manager of BT's intelligent systems group, explained that people now "have so much information available that they won't make any use of it."

This textual intimidation can be overcome using Netsumm, which uses statistical methods to summarise a piece of text. The summariser program accepts any plain-text document and automatically picks out sentences it considers to be the most relevant part of the text.



At present, Netsumm exists only as a prototype and will be demonstrated in the coming months to City dealers. Netsumm would be used by dealers to draw out key elements from detailed company reports.

The 'Dealing Room' will feature other technologies including speech-to-text conversion and videoconferencing, as well as improved presentation of market information. The overall aim is to improve the speed and efficiency of City dealers.

Dawn of the Solar Age

Solar electric power will soon be seen in all parts of the country as part of a Government programme to support important British technologies needed in the next 10 years.

Children who already study solar electricity (photovoltaics) in theory will be able to experience it working in reality in 100 schools and colleges. Although the technology is made in Britain, it is still virtually unknown and most of the panels are exported abroad. The scheme is aiming for maximum impact as all the systems

will be linked via the Internet to reach a wider national and international audience.

The Sclar Programme is part of the government's Foresight Initiative and is the brain-child of Philip Wolfe.

"This is excellent news for Britain," commented Philip. "The Foresight Award means we can bring the technology faster to a whole generation. By using photovoltaics on a bigger scale today we are also helping to avoid the energy problems of the future."

Dick Tracy arrives

Awristwatch phone weighing just 70 grams has been developed by Nippon Telegraph and Telephone (NTT) in Japan. The prototype personal handyphone system (PHS) is said to weigh 20% less and be 50% more compact than existing handsets.

This level of miniaturisation is achieved through the use of voice

recognition for dialling, removing the need for a keypad. The voice recognition software is located in the base unit, reducing the PHS's software requirements.

Users can either say a number or a previously recorded name. The system transforms the instruction into a telephone number.

Flat antenna for satellite tv

Annotech has developed a satellite receiving antenna halfway between the BSB 'squarial' and a dish – the panel is flat but a feedhorn projects.

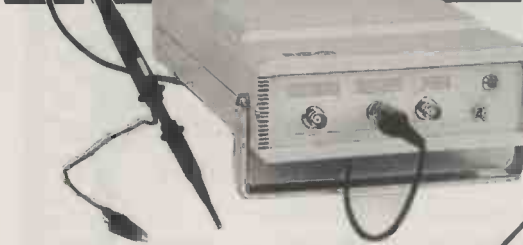
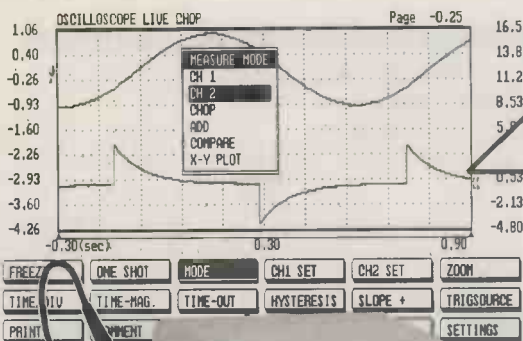
The panel is plastic, 5-8mm thick, incorporating a metal element to focus the satellite signal onto the feedhorn by diffraction.

This allows it to be flush mounted on any wall or roof with an unobstructed view of the satellite. Installation is similar to that of a dish but, because the electrical axes are offset, an additional pair of angles (focus and rotation) must be determined from a set of tables. Four panel type numbers will be produced to

cover all installation possibilities, with fine-tuning by adjustment of the feedhorn position. The sensitivity is about 60%, which is comparable to an average dish.

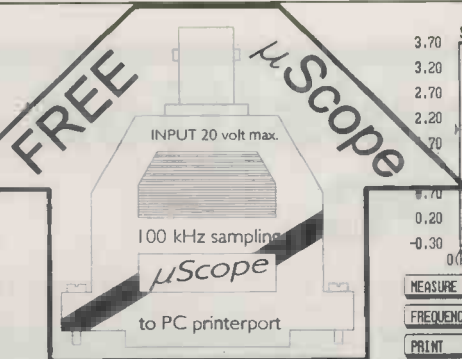
60-70cm panels will be launched at the end of August, with prices 'very competitive'. Any size is possible, using multiple panels for those over 1.2m, with the cost advantage increasing along with the size.

The panels will not only minimise 'unsightliness' in suburbia and help to spread satellite tv to poorer areas of the world, but will also reduce the time and cost of temporary installations and find uses for non-satellite microwave applications. ■



TiePieSCOPE HS508

- ▶ interface PC parallel printer port
- ▶ sampling speed 50 Msamples/sec
- ▶ resolution 8 bits
- ▶ input range 50 mV/div - 20V/div
- ▶ record length 32KByte/channel
- ▶ price £597.00, incl. software, user manual and 2 probes (1:1/1:10 switchable)



You get a free μ Scope when you buy a TP508 or a HS508 until september 1st 1996

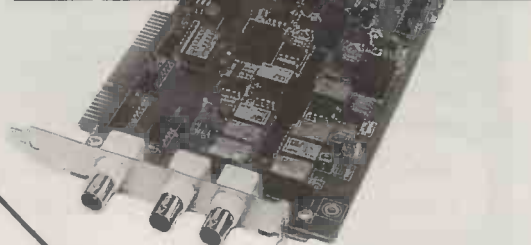
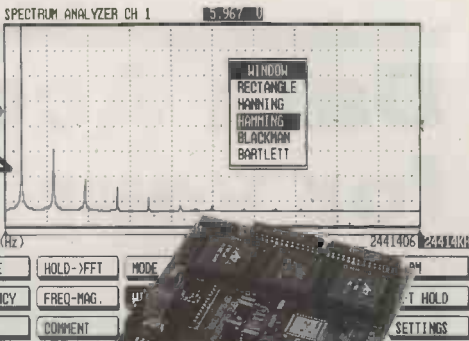
resolution 8 bits
sampling speed 100 kSamples/sec
input range 2.5V, 5V, 10V and 20V
connects to PC parallel printer port

Software for the PC-based instruments

contains an Oscilloscope, a Spectrum analyzer, a Voltmeter, and a Transient recorder. All instruments are controlled in the same intuitive way and provide for saving and recalling waveforms and settings, cursor measurements, hardcopy on matrix/laser printer and online help. Minimum requirements: a 80286-based PC with 2MByte and running MS-DOS 3.3 or higher.

Fax for a free demo disk and catalog of all our products

Easy installation: just plug in and measure



TP508

- ▶ interface PC-XT/AT ISA slot
- ▶ sampling speed 50 Msamples/sec
- ▶ resolution 8 bits
- ▶ input range 5 mV/div - 20 V/div
- ▶ record length 32 KByte/channel
- ▶ price £ 630.00 incl. software, user manual and 2 probes (1:1/1:10 switchable)

Prices are excluding V.A.T.

TiePie engineering (NL)
P.O. Box 290 Koperslagersstraat 37
8600 AG Sneek 8601 WL Sneek
The Netherlands The Netherlands
Tel: +31 515 415 416 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

Complete PIC Development System

All you need including ICE & Programmers at a low, low cost
Plus training package if required

8032 Available With Training



- Fully Integrated Package of Hardware and Software for the 16C5X series.
- Low cost upgrades for the 16C71,
- Real In Circuit Emulation
- Includes Everything Except the PC
- Supplied in Custom Case
- Development Hardware Includes In Circuit Emulator, Modules for other processors, programmers and Proto-Typing Boards
- Software Includes : Full Function Multi-Window Editor, Assembler, Simulator, ICE, Programmers, Plus Other Features in One Program
- Training Package available which Covers Real World Applications, with Case Studies

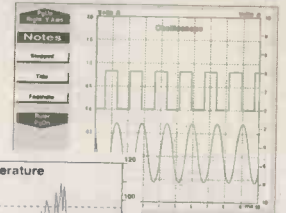
Overseas Distributors Wanted !

Please Call or Fax for Full Details

Kanda Systems, Innovation Centre, Pendre Hafod, Pontrhydygroes, Ystrad Meurig, SY25 6DX
Tel : (+44) (0) 1974 282670 Fax : (+44) (0) 1974 282356 email : Info@Kanda.demon.co.uk

Data Acquisition for your PC

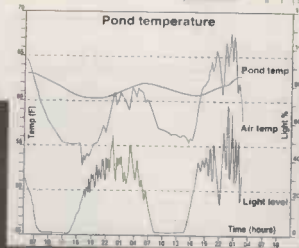
PicoScope
'Virtual instrument'
software.



Pico's Virtual Instrumentation enable you to use your computer as a variety of useful test and measurement instruments or as an advanced data logger.

Hardware and software are supplied together as a package - no more worries about incompatibility or complex set-up procedures. Unlike traditional 'plug in' data acquisition cards, they simply plug into the PC's parallel or serial port, making them ideal for use with portable PC's.
Call for your Guide on 'Virtual Instrumentation'.

PicoLog
Advanced data
logging
software.



SLA-16/SLA-32 Logic Analysers

Pocket sized 16 Channel Logic Analyser



- Connects to PC serial port
- Up to 50MHz Sampling
- Internal & external clock modes
- 8K Trace Buffer

SLA-16 £219
SLA-32 £349
with software, power supply and cables



ADC-100 Virtual Instrument

Dual Channel 12 bit resolution

- Digital Storage Scope
- Frequency Meter
- Data Logger
- Spectrum Analyser
- Chart Recorder
- Voltmeter

The ADC-100 offers both a high sampling rate (100kHz) and a high resolution. It is ideal as a general purpose test instrument either in the lab or in the field.

ADC-100 with PicoScope £199
with PicoScope & PicoLog £219

ADC-10
Gives your computer a single channel of analog input. Prices from £ 49.



NEW
from Pico
Thermocouple to PC Converter
TC-08 £199

PICO TECHNOLOGY



Pico Technology Ltd. Broadway House, 149-151 St Neots Rd, Hardwick, Cambridge. CB3 7QJ
Tel: (0)1954 - 211716 Fax: (0)1954 - 211880 E-mail: 100073.2365 @compuserve.com



Phone or FAX for sales, ordering information, data sheets, technical support. All prices exclusive of VAT. Carriage Overseas £9

CIRCLE NO. 110 ON REPLY CARD

TELECOM DECODERS

FX633 & FX643

Setting new standards for
Call Progress Monitoring.

These unique devices detect the audible tone signals used by the world's telecom systems to indicate:

- ★ Dial tone
- ★ Ringing tone
- ★ Busy tone
- ★ Special tones

Both the FX633 and FX643 use the latest digital processing techniques to provide the following features:

Feature	FX633/FX643	Other Call Progress Products
Minimum Supply Voltage	3.0V	4.5V
Typical Supply Current	300µA (3.3V)	up to 4mA
False on Noise	Low	High
False on Voice	Low	High
'Voice-Detect' Facility	Yes	No
Fast 'US Busy' Indication	Yes	No

FX602 Multi-standard caller line identification

Providing CLI data decoding for analogue telephone systems, the FX602 operates to the following specifications:

- ★ British Telecom
- ★ Bellcore
- ★ Cable Communications Association
- ★ Mercury Communications
- ★ ETSI CLI

The FX602 is available in a compact 16-pin small outline package.



PLUS
FX643 detects Special Information Tones and identifies single or dual tones

- ★ AUTO DIALLING
- ★ COMPUTER SYSTEMS
- ★ FAX MACHINES
- ★ FEATURE PHONES
- ★ PAY/CARD PHONES
- ★ PABX INSTALLATIONS
- ★ INTEGRATED ALARM & REPORTING SYSTEMS
- ★ MODEMS
- ★ ANSWERING EQUIPMENT
- ★ CTI - THE LATEST GENERATION OF COMPUTER TELEPHONE INTEGRATION EQUIPMENT

NEW
FX602 now features Caller ID with call waiting

ALL THREE DECODERS ARE 3.0 VOLT WORKING WITH LOW POWER CONSUMPTION



Consumer Microcircuits Limited.
1 Wheaton Road Witham Essex CM8 3TD England
Tel: +44 1376 513833 Fax: +44 1376 518247
e-mail: sales@cmlmicro.co.uk

CIRCLE NO. 111 ON REPLY CARD

RESEARCH NOTES

Jonathan Campbell

Nanotubes get wired up

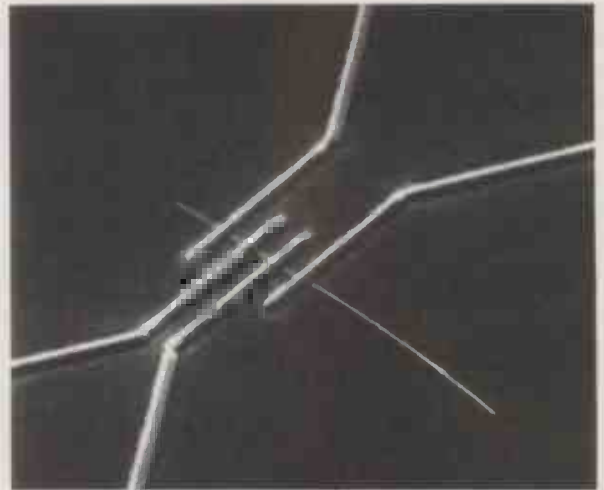
Carbon nanotubes – hollow tubes manufactured on the atomic scale – could offer an attractive method of connecting together circuits in tomorrow's highly miniaturised nanocircuits. Now, researchers at NEC and Micrion Europe have taken a step forward to exploitation of nanotube technology with the first detailed electrical measurements of individual tubes.

Various types of nanotubes have already been produced, but precise data on their properties has been scarce. However, the NEC/Micrion research is showing that each nanotube has unique electronic properties, including both metallic and non-metallic behaviour. It is also becoming clear that the differences between nanotubes are far greater than expected. And the results confirm that, at this scale, geometry and electronic properties are closely linked.

The method used for the investigation has been to attach four

80nm-wide tungsten leads directly to individual nanotubes, enabling accurate evaluation of their electronic properties, using a focused ion beam system. The experiment has shown that the current carrying capacity of the nanotubes is very high and also that the temperature dependence of the conductivity differs greatly between nanotubes. Also revealed is that different segments of a nanotube may have different temperature profiles and that nanotubes in general show significant variations in resistivities.

Early data suggests that nanotubes can be fabricated with a wide range of electronic properties. Interest has been greatly stimulated by theoretical predictions that their electronic properties would be strongly modulated by small structural variations. In particular, the diameter and helicity of carbon atoms in the nanotube are believed to determine whether the nanotube is metallic or semiconductor. The beguiling



prospect for researchers is that if they can be accurately characterised, they offer the possibility of being used as wires, with diameters about 1% the line width used in current 16Mb memory chips.

Contact William Gear, NEC Research Institute, Princeton, New Jersey, USA.

Nanotubes could dramatically reduce memory cell size. Here, four 80nm leads help reveal a tube's electrical properties.

Extreme chip production

Working microelectronic devices, with electrical gate widths of 0.1µm, have been fabricated at Sandia National Laboratories in California. The tiny dimension is more than three times smaller than that used for devices found on current chips, and has been made possible using extreme ultraviolet light as part of the lithographic process. The device is a field

effect transistor, a common building block of all integrated circuits.

Current leading edge chip patterns are printed with the photographic-like optical lithography, creating features that are 0.35µm wide. But, optical lithography is reaching physical limits. The shorter wavelengths of extreme ultraviolet light enable printing smaller features at high resolution.

Lithography has been targeted as a key technology for semiconductors as they continue to be made smaller, faster and more powerful. The Semiconductor Industry Association aims for commercial production of microchips with 0.1µm features in the year 2007.

Contact Sandia National Laboratories, Albuquerque, USA.

Crowning achievement: A spectacular view of the full northern auroral oval in ultraviolet light, just released by Goddard Space Flight Center, is a testament to the work of University of Iowa scientists who have developed the visible imaging system on the Polar spacecraft. The Earth is imaged from an altitude of 25,740km over the southern border of Alaska, and the auroral oval is seen as a 'crown' in the top portion of the image. Advances in technology for the construction of the cameras has allowed the auroral light to be extracted from the sunlit atmosphere with unprecedented clarity, as amply demonstrated by this picture of a complete auroral oval that extends well into the sunlit atmosphere. An extended region of light in the centre and bottom of the image is the glow from the Sun's illumination of Earth's upper atmosphere. The filter for this image passes ultraviolet emissions that are not directly visible to the human eye. Intensities of this light from atomic oxygen in Earth's atmosphere at altitudes in the range of about 100 to 500km are colour coded in the image with dark red as lowest intensities and whitish yellow as the brightest. A coastline superposed on the image shows that the aurora is positioned just north of the Great Lakes on the dayside of the Earth and over the Scandinavian peninsula on the far nightside of the Earth. Principal investigator for the visible imaging system instrument is Louis Frank and the instrument scientist and manager is John Sigwarth, both from The University of Iowa. Goddard Space Flight Centre, Greenbelt, MD.



Smart needle helps tumour treatments

More effective curing of cancerous tumours could be the result of work being carried out at MIT into development of a prototype sensor needle that contains integral microchips. The electronics give medics direct feedback on the progress of hyperthermic treatment in a cost-effective and simple manner so improving control. MIT's special needles could replace several of the probes currently used by doctors to characterise tissues, and should be less expensive than current probes while being 30% smaller in diameter.

The researchers, led by Research Affiliate Kenneth Szajda of the Harvard-MIT Division of Health Sciences and Technology (HST), have so far built a device that measures temperature. But the ultimate goal is a needle that measures a variety of parameters, such as pH, oxygen concentration, and radiation dosage.

Effectiveness of hyperthermic treatment of tumours is critically dependent on temperature control and is why it is so important to be able to measure temperature precisely during treatment.

In the prototype device, eight microchips are embedded in a channel milled down the length of the needle. Each smart chip not only senses temperature, but also processes and digitises the temperature signals so they can later be read by a computer. A separate chip near the head of the needle coordinates data flow between the microchip sensors and a personal computer.

The entire system consists of a series of 7mm long, 600µm wide integrated circuits mounted in the channel milled into a 22 gauge solid stainless steel needle. At its core is a low-noise, high resolution diode-based sensing circuit. The output of this sensor is then buffered by pre-amplifier, using correlated double sampling to maintain integrity of the signal. An oversampled modulator

digitally transmits the analogue temperature signal from the needle, and further digital signal processing is performed to complete the analogue to digital conversion. The process eliminates signal corruption caused by sensitive analogue signals travelling off chip.

A custom digital controller chip coordinates transactions between the sensors and a personal computer that processes and displays the data. The circuits are fabricated using a specially developed (2-poly, 2-metal) biocmos process, a non-optimised biocmos extension of the ccd/cmos process developed at MIT.

A silicon nitride passivation process is incorporated into the biocmos process to prevent cross contamination between the circuits and the patient since the devices will be operated in a hostile physiologic environment.

Purpose of this project is not only to measure temperature but also to demonstrate the feasibility of 'active needle' techniques.

The researchers say the system approach used for the project can easily be extended to other types of sensors, including – but not limited to – oxygen, radiation, and pH sensors, and Szajda is currently working on radiation and oxygen sensors with Thermal Technologies of Cambridge.

Other advantages of the needle include its size and potential cost. Use of microelectronic technology could reduce costs because, among other things, the sensors could be mass-produced.

In addition to the continuing development of radiation and oxygen sensors, the researchers are also working on the next generation of the temperature-sensor microchip, and the team has recently succeeded in cutting the length of each chip in half to about 4mm. This means that more chips can be packed into each needle, increasing the spatial resolution of the system.

Targeting diesel engine pollution

Technology that only a few years ago was being developed to knock enemy missiles out of the sky is being refined at the University of Southern California to repel an even more insidious air-borne invader –

vehicle pollution.

US researcher Martin Gundersen and Russian scientist Victor Puchkarev are working on a high energy plasma system fitted to a diesel engine that will do to pollutants

what it was once hoped it could do to satellites.

Current experimental test bed for the trial is an elderly green Volkswagen Golf wired up in a USC basement. A special prototype chamber attached to the car's exhaust contains a mechanism that, each second, sends between 100 and 1000 100ns extremely high-voltage spikes of electrical energy through the stream of exhaust gases.

The electrical emissions create a high-density flux of energetic, fast-moving electrons. These don't heat the gas. Rather, they set off a cascade of chemical changes in the exhaust, which breaks down one of the main raw materials that cause smog – the oxides of nitrogen – into harmless pure nitrogen and pure oxygen.

The new system is already working. But a crucial measure of its potential is going to be the efficiency by which the process is achieved.

As Gundersen puts it: "How much engine power does it take to remove

Missile technology helps clean up car exhausts.



how much pollutant?."

To be economical, less than 5% of the engine's output should be used for pollution control. Gundersen and Puchkarev believe this goal is feasible.

Diesel engines are highly fuel efficient. Unfortunately their exhaust contains more nitrogen oxides (NO_x) and other pollutants than conventional engines, and strategies that control emissions in non-diesel, automobile engines either don't work as well for diesels or considerably depress the diesel engine's efficiency.

Working under contract with the US Navy – which operates large fleets of diesel-driven ships and is under pressure to conform to environmental emission standards – the researchers are hoping to devise a simple unit that can be attached to the exhaust of any diesel-driven vehicle and bring it into compliance.

"A plasma system would allow continued use of existing efficient designs, and also permit cost-effective clean up of dirty older trucks and ships," says Gundersen.

Several problems remain to be solved before their electron plasma

method can live up to its potential.

First, there's some theoretical evidence that the device would be more efficient if the pulse were even shorter – about 20ns. That interval is beyond the reach of existing devices, but the researchers are working on a way to reduce the pulse time.

Second, the reactions produced by the high speed electrons need further study. While scientists have a general idea of the chemistry that takes place when a plasma hits exhaust gases, detailed data on the subject is virtually non-existent and the theoretical foundations for studying these reactions are not well developed. So hard data needed for modelling is not available and is extremely difficult to predict.

Nonetheless, Gundersen and Puchkarev have made enough progress that they will be testing a version of their system on a stationary diesel engine at Port Hueneme, in Ventura County, California later this year.

More information from Martin Gundersen, University of Southern California, Los Angeles CA 90089-2538, USA.

Fuel cells get 100% power boost

Researchers at Ernest Orlando Lawrence Berkeley National Laboratory have developed a thin-film electrolyte that both doubles the power output and significantly reduces the cost of solid oxide fuel cells (sofcs).

Fuel cells, which transform hydrocarbons into electricity without combustion, are highly fuel-efficient and almost non-polluting. But, until now, sofcs have been most fuel-efficient operating at 1000°C – increasing the cost of materials and decreasing the lifetime of cells.

In fact, as sofcs are solid-state devices, researchers know how to drop their operating temperature, but the problem has been that when the temperature is dropped, electrolyte conductivity is lost. One way to deal with this is by making the electrolyte thinner, and scientists around the world have looked for a way to thin down the electrolyte, from a 100µm film

down to about 10µm.

But now the Berkeley team says it has devised a technique that doesn't just preserve performance at a lower temperature of 800° but, with a new, ultra-thin ceramic electrolyte, actually doubles the power output to 2W/cm² of cell surface area.

Berkeley electrolyte, a yttria-stabilised zirconia film, starts out as a ceramic powder suspended in solution and is painted onto the anode and then fired. What has held back development is that the paint tends to fill in the pores and can crack during sintering due to thermal stresses. The Berkeley researchers say they have simply got the processing of both the anode and the electrolyte right.

More information from Steve Visco, Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, California.

Looking into a dark future

At night, driving at speed, how far ahead can you see with your headlights? A system currently being tested in the US promises to reveal the road ahead for three to five times further, using thermal imaging cameras and heads-up display (hud) technology to project a picture of the road ahead into the driver's field of view.

NightSight, under development by Texas Instruments, uses a Delco Electronics hud to project real-time thermal images onto the lower section of the car's windscreen. In this way the image, created by a thermal array which translates infrared heat into stark, high-contrast video images, is displayed in the same perspective as the driver's own vision, so is superimposed on the view through the screen.

Differences in heat emitted by objects are recorded and used to generate a real-time black-and-white video picture of the scene.

For automotive applications,

thermal imaging has the advantage of separating people, hazards and other objects from cluttered backgrounds in full daylight or total darkness.

The energy being sensed is heat and not light, so the system should work even in total darkness, and will not 'bloom' or shut down when hit directly by visible light. So it will not be affected by oncoming headlights, and will help reduce glare and distraction of oncoming traffic.

Texas Instruments has high hopes for the system, and says that feedback from automobile manufacturers suggests that the technology will prove to be as important to vehicle and driver safety as the air bag has been.

The motivation for the work has been the US statistics that show that though only 28% of driving takes place at night, 55% of all driving fatalities occur in darkness.

The military routinely use thermal systems and the police are also evaluating them. Could they become as common on the family car as air bags?



The route to pcb cad

Thinking of buying PC software for making your own pcbs? **Rod Cooper's** comprehensive – and possibly unique – run down of ten medium, low and no-cost packages will help you make the right choice. Part 1 covers *PIA*, *Easytrax* and *PCB Designer*.

Although the multi-thousand pound CAD system for designing pcbs has been in use by larger companies and specialist electronics firms for many years, the combined cost of hardware and software has undoubtedly deterred most small firms, many of whose core activities may not even be directly in electronics but who still use pcbs, designed by outside contractors.

Also deterred have been individual designers who would dearly have liked to get their hands on these design aids but who could not justify the expense. In addition, stories of program bugs and especially user unfriendliness have prompted others to hold back deliberately from buying a software package – not just until the price became more affordable, but also until performance had improved. This review is for these people.

Review scope

The range covered here is restricted to so-called 'budget' or entry-level systems, defined by an arbitrary limit of around £500 for a system. This review is only intended as a guide which will, in conjunction with the appropriate evaluation disk, point the way to the system that's right for you.

When choosing your first CAD package, bear in mind that some makers produce a low-cost, entry-level package that can be upgraded later. Suppliers often offer generous upgrading allowances.

To assess a pcb-design CAD program takes a lot of time. Engineers are often reluctant to spend time on a wide-ranging assessment. Time spent learning about systems that are not going to be purchased is naturally almost completely wasted. Also, you do not accumulate much general knowledge of operating CAD because each maker has its own way of doing things.

On the other hand, a quick scan of a few chosen programs can give a completely false impression. I found that a good deal of time was required not just for working the computer but for reading through the manual and making sense of it. And after that, you need to go through the steps of converting a schematic into a real board. To make assessment even more difficult, program manufacturers often have different terminology for the same thing.

It is symptomatic of the pcb CAD makers that they cannot even agree on a common name for the area on screen that holds the symbols that are about to be used – ie a parts bin. In *Quickroute*, it is called the parts bin, but in *Ranger2* it is called the tray, while in *Isis* it is called the object selector. Similarly, the area on screen where you put your drawing is called variously the edit window, main design window, the sheet or the drawing area.

In some cases, the description of the program glosses over or omits to mention shortcomings or over-emphasises the product's supposed superiority. All this disinformation takes time to sort out.



Big discrepancies

Products from the USA, the Continent and the UK – shareware, free-ware and evaluation versions – were collected for this review. What I found was astonishing; big discrepancies in value for money, wide and unexpected variations in the time taken to learn the program, a large spectrum of user-friendliness and an even wider spectrum of features provided. There was not a lot of correlation between cost and benefit.

This collection was then pared down to those that I thought would be of most interest to the intended audience. Each program was checked on a variety of computers ranging from an IBM 286, 12MHz, with just 2Mb of ram, through a couple of Compaq 386 machines, 20MHz with 4 and 8Mb ram, and a 'brand x' 486DX, 66MHz with 16Mb ram.

The computer chosen for a particular program was the one thought most suitable for testing the producer's stated minimum requirements. Outputs were checked on dot-matrix, bubble jet printers and a pen plotter.

In compiling this review, I omitted those programs that did not offer either shareware or usable evaluation disks. It is vital for the prospective purchaser not simply to watch a demonstration or to read about the features, but to try out the process of making a small pcb from start to finish for themselves.

Most of the program producers offer a working version of their product which is either limited by having the library files cut down, or by restricting the number of components in a diagram. In some cases the limitation is by preventing the artwork from being printed.

Some so-called evaluation disks are so cut-down that they almost refuse to work. I believe the disparaging buzz-word for these is 'crippleware'. If you cannot try out a program – and by this I mean produce a real pcb – my advice is to avoid it. It is inviting disaster to watch a slide-show demonstration disk, read the manufacturers claims, and then buy.

There are no long lists of every feature for the programs in this review, as this method would make very dull reading. Instead, as all the programs had strengths and weaknesses, these have been highlighted together with salient features. For example, no mention is made of how easy or difficult installation of the programs is, unless there is something out of the ordinary about it. Therefore if any special feature is required for a specific need, you will best find this feature by operating the evaluation program.

The review is not intended to enable the reader to choose one program to suit his or her particular requirements, but to point the way to a shortlist, and so avoid having to plough through numerous evaluation disks, sales leaflets, and operating manuals.

Do you really want CAD?

Firstly, you should ask yourself why you want CAD. There are four reasons or categories as far I can see. In the first category, if you merely want to present a smart-looking schematic to a prospective purchaser of your design, or if you want to publish the circuit, then a schematic

drawing program may not be what you want.

You could be better off with a general CAD drawing program. KeyCad for Windows*, for instance, is only £20. It has a library of electronic symbols which can be added to as required and gives excellent drawing quality. A big advantage is that you can also use it for simple 2D engineering drawing, for example designing the case or rack system, which you won't be able to do with a specialised electronic program.

In the second category, if you only want to test your circuit by means of a simulator, and have no interest in pcb artwork generation, then a schematic computer-aided design package with schematic capture and a netlist output in at least a couple of recognised formats can be the answer. Some have a built-in simulator. Such packages need not be very expensive.

In the third category, you may simply want to get that circuit diagram you scribbled down changed into a pcb without having to go to the trouble of re-drawing the whole thing again as a schematic on a computer screen. In this case, a manual pcb drawing program without schematic drawing will give you the precision and professional appearance that the computer offers. You will also be able to cut out the time-wasting ultra-violet exposure and development if you follow the suggestions that I make at the end of this review.

In the last, and probably largest category, are those who want to short-cut the whole tedious business of making a pcb design altogether. In this case, a schematic drawing program with schematic capture and an integrated autorouter may be the solution. But there are many snags to this last CAD alternative. An autorouter can be a big time-saver, but it can just as easily turn out to be exactly the opposite.

And if so, which type?

Before deciding on which CAD type to go for, you should analyse your motives for acquiring CAD. The advantages are that in laying the pads and tracks with CAD it is easy to get the precision that previously only a skilled draughtsman could achieve. Another advantage of those systems with a built-in library of components is that you may no longer need numerous component data books on your desk. Pin-out information is often included.

In addition, it is very easy to make a change to a board layout on the computer. With the conventional 'hard' artwork method, it was difficult to rip up and re-lay a track. There was a chance of destroying your whole artwork in the process. With CAD it can be quicker to get from schematic to finished board once you are familiar with the program you have selected, although reaching this stage may take longer than you think.

CAD certainly circumvents all the man-power usually needed to turn your circuit into a board. And light-boxes, multi-layer transparencies, transfers, fragile stick-on component outlines, and all the other paraphernalia of the conventional process can be thrown out. There is no need for careful storage of the finished artwork.

Review 1 – PCB Designer

This is a small and inexpensive Windows program for purely manual design of pcbs. It is about as basic as it is possible to get. Nevertheless it will still competently handle single-sided and double-sided boards. In effect, it is the computer equivalent of the conventional light-box and transfer method.

Most of the information needed to run *Designer* is in a tutorial on the disk. I found that there was really no need for anything else. The package has a good on-screen Help, and the system is very intuitive.

This product was obviously written from scratch as a Windows program – not as a conversion from DOS. It needs Windows 3.0 or 3.1 and MS-DOS 3.3 or above, or the equivalent,

so you will need at least a 286 and 2MB of RAM minimum.

Screen area available is good at about 9.5in by 5.5in. At the top is the usual Windows menu bar, and underneath a button bar with 27 buttons. Button coverage of the functions is sufficiently extensive that you will rarely have to resort to the menu system. Most of the pad outlines and tracks are directly available from the button bar, with an small extra library in reserve.

A pop-up reminder of all the button functions appears on selection, and these are reinforced by a longer explanation of functions at the bottom of the screen. With this system you should be able to switch on *Designer* even after a long absence from CAD and still be

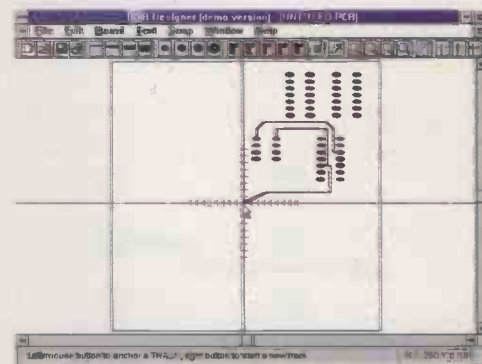
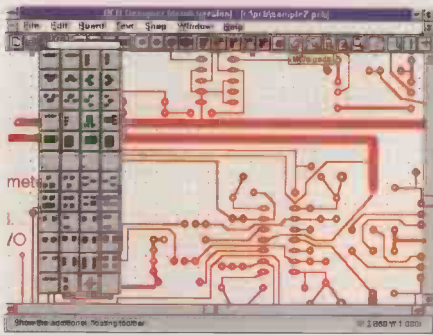


Fig. 1. Note unusual cross-hair cursor with *PCB Designer*.



Typical PCB Designer screen with grid on. Note extra pad library on lhs and text at button bar.

able to work it straight away. You cannot claim that for many CAD programs. There are no endless, meaningless, DOS commands to forget – its all there for you read on screen.

Surprisingly for such a small program, it has autosave, and its supplier, Niche, is to be commended for including it. Equally surprising is the absence of a grid system until the zoom is

operated. I found this a little disconcerting at first. Based on three fixed levels, the zoom system is very easy to use, and there is a custom zoom feature.

Another novel feature is that when placing parts on the board with the grid off, the mouse cursor is replaced by a large graduated cross-hair arrangement. This cross-hair is moved by the mouse just as the cursor is, Fig. 1. Although I did not get on well with this system, I could envisage some people liking it. I think it is another area where personal preference reigns.

The only thing I did not like about *Designer* was the lack of a library of component outlines. Only pads are visible, and I found this was not enough to make a good layout. Also, if you are without a built-in component library you will of course need a pile of data books for the pin-out.

I feel that the lack of a library in *Designer* is not making the best use of the computer's potential. Niche should rectify this with a small library of the common outlines, with the facility for users to add their own. They would then have a thoroughly commendable product.

PCB Designer uses the standard Windows

printer drivers. It has no Gerber or NC file outputs.

PCB Designer in summary

The first step away from light-boxes, transfers, tapes and transparencies and towards CAD provides the biggest gain. *PCB Designer*, although a small program, gives all the major advantages of using CAD at small cost and is a good introduction to pcb CAD.

Niche Software Ltd,
tel. UK 01432 355414, £49 all inclusive.

Review 2 – PIA

PIA is the next step up in terms of sophistication, as it has both pad and component outlines in its library and an autorouter. *PIA* is a relative newcomer, so as you would expect, it's a Windows program. It comes in three

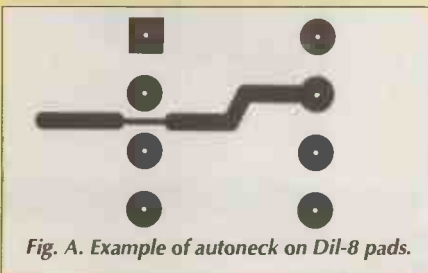
Terms used in PCB CAD

CAD for schematics and pcbs has its own jargon, which may be unfamiliar if you have not encountered CAD before. Here is a brief glossary of commonly used terms.

Autopan. Because the screen often displays only a small part of a circuit diagram, it is necessary to pan across the drawing area with your relatively small viewing window. With an autopan system, when the mouse reaches any side of the screen, the diagram is made to move into view from that side automatically. A useful – but not essential – feature which not many programs have. Manual panning is more common and some prefer it.

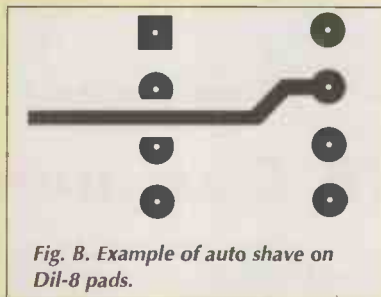
Autosave. There is always a possibility that you will tie yourself up in knots – especially while you are learning – or that the system will crash. What autosave does is to save your work to the hard disk every 5–15 minutes, overwriting the previous save. When you crash, you will – with luck – only have lost the last few minutes of work. This is a valuable time-saving feature and far superior to manual saving.

Autoneck. A system in which, if a routed track goes between two adjacent pads, track width is automatically reduced to pass between and maintain the specified clearance in the drc. A feature worth having, but not as useful as *Autoshave*, Fig. A.



Autorouter. A program which attempts to turn netlist, via a rat's nest, into a piece of pcb artwork using various strategies. (Read Lee's Algorithm and Gridless Techniques.) Although autorouters are, by definition, automatic, you will still have to manipulate the rat's nest to get the autorouter to work properly. You will also have to draw manually any tracks left uncompleted by the autorouter.

Autoshave. A similar feature to *Autoneck* above, but instead of reducing the track width, the pads are reduced in the area of the track to maintain clearances specified in the drc. This feature is not often seen, but is the way I prefer to treat tracks passing between DIL pads, Fig. B.



Backwards annotation. If you constantly make changes to your finished board design, this feature may interest you. With it, you can make an annotation change to the board design and the program will automatically make corresponding changes to up-date the other parts of the design e.g. the schematic. The converse of this is *Forward Annotation*.

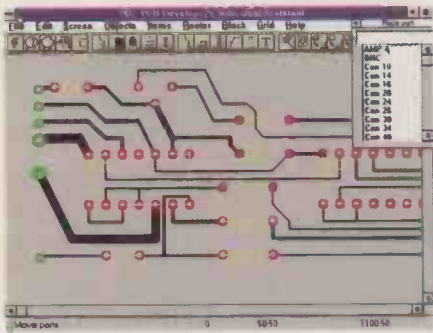
Connectivity check. It may seem obvious, but you expect a track drawn between two points on the schematic to be processed by the netlist/rat's-nest/autorouter as such. Unfortunately, it is not that simple. There

are many ways in which a track that appears perfectly ok, is not acceptable to the system, leading to a missed connection. Most programs allow an automatic check to ensure that the integrity, or connectivity, is kept.

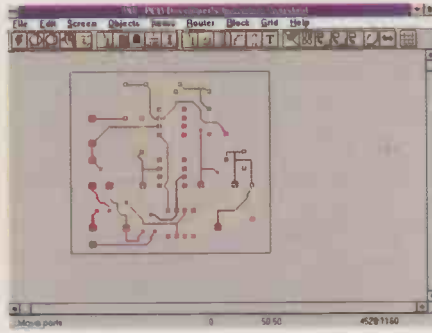
Design rule check. (drc) On most programs the designer is required to set a list of parameters for track width, spacing between tracks, distance from the edge of the board, etc. Programs have a method of checking these design rules automatically. This is vital feature when using an autorouter. Without running a check you are almost certain to have short-circuits, open tracks and burn-outs. Beware of programs with a limit on setting parameters; you are certain to want to change the specification at some time to suit your own needs.

Gate swapping. This autorouter feature concerns those ics that contain several identical gates. To ease the burden on the autorouter, it helps if the program can automatically swap the gates round to aid route-finding. This is a useful feature if large boards are involved. A similar situation occurs with pins, the feature is then called *pin-swapping*.

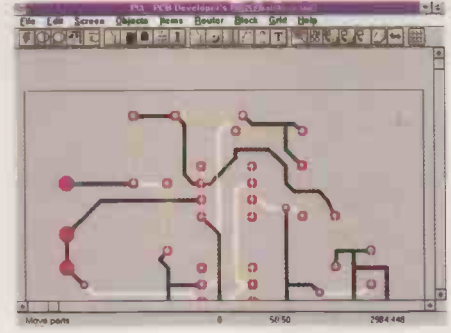
Gridless autorouting. Most budget-priced autorouters use a grid system to fix the routes between pads. If the pads do not lie on the grid, the router may mis-route or not route them at all. This is a generalisation and gridded autorouters can route off-grid to some extent. A gridless autorouter on the other hand can route anywhere it likes, if a little more slowly, and this is useful for components whose pins do not fall naturally to any particular grid. There are more of these components around than you might think. You could instruct a gridded autorouter to use a very fine grid to make the chances of a missed



Typical manually drawn pcb on PIA showing library of connectors at top rhs.



Double-sided PIA autorouter result on test circuit board.



PIA close-up of the shot to the left.

versions. All have approximately the same engine, but differ in the size of board they can handle and in output devices available.

The standard version handles up to 1000 pads and 1400 lines while the extended version achieves 2000 pads and 3000 lines. The 32-bit version handles 8000 pads and 12000 lines. Only the 32-bit version has HPGL plotter, Gerber file and numerically-controlled-

drill-file output. Both other versions use the Windows printers for artwork output.

Minimum hardware requirements for the standard and extended versions are a 386 – preferably with co-processor – and 4Mbyte of ram. Needless to say, a mouse plus and Windows 3.1 or higher are needed. For the 32-bit version, you need at least 8Mbyte of RAM and at least the WIN32S extension to

Windows 3.1. Performance is enhanced if you have more ram.

Despite these requirements *PIA* is a relatively simple program. Because of this, and because of its intuitive interface, *PIA* is very easy to operate – in fact probably the easiest of all to learn.

All *PIA* versions are programs for board routing only – there is no schematic drawing

connection small. But just halving the grid spacing quadruples the grid load on the computer. Suddenly, your reasonably fast autorouter becomes very slow.

Interactive. Programmers' double-speak for do-it-yourself. For example, manual routing of tracks that the autorouter has failed to route is sometimes referred to as 'interactive routing'.

Layer. You may see that a system operates on 12 layers. This does not mean 12 layers of copper track on a multilayer board. A layer is an operating plane used by the system to store information. A typical 12 layer system may use layers 1 and 2 for information on component-side and solder-side copper track on a double-sided board, then use 3 and 4 for silk-screen information, layers 5 and 6 for solder-resist and so on. Some of the remaining layers may well contain information on internal copper tracks and buried vias, if the router is capable of making a multilayer board.

Lee router. Autorouters use not just one but several strategies for routing tracks. These strategies are often listed and explained in the program's manual. The Lee algorithm – a type of maze solver – is claimed to be the most effective at finding routes. But it is slow, so it is sometimes left as the last strategy to try, to attempt completion of the board when the other strategies have failed. Now that faster pcs are here, the slowness is less relevant, so it is worth looking for this type of router in the autorouter specification.

Memory router. This is a strategy used for regular, repeating patterns of tracks. It is normally used on a single layer only, of the sort needed for memory systems, Fig. C. It is not suitable for routing anything other than this type of pattern.

Net. A connection between two or more component pins resulting, for example,

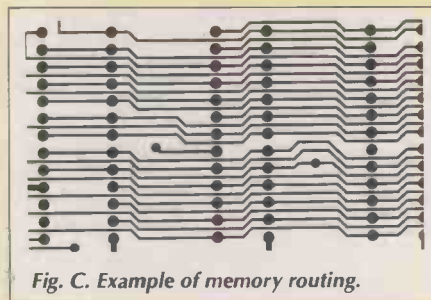


Fig. C. Example of memory routing.

from the pad-to-pad, track-to-pad, track-to-track connections made on the schematic.

Global Nets. As nets are given unique names by the program, nets with the same name are assumed to be connected even if not shown as such on the schematic. Such nets could be, for example, on a different sheet of the drawing, but still electrically connected as far as the program is concerned.

Netlist. A list of nets which can be automatically produced from a schematic or typed in by hand. The netlist describes the circuit, and is a necessary step between the schematic and automatic production of a rat's nest, or-connection to a simulator. In some programs the netlist contains both the nets and components. Others produce a separate component list. Most makers have their own netlist format so there is not much opportunity for transfer of netlists between different programs. But there are exceptions. As the netlist is usually in text, it can be used to verify by eye that the connections you thought you had made in the schematic are in fact present in the netlist. This often holds a few surprises. Viewing a netlist and checking each net by eye on a large board is – as you may have guessed – a very tedious process. Some programs have methods of

reducing this burden, as you will see.

Rat's nest. While most engineers will be familiar with rat's nests, those produced by the computer from the netlist may in fact be just an unrecognisable pile of what appears to be junk on the screen. Most programs need the operator to sort these out into a 'proper' rat's nest by hand, placing the components into your preferred position before the pcb routing can take place. The degree of difficulty experienced in doing this varies widely between programs.

Schematic capture. The act of turning the symbols of a schematic into a form usable by the computer for either routing, or simulation, or transfer to another system, the form being usually a netlist. Not all programs with schematic drawing combined with pcb artwork have schematic capture.

Rubber banding. A technique used in a lot of CAD drawing programs – not just electronic ones – for redrawing a line. The line appears to be stretched like a rubber band at the point where the mouse cursor is located, and stays attached for as far as you move the cursor. Corners are often added by keyboard typing. A very easy method for beginners and experts alike to tie Gordian knots.

Push-and-shove. An autorouter strategy in which tracks already routed, but causing obstruction to further routing, are realigned to make way – a very useful feature.

Rip-up-and-retry. Similar to push-and-shove, rip-up-and-retry allows tracks already routed to be automatically removed, completely, and rerouted. This feature and push-and-shove are only found on the more developed autorouters and are highly desirable. Together, they do a lot towards getting a near 100% routed design.

or capture. There are facilities for importing and exporting basic ASCII netlists on the 32-bit version.

The drawing area is good, at 9.5 by 5.5in on a 14in screen, and is presented in the standard Windows format. Panning is carried out with scroll bars – a very good method – and there are five fixed levels of zoom.

In all versions of *PIA*, there are two options. You can either route the board manually as in any other manual routing program, or you can use the autorouter. With the latter, it is necessary first to generate a rat's nest.

Some reviewers have commented that if you are going to draw rat lines, you may as well draw tracks and have done with it. But, in *PIA* all you have to do to produce a rat line is click on two pads, and the ratline is drawn for you.

Because of *PIA*'s snap-to grid system, you do not have to be accurate at the track-producing stage. In fact, you can be quite sloppy and it will still draw correct rat lines. This makes the process rapid. Drawing lines in space is inhibited so you can hardly go wrong.

With this system, if you have a design on paper that already has the pin connection information on it, you can transfer it to the screen ready to autoroute in a much shorter time than you could with a schematic drawing and capture program.

This attractive track routing concept means that the package will appeal particularly to experimental designers. Such designers do not require a neatly drawn schematic. What they do need is to produce a working prototype pcb without hassle. In particular, the operator does not need to remember how to use the program.

There is a constraint to using this method. As any pcb draughtsman will tell you, there is a well-defined limit to how many rat lines you can put in before making a mistake. With a schematic, it is relatively easy to spot a mistake, such as an unconnected pin, even on large schematics. But with a rat's nest that has been built up to certain stage of complexity, a mistake can be readily made and not noticed.

Although this point will vary with individual designers, I think it is fair to say that this limits *PIA* to small or medium sized boards – at least in the rat's nest mode. The manufacturer of *PIA* makes no bones about this, advancing the package as a 'pcb-developer's individual assistant', rather than as an all-singing, all-dancing pcb design tool.

In keeping with the theme of simplicity, there are no autosave, autopan, autoneck, etc., features, and there is no map to locate lost drawings. There is no parts bin. Selecting parts is done direct from a basic library of pad/component outlines to the screen.

The library is presented in text in a small area on the screen and is scrolled through to reach the part required. Alternatively, you can get common parts from the button bar. Most designers would want to add their own outlines to the basic library, and this is easy to do.

Like many others, *PIA*'s autorouter is meant for doing only double-sided boards. Although it can be made to do a single-sided board, the result will contain many uncompleted tracks.

The handbook specifically discourages single-sided use of the autorouter. The power of this simple autorouter is not great; it has only the standard features you would find at this price level. It does not have rip-up-and-retry or push-and-shove, for example, and only a small amount of pre-routing configuration is possible.

Some manual completion of boards has been anticipated by the unusual and welcome addition of a button on the tool-bar to provide jumpers. What a good idea. The autorouter is gridded with a choice of just three grid and track size combinations, so is quite basic. Although it would route off-grid, the autorouter did not like it, and always gave warning messages – even when it was able to give 100% routing.

Review 3 – *Easytrax*

Easytrax is a dos based pcb drawing program of medium size and complexity. It has no schematic capture or provision for importing a netlist. It will run on any IBM pc from XT upwards. The main program ran well using just conventional memory. When it came to plotting however, I needed to convert some extended memory into expanded memory in order to run the whole of some boards without receiving the 'out of memory' message.

The main attraction of *Easytrax* is that it is offered completely free to anyone who wants to use it. As such, it is an economical introduction to the world of pcb CAD. From using it you can find out which aspects are important to you and which are not. It even includes a method of automatic routing, but this is an unsophisticated semi-automatic type not a fully-fledged autorouter.

There is no written manual with *Easytrax*. It has to be extracted from the disk and is some two dozen pages long. The manual does not cover every aspect of the program – only the basic operation. You are left to discover the finer points for yourself. This may take some effort, but is well worthwhile.

As this is a free piece of software, do not expect any technical support. There is no on-screen help but the prompt system is good. Most of the control throughout is by a good, logical menu system, backed by the usual key-

The manual drawing part of the program is easy and pleasant to use and, bearing in mind the limits of the autorouter, is probably the main use to which *PIA* would be put by most users.

PIA in summary

Although the rat's-nest/autorouter method is a good way of producing a working prototype of a double-sided board quickly, I would like to see *PIA* developed further. It should be equipped with a much more powerful autorouter. Nevertheless, as it stands, *PIA* is an attractive product with an identifiable niche in a particular sector of the market.

AW Software, tel. Germany +49 89 6915352. *PIA* std DM99; extended DM171 32bit DM286, all inc. 15% tax.

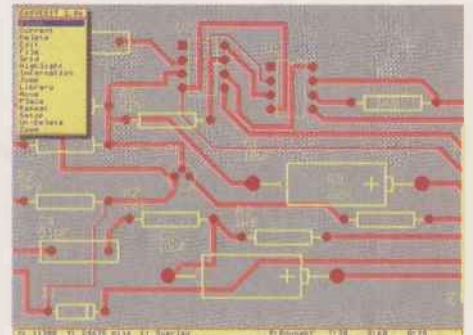


Fig. 2. Manually drawn exercise showing quality of graphics and typical menu in *Easytrax*.

board short-cuts. These short-cuts are mostly logical, but some alas are of the incomprehensible dos sort. For example, the asterisk key changes layers. Why not use 'L' for this?

The screen area is good at 9.5in by 6.5in when none of the menus is showing. Graphics are good, as Fig. 2 shows. There is an adequate library of component outlines which is easy to access. As you would expect in a relatively simple dos program, the library is in text form only. Many of the text descriptions of the components may appear to be somewhat cryptic until you get used to them. RADO.4, for example, is a generalised outline for a component,

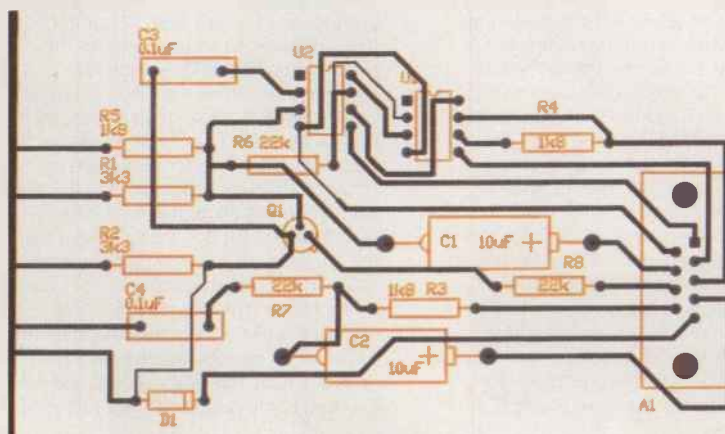


Fig. 3. Plot of exercise shown in Fig. 2 using *Easytrax* HPGL plotter driver, showing final artwork quality. Reproduced twice size and showing top overlay.

which could be a capacitor, resistor, etc., with radial leads on a 0.4in pitch.

Although a very straightforward program, *Easytrax* has some finer points. Examples are autopan, which can be turned on or off as you wish, adjustable autosave, and a 'jump' option which takes you to any component on the board that you specify. This could be useful on large circuits to get to a specific place on the board without panning.

It is easy to lose your work off-screen if you are not careful with the autopan. There is no map showing where you are. Beginners may find this very frustrating until they master this control.

The zoom/unzoom function has eight levels. It can be accessed via the menu system, which makes it a slow process. On the other hand, it can be accessed using page-up and page-down keys on the keyboard, which is very quick and convenient.

As you would expect with a dos program, screen redraws are fast. There is also a 'zoom-all' function which brings all the circuit to fit on the screen. This function can be used to retrieve lost circuits.

Drawing in the tracks manually was straightforward. Surprisingly, *Easytrax* is perfectly capable of making not just single-sided and double-sided, but multilayer boards too.

An alternative to manual routing is to use the automatic router. With this router, the operator selects two component pads with the mouse, which causes a track to be inserted - complete with vias. This two-layer router inserts vias far too freely, limiting its usefulness. It is essen-

tially non-configurable. This type of semi-automatic routing is a slow method compared with a full autorouter but quicker than drawing tracks by hand and not such hard work. The results may not be what is desired or intended. As a result, be prepared for odd-looking tracks and lots of vias.

Considering this is a free program, there is a good choice of output devices for the pcb artwork. As Fig. 3 shows it can produce high-quality artwork. The illustration was just an exercise drawn quickly on the manual system. It shows the quality of pad and track outlines and plotted on *Easytrax's* HPGL plotter driver. The final quality and appearance of a real board depends very much on the amount of time and effort you are prepared to put into the drafting.

Note that if you try out this program, and can't find the printer/plotter drivers after installation, re-install it, putting all the various parts of the program under the '*Easytrax*' directory, and not in the default directories.

Easytrax in summary

For a dos program, *Easytrax* is not too difficult to learn. If you master it, you will find it is pleasant to use, comparatively bug-free, and practical.

Its limitations should become immediately apparent on using it to make a real pcb. The merits of the program are that it is possible to design practical basic pcbs and that it is free of charge. It is claimed in the literature that files from *Easytrax* can be transferred to Protel's higher programs, such as *Autotrax* and their Windows products.

PCB CAD review subjects

This review, continued next month, covers the following ten products.

PCB Designer: Niche Software Ltd, tel. UK 01432 355414. £49 inclusive.

PIA: AW Software, tel. Germany +49 89 6915352. PIA std 99DM: extended 171DM 32bit 286DM inc tax.

Easytrax: Protel International pty, tel. Australia 408 437 7771, UK PDSL, tel. 01892 663298. £6 copying charge.

Electronics Workshop: Robinson Marshall.

CircuitMaker: MicroCode Engineering.

Quickroute 3.5 Pro+: Quickroute Systems Ltd.

Propak: Labcenter Electronics.

Proteus: Labcenter Electronics.

Ranger2: Seetrex CAE Ltd.

EasyPC Pro XM: Number 1 Systems.

Note that although starting with a couple of smaller packages, this review is not in any order of complexity or competence.

Protel International pty, tel. Australia 408 437 7771, UK - PDSL, tel. 01892 663298. £6 copying charge.

**KeyCad is a product of Softkey International Ltd.*

"Your low cost route to embedded 8051"



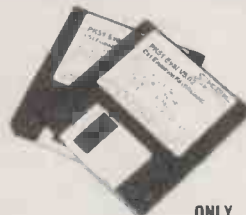
MICRO-PRO 51

"Hardware/software upgradeable programmer for the 8051 family"

- Accepts up to 40 pin DIL directly via Aries ZIF socket
- Surface mount and PLCC package adaptors available as optional extras
- Atmel 8951/8952 & 1051/2051 ICE cables available as optional extras
- Field programmable hardware to allow future upgradeability
- Fast PC parallel port based design

ONLY £125

Programming support for the following devices:
Generic 8751/8752 microcontrollers from Intel & Philips
Atmel 8951/8952 FLASH replacements for the 8751/8752
Atmel 1051/2051 20-pin FLASH 8051 microcontroller derivatives
Serial EEPROMS families: 24Cxx, 93Cxx, 59Cxx, 25Cxx (optional extra)



KEIL C51 PK LITE

"The complete Ansi-C development environment for the 8051"

- Optimising Ansi-C compiler
- dscope 51-8051 software simulator & source level debugger
- uVision-Integrated Windows based C51 project management system
- Support for most 8051 derivatives eg. Atmel, Intel, Siemens etc.
- Numerous microcontroller language extensions for the fastest, tightest code

ONLY £110

(Restricted to 2K total program code, SMALL model only)



Embedded C51 Starter Systems for the 8051 family

"Everything you require to develop an embedded 8051-based project in C"

- MICRO-PRO 51 device programmer
- KEIL C51 PK LITE
- Sample Atmel FLASH microcontrollers
- Full suite of C51 demonstration software



Atmel 8051 FLASH Microcontroller Range

	8951	8952	1051	2051
FLASH code ROM	4K	8K	1K	2K
RAM	128	256	64	128
I/O	32	32	15	15
Timer/Counter (16 bit)	2	3	1	2
Serial Port	YES	YES	NO	YES
Interrupt Sources	5	8	3	5
Pins (DIL/PLCC)	40/44	40/44	20	20
Special features		Timer 2	Comparator	Comparator

895X-ST (ONLY £215)

Comes complete with samples of Atmel 8951 and 8952 40 pin microcontrollers

X051-ST (ONLY £199)

Comes complete with samples of Atmel 1051 and 2051 20 pin microcontrollers

Equinox Technologies, 229 Greenmount Lane Bolton BL1 5JB, Lancashire, ENGLAND
Tel: (01204) 492610 Fax: (01204) 494883 Int. dialling code (UK +44 1204)
E-mail: sales@equintec.demon.co.uk Web Page: www.demon.co.uk/equintec
All prices exclusive of VAT and carriage.

Video inserter

Ian Polczynski's module superimposes text, together with time and date information, on any standard composite signal – whether PAL, SECAM or NTSC.

This article describes an on-screen display unit, osd, that allows date, time and text characters to be displayed on top of a background colour video signal. Devices similar to this circuit are common in security and surveillance systems. But low cost and simple construction make this unit suitable for home video processing and archive titling.

Basically this circuit is an eight-bit stand-alone microcontroller with real time clock, display and input/output facilities. It can perform virtually any task, from controlling your reticulation to titling your video tapes.

The function of this circuit is to input live video, add on-screen information, and output

the result as a composite video signal. Whether the unit is powered up or not, the input video signal is permanently output. A minimum battery back up time of not less than 90 days is achieved.

How the video inserter operates

Figure 1 shows block diagram of the on-screen display unit. In simple terms, a composite video signal is fed to the sync separation circuit and separated into two sync signals, HSYNC and VSYNC. These two signals clock the character generator IC. The generator receives commands from the cpu via serial link and outputs the necessary information to a buffer, which adds character signal to the composite video signal.

About the on-screen display

The unit is based on the NEC $\mu PD6145$ and its display character format is 6×9 dots. As there is no space between characters, the 6145 cmos IC, Fig. 2 enables display of a combination of two or more characters, kanji characters and graphs.

The device consists of a 288-character video ram array, for 12 lines by 24 characters, a 112-character font rom, a 16-character user defined font ram, the on-screen display logic, and a video clock oscillator.

The chip logic accepts horizontal sync., HSYNC, and vertical sync., VSYNC, and provides digital video outputs for character information.

Features of the $\mu PD6145$ video insertion chip

- Numbers of character displayed: 12 lines by 24 columns
- Numbers of character types: 112(rom), 16(ram)
- Character size: 2H, 4H, 6H, and 8H per dot
- Character matrix: 6×9 dots, no inter-character space
- Interface with microprocessor: 8-bit serial input format
- Power supply: Single +5V power rail

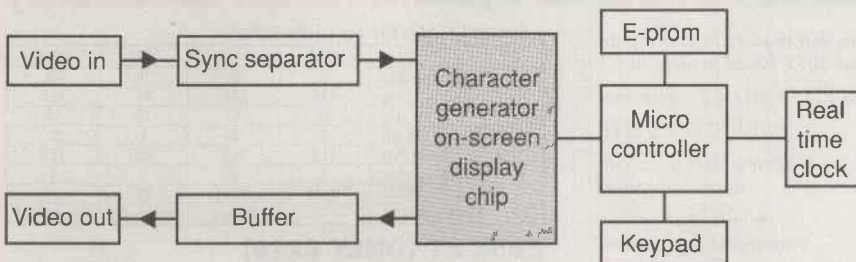


Fig. 1. Video switching is arranged so that the module can be left in circuit and by-passed transparently when not needed.

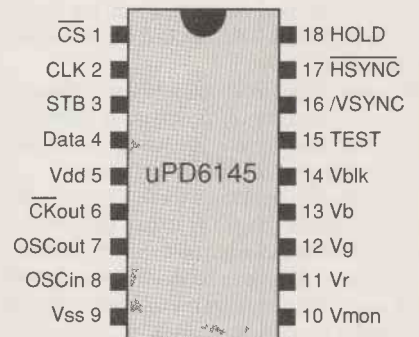


Fig. 2. Signal names for the $\mu PD6145$ video message inserter.

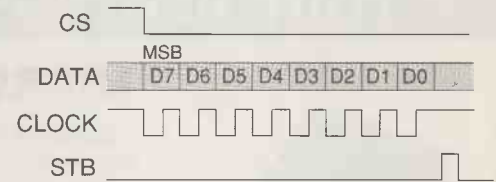


Fig. 3. Control input for the 6145 video insertion chip is clocked in serially while chip-select is low.

Timing for the character dots is provided by the video clock oscillator. In most applications, this oscillator is simply an LC tank circuit connected to the osc in/out pins. The frequency controls the character width.

Video ram stores the characters to be displayed on the screen along with certain attribute data pertaining to those characters. One nice feature of this IC is that once a character has been written to the on-screen display chip, no further cpu intervention is required to 'refresh' the screen.

Protocol of the display chip

Figure 3 shows the 6145 control-input format. After the CS line is set to 'L' the cpu starts to send clock impulses and data bits from msb.

The shift registers for serial interfacing with external units consist of eight bits, but the 6145 commands comprise nine bits. Because

of this, instructions are divided into two banks. One of these banks is selected by one bit of the format selection command, Fig. 4.

Each control command is executed when a strobe pulse is input after eight-bit data has been input. To write display character data continuously without changing the character attributes only character command is to be sent. To display the sequence '012' for example, the following control commands should be transmitted: 00_{16} , 01_{16} , 02_{16} . The write address is incremented automatically at the fall of the STB pulse when display character data is input.

Separating sync

The 6145 only accepts extracted horizontal and vertical sync signals, HSYNC and VSYNC. To provide the device with this timing information from a composite video signal, a dedicated sync separator circuit is employed, based on the Gennum GS4881 sync separator, Fig. 5. This IC is a drop-in replacement for the industry standard LM1881.

Composite video is ac coupled via an external capacitor to pin 2. The device clamps the sync tip of the input video to 1.5V and then slices at 77mV above the clamp voltage. Resultant signal, at pin 1, is the input signal with the active video portion removed.

For HSYNC timing, the BACK PORCH output, at pin 5, is used. Figure 6 shows the difference between these two signals.

In PAL composite video, horizontal sync pulses are followed by the back porch interval. The 4881 generates a negative-going pulse on pin 5 during this time. It is delayed typically 500ns from the rising edge of sync and has a typical width of 2.5 μ s – just enough for the 6145 display IC.

The vertical sync interval is detected by inte-

grating the composite sync pulses and is clocked in and out with a fixed width of 197.7 μ s.

No chrominance filtering is done within the device. If the input signal contains large chrominance components or has significant amounts of high-frequency noise, external filtering may be necessary. This filter can be a simple single-pole low-pass filter, having a corner frequency of approximately 500kHz, and providing an ample bandwidth for passing sync pulses with almost 18dB attenuation at 3.58MHz (NTSC colour subcarrier).

To control the source resistance seen by the sync separator, i.e. minimise the amount of attenuation, a low output impedance buffer is recommended. An NPN emitter follower works well.

Mixing video

To simplify the circuit and to make it compatible with NTSC, PAL and SECAM, a limitations need to be imposed on the project targets – colour availability. Unfortunately, the three standards use different colour encoding methods. It is impossible to produce a colour video signal that is compatible for the three standards, unless you go for vivid white only.

To envisage vivid white means, imagine a screen showing a colour video pattern from a video generator for all three colour standards and monochrome, Fig. 7. Displayed on screen, the video of Fig. 7 shows vivid-white dot in the middle of one of the horizontal lines, regardless which standard it is overlaid onto. The black line, 10% above white level, represents a 'white dot' overlaid on top of 'live' video signal.

Figure 8 shows the video mixer in outline, illustrating how a composite video signal passes through the on-screen display unit. A 75 Ω

Bank 0 commands

Display character data
Colour/blink data for each character
Character display line address
Character display column address
Background specifications
Write sync, smoothing on/off, display on/off
Blink/oscillation control

Bank 1 commands

Video ram write data
Video ram word address
Vertical display position address
Horizontal display position address
Character size specification

Fig. 4. Command descriptions for codes controlling the on-screen display chip.



Fig. 5. Pin compatible with the industry-standard LM1881, the GS4881 extracts horizontal and vertical sync signals from composite video.



Fig. 6. For horizontal sync, the 4881's back-porch signal is used. At 2.5 μ s, this pulse is just wide enough for the 6145 display chip.

Video signals and standards

NTSC: National Television Standard Committee, or NTSC, is the USA agency that developed standard monochrome and composite-colour video signals for the USA. NTSC (some say this means never the same colour) standard has been adopted by countries like Japan, Canada, Mexico and many others.

PAL: An acronym for Phase-Alternate-Line, PAL is a video standard for colour tv developed by Telefunken Company in Germany and from principals point of view is similar to NTSC. It includes a line-by-line alternation in phase for one of the two colour-signal components. PAL is used by most of Western Europe, except France.

SECAM: This standard, Sequential Couleur Avec Memoire, was developed in France. Luminance signals have the same format as those of NTSC and PAL, but colour-difference signals modulate two separate carriers that are transmitted on alternate line and to restore missing colour information SECAM decoders include a one-line (1H) delay element.

Colour Burst: is a reference subcarrier window for colour identification. It is transmitted after horizontal sync impulse and before video section of the composite video signal.

Composite Video: Composite video is an analogue signal

suitable for transmission on a single channel and is obtained by combining the chrominance and luminance signals with sync and blanking pulses.

RGB: This term refers to the three electrical signals corresponding to the red, green and blue components of an image.

YUV: After correction and shaping, the RGB signals are encoded to produce chrominance (C for Colour) and luminance (Y for brightness) signals. Then, combining the chrominance and luminance with sync and blanking signals produces a composite video signal. Video signals may pass through many stages of editing and recording. To maintain fidelity the video signal is best handled in a three-signal component format: the electrical analogous of luminance (Y) and the colour differences B-Y (U) and R-Y (V). YUV requires less bandwidth than RGB: equal amounts of picture detail reside R, G and B, but the YUV system conveys fine picture detail only in Y. Bandwidths are approximately 4MHz for Y, 500kHz for U and 1500kHz for V, resulting in a lower overall bandwidth. A VCR needs three tracks to handle RGB standard, but for YUV, the VCR requires only two tracks, one for Y and one for U and V together.

VIDEO DESIGN

composite video signal feeds the input connector and is output to the output pin via a low-value resistor.

From the input, the signal is buffered to the sync-separation circuit. An emitter-follower type circuit switches the on-screen display circuit to the output. This transistor is switched by the on-screen display IC. While on, the transistor saturates the live video signal to white, but while off, it has no effect on the output video.

In addition to mixing a live video signal with white overlaid information, the above circuit maintains the 75Ω characteristic impedance for both input and output. The unit can be permanently connected to the video path of any video system – regardless of being used or not. The unit will not have a negative

influence on the quality of the transmitted video signal.

Circuit details

Circuitry for the on-screen display module is shown in Fig. 9. Diode D_1 provides rectification as well as reverse-polarity protection. Any ac or dc input between about 8 and 12V should suffice. Unregulated voltage is sensed via a transistor which pulls down the chip select input of IC_4 .

Analogue circuits need to have a near constant current drain with time. Since the designer has less control over the variation in digital ground currents you must be aware of the logic power requirements. Current surges can be decreased through extensive bypassing. Even though the digital logic may not need it, providing a bypass ceramic capacitor for every power pin minimises interference from the digital circuit on the analogue signal.

CPU and the program memory

Logic is built around the 80C39 microprocessor, IC_5 . This controller contains a 128 byte ram, 24 i/o lines, 16 bit auto-reloaded timer, a fixed-priority interrupted structure and an on-chip oscillator.

Software resides in an external 27C64 eprom. For addressing this device, latch IC_7 is necessary to demultiplex the lower address bits from the data bits. The 80C39 is mapped in the external data memory area. To do this, external-enable pin EA is connected to 5V.

All i/o pins connect to pull-up resistor blocks. Resistor R_{15} pulls up e-prom address line 12, thus with LINK1 open the upper half of the program memory is selected. When closed, this link causes program memory to start from location zero.

LINK2 must be open to enable the cpu to fetch instructions from external program memory starting from address 0000. We have produced a pcb designed to operate with both internal rom cpus, i.e. 83xx, 87xx types, and rom-less versions in the 80xx range. With LINK2 closed, the circuit operate correctly only with internal-rom cpus.

Reading from the e-prom is carried out in two phases. First, the cpu sends out via PORT0 the lower address bits A_{0-7} . At the same time, the ALE line goes low and the lower part of current address is latched in IC_7 .

In the second phase of the cycle, the cpu sends out the upper address A_{8-11} via PORT2 pins P_{20-23} and the PSEN signal goes low. This activates e-prom data lines D_{0-7} and the cpu reads a byte of data from the e-prom.

The same occurs when the cpu talks to the cmos ram and real time clock, IC_4 . This device is accessible at any time because its chip select input pin is pulled down by the transistor and the RESET and PWR SENSE inputs are pulled up via resistor R_{11} .

There is no conflict on the address/data bus even though the two memories connect to the same port. The 80xx family has separate address spaces for program and data memory. In other words, when the cpu addresses an e-prom, it uses PSEN as the chip-select output,

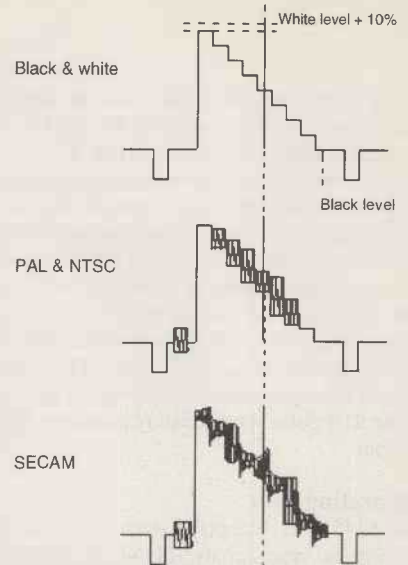


Fig. 7. Colour video patterns for the three colour standards and monochrome are dissimilar but it is possible to superimpose a vivid-white signal that provides the same display results with all four.

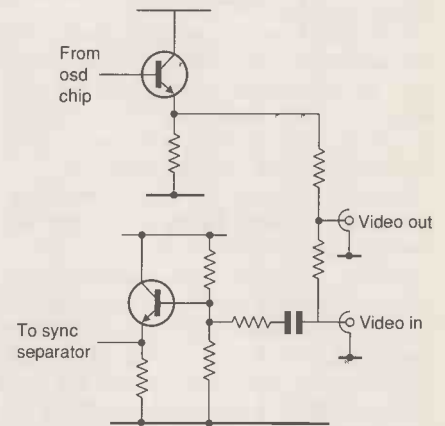


Fig. 8. In this video mixer arrangement, the top emitter follower is switched by the on-screen display unit between acting as a buffer and saturating the video to white.

whereas while addressing ram it uses RD and WR outputs to read or write.

RTC and memory with back-up

The 146818 real-time clock is a peripheral c-mos device combining three features – a complete time-of-day clock with alarm, a calendar, a programmable periodic interrupt and square-wave generator, and 50 bytes of low-power static ram. It includes a multiplexed bus interface circuit, so it can be directly connected to the 8039 cpu.

The on-chip oscillator is designed for a parallel resonant crystal at 4.194304MHz, or 1.0485765MHz, or 32.768kHz. However, if the internal oscillator is used, current con-

Technical support

Readers interested in a designer's kit incorporating the 6145 on-screen display IC, osd and keypad pcbs and a pre-programmed e-prom can obtain them from Polvision at 77 Glanton Way, Dianella, Western Australia 6062 for AU\$99.

On-screen display components

Resistors (all 1/4W metal film)

$R_{1,5,14}$	1k
$R_{2,3,10,11}$	10k
$R_{12,15,16}$	10k
R_6	75R
R_7	220R
R_8	2k2
R_9	100k
$R_{13,17}$	100R
R_{18}	680k

Resistor blocks:

$MR_{1,4}$	8x10k, 9pin
$MR_{2,5}$	4x10k, 5pin
MR_3	5x10k, 6pin
VR_1	Variable 2k

Capacitors

$C_{1,12}$	Ceramic	1μF
C_2	Ceramic	56nF
C_3	Ceramic	10nF
$C_{4,6,7,9,10}$	Ceramic	100nF
$C_{11,13,14,18}$	Ceramic	100nF
C_5	Electrolytic	1000μF/16Vdc
C_8	Tantalum	22μF/25Vdc
$C_{15,17}$	Ceramic	22pF
C_{18}	Variable	5-30pF

Semiconductors

D_1		UF4002
D_2		Red led
D_3		1N4148
Q_{1-3}		2N2369
IC_1	OSD	PD6145
IC_2	Oscillator	HA7210IP
IC_3	Sync sep.	GS4881
IC_4	RTC	6818
IC_5	8 bit cpu	80C39
IC_6	E-prom	M27C64
IC_7	Octal latch	74LS373
IC_8	Voltage reg.	L7805

Miscellaneous

Quartz crystals	
$XTAL_1$	32 768kHz
$XTAL_2$	12MHz
L_1	22H fixed inductor
Keypad push buttons	

sumption of the chip is too high and battery back up time would only be about a week. The target was set up to minimum 90 days. To solve the problem an additional low-power c-mos chip IC₂ has been employed, namely the HA7210IP. This is a very efficient oscillator IC and brings consumption down to battery

less than 30µA. As a result, 100mAh NiCd battery can easily provide more than 90 days' operation.

The battery is charged from the 5V rail via resistors R₁₇ and R₁₃ and diode D₃. This diode stops the battery being discharged by other components when the unit is in a standby mode.

Implementing the design

In our design, all major components of the on-screen display circuit are mounted on a single board.

A description of switch functions and software appears in a later article. ■

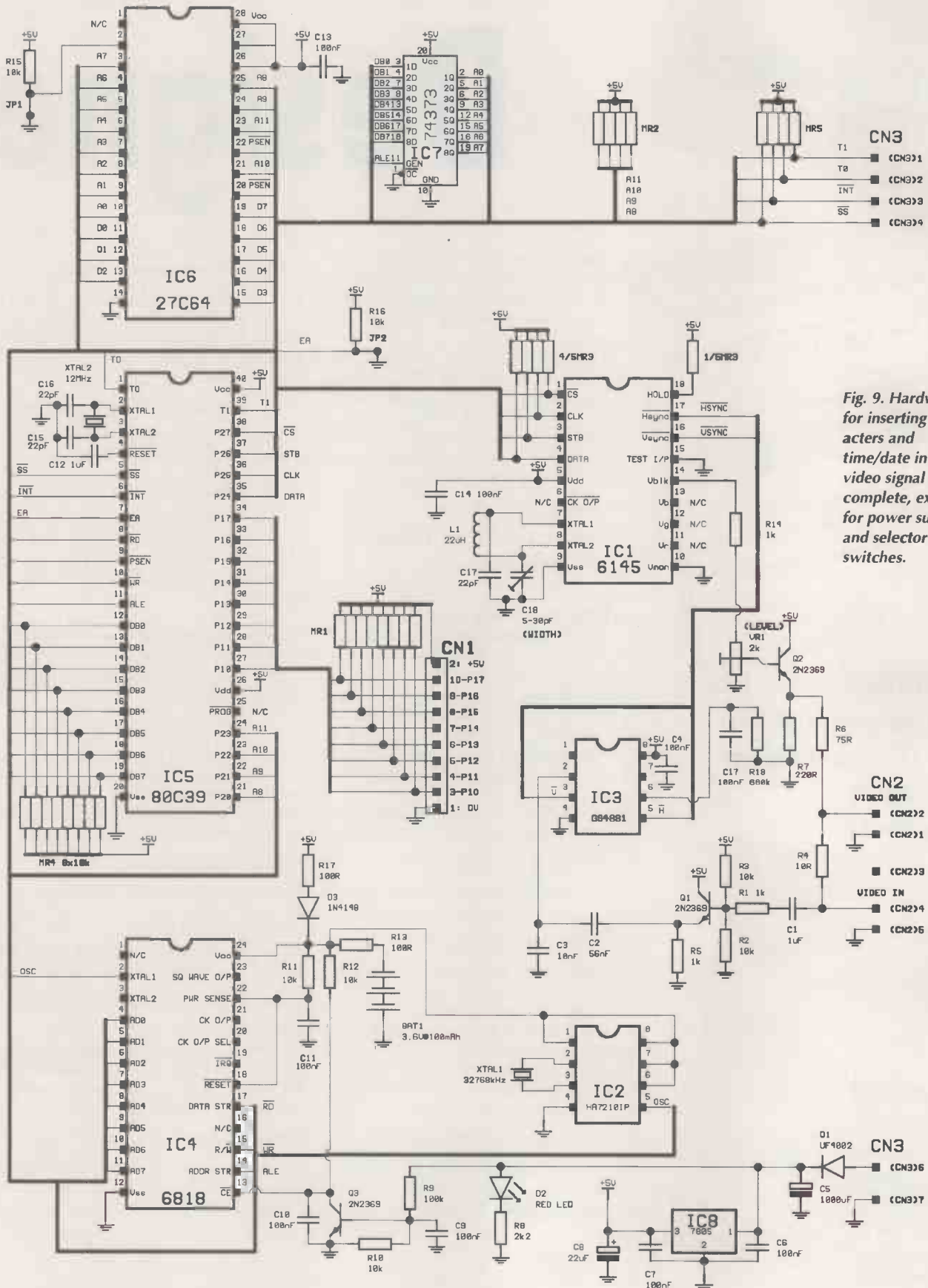
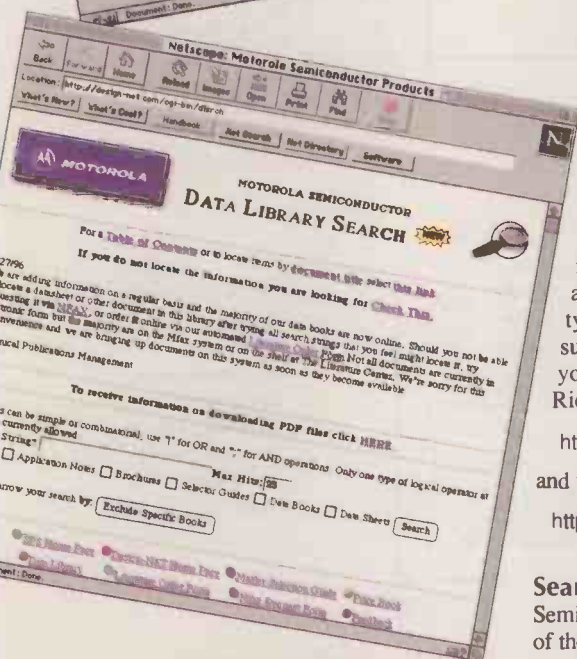
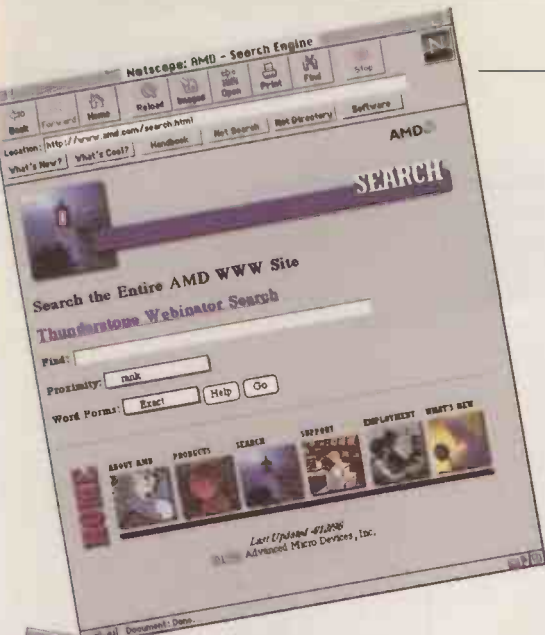
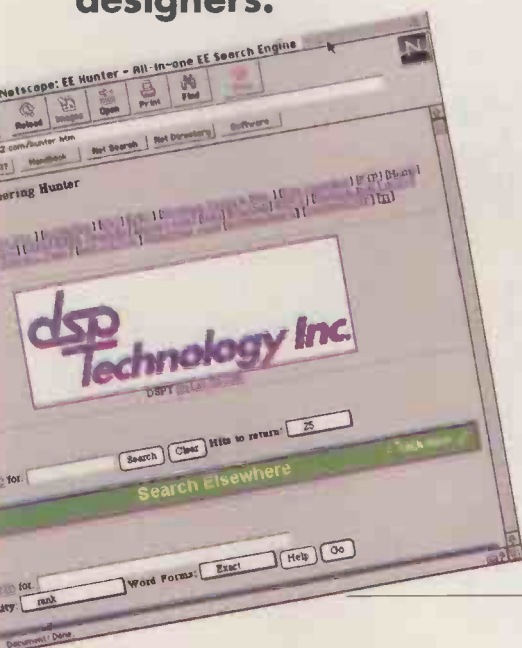


Fig. 9. Hardware for inserting characters and time/date into a video signal - complete, except for power supply and selector switches.

Designer



Jason McDonald has been searching for Web sites useful to electronics designers.



From your World Wide Web browser, you can now key in a few words, hit 'search', and presto – the Web site returns a hit list of applicable resources in seconds.

To benefit from these resources, you must have a World Wide Web browser, and a connection to the Internet. Simply type in the Uniform Resource Locator – such as <http://www.search.com> – and go. If you're new to the Net, useful overviews are Rice University's search report at,

<http://riceinfo.rice.edu/Internet>

and the Electronics Search FAQ at,

<http://www.eg3.com/srcnet.htm>

Search the chip companies

Semiconductor manufacturers now publish most of their data sheets, new product specifications, and other useful design information on their Web sites. The most innovative companies now offer search capabilities. These can range from simply entering a specific part number to retrieve its datasheet, to searching for useful information by keywords such as *68HC11* or real-time.

AMD, for example, has recently initiated their impressive Thunderstone search engine at,

<http://www.amd.com/search.htm>

Not to be outdone, Intel offers both a search engine, at,

<http://www-cs.intel.com/search.htm>

and a customizable Web interface. The latter means that you can customise Intel's site to display only the information you want.

Motorola has yet to make its semiconductor Web sites fully searchable. You can only search the Motorola corporate Web site. But the company does offer a search capability for its data library. The library search site is at,

<http://design-net.com/cgi-bin/dlsrch>

and allows you to identify Motorola data sheets or design information. Motorola's Master Selection Guide is also searchable at,

<http://motserv.indirect.com/cgi-bin/msg>

Like Intel, Texas Instruments offers a customisable Web interface, meaning you can customise the TI site to display only information useful to you. Texas Instruments also has search capability at,

<http://www.ti.com/corp/docs/search.htm>

An all-in-one interface to numerous semiconductor search sites is EE Hunter at,

<http://www.cera2.com/hunter.htm>

EE Hunter unifies a number of companies, such as Texas Instruments, Motorola, and Analog Devices, which allows you to easily toggle between them and quickly identify useful information.

Search non-commercial web sites

Even non-commercial Web sites now offer search capability. Don't miss the impressive Ada IC web site at,

<http://sw-eng.falls-church.va.us/AdaIC/>

There you can find everything you ever wanted to know about the Ada language and related topics, in seconds.

Norway's excellent contribution to Internet design information – FTP Search – is at,

<http://ftpsearch.unit.no/>

FTP Search is the fastest way to scan the Net for downloadable source code or files by entering key words like *68HC11* or *8051*. Looking for an *8051* compiler? Search no more – log on to the Free Compilers search engine at,

<http://cuiwww.unige.ch/cgi-bin/freecom>

and quickly locate your prey.

Looking for shareware? Perhaps you need a Windows 95 add-on, or a converter from HTML to ASCII for your company's Web site. The searchable Shareware.Com is at,

<http://www.shareware.com>

This is an outgrowth of the Virtual Software Library.

Indiana University operates the Unified

Web files

Computer Science Technical library, searchable at,

<http://www.cs.indiana.edu/cstr/search>

There, you can locate computer or EE-related technical reports, though most are highly academic. CERA Research maintains a comprehensive list of searchable non-commercial sites at,

<http://www.cera2.com/micro.htm>

Search the world wide web

As any design engineer who surfs the net will tell you, finding the Web sites of even major vendors like Hitachi Semiconductor can be difficult. Who would think of,

<http://www.halsp.hitachi.com>

Fortunately, major search engines now make finding them easier than ever.

One of the most popular is Alta Vista, underwritten by Digital Electronics Corporation at,

<http://altavista.digital.com>

On Alta Vista, use the symbols '+' or '-' to tighten your searches for exact matches. Enter '+embedded +microcontroller', for example, to identify Web sites having both embedded and microcontroller in their text. Lycos is a great alternative, at,

<http://www.lycos.com>

though not as fast as Alta Vista.

Even Yahoo – formerly only a subject-tree of resources – now provides a limited search capability at,

<http://www.yahoo.com>

There, you can have the best of both worlds – almost. First, select a category-specific area such as,

<http://www.yahoo.com/Computers/Hardware/Microprocessors/>

to browse for microprocessor-related information. Then, search the subarea by entering terms in the blank field at the top, such as 68K. Alternatively, go up a level and search

all of Yahoo.

Across the Net, at AT&T, don't miss the innovative new service called Phoaks – People helping one another know stuff – at,

<http://weblab.research.att.com/phoaks/>

Phoaks sifts through postings to USENET discussion groups, and tabulates the most popular Web sites for a particular group such as sci.electronics.components, or comp.realtime. It's a great way to identify which sites your electronics engineering peers find hot.

Search usenet

USENET discussion groups, such as sci.electronics.design, can be a wonderful yet frustrating way to obtain electronics design information. The problem is the high volume of 'noise' on groups such as comp.dsp, comp.arch.embedded, or sci.electronics.cad. The solution? Use a USENET search engine, such as Dejanews at,

<http://www.dejanews.com>

Dejanews will sift through postings based on key words, allow you to read postings, and you can even respond to postings of interest.

Other free search services for USENET are Alta Vista (simply select 'USENET') Infoseek at,

<http://www.infoseek.com>

or Excite at,

<http://www.excite.com>

In most cases, you can restrict your search to a specific group such as comp.dsp or sci.electronics.design.

About the author

Jason McDonald is an Internet and Web consultant, working in Fremont, California. He has a Ph.D. from the University of California, Berkeley, and has written for numerous trade magazines. He can be reached by email jasonm@violet.berkeley.edu or at Tel. 510-713-9493.



MIXED-MODE SIMULATION. THE POWER OF VERSION 4.

**New
Version 4**

Analog, Digital & Mixed Circuits

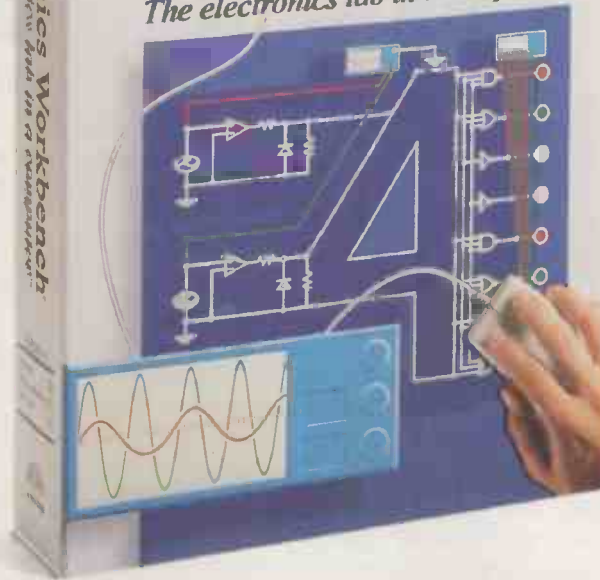
Electronics Workbench® Version 4 is a fully integrated schematic capture, simulator and graphical waveform generator. It is simple to mix analog and digital parts in any combination.

Design and Verify Circuits... Fast!

Electronics Workbench's simple, direct interface helps you build circuits in a fraction of the time. Try 'what if' scenarios and fine tune your designs painlessly.

Electronics Workbench®

The electronics lab in a computer™



More Power

Simulate bigger and more complex circuits. Faster. On average, Electronics Workbench Version 4 is more than 5 times faster than Version 3.

More Parts

Multiple parts bins contain over twice the components of Version 3.

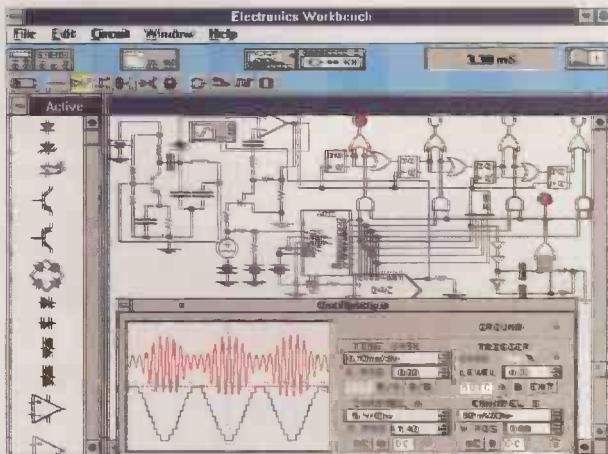
More Models

Over 350 real world analog and digital models are included free with Electronics Workbench. And, if you need more, an additional 2,000 models are available.

Incredibly Powerful. Incredibly Affordable.

If you need mixed-mode power at a price you can afford, take a look at this simulator and graphical waveform generator that mixes analog and digital with ease.

With over 20,000 users world-wide, Electronics Workbench has already been tried, tested and accepted as an invaluable tool to design and verify analog and digital circuits. With Version 4 true mixed-mode simulation is now a reality with incredible simplicity.



True mixed-mode simulation: Simultaneous AM transmission, digitization and pulse-code modulation of a signal.

Electronics Workbench™

The electronics lab in a computer™

Order Now! Just £199*
44-(0)1203-233-216

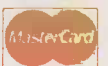
RM Robinson Marshall (Europe) Plc

Nadella Building, Progress Close,
Leofric Business Park,
Coventry, Warwickshire CV3 2TF
Fax: 44 (0)1203 233-210

E-mail: rme@cityscape.co.uk

Shipping charges UK £5.99. All prices are plus VAT.
All trade marks are the property of their respective owners.
Electronics Workbench is a trademark of Interactive Image Technologies Ltd., Toronto, Canada.

* 30 Day money-back guarantee.



Australia: 2-519-3933 • Brazil: 11-453-5588 • Cyprus: 2-62-1068 • Denmark: 33-250-109 • Finland: 0-297-5033 • France: 14-908-9000 • Germany: 711-62-7740 • Greece: 1-524-9981
Hungary: 1-215-0082 • India: 11-544-1343 • Israel: 3-647-5613 • Italy: 11-437-5549 • Japan: 3-3382-3136 • Malaysia: 603-7778945 • Mexico: 5-396-3075 • Netherlands: 18-031-7666
New Zealand: 9-267-1756 • Norway: 22-16-70-45 • Portugal: 1-814-6609 • Singapore: 462-0006 • Slovenia: 61-317-830 • South Africa: 331-68309 • South Korea: 2-222-3431
Spain: 1-553-3234 • Sri Lanka: 1-86-5970 • Sweden: 8-740-5500 • Thailand: 66-2-398-6952 • United Kingdom: 203-23-3216



CIRCLE NO. 113 ON REPLY CARD

656

MICROMASTER LV PROGRAMMER



APPROVED

by major manufacturers including

**AMD
MICROCHIP
ATMEL**

from only

£495

THE ONLY PROGRAMMERS
WITH TRUE 3 VOLT SUPPORT

The Only True 3V and 5V Universal Programmers

Ice Technology's universal programming solutions are designed with the future in mind. In addition to their comprehensive, ever widening device support, they are the only programmers ready to **correctly** programme and verify 3 volt devices NOW. Operating from battery or mains power, they are flexible enough for any programming needs.

The Speedmaster LV and Micromaster LV have been rigorously tested and **approved** by some of the most well known names in semiconductor manufacturing today, something that very few programmers can claim, especially at this price level!

Not only that, we give free software upgrades so you can dial up our bulletin board any time for the very latest in device support.

Speedmaster LV and Micromaster LV - they're everything you'll need for programming, chip testing and ROM emulation, now and in the future.

Speedmaster LV £495

Programmes 3 and 5V devices including memory, programmable logic and 8748/51 series micros. Complete with parallel port cable, software, re-charger and documentation.

8 bit Emulator card £125

Expansion card for Speedmaster LV/ Micromaster LV containing 8 bit wide ROM/ RAM emulator. Emulates 3V and 5V devices. Includes cable and software. Configuration: 128K x 8 expandable to 512K by 8.

Micromaster LV £625

As above plus support for over 130 different Microcontrollers, without adaptors, including PICs, 89C51, 68HC705/711, ST6, Z8 etc.

16 bit Emulator card £195

As above but containing 16 bit ROM/RAM emulator. Configuration: 128K by 16, 256K by 8, 2 by 128K 8, expandable to 512K by 16/1024K by 8.

FEATURES

- Widest ever device support including EPROMs, EEPROMs, Flash, Serial PROMs, BPROMs, PALs, MACH, MAX, MAPL, PEELs, EPLDs, Microcontrollers etc.
- Correct programming and verification of 3 volt devices.
- Approved by major manufacturers.
- High speed: programmes and verifies National 27C512 in under 11 seconds.
- Full range of adaptors available for up to 84 pins.
- Connects directly to parallel port - no PC cards needed.
- Built in chiptester for 7400, 4000, DRAM, SRAM.
- Lightweight and mains or battery operation.
- FREE software device support upgrades via bulletin board.
- Next day delivery.

For a copy of our catalogue giving full details of programmers, emulators, erasers, adaptors and logic analysers call, fax or dial the BBS numbers below.



ICE Technology Ltd. Penistone Court, Station Buildings,
Penistone, South Yorkshire, UK S30 6HG
Tel: +44 (0)1226 767404 Fax: +44 (0)1226 370434
BBS: +44 (0)1226 761181 (14400, 8N1)

CIRCLE NO. 114 ON REPLY CARD



NOW, THE BATTLE IS OVER

ULTI BOARD



ULTI BOARD

BUNDLED WITH  **SPECCTRA**
SHAPE BASED AUTOROUTER

ULTIboard's interactive strength has always been the major selection criterion of professional Printed Circuit Board designers. Now that every ULTIboard Designer system will be supplied with a SPECCTRA SP4 Autorouter, ULTIboard designers now get the best of both worlds.

All ULTIboard Designer Users with valid update subscription get a MAINTENANCE UPGRADE with the SPECCTRA SP4 (4 signal layers + power/ground layers) Shape based Autorouter. This shows that ULTIimate Technology is *the* PCB-Design Tool vendor that *really* cares for their customers!

**THE ULTIMATE
SPECIAL OFFER**

**ULTIboard Entry Designer* £ 1295 (excl. VAT) will now
be supplied with SPECCTRA Shape Based Autorouter
*free Upgrade with EMC-EXPERT mid 1996 (list price at release £ 1875)**

CIRCLE NO. 115 ON REPLY CARD

ULTIMATE
TECHNOLOGY

Corporate Headquarters:
Energistraat 36 • 1411 AT Naarden
The Netherlands

tel.: (+31) 35 - 6944444
fax: (+31) 35 - 6943345

UK/Ireland Sales-Office:
2 Bacchus House • Calleva Park
Aldermaston Berkshire • RG7 4QW

tel.: 01734 - 812030
fax: 01734 - 815323

A new variable capacitor?

Martin Grove proposes a variable capacitor that could form the basis of a variety of transducers – including a truly digitally driven loudspeaker.

Reading an overview article on digital audio, made it evident to me that digital transduction at both ends of the audio chain is still a problem. This provoked some thought, especially as far as sound reproduction was concerned. While pulse-width modulation, pwm, appears well suited to electromagnetic loudspeakers, power output circuitry is still required and does not appear to be purely digital.

In order to deal with parallel digital data, electrostatic speakers seemed to offer the best possibility of a solution, provided that the capacitance of the speaker could be altered by digital means. This implied that the surface of the plates be divided into compartments that could be activated independently according to the magnitude of the byte, the final capacitance depending on the sum of the active compartments. Since the capacitance of a capacitor is expressed by

$$C = \frac{\epsilon A}{d}$$

Physical dimensions of the capacitor would be fixed, so the only remaining variable would be the dielectric medium. If some medium could be found which would instantaneously change its dielectric properties in response to an electric current, a solution would become feasible.

At this point, inspiration struck. Two long strips of aluminium foil were attached diametrically opposite one another to a fluorescent lighting tube, held tightly with rubber bands. Leads were connected from each of the plates of the capacitor thus formed, to a capacitance measuring multimeter. The resting capacitance was measured before the tube was switched on, at which point I noticed an instantaneous increase of capacitance – by a factor of more than ten. In order to exclude possible ac interference, I repeated the procedure with a dc supply loaded by an incandescent lamp. With great delight, I noticed an even greater increase.

A better prototype

Following many abortive attempts at trying to manufacture a flat glass envelope with multiple gas discharge elements, I abandoned further experiments

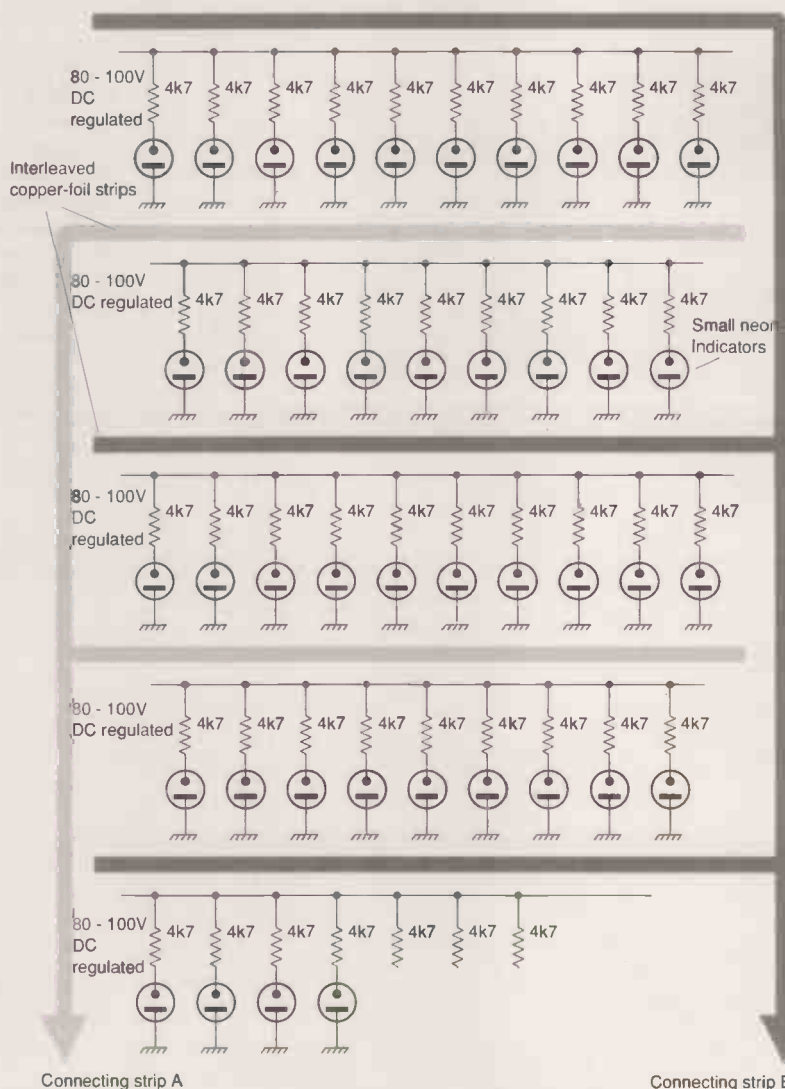


Fig. 1. In the prototype digital capacitor miniature gas discharge indicator tubes were switched to alter the capacitance between interlaced strips of copper foil. Capacitor elements were paralleled via connecting strips to alternate leaves.

until a job offer necessitated a translocation to England. With the greater availability of electronic resources here, I resumed my investigations. This work culminated in a prototype digital capacitor, illustrated in Fig. 1.

Figures 2 and 3 show the physical structure of the capacitor. In its resting state the capac-

itor recorded a reading of approximately 90pF on a digital multimeter.

I used the capacitor as a timing element in a 555 astable multivibrator circuit and took a series of measurements. As you will see from Graph 1, the change in apparent capacitance is clear. In addition, I repeated the experiment,

measuring the reactance with a square wave. Results are shown in Graph 2.

Energy required to produce this effect is almost certainly provided by the dielectric phenomenon, as can readily be shown by simply connecting the oscilloscope probes across the uncharged and isolated capacitor. By switching the tubes on and off rapidly with a square wave, a replica waveform of about 35V appears at the terminals. This effect is amplified by charging the capacitor. There is no dc component.

Although the material was very basic and the test equipment anything but professional, it appears that the plasma envelope does indeed enhance the dielectric properties. I could find no mention of this effect in standard physics texts. In my prototype, the gas envelope occupied only a small percentage of the volume between the plates, of less than 10%. By miniaturising the device to obtain the closest possible packing density, an enhancement by a factor of ten should be possible.

A practicable digital capacitor

Assuming a resting dielectric constant similar to the prototype and a diameter of 1mm per tube, a capacitor containing 65536 tubes would measure 256 by 256mm and have a resting capacitance of around 25nF. Whether a practical digital loudspeaker could be realised from this remains to be seen and will require further work.

Considering the intuitively appropriate nature of this dielectric enhancing phenomenon, it would be unlikely that it has remained unreported – especially taking into account that fact that this experiment could have been conducted a hundred years ago. Your comments would be very welcome.

I would like to express my thanks to Dr. M. Divine of Cranfield University, for his kind assistance. ■

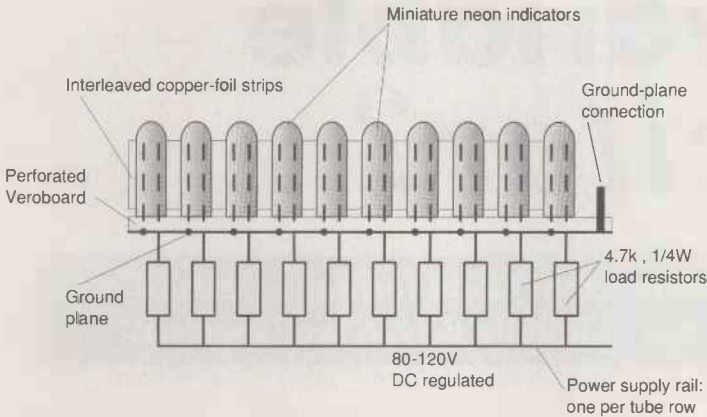


Fig. 2. Side view of the digital capacitor showing how the indicator tubes connect on one side to the Veroboard track and on the other, through the board, to current limiting resistors. There is one power supply rail per row of tubes.

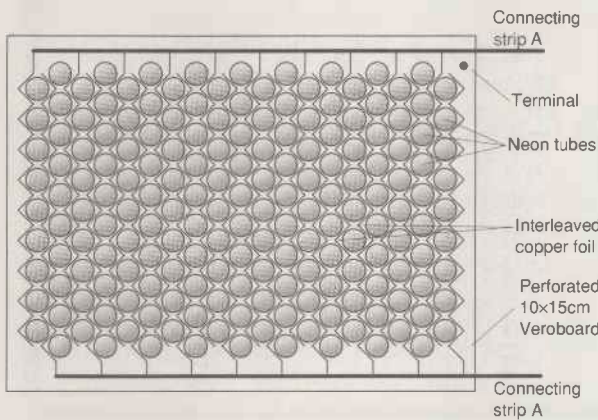
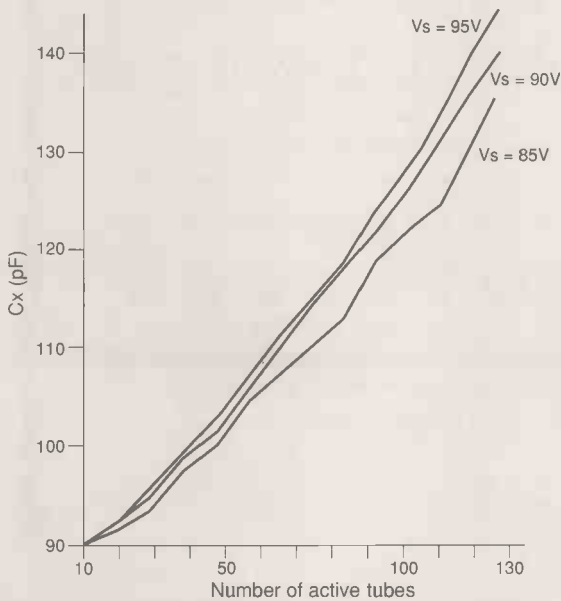
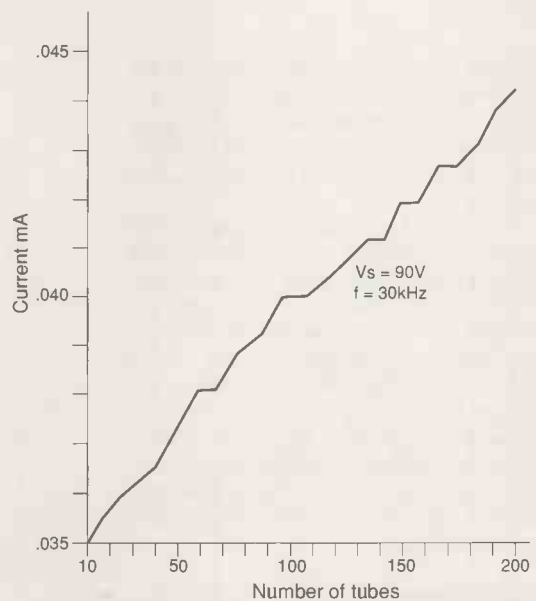


Fig. 3. Plan view of the digital capacitor's structure clearly shows how the copper strip sets form capacitor plates, between which are the neon indicators. Capacitance increases stepwise as each row of neons strikes.



Graph 1. Measurements taken after the variable capacitor was substituted for a timing capacitor in a 555 astable multivibrator.



Graph 2. Measuring varying reactance from Graph 1 with a square wave.

SYNTHESISED SIGNAL SOURCE

an innovative design from an established 'Off-Air' Company

- Custom designed chip set
- Sinewave output 0dBm into 50Ω
- Can be run independently or genlocked to external source
- dc to 16MHz in 0.1Hz steps, with option 0.0001 Hz steps
- Freestanding rack mounting, or OEM options available
- Increased resolution and increased stability options available

Models available October, contact us for prices

'OFF-AIR' FREQUENCY STANDARD



- * Provides 10MHz, 5MHz & 1MHz
- * Use it for calibrating equipment that relies on quartz crystals, TCXOs, VXCOS, oven crystals
- * Phase locks to DROITWICH (rubidium controlled and traceable to NPL)
- * For ADDED VALUE also phase locks to ALLOUIS (cesium controlled and traceable to OP — French eq to NPL)
- * British designed and British manufactured
- * Options available include enhanced receiver, sine wave outputs and 13MHz output for GSM. Prices on application.

Output frequencies — 10MHz, 5MHz, 1MHz
Short term stability — better than 1×10^{-8} (1 sec)
Typical — 4×10^{-9} (1 sec)
Long term — tends to 2×10^{-12} (1000 sec)
Call for 'Off-Air' Standard list

TEST EQUIPMENT

We are well known for our quality, new and used Test Equipment. Our list is extensive, ranging through most disciplines. Call for details and a complete list

HALCYON ELECTRONICS 

423, KINGSTON ROAD, WIMBLEDON CHASE, LONDON SW20 8JR
SHOP HOURS 9-5.30 MON-SAT. TEL 0181-542 6383. FAX 0181-542 0340

BROADCAST MONITOR RECEIVER 2

150kHz-30MHz



We have taken the synthesised all mode FRG8800 communications receiver and made over 30 modifications to provide a receiver for rebroadcast purposes or checking transmitter performance as well as being suited to communications use and news gathering from international short wave stations.

The modifications include four additional circuit boards providing *Rechargeable memory and clock back-up *Balanced Audio line output *Reduced AM distortion *Buffered IF output for monitoring transmitted modulation envelope on an oscilloscope *Mains safety improvements.

The receiver is available in free standing or rack mounting form and all the original microprocessor features are retained. The new AM system achieves exceptionally low distortion: THD, 200Hz-6kHz at 90% modulation — 44dB, 0.6% (originally — 20dB, 10%).

*Advanced Active Aerial 4kHz-30MHz *PPM10 in-vision PPM and chart recorder *Twin Twin PPM Rack and Box Units *Stabilizer frequency shifters for howl reduction *10 Outlet Distribution Amplifier 4 *Stereo Variable Emphasis Limiter 3 *Stereo Disc Amplifiers *PPM5 hybrid, PPM9 microprocessor and PPM8 IEC/DIN — 50/+6dB drives and movements *Broadcast Stereo Coders.

SURREY ELECTRONICS LTD

The Forge, Lucks Green, Cranleigh
Surrey GU6 7BG

Telephone: 01483 275997 Fax: 276477

TELFORD ELECTRONICS

- Admet 7404 UHF generator 0.1-1120MHz
Adevi 2730A — Frequency synthesizer 1MHz
Adevi 5104 — Driving synthesizer 90-120MHz
Advance 7W7Z — AC Voltmeter
Anacon Diode analyzer
Avo 2515/2 — AC/DC Breakdown leakage & Ionisation
Bainbridge 6127B — Programmable Scope calibrator
BJRC RIZ-90 JIN — Cellular tester
Boonton 8720 — Modulator meter
Boonton 97B — RF Millivoltmeter
Boonton 77B — Capacitance meter
Bradley 235 — Synthesised digital signal generator
Cohort 3131 — 15MHz Dual Oscilloscope
Data Tech 304 — Digital multimeter
Datron 1061 — Autocal digital multimeter
Datron 1061A — Autocal digital multimeter
Dutton 1054A — Autocal digital multimeter
Dutton 1030 — RMS Voltmeter
Dutton 1030A — RMS Voltmeter
Dutton 785S — DC Voltmeter
Dranetz J205 — Precision power & harmonic analyzer
Ducklin Escaped digital test meter
ERP EP545A — Microwave frequency counter
Farnell PS1000 — Synthesised signal generator 10kHz-1GHz
Farnell 556250 — Signal generator
Farnell TSF-70 MH11 — Power supply
Farnell CTS50711 — Insulation tester
Farnell L1302 — Power supply
Farnell TA2 — AC/DC Millivoltmeter
Farnell DM431 — Digital multimeter
Farnell 2085 — AF Power meter
Farnell DS61 — Synthesised signal generator
Farnell LPH2 — Sawtooth oscillator
Farnell MP90-90 — Auto ranging power supply
Farnell H60-50 — Auto ranging power supply
Farnell AP100-90A — Auto ranging power supply
Farnell AP100-90 — Auto ranging power supply
Farnell AP100-90A — Auto ranging power supply
Farnell AP100-90 — Auto ranging power supply
Feedback E6M4 — Electronic Watt meter
Fenograph RT52 — Recorder test set
Fluke 5200A — Programmable AC calibrator
Fluke 7281A — Universal counter/timer
Fluke 355D — DC Voltage standard/voltmeter
Fluke 8520A — Digital multimeter
Fluke 850A — Digital multimeter
Fluke 25 — Digital multimeter
Fluke 1953A — Counter/timer
Fluke 8000A — Digital multimeter
Fluke 5600A — Digital multimeter
Fluke 910A — Digital multimeter
G.R.C. 1222A — Trued amplifier & null detector
G.R.C. 1362 — 220-920MHz UHF Oscillator
Globet GR1101A — Signal generator 12-18GHz
Globet 8201 — 20MHz Pulse/function generator
Gould 05300 — 20MHz Oscilloscope
Gould 054000 — Oscilloscope
Gould 138 — Signal generator
- Gould DS0160A — 20MHz Oscilloscope
Gould TC314 — Timer counter
Gould 05250A — Oscilloscope
Gould 054000 — Oscilloscope
H. Wesley 5261 — Resistance bridge
Hiara RF2305 — Receiver exciter
Mitsubishi VC-4041 — Digital storage oscilloscope
HP HP10254A — Serial to parallel converter
HP HP11713A — Attenuator/variable driver
HP HP11879B — Amplifier switch
HP HP11879A — Amplifier switch
HP HP11220A — 15MHz Oscilloscope
HP HP1415 — Display section
HP HP1418A — Oscilloscope
HP HP1604A — Logic state analyzer
HP HP1725A — 275MHz Oscilloscope
HP HP1727A — 275MHz Oscilloscope
HP HP1740A — 100MHz Oscilloscope
HP HP1741A — Oscilloscope
HP HP1818A — Microwave C/W 100dB + 182SA
HP HP1818A — Oscilloscope
HP HP2053A — Function generator
HP HP3101A — HF/RF Transmitter
HP HP3225A — VHF generator
HP HP3325A — Synthesised/function generator
HP HP3330B — Automatic synthesizer
HP HP3335A — Synthesised level generator
HP HP3344A — Distortion analyzer
HP HP3400A — RMS voltmeter
HP HP3405A — Broadband sampling voltmeter
HP HP3451A — Digital voltmeter
HP HP3456A — Digital voltmeter
HP HP3465B — Digital voltmeter
HP HP3480A — Digital voltmeter
HP HP3490A — Multimeter
HP HP35677B — 5-Portmeter test set 100kHz-200MHz
HP HP3570A — Network analyzer
HP HP3571A — Tracking spectrum analyzer
HP HP3580A — Selective voltmeter
HP HP3581C — Selective Voltmeter
HP HP3582A — Spectrum analyzer
HP HP3591A — Selective voltmeter
HP HP3700A — Universal counter/timer
HP HP3702A — Data generator
HP HP3721A — Error detector
HP HP3727B — Telephone line analyzer
HP HP3964A — Instrumentation recorder
HP HP4200A — Oscillator
HP HP4311C — Signal generator 12-18GHz
HP HP 4323C — Power meter
HP HP 4332A — Distortion meter
HP HP4341A — Calibrator power meter
HP HP435A — Power meter
- HP HP461A — Amplifier
HP HP489A — Microwave amplifier
HP HP491C — Microwave amplifier
HP HP500A — Spectrum analyzer
HP HP500A — Spectrum analyzer
HP HP5150A — Thermal printer
HP HP52451 — Electronic counter
HP HP52461 — Electronic counter
HP HP5254C — Frequency counter 15-3GHz
HP HP5254A — Frequency counter 8.18GHz
HP HP5303A — 50MHz universal counter
HP HP5304A — Timer counter
HP HP5278A — Universal counter
HP HP5335A — Universal counter
HP HP5341A — Microwave frequency counter
HP HP5378B — Universal time interval counter
HP HP5378A — ASC 11 to parallel converter
HP HP5930A — Relay analyzer
HP HP5930A — RF switch
HP HP 59313A — A/D converter
HP HP5931A — HP18 voltmeter D/A/PSU/Programmer
HP HP6023A — DC power supply
HP HP6272A — DC power supply (0-20V/0-1A)
HP HP6130C — Digital voltage source
HP HP6261B — DC power supply
HP HP6318 — Test oscillator
HP HP6444A — Sweeping signal generator
HP HP646A — Phase amplitude tracking detector
HP HP6702B — Meter calibrator
HP HP7530A — Graphs plotter
HP HP8005S — Digital voltmeter
HP HP8018A — Pulse generator
HP HP8108A — Pulse generator
HP HP8154A — Pulse generator
HP HP8161A — Programmable pulse generator
HP HP8403A — Modulator
HP HP8410A — Network analyzer
HP HP8411A — Harmonic frequency converter
HP HP8412A — Tracking magnitude display
HP HP8412B — Phase magnitude display
HP HP8413A — Phase gain indicator
HP HP8414A — Polar display
HP HP8414A — Auxiliary display holder
HP HP8418A — Tracking generator/counter
HP HP8444A — Tracking generator 0.5-1.3GHz
HP HP8445 — Automatic generator
HP HP8447B — 0.1-1300MHz amplifier
HP HP8447A — Pattern generator
HP HP8477A — Calibrator
HP HP8414A — Signal generator
HP HP8440B — RF plug-in 12.4-18GHz
HP HP8445 — Signal generator
HP HP8480 — Signal generator 5.4-12.4GHz
HP HP8490B — Sweep oscillator
HP HP8709B — Synchronizer
HP HP8717A — Transmission bias supply
HP HP8740A — Transmission test unit
HP HP8741A — Reflection test unit 0.1-2.0GHz
HP HP8742A — Reflection test unit 2.0-12.4GHz

- HP HP8743B — Reflection transmission test unit 18GHz
HP HP8745A — S-Parameter test set 0.1-2.0GHz
HP HP8750A — Storage normalizer
HP HP8910A — Modulation analyzer
Hirochi VS508 — 50MHz Oscilloscope
Iwatsu DMS-6430 — Digital memory scope
Iwatsu SAS-8130 — Waveform analyzer
Iwatsu SS-5416A — Multimeter
Keithley 2100 — Multimeter
Keithley 177 — Microvolt digital multimeter
Keithley 179 — TRMS Digital multimeter
Keithley 179/20A — TRMS Multimeter
Kemo DP1 — 1Hz-100MHz phase meter
Kikusui PL210 — Electronic load 100W 1.5-120V
Kikusui TOS850 — W/ Auto Tester
Kikusui PL21027W — Power supply DC input 1000W
Kroh-Hite 1302A — Function generator
KSM 175 — Pulse generator
Leader LDC-7005 — Oscilloscope calibrator
Leader LCR-74C — LCR bridge
Levett 1703B — AC Micro voltmeter
Lyons PG-2B — Pulse generator
Lyons PG-13N — Pulse generator
Lyons PG-21N — Pulse generator
Lyons PG-22 — Pulse generator
Marconi TR690A — RF Power meter
Marconi TR8310 — AF Power meter
Marconi TR2019A — Signal generator 80kHz-104MHz
Marconi TR2020A — Signal generator 10MHz
Marconi TR2021 — Digital line monitor
Marconi TR2308A — Power analyzer
Marconi TR4601 — Power meter
Marconi TR5460 — Power meter
Marconi CA2705A — PCM Regenerator test set
Marconi TR2091C — Noise generator
Marconi TR2170B — Network synchronizer
Marconi TR2173 — Digital synchronizer
Marconi TR2169 — Pulse modulation meter
Marconi TR2000 — AF Oscillator
Marconi TR6567 — Levelling amplifier
Marconi TR2424 — Frequency counter
Marconi TR2430 — 80MHz Digital frequency meter
Marconi TR2431 — 20MHz Digital frequency meter
Marconi TR2432 — 50MHz Digital frequency meter
Marconi TR5550B — Programmable power meter
Marconi TR5550B1 — Programmable power meter
Marconi TR2437 — 100MHz Universal counter timer
Marconi TR2883A — Digital line monitor
Marconi TR6050A — Frequency meter
Marconi TR2171 — Universal bridge
Marconi TR2828A — Digital synchronizer
Marconi TR8281 — Channel access switch
Marconi TR2830 — Multiplex tester
Marconi TR2807A — PCM Multiplex tester
Marconi TR2829 — Digital analyzer
Marconi TR2175 — RF Power amplifier
Marconi TR2829 — PCM Digital analyzer
Marconi TR2825 — AF Oscillator
Meguro M6142A — Jitter meter
- Millicec MV872A — RF Millivoltmeter
MSI Capacitors meter/PCV plotter
Norma DS155 — AC Power analyzer
Norma DS154 — Auto function meter
Norma D4155 — Precision Watt meter
Philips DM5132 — Function generator 0.1Hz-2MHz
Philips PM93 — 50MHz Scopemeter
Philips PM661 — Universal counter 250MHz
Philips DM5250 — Microchronome test generator
Philips PM342 — Sweep generator
Philips PM423 — Digital multimeter
Philips PM5715 — TRMS Multimeter
Philips PM3055 — Oscilloscope 30MHz
Philips PM307 — RCL bridge
Philips PM5108 — 1Hz-1MHz Function generator
Philips PM321 — Automatic multimeter
Philips PM7841 — Power meter
Philips PM7832 — SWR Meter
Philips PM500B — PAL Colour TV pattern generator
Philips PE1511 — Power supply 0-30V/1A
Poladrad 1105B — Signal generator 0.80-2.4GHz
PSI A102 — Waveform generator
PSI A100 — Waveform generator
PSI 3151 — Function generator
PSI A102 — Waveform generator
R&S UR15 — Millivoltmeter 10kHz-2GHz
R&S 5404X — Signal generator 10kHz-130MHz
Racal 9900 — Modulation meter
Racal 9918 — UHF Frequency counter
Racal 1998 — Frequency counter
Racal 9903 — True RMS RF Level meter
Racal 9939 — UHF Frequency meter
Racal 9914 — VHF Frequency meter
Racal 9916A — RF Millivoltmeter true RMS
Racal 9906A — 200MHz Universal counter
Racal 1792 — HR Resistor
Racal 1778 — RF Receiver
Racal 5004 — Digital multimeter
Racal 5003 — Digital multimeter
Racal 1550 — Delay pulse generator
Racal 110 — GPIB Interface
Racal MA1105 — Bargraph
Racal 9500 — Timer/counter
Racal 4800 — Digital voltmeter
Racal 1700 — Universal patch controller
Racal 4022 — 100MHz Oscilloscope
Racal 4600 — Digital multimeter
Racal 9932 — Instrument Interface
Racal 9523 — VLF Counter/timer
Racal 9105 — RF Micro Watt meter
Racal 9053 — Selective Analyzer HF
Racal 9059 — Frequency reference meter
Racal 9028B — Signal generator
Racal 5001 — Digital multimeter
Radford DM52-2 — Low distortion measuring set
Radford L204 — Low distortion oscillator
Radford GR230X — Drive unit
Reddon SD1 — Drive unit
- Reddon WK218Z — Marine digital watch receiver
Rhode & Schwarz SF72 — Noise generator
Rhode & Schwarz Signal generator 10kHz-130MHz
Roland DFR-22 — Frequency counter
Roland DC-D11-885 — Plotter
Seymour 261 — 600MHz Frequency counter
Schlumberger 4419 — Function generator
Schlumberger A220 — Digital multimeter
Schlumberger 7022 — Microprocessor voltmeter
Schlumberger 1170 — Frequency response analyzer
Schlumberger 2712 — Universal counter
Siemens U2155 — Level meter
Siemens U2155 — 200Hz-400kHz Level meter
Sony/Tektronik TR438B — Data analyzer
Sound Technology 1100B — Distortion measurement system
Syrton Donner SD00A — Sweeper C/W 7000 display unit
Syrton Donner M107 — Precision DC voltage source
Tektronik TEK212 — Oscilloscope
Tektronik TR465 — Oscilloscope
Tektronik TEK577 — Curve tracer
Tektronik TR464A — Oscilloscope
Tektronik TR191 — Signal generator
Tektronik TR106 — Square wave generator
Tektronik TR214 — Storage oscilloscope
Tektronik TR465 — Oscilloscope
Tel equipment 034 — Oscilloscope
Tel equipment 067A — Oscilloscope
Tel equipment DR3 — Oscilloscope
Tel equipment D1011 — Oscilloscope
Tel equipment TG1000 — Triding generator
Tascon TS505B — Sweep generator
Thunder TA2160 — 20MHz Logic analyzer
Trio CS-1566A — 20MHz Oscilloscope
T&G SW Level generator 10kHz-110MHz
W&G PS12 — 200Hz-4.5MHz Level generator
W&G SP412 — Level meter
WB3 SA1322 — Signal meter
WB1 FTK232 — Tape converter
Wavelek 107A — Signal generator 7-12GHz
Wavelek 185 — 5MHz Logic/level generator
Wavelek 147 — HF Sweep generator
Wavelek 164 — 30MHz Sweep generator
Wayne Kerr 8900 — Automatic bridge
Wayne Kerr 8522 — Component bridge
Weinchel 1810A — Stabilized RF ratio meter
Wit 413 & 460 — Power supply
Wilson S01 — Level meter

AN EXTENSIVE RANGE OF TEST EQUIPMENT IS AVAILABLE. PLEASE SEND FOR OUR NEW CATALOGUE — Postage and packing must be added. Please phone for price. VAT @ 17.5% to be added to all orders. Please send large SAE for details.

Telford Electronics, Old Officers Mess, Hoo Farm, Humbers Lane, Horton, Telford TF6 6DJ
Tel: 01952 605451 Fax: 01952 677978



Field Electric Ltd.

Tel: 01438-353781 Fax: 01438 359397

Mobile: 0836-640328

Unit 2, Marymead Workshops,
Willows Link, Stevenage, Herts, SG2 8AB.



Sony New 1.44Mb 3.5" D/Drives	£14.50 c/p £2.50
Sony 9" Super Fine Pitch Trinitron RGB VDU	£35 c/p 12.50
AT Keyboards for IBM Compatibles	£7 c/p 3.50
IDE Hard Disk Drives 40Mb upwards from	£24.95
12" Colour SVGA 800 x 600 NEC	£45.95 c/p 14
Marconi Inst = 2830 Multiplex Tester	£300
Marconi Inst = Data Comms Tester	£385
Marconi Inst = Digital Line Monitor	£350
Marconi Inst = Digital Analyser	£375
Farnell PSU 0-70V 0-5A/0-30V 0-10A	£245
Siemens Data Line Analyser K1190	£375
Avo AC/DC Breakdown/Ionisation Tester RM 215L1	£200
Tektronix DAS 9100 Digital Analysis System	£175
Tektronix 7CT 1N Curve Tracer	£295
Tektronix 7A15A Amp	£150
Tektronix 7511 Diff = Comp =	£100
Tektronix 7A13	£140
Tektronix 7603 with DF2 + 7DOI Logic Analyser	£350
Wandell & Golterman PMP20 Level Meter	£90
IBM 486 SLC2-50 486 Computer c/w K/Board, Mouse, 5Mb Ram, 1-44, 70Mb H/Disk	£250
12 VAC 200 Watt Transformer	£15
27 VAC 130A Transformer New	£18
7 VAC 130A Transformer New	£18

PLOTTERS · COMPUTERS · COMMUNICATIONS · PSU · VDU'S · VIDEO ·
FANS · TEST · CABLE · NETWORK · PRINTERS ·
DISK DRIVES ALWAYS IN STOCK.
OVERSEA'S ENQ. WELCOME.
TELEPHONE ORDERS ACCEPTED.
C/P DETAILS PLEASE RING.
ALL PRICES PLUS 17.5% VAT.

CIRCLE NO. 121 ON REPLY CARD

The Balance Box

Microphone or line level amplifier for
balanced or unbalanced signal lines

Professional portable units operating from an internal
PP3 battery or external DC supply



★ Precision true floating transformers balanced input and output at microphone or line level ★ Simple interfacing and conversion between balanced and unbalanced signal lines ★ Low noise and distortion ★ High common mode rejection ★ Switchable gain selection ★ Extensive RFI protection

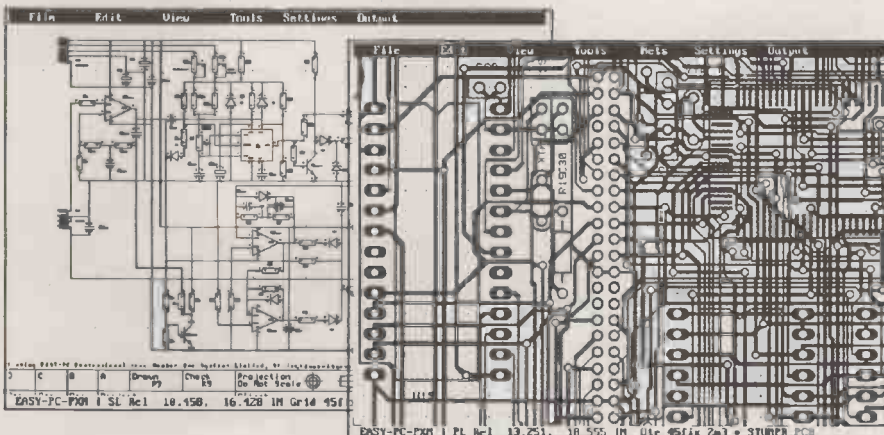
The Phantom Power Box – The Headphone Amplifier Box – The OneStop DIN rail mounting radio frequency interference filter and voltage transient protector for voltage and current loop process signal lines

Conford Electronics Conford Liphook Hants GU30 7QW
Information line: 01428 751469 Fax: 751223

CIRCLE NO. 122 ON REPLY CARD

EASY-PC Professional XM Schematic and PCB CAD

From Super Schematics



To Perfect PCB's

Number One Systems

UK/EEC: Ref: WW, Harding Way, St.Ives, Cambridgeshire, ENGLAND, PE17 4WR. Email: sales@numberone.com
Telephone UK: 01480 461778 (7 lines) Fax: 01480 494042 International +44 1480 461778

USA: Ref: WW, 126 Smith Creek Drive, Los Gatos, CA 95030
Telephone/Fax: (408) 395-0249



CIRCLE NO. 123 ON REPLY CARD

Design lab bytes

Tina is a pc-based circuit design lab with virtual instrumentation including scope and spectrum analyser. Until now it has bubbled under as a DOS package, but **Clive Ousbey** believes that the new Windows version poses a serious threat to the competition.

Recent years have seen a greater use of simulators as an aid to electronic design. This has been due largely to easier to use graphically driven systems. While being powerful in experienced hands, older style netlist entry types of simulator were not user friendly. On the other hand, the early graphics-based programs that were easier to use were either expensive 'professional' systems or lacked much power or flexibility.

TINA for Windows, version 4, from DesignSoft, is the latest simulator package attempting to close this gap. An acronym for Toolkit for Interactive Network Analysis, *TINA* is a Hungarian product that has existed in a DOS form for several years. Until now, it has had quite a low profile in the UK. In order to address these problems, the makers have appointed a new distributor to market the significantly enhanced new Windows version.

TINA's graphical interface is similar in style to its main competitor *Electronics Workbench*, but offers a wider variety of output presentation, greater flexibility, optional instrumentation hardware and more extensive analysis options. The latter gives it a functionality more in line with something like PSpice.

Circuit capture facilities

The schematic editor is normally used for working on a circuit for analysis.

The alternative is to import a PSpice type netlist: exporting is also a possibility. *TINA* has an editor which is easy to use and operates as you would expect a Windows program to work.

Component symbols are selected from tabbed groups on the tool bar. In some cases, a generic symbol is not appropriate. Clicking the symbol icon instead opens a list of related parts to choose from. The symbol can be rotated or mirrored and its properties modified, either while placing or at any time thereafter. Various parameters relating to the component can be edited – value or tolerance for example – via the properties window.

In addition to the usual components, there are various others to aid building and simulating a circuit. These include voltage sources, jumpers allowing separate parts of the circuit to be connected by a signal name and the ground symbol that must always be present.

Input and output can be slightly confusing due to the variety of ways it can be achieved, depending on the type of analysis required. For measuring basic signal input and output, there are voltage or current generators, various meters and voltage test pins available. A selection of signal types can be applied to the input – including the option of a user-defined waveform.

Virtual function and digital signal generators are available to provide stimulus. For more complex analysis, a

Tina's vital statistics

Editors

Schematic and netlist editors
Text and equation editors with interpreter

Presentation

Bode plots and Nyquist diagrams
Transient response plots and digital waveforms
Linear or log scales

Analysis

Fourier
DC, with automatic circuit optimisation
AC, with complex V , I , Z and power analysis
Transient analysis for analogue and mixed mode
Symbolic analysis gives closed form expressions

Simulation

Analogue, digital and mixed-mode

Stimulation

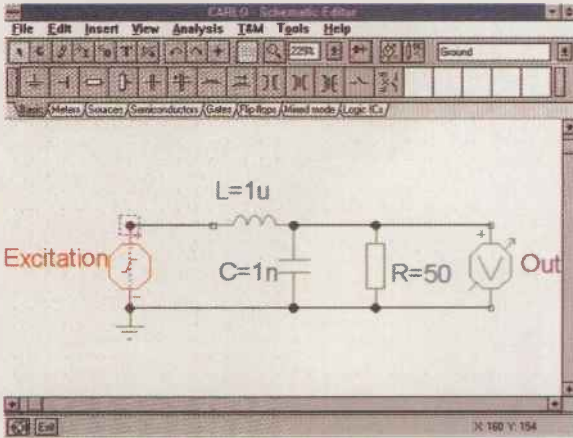
Standard and user-defined circuit excitation

Virtual instruments

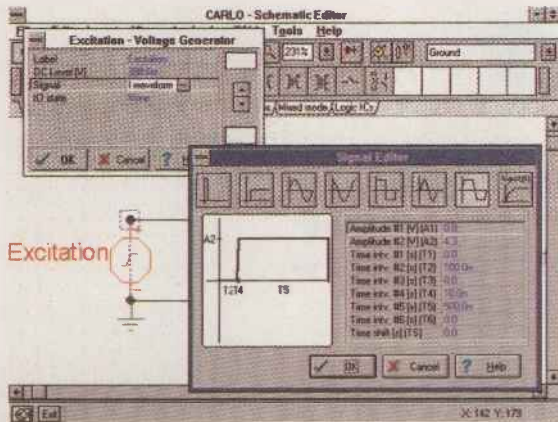
Signal analyser
Storage oscilloscope
Function generator
Logic analyser
Digital multimeter
Digital signal generator

Hardware options

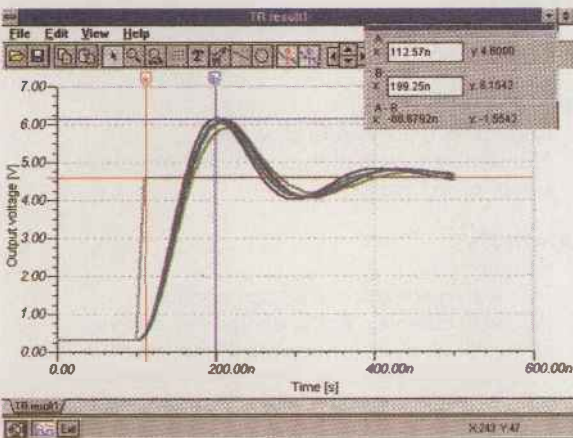
PC measurement expansion card
Experimenter box with plug-ins



Main editing window with example RLC circuit.



Setting up non-ideal step excitation.



Output graph showing result of transient analysis with Monte Carlo tolerance sweeping (5 runs only), the step input and the cursors can also be seen.

special input, and or output, need to be added.

To enhance presentations, teaching materials or other literature, text – including mathematical expressions – may be added to the circuit diagram. Pressing F9 automatically inserts the component value as a label on the diagram. Alternatively, the component label can be entered manually and customised.

Symbols are connected with the wiring tool and this is one of TINA's weaker features. While better than some packages, when first wiring up a circuit in the usual way, care is needed as it is reasonably easy to fail to connect things up.

DesignSoft is currently working on improvements in this area which I am told will be ready by the time the production version becomes available. Even so, using the mouse in conjunction with 'hot keys' makes wiring much easier. Also, if a circuit element is not connected, it is highlighted before analysis, and pressing DEL gets rid of any extra wires.

Wiring is made up of vertical or horizontal segments. These can start or end on any grid point – not just at pins. Segment lengths can be changed but if a mistake is made it is probably easier to delete the original and add a new segment of wire. This also means that if a component is moved the wiring stays put, unless all the wiring segments are selected as well. Moved components then have to be reconnected and the original wires deleted.

The above problem is only relevant when one component is moved. You can move whole circuits or circuit segments and the wires stay connected. DesignSoft says it is currently working on an upgrade involving rubber banding, which will solve this inelegance.

With the exception of the virtual instruments, almost all analysis is controlled from the menu. The usual Windows type dialogue/control boxes make it reasonably easy.

Analyses include mixed-mode

There are three basic types of analysis – namely digital, analogue and mixed mode. For a purely digital circuit you can choose whether or not to look at delays, but all high/low transitions are considered ideal – i.e. almost instantaneous. In analogue mode, a full simulation takes place and in mixed mode, propagation delays of the digital parts is also taken into account.

A digital-only circuit can optionally be run in mixed mode. In mixed-mode analysis, again you can choose to include delays, but in this case, rise times and slopes are calculated. In analogue modes, options include dc, ac, transient and noise. Having run a transient analysis, a Fourier series or spectrum can be obtained via the process menu.

Particular component parameters can be swept to determine their effect on a circuit. The component can also be optimised to a target or maximum/minimum value. Component tolerances can also be varied using various distributions or worst case. This is useful for seeing how sensitive a circuit will be to

real component variations.

The analysis can be run at any desired temperature or swept over a range of temperatures. There is also the option of running a PSpice analysis by first generating a netlist.

Output facilities

Standard analysis output is a graph, or set of graphs, in a new window. There is also the option of using a virtual multimeter, oscilloscope, signal and logic analyser.

The graphs windows allows the placing of a moveable cursor that can track any curve to obtain the x and y values. To aid presentation, etc lines and circles can be drawn on the graph as well as text and labelling. The graphs can be rescaled and the annotation of axes can be changed before printing.

Libraries

A library catalogue compiler – running in DOS only – is available, allowing users to add their own parts into the library. This was not included in the review release.

The method as described in the manual uses a text file that contains the various component modelling details as well as symbol drawing directives. This is compiled into the binary catalogue that TINA uses.

Additional features include matching hardware

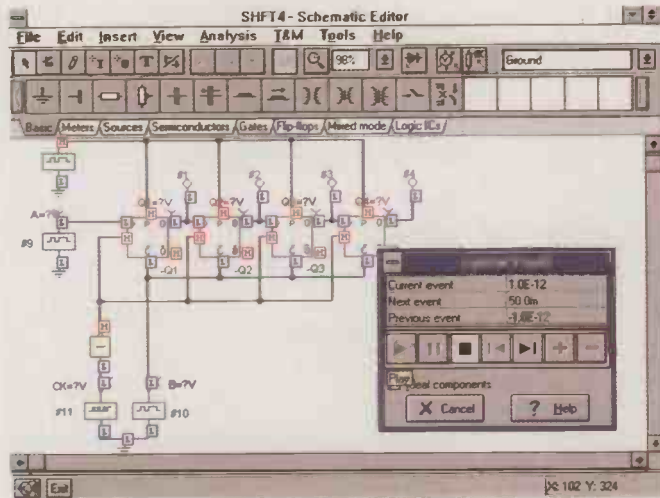
A mathematical interpreter is provided to allow the entry and evaluation of expressions and equations. Other uses include plotting results and defining arbitrary signals for circuit stimulation.

As already mentioned there are also features included that can assist in the teaching of electronics. There are modes for training and examination that provide for students' exercises pre-assigned by a lecturer. Fault simulation is also a useful feature for the teaching environment.

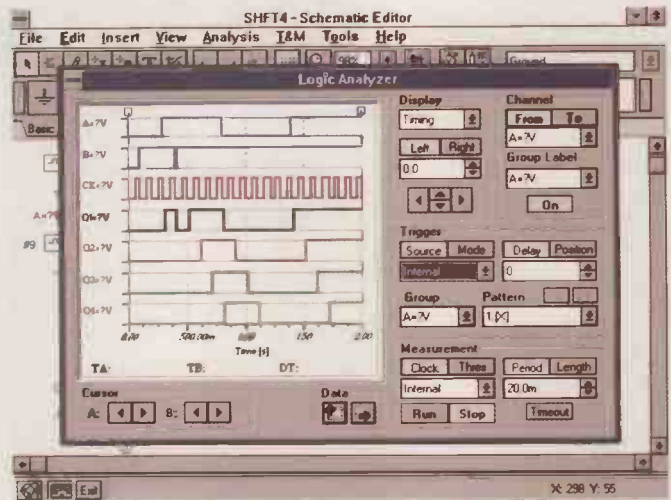
Matching hardware, for use with TINA, is available but was not reviewed. A plug-in instrumentation PC card – known as TINAlab – provides a multimeter, oscilloscope and signal generator under TINA's control. User interfacing for these features is provided by the virtual instruments. This allows a real circuit to be built and directly compared with the simulated version.

Further available hardware includes an experimenter box with a breadboarding area that connects to TINAlab. This also has a slot for plug-in modules such as a fault insertion card or a digital measurement card.

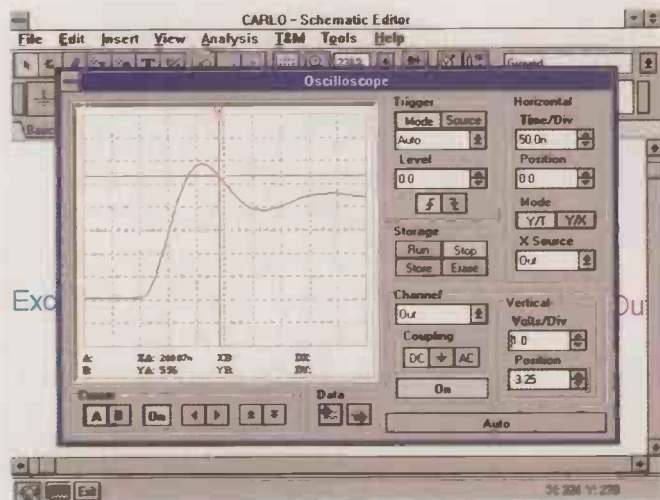
This feature of matching hardware for real world interfacing is something quite rare in simulators and provides new scope to their use.



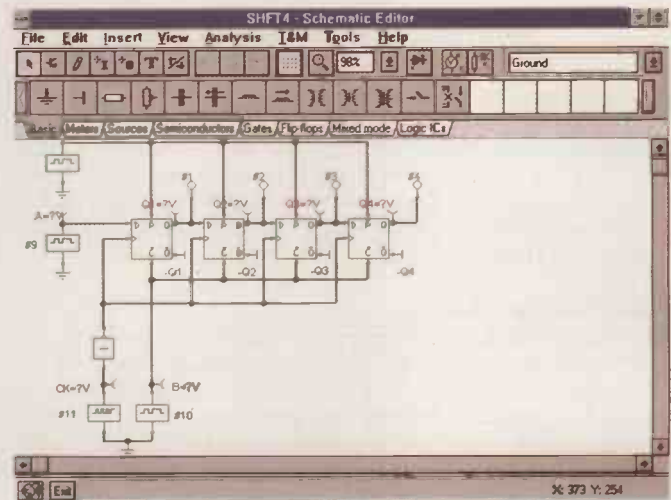
Four-stage shift register showing logic states of nodes and step-by-step analysis control control.



Virtual logic analyser showing resulting states of shift register circuit.



Virtual oscilloscope showing response of RLC circuit.



4 stage shift register.

Capabilities, requirements and manuals

TINA's capacity is stated as being 1000 components and 2000 nodes, dependent on memory. But the actual relationship between capacity and memory size is not given. The minimum specification for the package is a 386SX running Windows 3.1.

Generally, the manuals are good, but some areas are not explained very well. For example, the different methods of input and output are not made clear. On the other hand, good attention is paid to the various components and to the simulator itself. Appendices covering the library compiler, interpreter, additional hardware and the educational aspects are also good.

I found some inconsistency in the getting started section. The screen shots did not always show what had been described in the text. For example, a meter symbol that has been

placed on a circuit as instructed in the text is different from that shown in the screen shot.

In summary

Overall this is an excellent package, versatile, value for money and easy to use. It poses a serious threat to the competition. TINA scores particularly well with the ability to take into account tolerances, do parameter sweeping and being able to define new symbols as well as simulation models.

The features to aid training and presentations are very good and the additional instrumentation hardware could be very useful.

The supplier has indicated various forthcoming features which - if they don't fall into the everlasting 'coming real soon' category of upgrades - will usefully enhance TINA.

Top of the list must be an interface to a pcb layout tool. This is a natural pro-

gression as what often happens is that a simulated circuit has to be re-entered into the pcb system before layout can commence. Improvement to the schematic editor giving 'rubber banding' of the connections is also promised.

Macros or the ability to make sub-circuit blocks from a circuit to give a form of hierarchical design could make the handling of larger circuits easier.

Although not mentioned, the ability to have component parameters visible or not would be very useful instead of having to enter them separately as a text label or automatically via the F9 function key.

Beyond these features, what would make a very interesting application would be the ability to use the simulator itself as a sub-circuit. That is by using the hardware to take input from and provide output to the real world TINA would act as a virtual breadboard. ■

Free circuit design software

TINA for Windows

This month's cover disk* is a working, interactive version of TINA for Windows. Newly launched, this comprehensive package is an electronics toolkit integrating all the functions needed for the design, development and test of electronic circuits. TINA makes it easier and faster to simulate circuits with realistic characteristics.

TINA comprises a software simulation and analysis package, together with a complete range of 'virtual' test and measurement instruments for testing design theories as well as breadboards, prototypes or any other electronic product.

The demonstration version of TINA presented free with this issue of *Electronics World* allows circuits of any size to be constructed but analysis only works on a limited number of nodes. Save and print facilities are also disabled.

PSpice compatibility

Unlike many circuit design systems, TINA can save your designs as an industry standard PSpice format netlist – which means that design concepts are based on the specifications of actual components. This makes simulation more realistic and the identification of faults easier. It also simplifies 'what if' questions, and allows different components to be tested quickly, easily and without the need to build breadboards. This obviously saves considerable time, as well as the cost of components.

Comprising all the necessary hardware and software, Tina is a complete system which allows digital, analogue or mixed-mode circuits to be simulated. Tina is also a powerful analytical tool and can perform AC, DC or transient analysis as well as noise, tolerance and Fourier analysis.

Comprehensive library

A comprehensive library of components contains power supplies, resistors, capacitors, inductors, amplifiers, switches, etc. Using familiar Windows-style commands, these are simply selected, dragged and dropped into the desired circuit diagram. Component values can then be changed to create and test the feasibility of the ideal circuit.

The library features digital components, including a large selection of TTL and CMOS standard devices.

Low price

Tina, is very cost effective. A single copy of the software costs only £299 and a 20-user site licence is only £1,800, excluding hardware. Special discounts are available for educational establishments.

For further information contact: Tandem Technology Limited, Breadbare Barns, Clay Lane, Chichester, West Sussex, PO18 8DJ, telephone: 01243 576121 fax: 01243 576119, e-mail 101626.3234@compuserv.com.

*Available to UK readers only.



Virtual instruments – supplied with the Tina circuit design tool is a complete range of test and measurement 'virtual instruments' – including a function generator, multimeter, power supply and oscilloscope. These are used to analyse test circuit designs as well as providing real time test and measurement of actual circuits, prototypes and breadboards. The benefit of these 'virtual' instruments is that they operate via the PC. This makes it easy to incorporate measurement values into calculations and analyses.

Until 4 October, this voucher is worth £100 off TINA's normal price of £299 excluding VAT and delivery. Simply send this voucher together with £237.93 – fully inclusive – to Tandem Technology Limited, Breadbare Barns, Clay Lane, Chichester, West Sussex, PO18 8DJ. Telephone: 01243 576121 fax: 01243 576119, e-mail 101626.3234@compuserv.com.

Loading your free software

Full instructions on loading the demonstration version of Tina are given in the README.TXT file on the disk. This file is accessed by inserting the disk in drive A and double-clicking on the file under Windows' File Manager. Once the software is installed, this read-me file appears as a Windows icon.

SEETRAX CAE RANGER PCB DESIGN

WITH COOPER & CHYAN AUTOROUTER

RANGER3 - DOS £2500
- Windows\NT £2900

RANGER2 £150

Hierarchical or flat schematic linked to artwork.
 Unlimited design size, 1 micron resolution
 Any shaped pad, definable outline library
 Pin, gate & window swapping - auto back annotation
 Split power planes, switchable on - line DRC

Upto 8 pages of schematic linked to artwork
 Gate & pin swapping - automatic back annotation
 Copper flood fill, Power planes, Track necking,
 Curved tracks, Clearance checking,
 Simultaneous multi-layer auto-router

COOPER & CHYAN SPECCTRA

autorouter (SP2)
 Inputs: OrCAD, Cadstar,
 PCAD, AutoCAD DXF

RANGER2 UTILITIES £250

COOPER & CHYAN SPECCTRA auto-router (SPI)
 Gerber-in viewer, AutoCAD DXF in & out

Outputs: Postscript, Windows bit map

R2 & R3 Outputs: 8/9 & 24 pin printers, HP
 Desk & Laser Jet, Cannon Bubble Jet,
 HP-GL, Gerber,
 NC Drill, AutoCAD DXF

UPGRADE YOUR PCB PACKAGE

TO RANGER2 £60

TRADE IN YOUR EXISTING PACKAGE TODAY

Seetrax CAE, Hinton Daubnay House, Broadway Lane, Lovedean, Hants, PO8 0SC
 Call 01705 591037 or Fax 01705 599036 + VAT & P.P

All Trademarks Acknowledged

CIRCLE NO. 124 ON REPLY CARD

8 CAVANS WAY,
 BINLEY 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)

MISCELLANEOUS

Anritsu ME462B - DS-3 transmission analyser	£3000
Anritsu MG642A - Pulse pattern generator	£1500
Barr & Stroud - EF3 variable filter (0.1Hz-100kHz)	£150
Datalab DL 1080 - Programmable Transient Recorder	£350
Datron 1061 - Precision multimeter	£650
Dynapert TP20 - Intelliplace tape peel tester, immac. cond.	£1950
E.I.P. 331 - 18GHz frequency counter	£850
E.I.P. 548A - Frequency counter (26.5GHz)	£2750
Farnell SSE520 - Signal generator (10-520MHz)	£400
Farnell TSV70 Mkl - Power Supply (70V-5A or 35V-10A)	£225
Fluke 5200A - A.C. calibrator	£2500
Fluke 5205A - Precision power amplifier	CP.O.A.
Fluke 7105A - Calibration system (As new)	CP.O.A.
Heiden 1107 - 30v-10A Programmable power supply (IEEE)	£650
Hewlett Packard 334A - distortion analyser	£300
Hewlett Packard 339A - distortion measuring set	£1500
Hewlett Packard 432A - Power Meter (with 478A Sensor)	£275
Hewlett Packard 435A or B - Power Meter (with 8481A/8484A)	from £750
Hewlett Packard 5328A - 100MHz universal frequency counter	£250
Hewlett Packard 3325A - 21MHz synthesiser/function gen.	£1500
Hewlett Packard 3437A - System voltmeter	£350
Hewlett Packard 3438A - Digital multimeter	£200
Hewlett Packard 3455A - 6 1/2 digit multimeter (autoscal)	£750
Hewlett Packard 3456A - Digital voltmeter	£750
Hewlett Packard 3488A - HP-IB switch/control unit (various plug-ins available)	£650
Hewlett Packard 3490A - Digital multimeter	£250
Hewlett Packard 3711A/3712A/3791B/3793B - Microwave link analyser	£2995
Hewlett Packard 3746A - selective level measuring set	£1750
Hewlett Packard 3776A - PCM Terminal test set	CP.O.A.
Hewlett Packard 3779 A/C - Primary Mix analyser	£600/£1500
Hewlett Packard 4271B - LCR meter (digital)	£900
Hewlett Packard 4342A - O meter	£995
Hewlett Packard 4948A - transmission impairment measuring set	£2000
Hewlett Packard 4953A - Protocol analyser	£2500
Hewlett Packard 4954A - Protocol analyser	£2750
Hewlett Packard 5314A - (new) 100MHz universal counter	£250
Hewlett Packard 5342A - Microwave freq. counter (18GHz)	£1500
Hewlett Packard 5359A - Time synthesiser	CP.O.A.
Hewlett Packard 5385A - Frequency counter 1GHz (HPIB) with Opts 001/003/004/005	£995
Hewlett Packard 5505A - Laser display	CP.O.A.
Hewlett Packard 6002A - autoranging 50V-10A	£650
PSU	£1500
Hewlett Packard 6034A - System P.S.U. 0-60v /10a	£1500
Hewlett Packard 6181C - D.C. current source	£150

TELNET

Hewlett Packard 6261B - Power supply 20V-50A £450
 DISCOUNT FOR QUANTITIES

Hewlett Packard 7402 - Recorder with 17401 A x 2 plug-ins	£300
Hewlett Packard 8005B - Pulse generator	£250
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 8165A - 50MHz programmable signal source	£1650
Hewlett Packard 8349B - Microwave broadband Amp (as new)	£4250
2-20MHz	£2500
Hewlett Packard 8350B - Sweep oscillator mainframe (plug-ins avail)	£500
Hewlett Packard 8403A - modulator	£400
Hewlett Packard 8620C - Sweep oscillator mainframe	£4500
Hewlett Packard 8660D - Synthesised signal gen. 10kHz-2.6GHz	£2500
Hewlett Packard 8683A - Microwave signal gen. (2.3-6.5GHz)	£2500
Hewlett Packard 8684A - 5.4GHz to 12.5GHz Sig Gen	£375
Hewlett Packard 8750A - Storage normaliser	£1995
Hewlett Packard 8903A - Audio analyser (20Hz-100kHz)	£4000
Hewlett Packard 8958A - Cellular radio interface	£2000
Hewlett Packard 11729B - Carrier noise test set	£295
Marconi 893B - A/F power meter	£1950
Marconi 2019A - 80kHz-1040MHz synthesised sig. gen	£2000
Marconi 12871 - data communications analyser	£1750
Marconi 6500 - automatic amplitude analyser	£400
Philips PM 5167 - 10MHz function gen.	£800
Philips PM 5190 - LF synthesizer with GPIB	£800
Racal Dana 1992 - 1300MHz frequency counter opts 4B+55	£750
Racal Dana 3100 40-130MHz synthesiser	£450
Racal Dana 9084 Synth sig. gen. 104MHz	£3000
Racal 9301A True RMS R.F. millivoltmeter	£650
Racal Dana 9303 True RMS/PF level meter	£450
Racal Dana 9921 3GHz frequency counter	£1250
Schaffner NSG 200E - Mainframe for NSG plug-ins	£850
Schaffner NSG 203A - Line voltage variation simulator	£600
Schaffner NSG 222A - Interference simulator	£850
Schaffner NSG 223 - Interference generator	£600
Schlumberger 2720 - 1250MHz Freq. Counter	£4995
Schlumberger SI 4040 - Stablock high accuracy 1GHz radio test set	£1000
Schlumberger 923 - Radio Code Test Set	£2500
Syston Donner 1980B - Microwave Sweeper (12-18GHz)	£1150
Tektronix 577 - Curve Tracer	£1150
Tektronix - Plug-ins - Many available such as PG508, FG504, SC504, SW503, SG 502 etc	£1750
Tektronix TM5003A - AFG5101 Arbitrary Function Gen	£750
Tektronix 1240 Logic Analyser	£395
Tektronix AM503 + TM501 + P6302 - current probe amplifier	£1995
Tektronix PG506 + TG501 + SG503 - Oscilloscope calibrator	£4995
Tektronix GG9001 - Programmable oscilloscope cal. generator	£500
Time 9811 Programmable resistance	£750
Time 9814 Voltage calibrator	CP.O.A.
Wavetek 172B - Programmable sig. source (0.001Hz-13MHz)	£850
Wayne Kerr N905 - Precision LCR meter	£1800
Willtron 560 - Scalnar Network analyser	£650
Willtron 6620S - Programmable sweep gen. (3.6-6.5GHz)	£650

OSCILLOSCOPES

Gould OS3000 - 40MHz, dual ch.	£250
Gould OS4000 - 10MHz Digital storage	£200
Gould 5110 - 100MHz intelligent oscilloscope	£750
Haemeg 203/203-4/203-5/203-6 - 20MHz Dual CH	From £175
Hewlett Packard 180D - 100MHz 4 channel	£300
Hewlett Packard 182C - 100MHz 4 channel	£350

Hewlett Packard 1707A, 1707B - 75MHz dual ch.	from £275
Hewlett Packard 1740A, 1741A, 1744A, - 100MHz dual ch.	from £350
Hewlett Packard 54100D - 1GHz digitizing	£3995
Hewlett Packard 54201A - 300MHz Digitizing	£1750
Hewlett Packard 54501A - 100MHz Digitizing - 4 channel	£1950
Hitachi V212 - 20MHz dual channel	£180
Hitachi V222 - 20MHz dual channel	£200
Hitachi V650F - 60MHz Dual channel	£350
Kikusui COS 6100 - 100MHz 5 channel 12 trace	£475
Nicolet 3091 - Low freq D.S.O.	£1100
Philips 3217 - 50MHz Dual CH	£350
Philips 3219 - 50MHz with analogue storage, Dual CH	£400
Philips 3295 - 350MHz dual ch.	£1500
Philips 3302 - 20MHz Digital storage	£475
Philips 3315 - 60MHz D.S.O.	£750
Philips PM295A - 400MHz dual channel	£1950
Tektronix 455 - 50MHz dual channel	£350
Tektronix 2221 - 60MHz digital storage	£1500
Tektronix 7854 - 400MHz Waveform processing oscilloscope	£1500
Tektronix 464/466 - 100MHz, storage	from £350
Tektronix 465/465B - 100MHz dual ch.	from £350
Tektronix 468 - 100MHz D.S.O.	£750
Tektronix 2213 - 60MHz dual ch.	£425
Tektronix 2214 - 60MHz dual ch.	£425
Tektronix 2225 - 50MHz dual trace	£450
Tektronix 2236 - 100MHz Dual Trace with Counter/Timer/Dimm	£995
Tektronix 2335 - 100MHz dual ch. (portable)	£750
Tektronix 7313, 7603, 7613, 7623, 7633, - 100MHz 4 ch.	from £300
Tektronix 1700 250MHz 4 ch.	from £850
Tektronix 7904 - 50MHz	from £850
Tektronix 7934 - 500MHz with storage	from £1000
Teletquipment DB3 - 50MHz dual ch.	£200

Other scopes available too

SPECTRUM ANALYSERS

Advantest 4133A - 10kHz-20GHz	£6995
Alltech 757 - 10kHz-22GHz	£2750
Hewlett Packard 1411 + 8552B + 8555A (10MHz-18GHz)	£1600
Hewlett Packard 182T with 8559A (10MHz-21GHz)	£3750
Hewlett Packard 853A with 8559A (0.01-21GHz)	£4250
Hewlett Packard 3562A - dynamic signal analyser, dual channel	£7500
Hewlett Packard 3580A - 5Hz-50kHz	£995
Hewlett Packard 3582A - 25kHz analyser, dual channel	£2500
Hewlett Packard 3708B - Constellation Analyser with 15709A High Impedance Interface (as new)	£6750
Hewlett Packard 8505A - Network analyser (500kHz-1.3GHz)	£4000
Hewlett Packard 8565A (0.01-22GHz)	£4000
Hewlett Packard 8590A - Khz-1.5GHz	£4250
Hewlett Packard 8754A - Network Analyser - 4 - 1300MHz	£2350
Hewlett Packard 3708B - Constellation Analyser with 15709A High Impedance Interface	£1600
Marconi 2370 - 10MHz	£995
Marconi 2371 - 30Hz-200MHz	£1250
Meguro MSA 4901 - 1MHz-300MHz (as new)	£1500
Meguro MSA 4912 - 1MHz-1GHz (as new)	£2500
Poirad 641-1 - 10MHz-18GHz	£1500
Rohde & Schwarz - SWO3 S Polykop 0.1-1300MHz	£2500
Tektronix 2710 - Khz-1.8GHz	£4250
Tektronix 7L18-mainframe - (1.5-60GHz with ext. mixers)	£2000

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

CIRCLE NO. 125 ON REPLY CARD

HART AUDIO KITS - YOUR VALUE FOR MONEY ROUTE TO ULTIMATE HI-FI

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.

K1100 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 of components and ease of construction. Useful options are a stereo LED power meter and a versatile passive front end giving switched inputs, with ALPS precision Blue Velvet low-noise volume and balance controls. 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 at £29.60 extra per channel, plus u2.40 if you want to include Gold Plated speaker terminals.

K1100B Complete STANDARD Amplifier Kit.....	£395.21
A1100B Factory Assembled.....	£499.21
K1100SC Complete SLAVE Amplifier Kit.....	£333.62
A1100SC Factory Assembled.....	£422.62
K1100M Complete MONOBLOC Amplifier Kit.....	£261.20
A1100M Factory Assembled.....	£329.20
RLH11 Reprints of latest Amplifier articles.....	£1.80
K1100CM Construction Manual with full parts lists.....	£5.50

"CHIARA" SINGLE ENDED CLASS "A" HEADPHONE AMPLIFIER.



This unit provides a high quality headphone output for 'stand alone' use or to supplement those many power amplifiers that do not have a headphone facility. Easily installed with special link-through feature the unit draws its power from our new Andante Ultra High Quality linear toroidal 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. Pre-terminated interconnecting leads and PCB mounted sockets prevent supply polarity reversal and on-board diagnostics provide visual indication of supply line integrity. Volume and balance controls are Alps "Blue Velvet" components. Very easily built, even by beginners, since all components fit directly on the single printed circuit board. The kit has very detailed instructions, and even comes with a complementary roll of Hart audiograde silver solder. It can also be supplied factory assembled and tested. Selling for less than the total cost of all the components, if they were bought separately, this unit represents incredible value for money and makes an attractive and harmonious addition to any hi-fi system.

K2100 Complete Kit.....	£109.50
K2100SA Series Audiophile version with selected audiophile components.....	£112.46
A2100SA Series Audiophile version, factory Assembled.....	£149.46
K3565 "Andante" Power Supply Kit to suit "Chiara".....	£85.42
A3565 Power Supply, Factory Assembled.....	£128.42
CM2100 Construction Manual.....	£2.50
SPECIAL OFFER. Both units together, Kit Form.....	£184.92
Factory Assembled and Tested.....	£267.88

"Andante" SERIES 20VA AUDIOPHILE POWER SUPPLIES

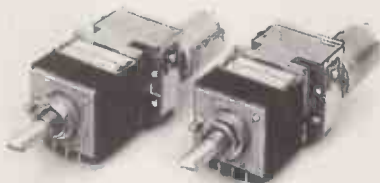
Specially designed for exacting audio use requiring absolute minimum noise, low hum field and total freedom from mechanical noise this unit is a logical development from our highly successful 1550 series.

Utilising linear technology throughout for smoothness and musicality makes it the perfect partner for any module requiring fully stabilised $\pm 15v$ supplies.

Two versions are available. K3550 has 2 $\pm 15v$ supplies and a single 15v for relays etc. and can be used with our K1400 preamp and our K1450 RIAA pickup preamp, as well as other useful modules soon to be introduced. The K3565 is identical in appearance but only has the $\pm 15v$ lighter current supply for use with the K1450 RIAA pickup pre amplifier or "Chiara" headphone amplifier.

K3550 Full Supply with all outputs.....	£93.75
K3565 Power Supply for K1450 & K2100.....	£85.42

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

JOHN LINSLEY HOOD SINGLE ENDED CLASS 'A' POWER AMPLIFIER

This amplifier represents an extremely novel concept in that it has been developed from a design in an earlier part of the evolutionary cycle, to meet the needs of modern users who want the warmth and purity of sound given by valve amplifiers from the vintage years, without the problems of cost, deterioration and danger associated with trying to use valves today.

It employs the newly re-discovered single-ended circuit configuration to give total freedom from crossover artifacts and to give a sound that is indistinguishable from the famous 'Williamson' design, the undisputed leader of the field, with its triode connected KT66s and all-triode drivers.

The new circuit, described in the September 1996 issue of Electronics and Wireless World, the same magazine that published the Williamson design back in 1947, it itself a development of an earlier 10watt design by the Author, the new version retains the basic simplicity and purity of the original but with modern components and an increased power rating of 15W RMS per channel.

Hart have developed a completely new and highly sophisticated kit, incorporating all the important options, within a very high quality 3U high 19" rack mountable case.

Please ask for your free copy of our list which gives full details.

Our List of these and many other Kits & Components is FREE in UK. Ask for your copy now. Overseas customers are very welcome, but PLEASE send 2 IRCs if you want a list sent surface post, or 5 for Airmail.

Ordering is easy. Simply write, telephone or fax your order anytime. Let us know what you require, with your name address, cheque or credit card number and expiry date. Your daytime phone number is useful in case we need to get back to you. Further information on all our kits is given in our FREE lists. Overseas/trade orders are welcome and we can send anywhere in the World. Post on UK Orders up to £25 is £1.50, over £25 - £4.50. Express Courier £10. OVERSEAS postage - please enquire.

VALVE & EARLY CLASSIC BOOKS

THE VTL BOOK David Manley BKVT1.....	£17.95
LOUDSPEAKERS; THE WHY AND HOW OF GOOD REPRODUCTION. G.Briggs. 1949 0-9624-1913-3.....	£8.95
MULLARD TUBE CIRCUITS FOR AUDIO AMPLIFIERS BKAA27.....	£13.95
"THE WILLIAMSON AMPLIFIER." 0-9624-1918-4.....	£6.95
AN APPROACH TO AUDIO FREQUENCY AMPLIFIER DESIGN. GEC 1957, 1-882580-05-2.....	£18.95
AUDIO ANTHOLOGIES, articles from Audio Engineering. Six volumes covering the days when audio was young and valves were king! BKAA3/1 to 6. All.....	£13.95 each.
"A SIMPLE CLASS A AMPLIFIER" J.L.Linsley Hood M.I.E.E. 1969, RLH12.....	£2.50

Postage on all books, unless starred, is only £1.50 per book, maximum u4.50 for any number, any size! Starred items are heavy books costing £2.50 to send.

No waiting! All listed books are normally in stock!

SPECIAL OFFER. All book orders over £15 will receive a FREE John Linsley Hood monograph entitled "Digital versus Analogue. Black Disks or Silver?"

SPECIAL OFFER 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.



HC80 Replacement Stereo Cassette Head.

The excellent performance of modern cassette recorders depends totally on the quality of the R/P head. Even the slightest amount of wear can impair the frequency response and distortion levels. Our HC80 is atop quality head from one of the foremost manufacturers in Japan, easily fitted to most standard stereo recorders (except Sony) and will transform the performance over a worn head. Only the fact that we buy these in vast quantities enables us to offer them at the amazing price of only £11.70 each or 2 for £17.60. We also stock a range of other heads, including "T" reel-to-reel stereo heads.

SOLDERING

The size of modern components makes the right soldering equipment essential for good results. Everything we offer we actually use in our own workshops! See our Lists for the full range. 845-820 XS240 ANTEX 240v 25w Soldering Iron. This is the ideal Multi-purpose iron as the bit is designed to totally surround the element giving the best heat transfer. This excellent design also means that although it is small and handy enough for modern components its heating capacity is better than larger irons of conventional construction. Excellent Value..... £12.43

845-080 ST4 Lightweight Soldering Iron Stand. This has provision for the classic damp sponge for bit wiping..... £3.95

HART SUPER AUDIOGRADE SILVER SOLDER.

Hart Super Audiograde Silver Solder has been specially formulated for the serious audiophile. Not only does it give beautiful easy-to-make joints but it is designed to melt at normal soldering temperatures avoiding the possibility of thermal damage to components or the need for special high temperature irons. A very low residue flux makes perfect joints easy but eliminates the need for board cleaning after assembly.

845-007 3mtrs 22SWG in Hart Mini Tube.....	£3.90
845-008 100g, Reel Special Valve Grade, 20swg.....	£12.90
845-009 100g, Precision PCB Grade, 22swg.....	£14.75
845-110 100g Reel Superfine 24swg for ultra precise control and easy working.....	£21.45

QUALITY AUDIO KITS

24 hr. Orderline 01691 652894
Faxline 01691 662864

ALL PRICES INCLUDE UK/EC VAT



Prescale to 1GHz

Nick Wheeler describes a low-cost prescaler designed to extend the useful range of a frequency counter to just over 1GHz.

Table 1. On the SA701 prescaler, logic levels on two pins determine the division ratio.

Divisor	SW	MC
128	Low	High
129	Low	Low
64	High	High
65	High	Low

Until recently, digital frequency meters with gigahertz capability were confined to costly laboratory models, the more affordable types generally extending up to, typically, 200MHz. Some eight years ago, and possibly even earlier, it was possible to obtain gigahertz prescalers based on emitter-coupled logic to extend the range of these inexpensive instruments – many of which must still be in use.

While ecl-based gigahertz prescalers have been around for years they have either been expensive or only obtainable in production quantities. One of the earliest was the Philips SAB456, used in a tv tuner for digital frequency control, but this was discontinued in eight-pin DIL form some years ago.

More recently, the developing portable phone market has caused several manufacturers, including Philips, to produce useful low-cost parts. I used the quadruple-modulus SA701, which is intended for 64/65 and

128/129 division. This device is obtainable in small quantities from RS and Macro. Note that its part number for the DIL version has an 'N' suffix.

Applying the GHz prescaler

With the exception of the Plessey SP8680, which is a 650MHz part, ecl prescalers have ecl output levels and limited output drive capability into capacitive loads. Figure 1 shows how these problems are overcome.

Emitter follower Tr_1 imposes negligible load on the prescaler and the diode clamp ensures that there is a big enough positive excursion at the base of Tr_2 to bottom it. Collector swing of Tr_2 is enough to drive the high-speed c-mos divider chain which follows. Pins 3 (SW) and 6 (MC) determine the division ratio, as in Table 1.

For this application, the division ratio needed is 64, so both SW and MC are high. To avoid having to use a calculator to determine

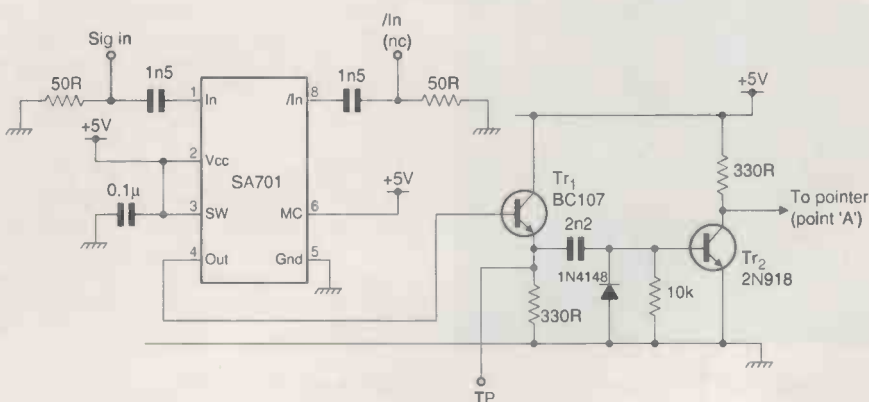


Fig. 1. Since the prescaler has an ecl-level output, buffering is needed to feed the c-mos circuitry.

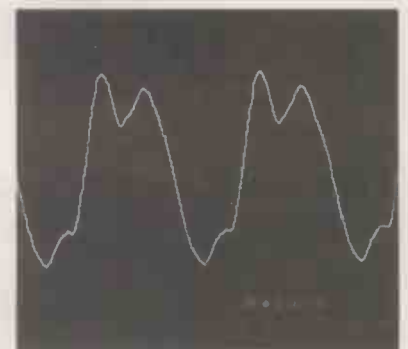


Fig. 1a. Output at TP, 808MHz input. Absence of noise or jitter characterises correct pre-scaler operation.

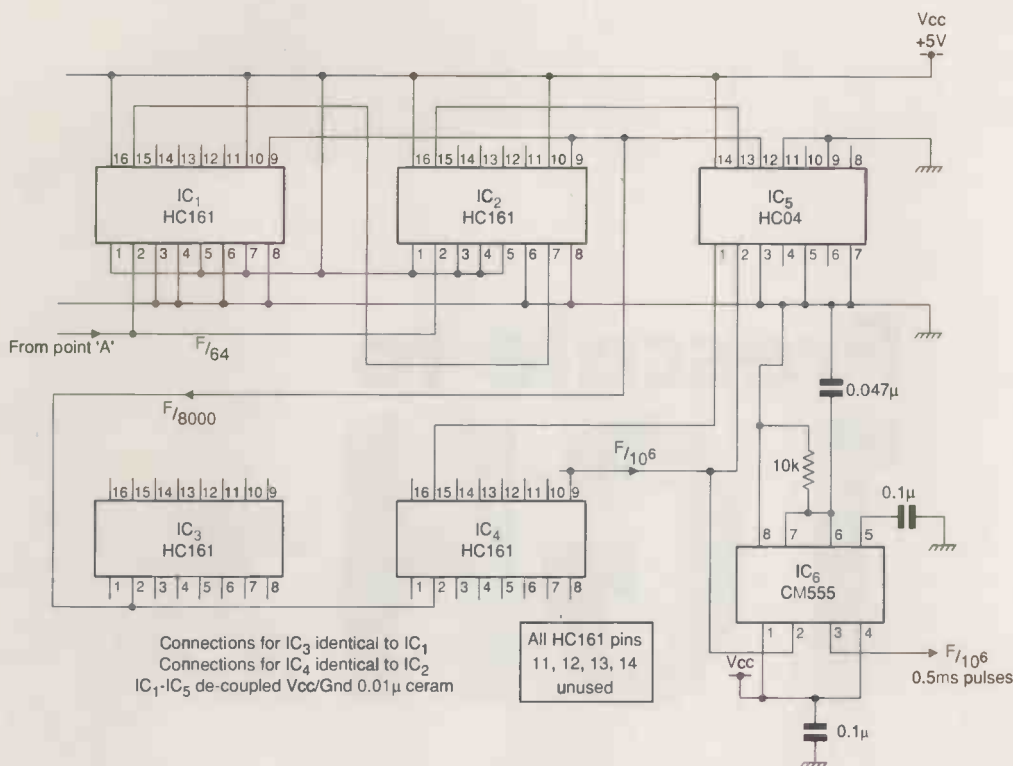


Fig. 2. Using this configuration to divide by 125 avoids glitch problems. Narrow pulses output by the divider chain could cause erratic readings so a pulse-stretching 555 is added.

the frequency being measured, the overall division ratio must be a multiple of ten. There is a way round this but it usually involves having a special crystal made for your frequency counter. Suppose the counter has provision for an external frequency standard. This will certainly be a multiple of 1MHz. However, if an external source which is an appropriate multiple of 976.5625kHz is applied, then a binary divider chain of ten stages will give a readout of kilohertz for gigahertz – which is manageable.

Fortunately, division by 2^6 (64), followed by 5^6 (15625) equates to division by 10^6 . This is done by dividing twice by 125.

Dividing by 125

Figure 2 shows the divider, taken from ref. 1.

The timing diagram for this rather unusual ratio is complicated. It is fortunate that this ratio is not one of those which suffer from incurable glitches. Note that the quirky timing of this circuit calls for 116 to be preloaded. Follow the circuit diagram and you will arrive at the desired result.

The circuit works without problems from 20MHz down to 1MHz, representing an input signal frequency range of 1.28GHz down to 64MHz. Division in two cascaded blocks of 125 is essential as there is a possible glitch problem if three or more HC161s are cascaded. Texas Instruments' manual explains this.

Unlike binary division, which yields successive outputs of close to unity mark-space ratio, each of the two cascaded divide-by-125 stages yields a signal of 1:124 mark-space

ratio. Thus an input signal of 1GHz produces an output of 1kHz, but with a pulse width of $8\mu\text{s}$. Some inexpensive frequency counters respond erratically to waveforms of this sort, so the c-mos 555 monostable is included to stretch the pulses to around 0.5ms.

Implementation problems

It appears to be a characteristic of ecl prescalers that if no input, or too small an input, is connected, oscillation occurs around the upper frequency limit of the device. Such oscillation can be detected at the emitter of Tr_1 which, fed to a suitable rf connector, forms the output. The oscillatory mode

has random time-jitter and is quite different in appearance from the waveform observable when division is occurring properly, Fig. 3.

This test point has another important function. Because the signal frequency is divided by 10^6 long gate times are required to make accurate frequency measurements. At 1GHz, and with 100 seconds of gate time, the display is only to five decimal places or 100kHz. Often this will be unimportant. Where greater accuracy or a quicker response is needed, the divide-by-64 point gives results at once and to the full accuracy of the frequency meter. But you will need a calculator to work out the real frequency being read.

Best results are obtained at the upper frequency end if the prescaler is mounted on PTFE based pcb, but much the same effect can be achieved by preceding the prescaler with a monolithic microwave IC such as the MAR 6.

Measurements at gigahertz frequencies can only be conducted remotely, and in this case remotely means at distances of more than a few cm, via properly matched transmission lines. You can see from Fig. 1 that this is a 50Ω system.

For remote measurements, where the imposition of a 50Ω load is unacceptable, an approach on the lines of ref. 2 is appropriate. This type of circuitry still has gain well beyond 1GHz, though it has fallen off a lot compared with the flat frequency performance up to 130MHz.

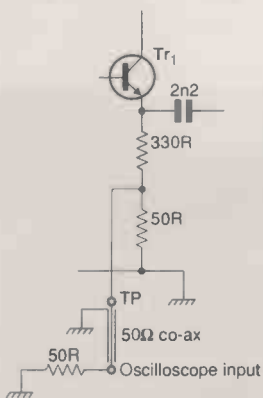


Fig. 3. To check for correct operation of the prescaler, care must be taken with loading and termination.

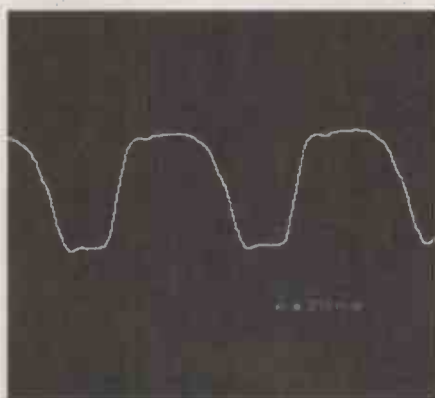


Fig. 3a. Waveform at TP viewed in properly terminated system. Absence of noise and jitter characterises correct prescaler operation. Test frequency 808MHz.

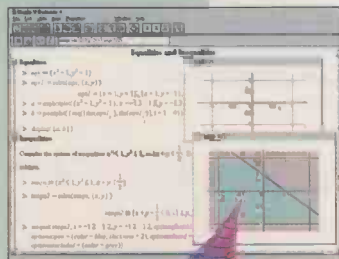
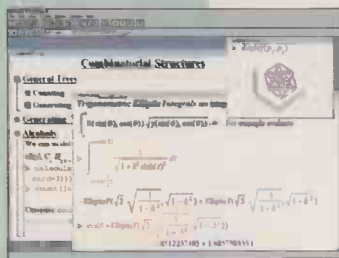
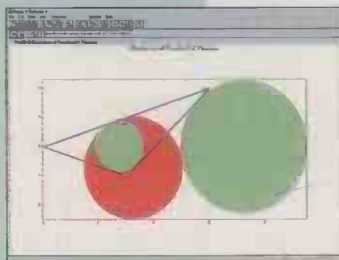
References

1. Lancaster, D., Sam's TTL Cookbook, 1988.
2. Wheeler, N., 130MHz probe, EW+WW Aug 1995.

Why settle for second best?



**Your applications are critical.
Your mathematics have to be right.
So your first choice has to be **Maple**.**



Maple V's high-end symbolic and numerical mathematical tools offer supreme accuracy and flexibility. Faster, more efficient and more reliable than its rivals - and that's not us speaking but reviewer *Mike James* in *Computer Shopper*, January 1996.

Now with the new **Maple V Release 4 - The Power Edition**, you can produce publication- and presentation-quality documentation with ease. Its versatile technical document processing environment allows fully-formatted text and graphics to be combined seamlessly with **Maple** equations and formulae.

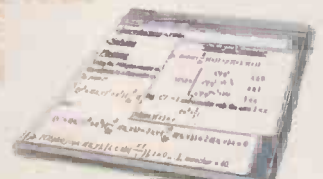
Maple V gives you full symbolic maths power *without* having to program. Enter your problem and get real equations on screen. And **Maple V's** extensive libraries comfortably handle just about every symbolic or numeric problem you throw at it. *No other mathematics software offers as much.*

Maple V's enormous range of mathematical algorithms, programmable functions and built-in routines has to be seen to be believed.

Check our Web site, <http://www.adeptscience.co.uk/>. To order or find out more, fax us the coupon or call:

01462 480055

Maple V - The Power Edition is available on PC (Windows 3.1x, NT and Win 95) and Macintosh platforms; Linux and other UNIX variants will be released soon. Call us for details and prices, including educational pricing and our advantageous site and CHEST licence terms.



Need more Information?

Please fill out and fax back or post this coupon to **Adept Scientific** for your **FREE Maple V** information pack!

Name

Telephone No.

Position

Company

Department

Address

Town

County

Post Code

CIRCLE NO. 127 ON REPLY CARD

Waterloo Maple
ADVANCING MATHEMATICS

ADEPT SCIENTIFIC **Adept Scientific plc**
6 Business Centre West, Avenue One, Letchworth,
Herts, SG6 2HB
Tel: 01462 480055 Fax: 01462 480213
Email: maple@adeptscience.co.uk

Dictionary of Communications Technology

Terms, definitions and abbreviations

Gilbert Held, 4-Degree Consulting, Macon, Georgia, USA

In response to the changing face of the telecommunications industry and the rapid expansion in the use of microprocessors, fibre optics and satellites, Gil Held has updated his earlier telecommunications dictionary to bring readers in line with the very latest developments and terms in communications technology.



Features Include:

- Over 9000 references and 250+ illustrations
- Comprehensive coverage of data and computer communications
- New entries on PC LANs, the Internet, client/server operations and communications testing
- Trade name information

First Edition Review:

"For a consultant or telecommunications operative, this book is a must. It is comprehensive and timely ... an excellent reference for the IS professional."

Data Processing Digest

ISBN 0471 95542 6, 512pp, hardback, UK £68.50, Europe £73, ROW £85

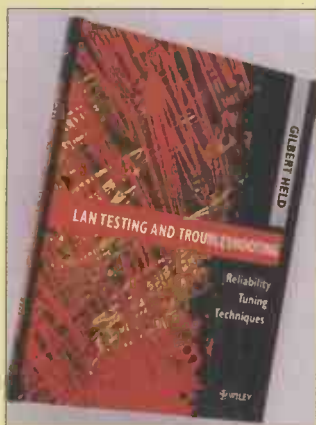
ISBN 0471 95126 9, 512pp, paperback, UK £38.50, Europe £43, ROW £55

Testing, Troubleshooting and Tuning Local Area Networks

Techniques and tools to isolate problems and boost performance

Gilbert Held, 4-Degree Consulting, Macon, Georgia, USA.

Recognising the problems



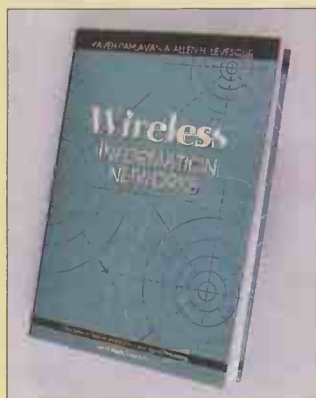
encountered by network users and administrators on a daily basis, this book is designed to assist readers by focusing on testing, troubleshooting and tuning of Ethernet and Token-Ring networks. It is devoted exclusively to: how things go wrong how to recognise, monitor and test for problems; network analysis and network management products that assist users in examining the flow of data in a complex network.

ISBN 0471 95880 8, 275pp, hardback, UK £37.50, Europe £40, ROW £50

Wireless Information Networks

Kaveh Pahlavan, Worcester Polytechnic Institute and Allen H Levesque, GTE Government Systems Corporation.

Wireless Information Networks organises all major elements of wireless technology - cordless and cellular telephony, Personal Communications Systems (PCS), mobile data networks and Wireless Local Area Networks (WLANs), presenting them from a logical, systems engineering perspective. Technical material is thoroughly integrated with special applications and focuses on four main areas: Wireless



standards and descriptions of systems and products; Measurement and modelling of radio and optical wave propagations; Wireless transmission techniques and Wireless multiple access techniques.

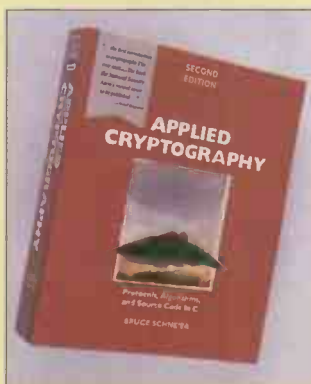
Contents: Overview of Wireless Networks. Frequency Administration and Standards Activities. Characterisation of Radio Propagation. Channel Measurement and Modelling for Narrow-band Signaling. Measurement of Wide-band Channel Characteristics. Computer Simulation of the Radio Channel. Modem Technology. Signal Processing for Wireless Applications. Spread Spectrum for WIN Systems. Wireless Optical Networks. Networks and Access Methods. Standards and Products.

ISBN 0471 10607 0, 304pp, hardback, UK £63.50, Europe £68, ROW £81

Applied Cryptography

2nd Edition
Protocols, Algorithms and Source Code in C

Bruce Schneier, Security Consultant and President of Counterpane Systems, USA
This revision of the programmer's and system designer's guide to the practical applications of modern cryptography



provides the most comprehensive, up-to-date survey of modern cryptographic techniques, along with practical advice on how to implement them.

New to this edition:

- Detailed treatment of the US government's Clipper Chip encryption program
- New encryption algorithms (eg. 'GOST') recently obtained from the former Soviet Union
- More detailed information on incorporating algorithms and programming fragments

into working software

• The latest developments in the fields of message authentication ('digital signatures') and digital cash.
ISBN 0471 12845 7, 816pp, hard back, UK £59, Europe £64, ROW £78

ISBN 0471 11709 9, 816pp, paperback, UK £44, Europe £49, ROW £63

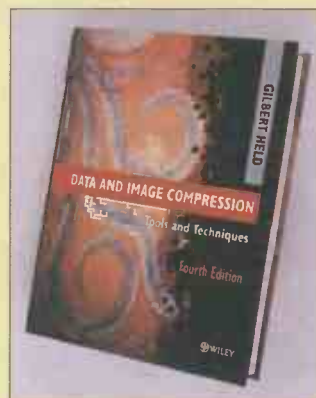
Data and Image Compression

4th edition

tools and techniques

Gilbert Held, 4-Degree Consulting, Macon, Georgia, USA

Data and image compression are key issues in computer communications with the increasing demand for data transmission capacity.



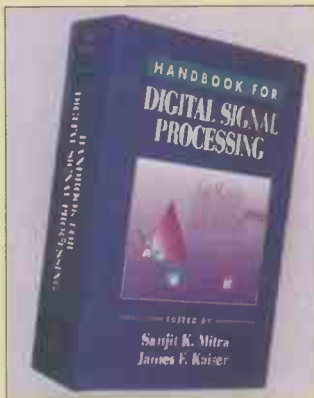
Guiding the reader through the main techniques, this book explains how practical data and image compression techniques are now vital for efficient, low-cost transmission and data storage requirements. Building on the success of the previous editions of *Data Compression*, the scope of the fourth edition has been considerably expanded. Now covering image and fax compression, the text has been restructured to take account of the many new advances in this important field. It is also accompanied by an updated disk containing compression routines.

ISBN 0471 95247 8, 450pp+disk, hardback, UK £58.50, Europe £63, ROW £75

Handbook for Digital Signal Processing

S.K. Mitra, University of California and J.F. Kaiser, Bell Communications Research, New Jersey, USA

This is the definitive source of detailed information on all important topics in modern



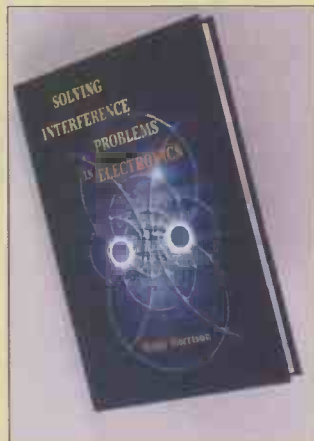
digital signal processing. The only current handbook of its kind, it meets the needs of practising engineers and designers of hardware, systems and software. Written by world authorities, the *Handbook for Digital Signal Processing* is supplemented with hundreds of informative tables and illustrations. For professional engineers, designers and researchers in electronics and telecommunications, this work will be an indispensable reference – now and for years to come.

Contents: Introduction; Mathematical Foundations of Signal Processing; Linear Time-Invariant Discrete-Time Systems; Finite-impulse Response Filter Design; Digital Filter Implementation Considerations; Robust Digital Filter Structures; Fast DFT and Convolution Algorithms; finite Arithmetic Concepts; Signal Conditioning and Interface Circuits; Hardware and Architecture; Software Considerations; Special Filter Designs; Multirate Signal Processing; Adaptive filtering Spectral Analysis; Index.
 ISBN 0471 61995 7, 1302pp, hardback, UK £110.50, Europe £118, ROW £138

Solving Interference Problems In Electronics

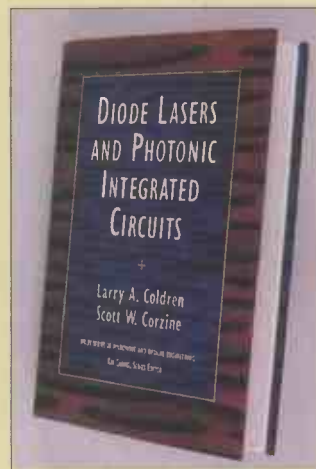
R. Morrison, Eureka California, USA
 Interference in electronic equipment is a constant source of difficulty for the design and systems engineer. Until now, there has not been a coherent theory that engineers can refer to in their design work and the solution of interference problems has therefore often considered to be an 'art'. Written by an acknowledged expert in the field, this new title provides methods and techniques for testing and evaluating

designs, and covers interference questions in computer manufacturing and systems design.
 ISBN 0471 12796 5, 206pp, hardback, UK £47.50, Europe £48.50, ROW £54



Diode Lasers and Photonic Integrated Circuits

L. A. Coldren and S. W. Corzine, both of the University of California, Santa Barbara, USA.
 Diode lasers are found in numerous applications in the optoelectronics industry,



telecommunications and data communications, ranging from readout sources in compact disc players to transmitters for optical fibre communications systems. This new title provides a comprehensive treatment of diode laser technology, its principles and theory, treating students as well as experienced engineers to an in-depth exploration of this fast growing field.
 ISBN 0471 11875 3, 620pp, hardback, UK £63.50, Europe £67, ROW £78

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 _____

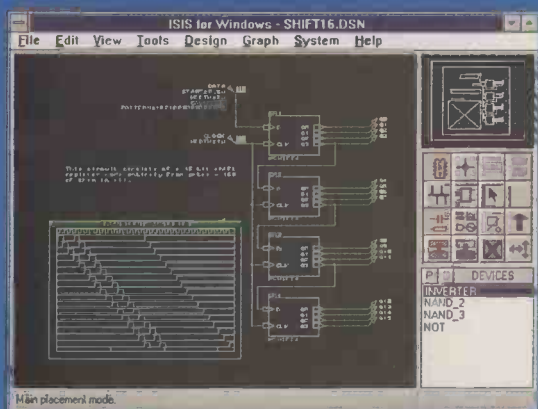
Signed _____

Please allow up to 28 days for delivery

PROTEUS

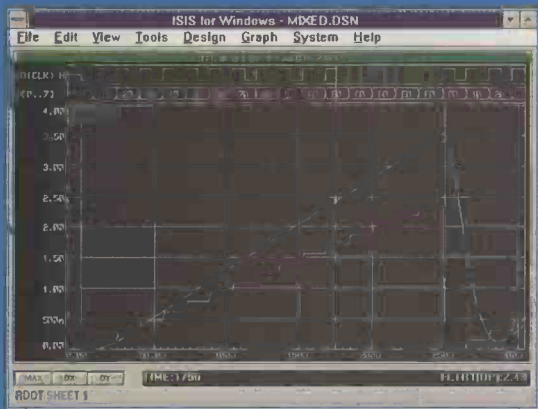
New for Windows 3.1, 95 & NT

The Complete Electronics Design System - Now With RIP-UP & RETRY!



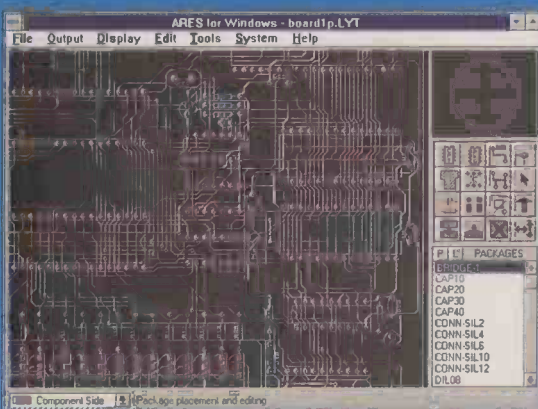
Schematic Capture

- Easy to Use Graphical Interface under both DOS and Windows.
- Netlist, Parts List & ERC reports.
- Hierarchical Design.
- Extensive component/model libraries.
- Advanced Property Management.
- Seamless integration with simulation and PCB design.



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

- 32 bit high resolution database.
- Multi-Layer and SMT support.
- Full DRC and Connectivity Checking.
- RIP-UP & RETRY Autorouter.
- Shape based gridless power planes.
- Output to printers, plotters, Postscript, Gerber, DXF and clipboard.
- Gerber and DXF Import capability.

Labcenter
Electronics

*Write, phone or fax for your free demo disk, or ask about our full evaluation kit.
Tel: 01756 753440. Fax: 01756 752857.
53-55 Main St, Grassington, BD23 5AA.*

Proteus runs as a 32 bit application under both DOS and Windows (3.1, 95 and NT).
Prices start from £470 ex VAT; full system costs £1645 for DOS, £1875 for Windows. Call for upgrade pricing and/or information about our budget and educational products. All manufacturers' trademarks acknowledged.

Light update

Derek Robinson* has been looking at how Texas' light sensors are evolving. Line imagers have been added to the product range and there's emphasis on easier interfacing with increased performance.

*Derek is with TI in Freising, Germany

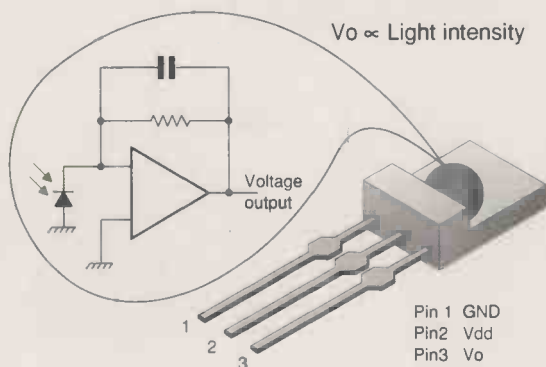


Fig. 1. Integrated photodiode plus op-amp light-to-voltage sensor.

With the predominance of digital systems in measurement and control applications, comes the increased importance of analogue-to-digital conversion, in order to interface real-world analogue signals to the system.

Light is such a real-world signal that is often measured either directly or used as an indicator of some other quantity. Most light-sensing elements convert light to an analogue signal in the form of a current or voltage, which must be further amplified and converted to a digital signal in order to be useful in such a system.

Important considerations in the conversion process are dynamic range, resolution, linearity and noise. In former times, a discrete light sensor was followed by some form of analogue signal conditioning circuitry, before being applied to an analogue-to-digital converter, which effectively interfaced it to a digital system. Now, a wide range of intelligent opto sensors are available, combining sensor and signal conditioning in a single device. Typical of these are light-to-voltage converters, light-to-frequency converters and integrated line imagers.

Light-to-voltage converters

Good examples of light-to-voltage converters are the *TSL25x* range of single-supply visible-light sensors, Fig. 1. These combine a photodiode and an op-amp connected as a transresistance amplifier, complete with frequency compensation for stability. The photodiode is used without reverse bias, and operates into a virtual earth. This results in a negligible voltage across the diode, minimising dark current.

Figure 2a) shows the sensitivity of the three members of the family to illumination on the optical axis, and b) shows the relative sensitivity as a function of angular displacement from it. A feature of the *TSL25x* family is a very low temperature coefficient of output voltage V_o – typically $1\text{mV}/^\circ\text{C}$. This is because the internal feedback resistor, namely $16\text{M}\Omega$, $8\text{M}\Omega$ or $2\text{M}\Omega$ for the -250 , -251 or -252 types, is polycrystalline silicon. This material has a temperature coefficient which compensates for the temperature coefficient of the photo-diode.

The *TSL26x* range of sensors designed for infrared applications share the same package and circuit arrangement. Figure 3a) shows the on-axis sensitivity of the three members of the family – the angular displacement response is as Fig. 2b). Figure 3b) compares the spectral response of the *TSL250* and -260 families.

A selection of useful application circuits, which are equally applicable to the *TSL25x* family¹, is included in the data sheet for the *TSL26x* range of devices.

Light-to-frequency converter

The light-to-frequency converter is a natural solution to the problem of light intensity conversion and measurement, providing many benefits over other techniques. Light intensity can vary over many orders of magnitude, and this complicates the problem of maintaining resolution and signal-to-noise ratio over a wide input range.

Converting the light intensity to a frequency overcomes limitations imposed on dynamic range by supply voltage, noise, and a-to-d resolution. Since the conversion

is performed on chip, effects of external interference such as noise and leakage currents are minimised. The resulting noise-immune frequency output is easily transmitted even from remote locations to other parts of the system.

Since the data is in serial form, interface requirements can be minimised to a single

microcontroller port, counter input or interrupt line. This saves the cost of an analogue-to-digital converter. Isolation is easily accomplished with optical couplers or transformers.

The conversion process is completed by counting the frequency to the desired resolution, or period timing may be used for faster data acquisition. Integration of the signal can be performed in order to eliminate low frequency (such as 50 or 60Hz) interference, or to measure long-term exposure.

The *TSL220* is a high-sensitivity, high-resolution single-supply light-to-frequency converter. Its dynamic range is 118dB, and it has a convenient c-mos-compatible output, all housed in a clear plastic eight-pin DIL package.

Figure 4a) shows a block diagram of the device². Output pulse width is determined by a single external capacitor, and the frequency of the output pulse train determined by the capacitor and the incident light intensity, as in Fig. 4b).

Figure 4c) shows the output frequency as a function of the ambient temperature, normalised to that at 25°C. This indicates a need for compensation which can be easily looked

after in the subsequent digital-signal processing, with the aid of a temperature sensor. Spectral response of the device is very similar to that of the *TSL25x* range shown in Fig. 3b), extending a little further into the infra-red but not quite so far into the ultra-violet.

Sensors featuring frequency output

The *TSL235* and *245* are visible-light and infra-red sensors, packaged in the same three-pin encapsulations as the *TSL25x* and *26x* ranges. However, they produce a frequency output in place of a voltage output. Figure 5a) shows output frequency versus incident illumination for the *TSL235*, under the conditions shown.

Figure 5b) shows how the tempo of output frequency varies with the wavelength of the incident radiation. Note the very low temperature coefficient at wavelengths shorter than 700nm. The *TSL245* is basically the same device as the *235*, but packaged in an encapsulation material which is transparent in the infra-red but opaque to visible light.

The *TSL230* programmable light-to-frequency converter also consists of a monolithic silicon photodiode and a current-to-fre-

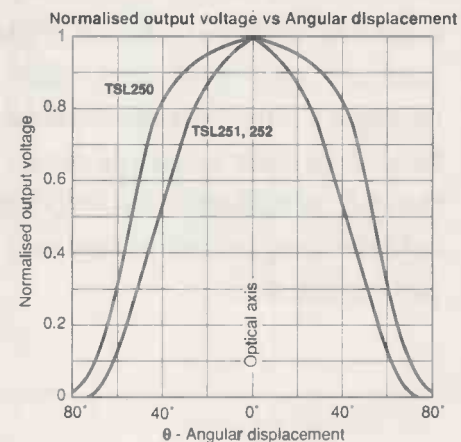
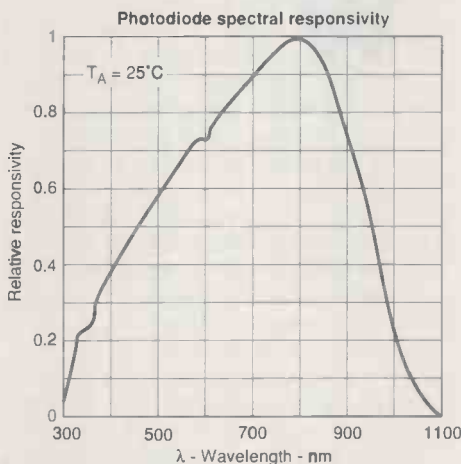
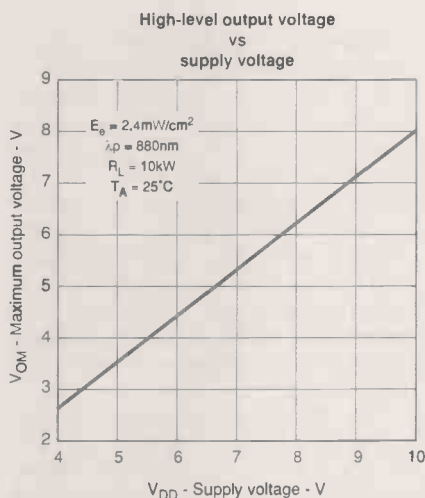
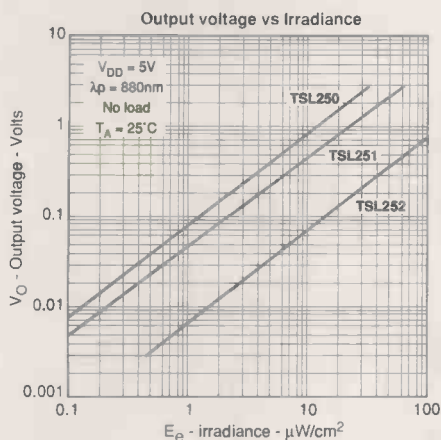


Fig. 2a). Output voltage as a function of incident illumination for the *TSL25x* series devices, top, with curves for maximum o/p against supply, bottom left, and spectral responsivity, right.

Fig. 2b). Angular response of the *TSL25x* devices.

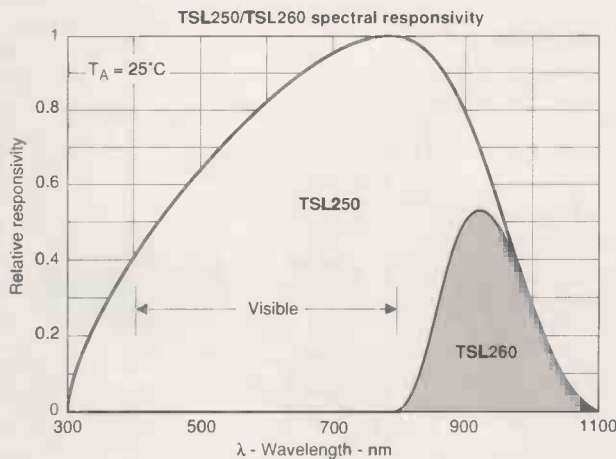
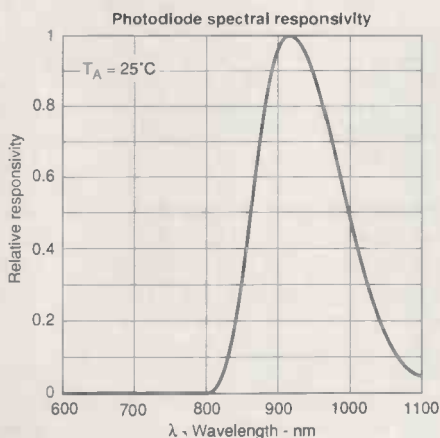
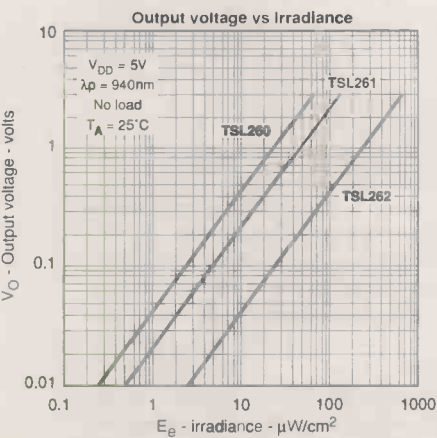


Fig. 3a). Output voltage as a function of incident illumination for the *TSL26x* series devices, left, together with spectral response, right.

Fig. 3b). Comparing the spectral response of *TSL25x* and *TSL26x* series devices.

frequency converter circuit. A simplified internal block diagram of the device is shown in Fig. 6a). Figure 6b) shows how the device simplifies interfacing with an associated microcon-

troller. Light sensing is accomplished by a 10-by-10 photodiode matrix. The photodiodes, or unit elements, produce photocurrent proportional to incident light.

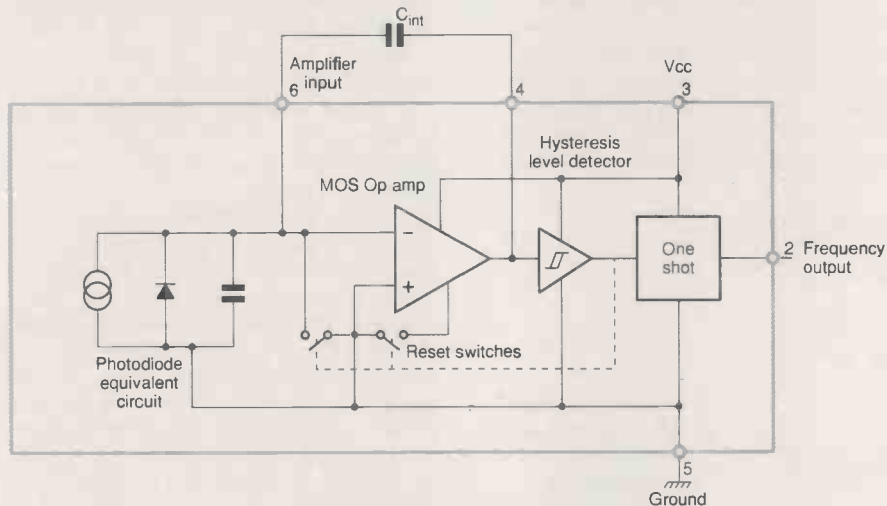


Fig. 4a). Internal workings of the TSL220. (First Figure in article, Ref. 2)

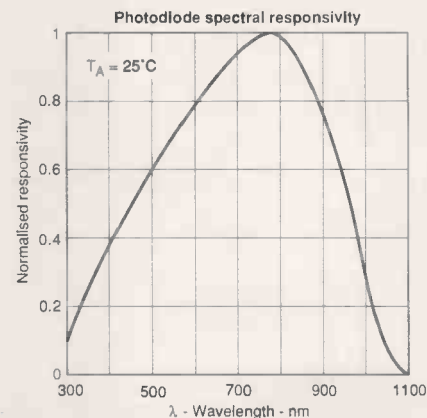
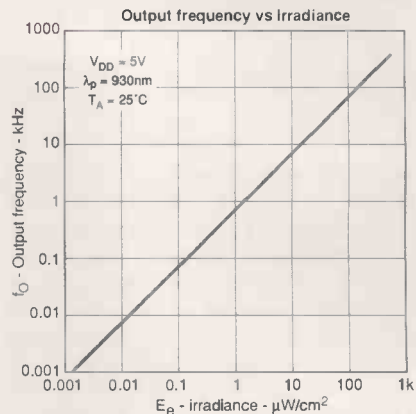


Fig. 5a). Output frequency versus incident illumination, top, and spectral response, bottom, for the TSL235 light-to-frequency converter.

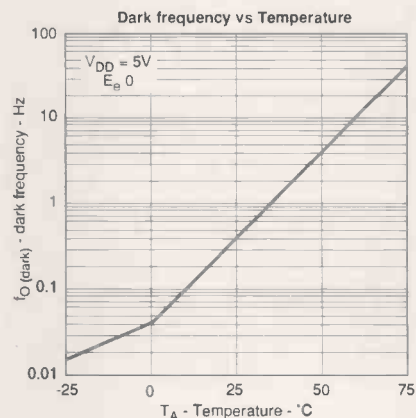
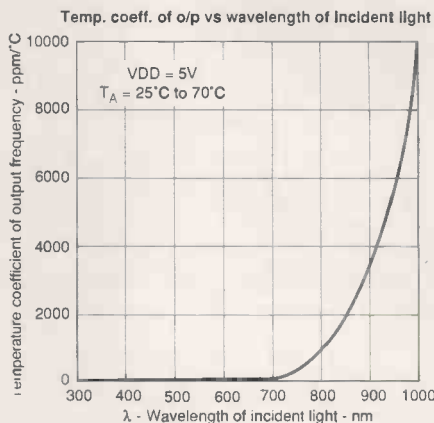
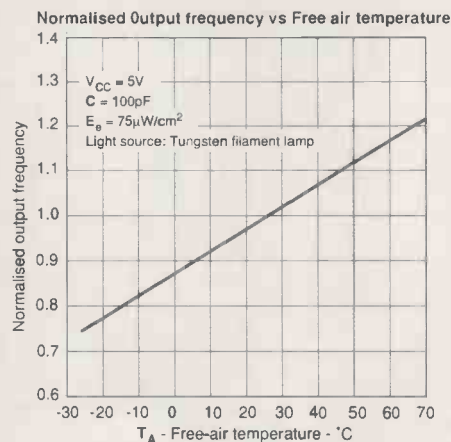
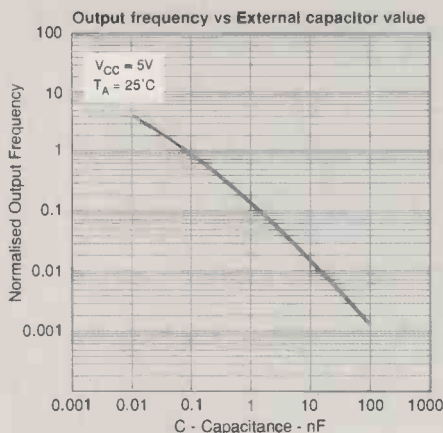
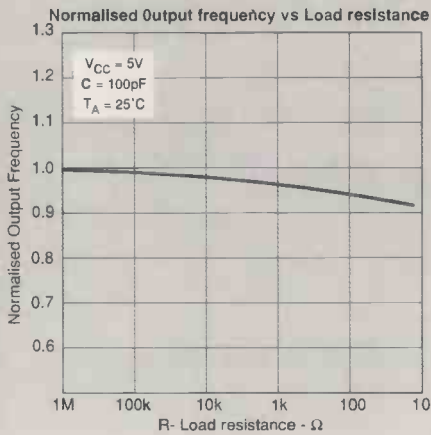
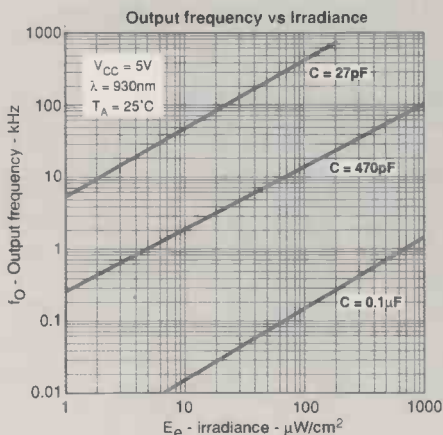


Fig. 4b). TSL220 output frequency versus illumination for various values of capacitor, top left, with load and normalised capacitance curves.

Fig. 4c). Output frequency versus temperature, normalised to 25°C, of the TSL220 under the stated conditions.

Fig. 5b). TSL235 temperature coefficient of output frequency as a function of wavelength, top, and dark frequency performance, bottom.

Sensitivity control inputs S_0 and S_1 control a multiplexer which connects either 1, 10, or 100 unit elements thereby adjusting the sensitivity proportionally, implementing a kind of 'electronic iris'. The unit elements are identical and closely matched for accurate scaling between ranges which are illustrated in Fig. 6c). The exceedingly low dark current of the photodiode results in the dark frequency output being generally below 1Hz, Fig. 6d).

The current-to-frequency converter utilises a unique switched capacitor charge-metering circuit to convert the photo-current to a frequency output. Output is a train of pulses which provides the input to the output scaling circuitry, and is directly output from the device in divide-by-one mode. Scaling of the output can be set via control lines S_2 and S_3 to divide the converter frequency by 2, 10, or 100, resulting in a 50:50 mark/space ratio square wave.

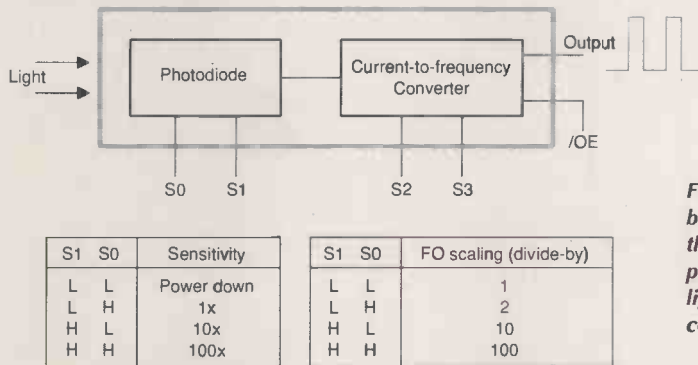


Fig. 6a). Functional block diagram of the TSL230 programmable light-to-frequency converter.

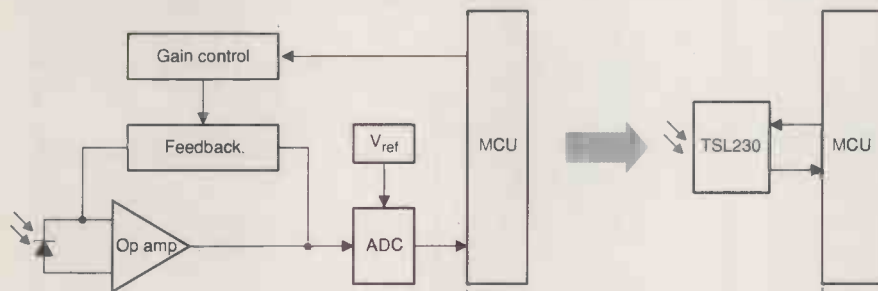


Fig. 6b). Illustrating the system simplification possible with the TSL230 Programmable Light-to-Frequency Converter.

The TSL230 is designed for direct interfacing to a logic-level input. It includes circuitry in its output stage to limit pulse rise and fall times, thus lowering electromagnetic radiation. Where lines longer than a 1m must be driven, a buffer or line driver is recommended. An active low output-enable line, \overline{OE} , is provided which, when high, places the output in a high-impedance state. This can be used when several TSL230 or other devices are sharing a common output line.

Like other light-to-frequency converters, the TSL230 is easily interfaced to digital control systems. But it has the added advantage of sensitivity and output frequency range adjustable over a four wire bus, S_{0-3} . Details of interfacing to a particular controller were given in a recent article in this magazine³, but the device interfaces simply with any controller, such as the Texas Instruments TMS370C010, the Microchip Technology PIC16C54HS, or Motorola's MC68HC11A8¹.

Integrated line imagers

Reference 1 includes data on a number of line imagers, fabricated in LinCMOS technology. Each consists of a linear array of light sensing pixels on a 125µm pitch, together with gates and control circuitry which sequentially address and read out the pixels contents.

Voltage read out from each pixel is proportional to the accumulated charge, which is in turn proportional to the product of the incident light intensity and the period of time elapsed since the last read-out and reset.

Both TSL213 and 214 are 64-element sensors, while the TSL215 has 128 elements and the TSL218 has 512. An article featuring the TSL214 has appeared in these pages, Ref. 4, and can be found reproduced in Ref. 5. Compared with charge-coupled-device imagers, or ccds, the addressed-array line

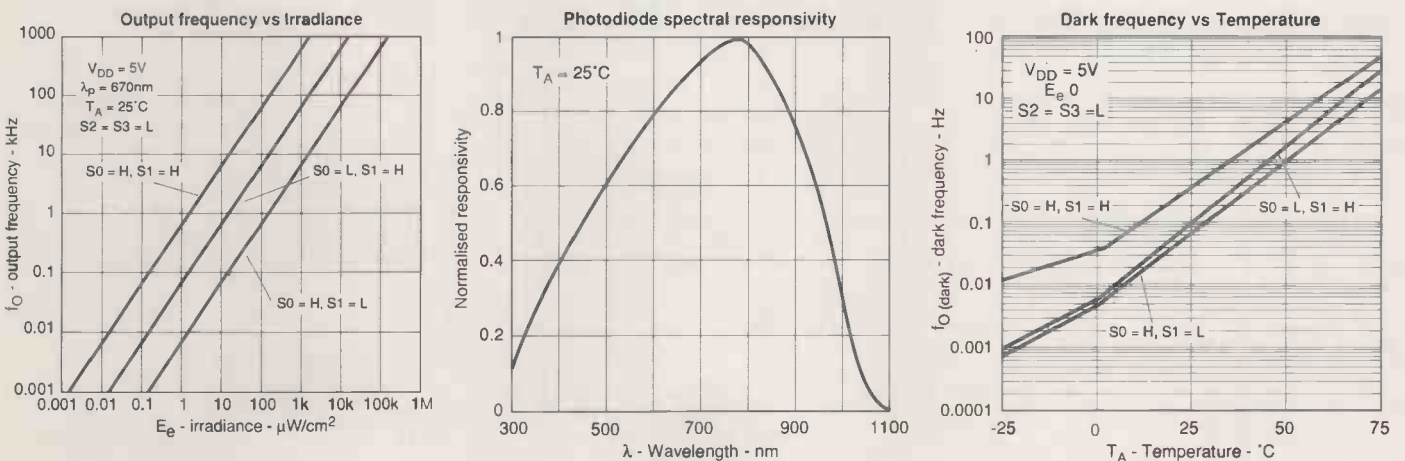


Fig. 6c). Illustrating the various sensitivity ranges available to the user with the TSL230, left, together with spectral responsivity, right.

Fig. 6d). Showing the very low dark frequency output of the TSL230, as a function of temperature.

imagers offer only a 1MHz max data rate as against the ccd's 10MHz. But to set against this are a number of other advantages, resulting in a simpler and cheaper system solution, Fig. 7a). In particular, the wider pixel spacing

of 125µm – against 12.7µm for the ccd sensor – allows the use of inexpensive plastic lenses, while in some applications a lens can be dispensed with entirely.

Figure 7b) shows a block diagram of the

internal workings of the TSL218 512 pixel linear array. Note that a readout sequence is initiated by a single pulse, SI, one clock pulse wide. Also, the clock frequency must be at least high enough to shift out all 512 pixel outputs before the next SI pulse, although it can be higher. Figure 7c) shows this in a timing diagram.

During the analogue output period, all 512 pixel output voltages are presented sequentially on the AO line, with but a small glitch between each output sample's level, due to the on-chip NOCG, or non-overlapping clock generator. As it exits the last stage of the shift register, the SI pulse is output from the device as an SO pulse. This can be used as the SI pulse to another device, permitting the implementing of arrays longer than 512 pixels, all devices being fed with the same clock, with the SI pulse being applied only to the first device. ■

Fig. 7a). Comparison of 128 pixel imagers.

	TSL215 (addressed array)	TC102 (ccd imager)
Pitch	125µm	12.7µm
Speed	1MHz o/p data (parallel)	10MHz o/p data
Input	5V digital supply integration and readout clocks	+2V, -16V clock +16V V _{DD} , +7V ref Needs mos-drivers (ext.)
Readout	Pixels individually addressed	All pixel charges simultaneously moved.
Output conditioning	Analog video output	Needs video clamp, external sample/hold to remove clock noise.

Fig. 7b). Showing the internal workings of the TSL218 512 pixel linear array.

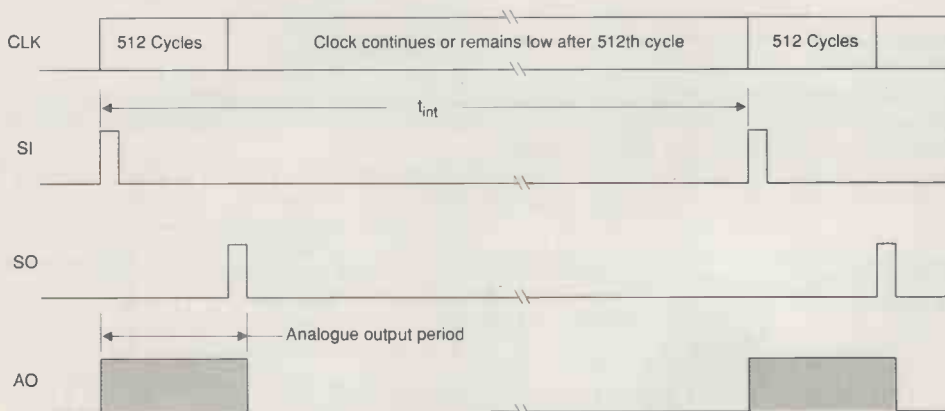
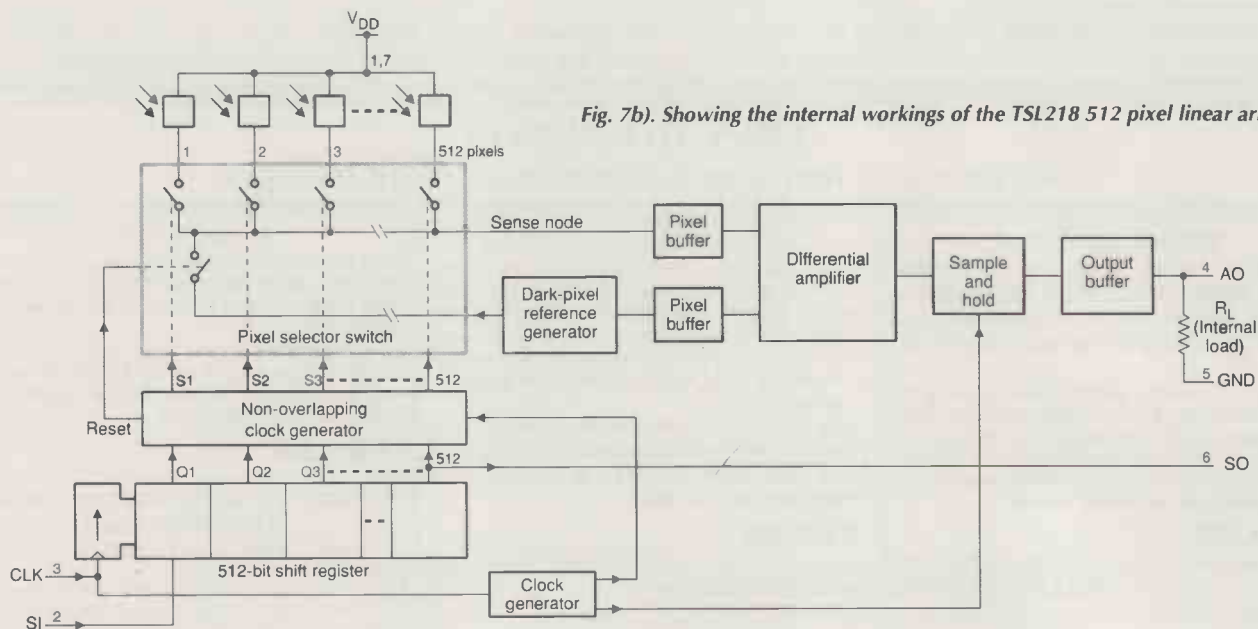


Fig. 7c). Following an SI pulse, the contents of all 512 pixels are read out serially. An SO pulse follows, which may be used as the SI pulse for a second device.

References

1. Texas Instruments Intelligent Opto Sensor Data Book, P/N SOEDE02B.
2. F. Ogden, 'An Easier Route to Light Measurement', *Electronics World + Wireless World*, June 1993, pp 490, 491.
3. C Kuhnel, 'Bits of Light', *Electronics World*, January 1996, pp 68, 69.
4. Ian Hickman, 'Sensing the Position', *Electronics World + Wireless World*, November 1992, pp 955-957.
5. Ian Hickman, *Analogue Circuits Cookbook*, Newnes (Butterworth-Heinemann), 1995, ISBN 0 7506 2002 1.

SMART CARD EVALUATION SYSTEM

Low Cost Introduction to Microprocessor Smart Cards

SMART CARD EVALUATION PACKAGE

Comprising of Presentation case containing:-

- ◆ Smart Card Reader / Writer (Programming Interface)
- ◆ 244 page Hard Back reference book, covering all aspects of Smart Card design and programming.
- ◆ Smart Card Interogation System, to identify the commands accepted by a target Smart Card.
- ◆ Evaluation application, for use with Smart cards provided in the package.
- ◆ 'C' Library & Command descriptions. For the user to design their own Smart card applications using the cards provided.
- ◆ Programmers Development Suite. Text Editor Assembler, Simulator for programming the Cards provided.
- ◆ Development Boards for use with the programming interface. Allowing the user to simulate a Smart Card
- ◆ Selection of real Smart cards with full programming details.

This package is all that is required to understand and develop, your first Smart Card application. The comprehensive documentation and specially written applications, give the user a valuable insight into Card architecture and Programming techniques. Comprehensive 'C' listings are included as is a complete 'RISC- like' processor development system. The package includes development PCB's to allow the user to program and Simulate a Smart Card, also included are REAL SMART CARDS along with access commands and complete UNRESTRICTED programming information. The unique SMART CARD INTEROGATON SYSTEM allows the user to Communicate with a Target card and extract the command set used by that card !

For more detailed product information please send a LARGE SAE with your request.

£225.00

discounts are available for multiple orders and Educational establishments.

THE SMARTEST SOLUTION

Crownhill can offer a broad range of processor based smart cards. Crownhill are not aligned to any single microprocessor or die supplier. This allows us to work with you the customer, in the selection of the optimal processor for your application.

Crownhill can supply over 150 different types of IC from more than 12 silicon suppliers, all can be incorporated into smart card format. Some cards are available from stock, most are manufactured to the customers specification.

JOHN MORRISON

DEVELOPMENT SOFTWARE & OEM PROGRAMMING MODULES

PIC PROGRAMMER

PIC16C54, 16C55, 16C56, 16C57, 16C58A, 16C61 16C64, 16C65, 16C71, 16C74, 16C84, 16C620, 16C621, 16C622 & Memory Chips 24LC01, 24LC02, 24LC16, 24LC 32, 24LC65

Supplied with powerful editing software allowing the user to Read, Write & Copy PIC devices including data memory and fuse areas. Supplied with an integrated Editor Assembler software suite. Sample files and notes. (PIC 16C84 copy protection removal is possible with the enhanced version)

£69.95

PIC IN CIRCUIT EMULATOR

A low cost ICE to emulate all 18 or 28 pin PIC devices. All ports are Bi-Directional with OSC2 output and RTCC input. An onboard A/D converter allows emulation of the PIC16C71. Supplied with PIC DEV software suite, user manual, connecting leads, headers and sample programs and projects.

Note the ICE is not 'real time' the speed of emulation is determined by the host PC. However a local clock output is available to enable real time measurements to be taken.

£99.95

MEGA PROM II

A versatile EPROM programmer capable of handling EPROMS, EEPROMS, Flash Memeory from 2Kb to 8Mb NOW Including Microchip 24LC Series serial memory chips.

The programmer operates with a host PC via the centronics port using a standard printer cable. The unit features AC / DC input Voltage handling and production quality ZIF socket.

£89.95

EPROM Emulator

A versatile EPROM pEmulator for ROM from 1Kb to 32Kb

The Emulator operates with a host PC via the centronics port using parallel cable. The unit features very fast Download to target board EPROM socket and complete integration with our development software suites.

Will also operate without our development software suite with no loss of functionality.

£59.95

SMARTIE EEPROM PROGRAMMER

EEPROM programmer covering: 24xx01, 02, 04, 08, 16, 32, 65, 164, 174, 29xx, 59xx, 85xx, 93xx, NMC, PCF. Smart little unit, just plugs into a free parallel port on the IBMPC and auto detects Microwave or 12C types. Simple to use and fast operation make this little programmer indispensable.

£49.95

Although this unit can be used to decode Car Radio's and Cassete players, we offer no advice or support for that use.....please do not ask!

We stock the full range of JOHN MORRISON development software for PIC devices, Microprocessors and Microcontrollers. Each software suite has a **FULLY INTEGRATED TEXT EDITOR, ASSEMBLER, SIMULATOR and DISASSEMBLER.**

Code can be downloaded directly to our Emulators. All software is supplied with sample code and operating instructions. Devices catered for include: MCS-8051/52/552, MCS-8048/49, PIC-16C54/55/56/57 and compatible, PIC 16C71/84 and compatible. HD-63/6809, 6502.

£19.95

CROWNHILL ASSOCIATES LIMITED
PO BOX 845
Waterbeach
Cambridge
CB4 9JS

TEL 07010 700017
01223 235895
FAX 01223 441645
BBS 07010 700018

CHEQUE
POSTAL ORDER
SWITCH
DELTA
International Money order

◆ **VISA**
 ◆ **ACCESS**
 ◆ **MASTER CARD**
Subject to 5% Surcharge

All prices are subject to VAT at the prevailing rate (17.5%) for EC orders.

CIRCLE NO. 129 ON REPLY CARD

Class-A power



After two and a half decades, **John Linsley-Hood's Class-A power amp** is still rated among the best. Here, John explains how to bring the design up to date, adding enhancements such as dc-coupled output.

The current debate, among some of the more reactionary of the hi-fi devotees, about the relative merits of thermionic valve operated audio amplifiers makes intriguing reading, if only because, in a sense, this is 'where I came in'. I will explain.

I have had an interest in the reproduction of music, principally from gramophone records, for a very long time. I made my first, two-valve, battery-operated, audio amplifier as a twelve year old school boy, some time before the outbreak of the 1939–1945 war.

This gave way – in the interests of economy, – to a series of mains powered audio amplifiers, which were usually combined with a radio receiver. Electricity from the mains was free, to me at least, whereas high-tension batteries

had to be bought from my pocket-money.

My early work culminated, in 1951, with the assembly of a luxurious kit for the highly esteemed high-fidelity Williamson 15W amplifier design. Although, by this time, I had my first proper job – in the electronics labs of the Sellafield nuclear research establishment in Cumberland – and cash was a bit more plentiful, I still wouldn't have built that particular, rather expensive version of the hardware if I hadn't heard through the lab grapevine that one of the research chemists had bought himself a Williamson kit, but, on receiving the parcel, lacked the courage to assemble its contents. Rumour had it that he was open to offers, and I was happy when he accepted mine.

This was an excellent amplifier, and

Valves versus transistors

Not all of the considerations of valves versus transistors relate solely to performance. It is worth bearing in mind that products involving obsolete technology will be disproportionately expensive, difficult to obtain and possibly of inferior quality.

Valves can also vary in operating characteristics from sample to sample – especially where two valves of the same type are obtained from different sources. Characteristics that can vary are mutual conductance, gain, operating grid bias, anode current impedance, and even usable anode voltage.

By comparison, the performance characteristics of, say, a range of 2N3055 epitaxial base output transistor are almost identical, whether made in the Philippines or in Toulouse.

Again, all valves deteriorate in use, exhibiting a gradual loss of cathode emission over a typical 3000 hour service life. If a valve is persistently over-driven, the heating of the anode may cause the metal to out-gas. This impairs the vacuum essential to proper operation, and shortens the valve's life.

A further consideration is that valves are high voltage devices, which can be dangerous. And the need for high working voltages can lead to more rapid failure of other components in the circuit – especially capacitors.

**YOUR
Ideal Partner
in UHF and VHF
COMMUNICATION**



**One stop solutions
for all your radio
telemetry module needs.**

When the success of your products depends on radio telemetry modules, you need a business partner you can trust. A skilled and experienced manufacturer that can offer modules of the highest quality, operating over a wide range of frequencies.

In other words, a partner like Wood & Douglas. Founded on technical excellence, Wood & Douglas is a British company that specialises in the design, development and production of radio-based products. With over 30 staff dedicated to meeting your requirements, the company is able to provide true one-stop purchasing - whatever your RTM needs.

All radio modules are highly functional, capable of meeting a wide range of requirements. Designed to offer efficient, easy-to-use radio telemetry components for system designers, they can open up a whole new world of product possibilities.



From portable bar-code readers to earthquake monitors, Wood & Douglas can help you make the most of the opportunities in radio telemetry.

To find out more about the possibilities, contact...



WOOD & DOUGLAS

Lattice House, Baughurst, Tadley, Hampshire RG26 5LP, England
Telephone: 0118 981 1444 Fax: 0118 981 1567
email: info@woodanddouglas.co.uk
web site: http://www.woodanddouglas.co.uk

**WE ONLY USE THE BEST
TEST AND MEASUREMENT
INSTRUMENTS ON OUR
OWN PRODUCTS...**

OSCILLOSCOPES



Over 34 models including: Digital, Analogue and Portables. Bandwidths from 5MHz to 150MHz. Sophisticated triggering, single and dual timebases, Multiple channels and large memory Dso's. Prices start from £235 (20MHz 2 Channel £399)

POWER SUPPLIES

Four separate ranges comprising of 40 models from low cost analogue displays to the latest high performance digital units. Providing up to 250 volts and 120 amps with Master-slave, RS 232 and GPIB are available on many models, as are optional rack mount facilities.



AUDIO VIDEO RF



Audio Oscillators, Analysers Wow and Flutter, Millivolt Meters and Distortion Meters Pattern

Generators, Vectorscopes, Waveform Monitors Video Analysers and Noise Analysers.

Five models of AM/FM Standard RF Generators offering a highly stable frequency range of 10KHz to 2GHz with digital readouts for Level, Frequency, Modulation and Memory address.

GENERAL PURPOSE

Frequency Counters, Function Generators plus a complete range of accessories to complement the complete range of instruments.



**...NOW YOU CAN DO
THE SAME**

If you like the idea of working with the best, contact us, we can provide brochures with a complete specification for all our measurement products.

**Kenwood UK Ltd, Kenwood House,
Dwight Road, Watford WD1 8EB, England**

TEL: +44 (0)1923 218794

FAX: +44 (0)1923 212905

KENWOOD

was better, in my judgment, by a greater or lesser extent, than any of its predecessors of my own design, or, indeed, any of the other valve amplifiers, belonging to my friends, with which I had had a chance to compare it. It gave me great pleasure until early 1968, when I replaced it with a solid-state equivalent.

What I replaced it by, and the circumstances of this replacement, were described in an article in *Wireless World* in April 1969, entitled 'A simple class A amplifier'. This was a long time ago. In the light of the current debate, it seems possible that both my listening trials at the time, and an up-dated version of my original class A design, may be of interest to you. By up-dated, I mean using more modern components and delivering a bit more power output,

The Williamson amplifier

In the inter-war years, with the improvement in audio quality of both gramophone records and radio broadcasts, considerable attention was paid to improving the quality of ac mains-powered audio amplifiers. A number of interesting designs were offered. These were mainly based on the use of push-pull output stage layouts. Relative to straight single ended circuits, push-pull stages would give greater output power for a given distortion level.

At that time, there were audiophiles who decried the use of push-pull output stage layouts. They claimed that the best audio quality was only obtainable from the much less efficient single ended arrangements, i.e. those in which the output valve had a simple resistor, choke or output transformer load. Interestingly, this is a claim which was examined and dismissed by Williamson at the time, but which has recently been resurrected.

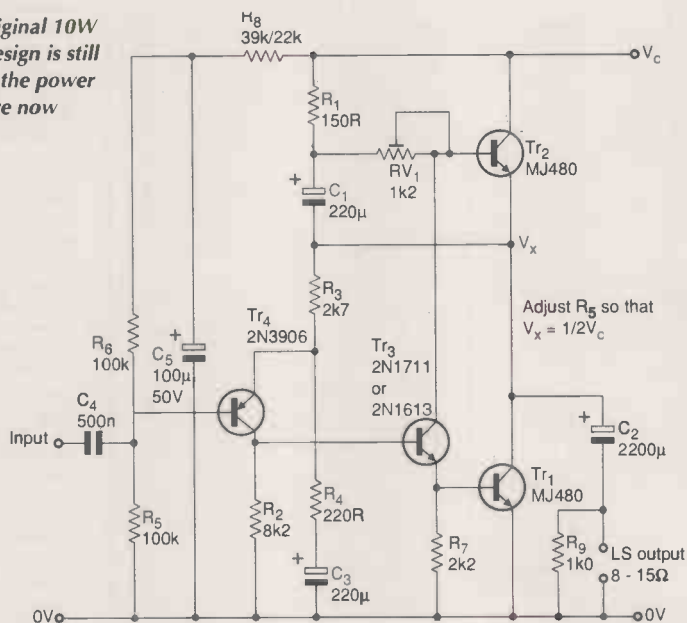
Using negative feedback

Almost all valve operated audio power amplifiers require an output transformer to match the relatively high output impedance of the valve output stage to the low impedance load presented by the loudspeaker.

In general, the transformer is the most difficult and expensive part of the system to design and construct. This is because of the following conflicting demands:

- For a low leakage reactance – combining both leakage inductance and interwinding capacitance – from the primary to the secondary windings, to avoid loss or impairment of high frequency signal components.
- For a low level of leakage inductance from one half of the primary to the other, to reduce the discontinuities due to push-pull operation, and the odd-order harmonic distortion resulting from these.
- For a high primary inductance, to give a good low-frequency response.

Fig. 1. Original 10W Class-A design is still valid, but the power devices are now obsolete.



- For a low winding resistance, to avoid power losses.
- For a good quality grade of core laminations to ensure a low level of core-induced distortion, due to magnetic hysteresis and similar effects.

Intrinsic signal distortion of a valve amplifier stage could range from 0.5 to 10%, depending on its circuit form and operating characteristics. It had been appreciated for some time that such intrinsic distortion could be reduced significantly by applying local negative feedback. Various amplifier designs incorporating local negative feedback had been proposed. However, this still left the output transformer – however well made – as a major source of transfer and frequency response non-linearities.

At this point, D. T. N. Williamson, who was working at the time as a development engineer for the valve section of the GEC Research Laboratories, described a high-quality audio amplifier design, using the recently developed GEC 'kinkless tetrode' output valve, namely the *KT66*. In this design, a single overall negative feedback loop embraced both the whole of the amplifier and the loudspeaker output transformer.

With the exception of the output valves, which were triode connected *KT66*s, Williamson's design employed triode amplifier valves, exclusively because these had a lower intrinsic distortion figure. He also made use of extensive local negative feedback, provided by un-bypassed cathode-bias resistors. This had the additional benefit of eliminating the electrolytic bypass capacitors – a philosophy which is in accord with much of contemporary thinking.

Williamson also used non-polar rather than

electrolytic high-tension reservoir and smoothing capacitors, in the interests of more consistent ac behaviour. Electrolytic capacitors were much worse at that time.

If overall negative feedback was to be applied without causing either high or low-frequency instability, careful design was essential – both in the amplifier stages and in the output transformer. These problems had frustrated earlier attempts to do this – but Williamson demonstrated that it could be done.

The performance given by his design, if his detailed specifications were carried out to the letter, was superb. The performance criteria of better than 0.1% thd, at 15W output, from 20Hz to 20kHz, and a gain bandwidth from 10kHz to 100kHz ± 1 dB, are at least as good as those offered by many of today's better commercial designs.

The series of articles written by Williamson, in *Wireless World* over the period 1947-1949 described the power amplifier and its ancillary units. This series had an enormous impact on audio design thinking, and if I may quote the *WW* editor of the time, in his introduction to a reprint of all of these articles.

"Introduced in 1947 as merely one of a series of amplifier designs, the 'Williamson' has for several years been widely accepted as the standard of design and performance wherever amplifiers and sound reproduction are discussed. Descriptions of it have been published in all the principal countries of the world, and so there are reasonable grounds for assuming that its widespread reputation is based solely on its qualities".

All in all, the Williamson was a hard act to follow.

TRANSISTORS

IN 4001	100 for £2
IN 4004	100 for £2
IN 4007	100 for £2
IN 3024B	20 for £1
IN 3155V	20 for £1
IN 4577A V	20 for £1
IN 4742A	20 for £1
IN 5230B	20 for £1
IN 5246B	20 for £1
IN 5253B	20 for £1
IN 5336B	20 for £1
IN 5337B	20 for £1
IN 5340B	20 for £1
IN 5343B	20 for £1
IN 5346B	20 for £1
IN 5363B	20 for £1
IN 5379B	20 for £1
IN 5380B	20 for £1
IN 5384B	20 for £1
IN 5385B	20 for £1
IN 5386B	20 for £1
IN 5648A	20 for £1
IN 5653A	20 for £1
IN 5656A	20 for £1
IN 6055A	20 for £1
IN 6057A	20 for £1
IN 6059A	20 for £1
IN 6061A	20 for £1
IN 6064A	20 for £1
IN 6068A	20 for £1
IN 6070A	20 for £1
IN 6072A	20 for £1
2N 1711	10p each
2N 2369A	10p each
2N 2484	10p each
2N 2894	10p each
2N 2905	10p each
2N 2906	10p each
2N 3419	10p each
2N 3700	10p each
2N 3725	20p each
2N 3824	16p each
2N 4117A	20p each
2N 4918	20p each
2N 5038	20p each
2N 5039	20p each
2N 5179	16p each
2N 5192	20p each
2N 5320	20p each
2N 5322	20p each
2N 5323	20p each
2N 5486	20p each
2N 6288	20p each
2N 6386	20p each
BC 108	5p each
BC 109	5p each
BC 161	5p each
BC 179B	5p each
BC 477	10p each
BC 546	5p each
BC 558	5p each
BCY 59B	10p each
BCY 791X	10p each
BD 175	20p each
BD 237	20p each
BD 238	20p each
BD 239	20p each
BD 240C	20p each
BD 436	20p each
BD 707	20p each
BD 909	20p each
BDW 84A	20p each
BDW 91	20p each
BDW 93C	20p each
BDW 94A	20p each
BDX 54	20p each
BDX 87C	20p each
BF 257	10p each
BF 258	10p each
BFR 36	20p each
BFR 852	5p each
BFR 856	5p each
BFW 43	20p each
BFW 44	20p each
BFX 38	20p each
BFX 40	20p each
BFX 86	20p each
BFY 64	20p each
BSX 19	10p each
BSX 33	10p each
BTA06-400B	3 for £1
BTA08-400B	3 for £1
BTA12-400B	3 for £1
BTB15-700B	3 for £1
BTB16-600B	3 for £1
BU208	3 for £1
BU208D	3 for £1
BU326A	3 for £1
BU911	3 for £1
BU326A	3 for £1
BU508A	3 for £1
BU931	3 for £1
BUR21	3 for £1
BUR50	3 for £1
BUR52	3 for £1
BUT11	3 for £1
BUV48	3 for £1
BUV50	3 for £1
BYT11-800	5p each
BYW78-100	10p each
MJ11028	£1.60 each
MJ11029	£1.80 each
P 600D	20 for £1
SD 1285	£2.60 each
SD 1487	£4.80 each
SD 1729	£6.20 each
T0509 MH	20p each
T0606 MJ	20p each
T1006 MJ	20p each
T1206 NH	20p each
T1216 MH	20p each
1.5 KE 39 CP	20 for £1
P 6 KE 75 CP	20 for £1

INTEGRATED CIRCUITS

HCF4000BEY	35p each
HCF4002BEY	37p each
HCF4006BEY	68p each
HCF4007BEY	17p each
HCF4008BEY	34p each
HCF4009UBEY	22p each
HCF4010BEY	20p each
HCF4012BEY	33p each
HCF4015BM1	41p each
HCF4016BEY	21p each
HCF4018BM1	61p each
HCF4023BM1	33p each
HCF4027BEY	50p each
HCF4035BEY	40p each
HCF4040BM1	74p each
HCF4041UBEY	34p each
HCF4054BSY	52p each
HCF4063BEY	60p each
HCF4067BM1	£3.47 each
HCF4068BEY	32p each
HCF4071BEY	34p each
HCF4075BM1	32p each
HCF4082BEY	34p each
HCF4097BEY	£3.47 each
HCF4099BEY	61p each
HCF4510BEY	86p each
HCF4516BEY	76p each
HCF4517BEY	£1.74 each
HCF4518BEY	39p each
HCF4532BEY	69p each
HCF4724BEY	58p each
HCF40105BEY	45p each
HCF40174BM1	62p each
M74HCU04BIR	30p each
M74HCU10BIR	30p each
M74HC21BIR	29p each
M74HCUT27BIR	16p each
M74HC30BIR	24p each
M74HC51BIR	39p each
M74HC109BIR	39p each
M74HC112BIR	90p each
M74HC137BIR	£1.75 each
M74HC151BIR	51p each
M74HC153BIR	51p each
M74HC157BIR	51p each
M74HC158BIR	49p each
M74HC160BIR	57p each
M74HC161BIR	57p each
M74HC174BIR	53p each
M74HC175BIR	23p each
M74HC190BIR	61p each
M74HC191BIR	61p each
M74HC195BIR	£1.09 each
M74HC241BIR	58p each
M74HC242BIR	58p each
M74HC243BIR	58p each
M74HC251BIR	54p each
M74HC280BIR	71p each
M74HC299BIR	£1.41 each
M74HC352BIR	55p each
M74HC367BIR	22p each
M74HC368BIR	40p each
M74HC390BIR	39p each
M74HC534BIR	70p each
M74HC563BIN	70p each
M74HC688BIR	86p each
M74HC6931BIN	86p each
M74HC696BIR	£1.89 each
M74HC697BIR	£1.89 each
M74HC698BIR	£1.20 each
M74HC4020BIR	40p each
M74HC4028BIR	27p each
M74HC4040BIR	32p each
M74HC4075BIR	30p each
T74LS13BI	30p each
T74LS14BI	19p each
T74LS20BI	16p each
T74LS27BI	49p each
T74LS33BI	67p each
T74LS37BI	40p each
T74LS42BI	87p each
T74LS51BI	32p each
T74LS74BI	42p each
T74LS75BI	41p each
T74LS86BI	28p each
T74LS93BI	£1.09 each
T74LS109BI	55p each
T74LS125BI	37p each
T74LS132BI	42p each
T74LS133BI	41p each
T74LS136BI	92p each
T74LS139BI	21p each
T74LS148BI	95p each
T74LS151BI	39p each
T74LS153BI	51p each
T74LS155BI	28p each
T74LS156BI	93p each
T74LS157BI	27p each
T74LS158BI	49p each
T74LS164BI	28p each
T74LS166BI	35p each
T74LS174BI	53p each
T74LS175BI	23p each
T74LS191BI	69p each
T74LS192BI	88p each
T74LS193BI	55p each
T74LS196BI	73p each
T74LS240BI	54p each
T74LS241BI	54p each
T74LS251BI	54p each
T74LS260BI	82p each
T74LS266BI	80p each
T74LS279BI	25p each
T74LS293BI	£1.63 each
T74LS352BI	55p each
T74LS353BI	70p each
T74LS366BI	60p each
T74LS367BI	22p each
T74LS368BI	40p each
T74LS378BI	61p each
T74LS390BI	60p each
T74LS393BI	57p each

SPECIAL INTEREST

Rittal Steel Cabinet Enclosures 800x1000x300mm	£100 each
Panel Mounted IEC Plug Filter with Switch	£2 each
Mitsubishi 12vdc Fans Type MMF-06B12DS	£4 each
Papst Fans 220vac Type 8550N	£6 each
Belling Lee IEC Plug Filter Type L2133CL	£1 each
Mains Filters Chassis Mounting, 5 Amp 115/250vac	£1 each
Papst Fans 8-16 vdc Type 8112K	£8 each
Bulgin Panel Mounting Fuse Holder 20mm with Tool Releasable Cap	£1 for 4
Festoon Bulbs 28v Amber	£1 for 3
Din Leads 5 pin Plug 180' to 5 Pin Socket 240'	£1 for 3
Metal Cases Two Piece Construction 220 x 125 x 95mm	£9 each
Simms Sockets Dual Readout Type 382759-1	£1.50 each
Bulkhead Lights, Red Diffuser, 100 x 60mm	£1 each
Crabtree Ceiling Switches, 6 Amp Retractive, Red Cord	£3 each
Diodes Type BY206	£1 for 20
System Sensor Automatic Smoke Detector Model 2424E	£3 each
Polyethylene Terminals Blocks, 12 Way 6 Amp	£3 for 10
Relays 11 Pin Latching DPCC, 24 vdc with Bases	£10 each
Hochiki Thermal Detectors Model DFF-60ELPC	£5 each
Robinson Nugent IC Sockets Type PLCC 68TP SMT	£1 each
Capacitors Radial Electrolytic 3M3, 63v	£1 for 20
Capacitors Radial Electrolytic 2200M, 16v	£1 for 20
Capacitors Radial Electrolytic 220M, 63v	£1 for 20
Capacitors Radial Electrolytic 470M, 50v	£1 for 20
Capacitors Radial Electrolytic 470M, 35v	£1 for 20
Capacitors Radial Electrolytic 1000M, 16v	£1 for 20
Capacitors Radial Electrolytic 330M, 63v	£1 for 20
Bulgin IEC Mains Inlet Fused Chassis Plug Type PF0011/10/28	£1 for 5
Ceramic Trim Capacitors 20pF (red)	£1 for 10
Ceramic Trim Capacitors 50pF (orange)	£1 for 8
GD 4001	£8 for 100
GD 4013	£8 for 100
Crystals 12 MHz & 16 MHz	£1 each
Crystals Oscillator Modules 20 Mhz, 28.322 & 32 MHz	£1.50 each
Capacitors Dip Poly 0M01 400V 10mm	£1 for 20
Capacitors Dip Poly 1M 100V 15mm	£1 for 20
Capacitors Dip Poly 0M33 100V 15mm	£1 for 20
Capacitors Axial Electrolytic 470MFD 16v	£1 for 20
Capacitors Axial Electrolytic 47MFD 10v	£1 for 20
Capacitors Box Poly 0M047 400V 15mm	£1 for 20
Transistors Type BC212L	£1 for 100
Light Emitting Diodes SLT-35 Series Triangular Lamps 3 x 4.5m	£1 for 10
Harwin Low Profile 10 Way IC Sockets on Sil Carriers	20p each
Densitron Liquid Crystal Displays, 5 Digit, Type LSH5060RP	£1 each
Super Twist Graphics Blue Model LCDs 320 x 240 Pixel Size 132 x 103mm Overall	£5 each
Valves QOV06-40A (Ex Equip)	£10 each
Victron Invertors Type VBB 48/1000, 48 vdc Input, 230 vac Output @ 1.0 KVA	£260
Stepper Motor Drive Boards 70V/5A Step and Microstep Type GS-D500	£45
Farnell Portable Synthesized Signal Generator 10-520 MHz Type PSG 520	£475
Processors TS68000 CFN12	£3 each
TS68230 CP8	£3 each
M38SH74AHBI	£2 each
LM148J	£1.80 each
L7820C-V	85p each
L4922	£1.35 each
HCC4013FOM2RB	43p each
L78L09CD	29p each
Panaflo Fans 40 x 40 x 20mm, 12vdc Model FBK-04F12L	£6.45 each
Papst Fans 60 x 60 25mm, 24vdc Model Type 614	£5.45 each
M ² Controllers 8/16-Bit Cmos Type ST90E40ZLI	£12.50 each
UPD 80C 39HC-0, 8 Bit Cmos CPU	£2.40 each
Resistor Packs Mixed 0.25W	£1 for 200
Mixed Component Box Loads of Goodies, Weighing 2 Kilos (lucky dip)	£6
Eproms 27C4, 27C128, 27C256, 27C512, 27C1001	£2.00 each
SEI Quartz Oscillators 13.5 MHz Type QC1311/10-1A	£25 each
TV Tubes 20" Hitachi 501 XTB22 Grade 2	£60 for 2
High Def Wide Screen 28" Tubes Type W67 EWS001X42	£60 each
Regulators Type LM7812CT & LM7912CT	30p each
ERDEHT Tripler Type BG2087-641-1021	£2 each
MQSIEHT Tripler Type MII1209C02	£2 each
Key Switches, 2 Pole c/o	£2 each
Briton Over Head Door Closers Type 2004s/se	£20 each
Yuasa Lead Acid Type Rechargeable Batteries 12v, 2.1AH in Plastic Box With Charger	£15 each
M38SH74AHBI	£2 each
LM148J	£2 each

B. BAMBER ELECTRONICS

5 STATION ROAD, LITTLEPORT, ELY, CAMBS CB6 1QE
TEL: 01353 860185 FAX: 01353 863245

MAIL ORDER ONLY

TERMS: CASH WITH ORDER. DELIVERY CHARGES ARE FREE WHEN YOUR ORDER TOTALS £30 OR MORE. IF LESS PLEASE ADD £3.35 + V.A.T.

VISA AND ACCESS WELCOME

V.A.T. @ 17.5% MUST BE ADDED TO THE TOTAL OF ALL ORDERS

Alternative hardware

The world had not stood still since 1951. My equipment had remained monophonic, while the rest of the audio world was changing over to stereo.

My main interest was in music, not in circuitry, so I thought it would be prudent to ask my ears what they thought of the alternatives, before I started to replace my hardware.

To this end, I built or borrowed six well thought-of audio amplifiers, my own Williamson, a *Quad 2*, two dissimilar but recently published class AB transistor amplifiers, a commercial 30W solid-state unit, and a simple Class-A unit of my own design.

I included the Class-A design out of curiosity. If it turned out to be any good, it would be cheap and easy to build. It was not expected to offer any special merit in performance.

In the event, as I reported at the time, (*WW* April 1969, p. 152), the six amplifiers divided quite clearly into two separate tonal groups. The three class AB transistor amplifiers formed one group, while the two valve amplifiers and the simple class A amplifier formed the other.

To be fair, the differences between any of these were not very great – but they were audible. Once they were noticed, they tended to become more apparent on protracted periods of listening. Certainly, for me – and I was doing these tests for my own benefit – in these comparative trials, the two best were the Williamson and the class A. They were virtually indistinguishable. Of these two, the Williamson was vastly more massive and costly to construct.

The only remaining question was, if I replaced the 15W Williamson with the 10W Class-A design, would the output be adequate? Connecting an oscilloscope across the loudspeaker terminals showed that I seldom needed more than 2–3W from the power amplifier – even under noisy conditions.

I suppose that the final proof of my satisfaction with the class A transistor amplifier was that, a year or so later, I gave my old Williamson to a friend.

The class A design

My original design is shown in Fig. 1. This is still a valid design, except that the *MJ480/481* output transistors are now obsolete. However, they can be replaced by the more robust *2N3055*. In this case, the epitaxial-base version of this device should be chosen rather than the homotaxial, since the f_T of the output transistors should be 4MHz or higher.

As I commented, at the time, the design gave a somewhat lower distortion if the h_{FE} of Tr_1 was greater than that of Tr_2 . This caused the output circuit to act as an amplifier with an active collector load rather than an output emitter follower with an active emitter load.

A simple modification which takes advantage of this effect is the use of a Darlington

transistor such as an *MJ3001* for Tr_1 . At 1kHz, this reduces the distortion level at just below the onset of clipping from about 0.1% down to nearer 0.01%. As before, residual distortion is almost exclusively second harmonic. Also, as before, it fades away into the general noise background of the measurement system as output power is reduced.

While this transistor substitution seems to be a good thing, it was not a modification whose effect I was able to check, in listening trials, against the Williamson. As a result, for the sake of historical fidelity, I would still recommend the use of epitaxial-base *3055s* as Tr_1 and Tr_2 .

I have checked all the other changes which I have proposed with the exception of the power increase.

Improving performance

With regard to the original 10W design, as published, I feel the following improvements will be beneficial:

- Provide a more elegant means of controlling output transistor operating current by including a variable resistor in the base of Tr_2 .
- Arrange the circuit so that it would operate between symmetrical power supply lines, allowing the amplifier to be directly coupled to the loudspeaker.
- Increase output power from 10 to 15 watts per channel.
- Up-grade the smoothed but not regulated power supply arrangement.

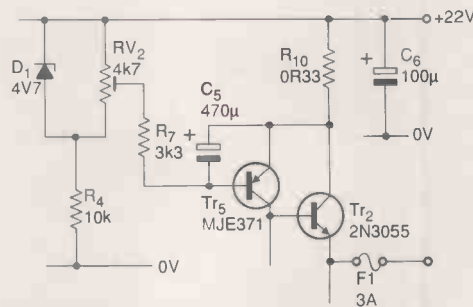


Fig. 2. Improved method of adjusting quiescent current, suggested as a postscript to the original design.

In my postscript to this design, which *WW* published in December 1970, I suggested both alternative transistor types and an improved method of adjustment and control of the output transistor current flow, Fig. 2.

Although, in theory, this layout should give a superior performance, when I changed my prototype amplifier to this arrangement, I found little change in measured thd and I couldn't hear any difference in sound quality.

Although directly coupling the amplifier to the loudspeaker will not have much effect on thd, it is still beneficial since it eliminates the output coupling capacitor. The most obvious way of doing this is to rearrange the input layout, around Tr_4 , so that it becomes the input half of a 'long-tailed' pair.

I am reluctant to do this because this would alter the overall gain/phase characteristics of the amplifier. It would also require additional high-frequency stabilisation circuitry, with all

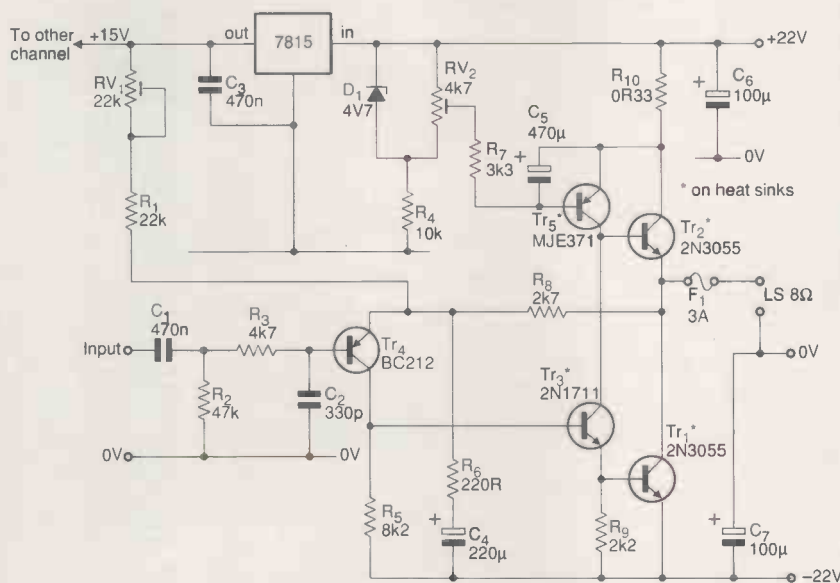


Fig. 3. One channel of the enhanced 15W Class-A design incorporating – among other things – direct loudspeaker coupling.

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 - 10KHz-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
 HP 141T Mainframe - £350.
 HP8552B IF - £300.
 HP8553B RF 1KHz to 110Mc/s - £200.
 HP8554B RF 10KHz 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 - 21GHz - £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-12.4GHzS-40GHzS. £750. 12.4Ghzs-40Ghzs with Mixers.
Tektronix Mixers are available for above ANZ to 60GHzs
 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 2-18GHzS
 R&S SWP Sweep Generator Synthesizer AM FM 4-2500Mc/s - £3.5k.
 ADRETE 3310A FX Synthesizer 300Hz-60Mc/s - £800.
 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.
 HP8150A Optical Signal Source.
 HP1630C 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.
 Rcal/Dana 2101 Microwave Counter - 10Hz-20GHz - £2k.
 Rcal/Dana 1250-1261 Universal Switch Controller + 200Mc/s PI Cards.
 Rcal/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 IEEE - 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 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 8474A - 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.
 Rcal/Dana 9301A - 9302 RF Millivoltmeter - 1.5-2GHz - £250-£400.
 Rcal/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 - DC506 - 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 0.1Hz - 100Kc/s + high pass + low pass - £150.
 Marconi TF2163S attenuator - 1GHz. £200.
 Farnell power unit H60/50 - £400 tested. H60/25 - £250.
 Rcal/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 - 7514 - 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.
 Rcal/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.
 Rcal/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.
 Rcal/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.
 HP 3325A syn function gen 20Mc/s - £1500.
 HP 3355A 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 86222B 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 3580A Analyser 5Hz - 50kHz - £1k.
 HP 1980B 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 8170A Logic pattern generator - £500.
 HP 59401A Bus system analyser - £350.
 HP 59500A Multiprogrammer HP - IB - £300.
 Philips PM5390 RF syn - 0.1 - 1GHz - AM + FM - £1000.
 S.A. Spectral Dynamics SD345 spectroscope 111 - LF ANZ - £1500.
 Tektronix R7912 Transient waveform digitizer - programmable - £400.
 Tektronix TR503 + TM503 tracking generator 0.1 - 1.8GHz - £1k - or TR502.
 Tektronix 576 Curve tracer + adaptors - £900.
 Tektronix 577 Curve tracer + adaptors - £900.
 Tektronix 1502/1503 TDR cable test set - £1000.
 Tektronix AM503 Current probe + TM501 m/frame - £1000.
 Tektronix SC501 - SC502 - SC503 - SC504 oscilloscopes - £75-£350.
 Tektronix 465 - 465B - 475 - 2213A - 2215 - 2225 - 2235 - 2245 - £250-£1000.
 Kikusui 100Mc/s Oscilloscope COS6100M - £350.
 Nicolet 3091 LF oscilloscope - £400.
 Rcal 1991 - 1992 - 1988 - 1300Mc/s counters - £500-£900.
 Fluke 80K 40 High voltage probe in case - BN - £100.
 Rcal Recorders - Store 4 - 4D - 7 - 14 channels in stock - £250 - £500.
 Rcal Store Horse Recorder & control - £400-£750 Tested.
 EIP 545 microwave 18GHz counter - £1200.
 Fluke 510A AC ref standard - 400Hz - £200.
 Fluke 355A DC voltage standard - £300.
 Wiltron 610D Sweep Generator + 6124C PI - 4 - 8GHz - £400.
 Wiltron 610D Sweep Generator + 61084D PI - 1Mc/s - 1500Mc/s - £500.
 Time Electronics 9814 Voltage calibrator - £750.
 Time Electronics 9811 Programmable resistance - £600.
 Time Electronics 2004 D.C. voltage standard - £1000.
 HP 8699B Sweep PI YIG oscillator .01 - 4GHz - £300. 8690B MF - £250. Both £500.
 Schlumberger 1250 Frequency response ANZ - £1500.
 Dummy Loads & power att up to 2.5 kilowatts FX up to 18GHz - microwave parts new and ex equip - relays - attenuators - switches - waveguides - Yigs - SMA - APC7 plugs - adaptors.
 B&K Items in stock - ask for list.
 W&G Items in stock - ask for list.
 Power Supplies Heavy duty + bench in stock - Farnell - HP - Weir - Thurby - Rca etc. Ask for list.

ITEMS BOUGHT FROM HM GOVERNMENT BEING SURPLUS. PRICE IS EX WORKS. SAE FOR ENQUIRIES. PHONE FOR APPOINTMENT OR FOR DEMONSTRATION OF ANY ITEMS, AVAILABILITY OR PRICE CHANGE. VAT AND CARRIAGE EXTRA

ITEMS MARKED TESTED HAVE 30 DAY WARRANTY. WANTED: TEST EQUIPMENT-VALVES-PLUGS AND SOCKETS-SYNCRS-TRANSMITTING AND RECEIVING EQUIPMENT ETC.

Johns Radio, Whitehall Works, 84 Whitehall Road East, Birkenshaw, Bradford BD11 2ER. Tel. No: (01274) 684007. Fax: 651160

CIRCLE NO. 133 ON REPLY CARD

its incipient problems of transient intermodulation or slew-rate limiting.

Fortunately, the need to remove the dc offset at the output can be achieved without altering the good phase margins of the design, by simply injecting an appropriate amount of current into the base circuit of Tr_4 .

Output power and dissipation

In essence, all that is required to increase the power output from the amplifier is to increase the rail voltages and standing current through the output devices. Restrictions are that power consumption must remain within the confines of what the mains transformer and rectifier can deliver. Also, the heat-sinks must be able to dissipate the extra heat and the output transistors must be adequately rated.

For a 15W (sinusoidal) output into an 8Ω load, an 11V_{RMS} drive voltage is required. This, in turn, means a 31V_{P-P} voltage developed across the load, and an output current into the load of 2A_P. Since the circuit is a single-ended configuration, in which the collector current will not increase on demand, this means that the output transistor operating current must be at least 2A to allow this.

With the circuit shown, using the improved current control layout – which is rather less efficient than the boot-strapped load for Tr_3 which I originally proposed – the rail voltage needed is $\pm 22V$.

This will lead to a dissipation, in each output transistor, of 44W. Prudence suggests that a heatsink having a rating of no more than 0.6°C/W, should be used for each output pair.

Most 2N3055s have a V_{ce} of 60V, a maximum collector current of 15A, and a maximum dissipation, on a suitable heatsink, of 115W. However, RCA's 3055, and its complementary MJ2955, are rated at 150W.

Working conditions for the output transistors lie entirely within the devices safe operating area, so no specific overload protection circuitry is needed. Even so, the inclusion of a 3A fuse in the loudspeaker output line would seem prudent.

DC offset cancellation

Figure 3 shows the full circuit for one channel of the 15W Class-A audio amplifier. I have inserted a 15V three-terminal regulator ic into the positive rail to prevent any unwanted signal or hum intrusion into the emitter of Tr_4 .

It is easy to set the dc offset to within $\pm 50mV$. The offset does not change greatly with time, although this assumes that Tr_5 is not allowed to warm up too much. This is because the base-emitter potential of this transistor controls the operating current, which in turn, affects output dc offset.

Small-signal bandwidth.

In the original circuit the small-signal bandwidth was 10Hz–250kHz, $\pm 3dB$, which was needlessly wide. Because of this, I have added

an input high-frequency roll-off network, R_3/C_2 , to the input circuit to limit the top end response to some 50kHz. This assumes an input source impedance of 10kΩ or less.

As it stands, the low-frequency –3dB point is about 7Hz. It can be lowered even further, if necessary, by making C_1 larger – say to 1μF.

Supplying power

As was shown in the 1970 postscript, it is possible to operate this amplifier from a simple rectifier/reservoir capacitor layout. Fig. 4 is an example. The only penalty is a small 100Hz background hum, probably about 3mV in amplitude. However, I feel that, if you are

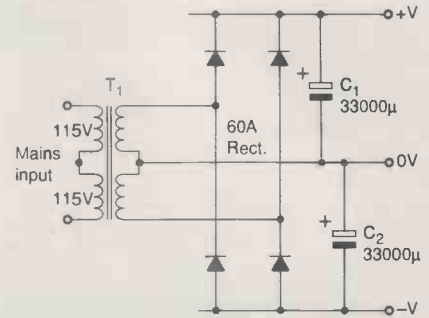


Fig. 4. Simple but adequate dual-rail supply using a single bridge.

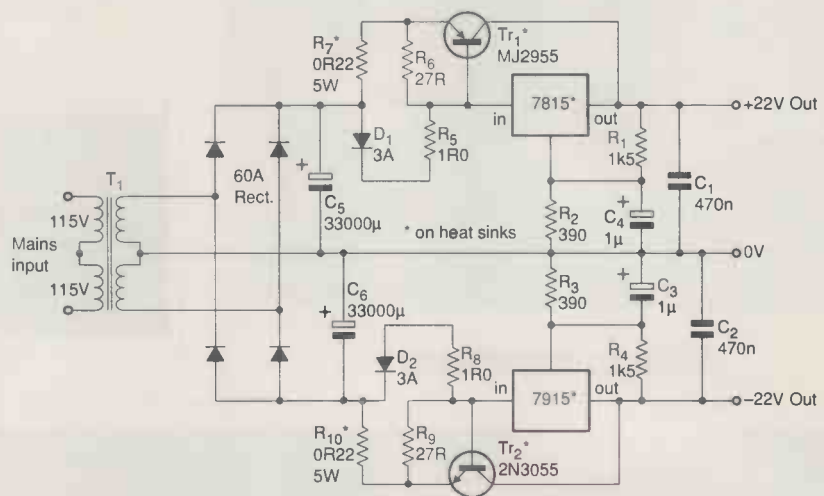


Fig. 5. Regulated power supply for the Class-A amplifier uses boosters around the three-terminal regulators. These take advantage of the regulators' current-limiting feature.

seeking the best, a proper regulated power supply is preferable, Fig. 5.

The circuit shown for the current booster pass transistors, Tr_1/Tr_2 , is one suggested by National Semiconductor. It takes advantage of the internal current limiting circuitry of the 7815/7915 devices to limit the short-circuit current of these ICs to 1.2A. By choosing the correct ratios of $R_5:R_7$ and $R_8:R_{10}$, the short-circuit current drawn from Tr_1 and Tr_2 will also be limited.

For a satisfactory ripple free dc supply of $\pm 22V$, the on-load voltage supplied to the regulator circuit should be $\pm 27V$.

Performance

I prefer measurements made with appropriate instruments to judgments based on listening tests.

Measured distortion is less than 0.1% near the onset of clipping. It fades away into the background noise level of the measuring system as output power level is reduced.

For me, the fact that the distortion given by this circuit is almost pure second harmonic is more persuasive of its performance than any

'golden eared' judgment of tonal purity.

If you then add the observation that the circuit remains stable on a square-wave drive into typical reactive loads, I am not surprised that its performance was capable of equalling the Williamson on listening tests. No significant overshoot is observed on the square-wave, and stability is achieved without the need for internal high-frequency compensation arrangements.

So, as a final thought, if any of you want to find out how a top quality valve amplifier like the Williamson sounds, you can find out at a tenth of the cost of building one by making up this Class-A design. It has the additional advantage of incorporating readily available and modern components. ■

Technical support

Hart is supplying full component sets for this design. Ring 01691 652894 (24h) or find Hart in the advertisers' index at the end of this issue.

The Universal Programmer that stands-alone



with everything you need. Don't buy your next programmer until you see the 'Eclipse'

- Windows and DOS user interface
- Unparalleled in speed & sophistication ideal for R&D and volume production
- 96 to 256 pin drivers
- Programs PLDs, EPLDs, FPGAs, PROMS, EPROMS, E/PROMs, FLASH & Micros
- Universal DIP, PLCC, PGA and QFP modules - no more socket adaptors
- Stand-alone or remote operation

Europe's largest programmer manufacturer

call today on +44 (0)1707 332148 or fax +44 (0)1707 371503 for further information

All trade marks are acknowledged and respected



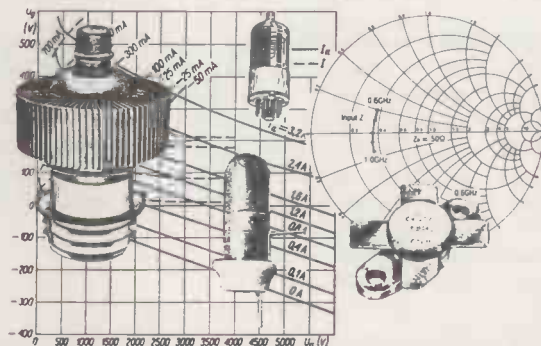
CIRCLE NO. 134 ON REPLY CARD



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

CIRCLE NO. 135 ON REPLY CARD

The Art Of In-Circuit Emulation

051 SABC16x 80x
112H89
XXX89 98x

Get us now for comprehensive information on the full range of state-of-the-art microprocessor tools.
Hitex (UK) Ltd, Tel: 01203 692066 FAX: 01203 692131
E-mail: sales@hitex.demon.co.uk
CompuServe: 100646.1526
hitex

CIRCLE NO. 136 ON REPLY CARD



Voted

BEST New HARDWARE*

Reliability

"Backer passes this test with flying colours"

PC Format

Performance

"Backer's top transfer rate of 9Mb per minute runs rings around the 1.8Mb per minute that most tape streamers can manage"
"Frightfully good stuff"

PC Format

Practical

"As conventional tape streamers and other back-up devices are generally financially impractical for most home users, Backer is an innovative fail-safe solution for your hard drive's content"

PC Advisor

Innovation

"A little gem of a product that allows you to use a video recorder as a hard disk back-up"

Windows Plus

Cost

"It represents unbeatable value for money"

Windows Plus

Capacity

"For an E180 tape at £2 you're talking about a cost of less than 1 penny per 8Mb of stored data! A single E180 tape can back-up over 1.5Gbytes of data"

Windows Plus, Home Office

* PC Format Customer Survey.

Distributor enquiries welcome.

Danmere Limited,
Whitehall, 75 School Lane, Hartford, Northwich, Cheshire CW8 1PF.
Tel: 01606 74330, Fax: 01606 75020, e-mail: sales@danmere.com



Backer® is a high performance back-up system designed specifically for the home user. For less than the price of most video games, you can store 1.5Gbytes of data on a single standard video tape, the equivalent of 3 CD-ROMs. Backer® utilises your existing video recorder to transfer data from your hard disk at up to 9Mbytes per minute, faster than many of the significantly more expensive tape drives. Backer® runs on a 486 and upwards with a minimum of 4Mb memory and utilises a standard 75 ohm video grade cable - scart to phono.

- Free up extra disk space by archiving less frequently used files.
- Transfer data between PC's, copy hundreds of Megabytes quickly and easily.
- Protect important files by keeping back-up copies.
- Uses low cost standard video tapes.
- Comprises an 8 bit ISA expansion card and easy-to-use software.
- State of the art sophisticated error correction ensures reliable operation.

Order now by completing the form below and sending together with a cheque or postal order made payable to Danmere Limited. Alternatively telephone, send a fax or e-mail quoting the information requested in the form below.



Backer runs under Windows® 3.1, 3.11 or Windows® 95. During archiving Backer operates in the background allowing the user to continue working in other Windows-based applications.



Microsoft® and Windows® are either registered trademarks or trademarks of Microsoft Corporation in the U.S.A and/or other countries.

Danmere 
Backer
The PC hard disk back-up system

Title: Mr/Mrs/Ms: Initials: Surname:

Address:

Postcode:

Daytime Telephone Number:

Credit Card Number:

Expiry Date: Issue Number:



PC Processor (e.g. 486, Pentium): Clock Speed (e.g. 66 Mhz):

Windows Version(s) Used:

Where did you see Backer advertised?

Item	Unit Price £	Qty	Total Price £
Backer	39.95		
3 Metre Scart to Phono Cable	4.95		
5 Metre Scart to Phono Cable	6.95		
Delivery to UK	2.50		
Delivery to Europe	5.00		
Delivery Overseas	7.50		
Order Total			£

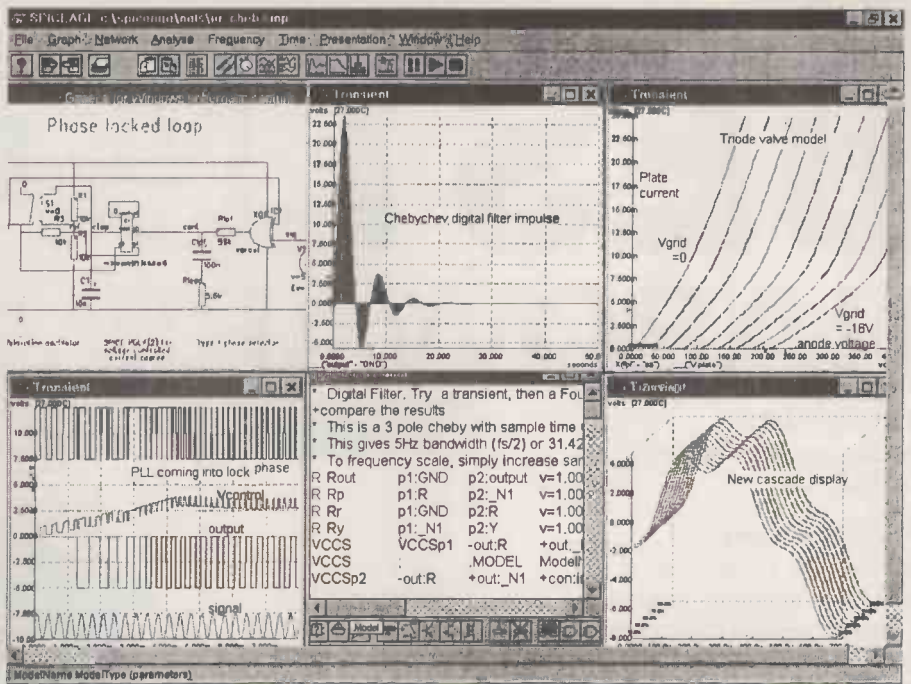
Please call, fax or e-mail for discounts on orders of 10 units or more. Allow 14 days for normal delivery, however same day despatch can be arranged if the order is received before 2.00pm and marked urgent. A 30 day money back guarantee plus 12 month warranty applies.

CIRCLE NO. 137 ON REPLY CARD

Get out of a pickle - get into SpiceAge!

Hands up all who have been there? A great idea turns into sleepless nights: getting one thing right breaks something else...

Some circuits require the digital refining of many interdependent variables. SpiceAge provides a virtually limitless inventory of components, signal functions and instruments with facilities for sweeping values, with am and fm through arbitrary functions. It can guide you to a solution that could take much longer to find using hardware.



SpiceAge up your design without burning a hole in your pocket. Prices from just £85 + VAT to £695 + VAT. Friendly technical help comes free (dreadful puns optional). For a demonstration kit and details of our other and third party support programs (includes schematics, PCB layout, filter synthesis and model synthesis), please contact:

Charles Clarke at Those Engineers Ltd, 31 Birkbeck Road, LONDON NW7 4BP.
Tel: 0181 906 0155 Fax: 0181 906 0969 Email 100550.2455@compuserve.com

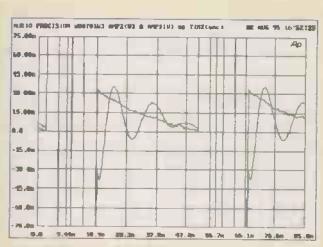


CIRCLE NO. 138 ON REPLY CARD

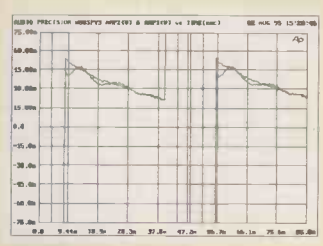
SUPRA Ply[®] speaker cable



SUPRA Ply 2.0
£6.00/m



Other brand 125Hz
Wavy trace shows poor damping after a transient



SUPRA Ply 125Hz
Superior damping - similar results at all audio frequencies

The test winner!

Stereophile USA December 1995
Studio Sound UK December 1995
Reproduced Sound Conference Nov 1995
"Speaker cable differences: CASE PROVEN"
by Ben Duncan Research.

Low inductance concept, low, benign oxidation
Much faster, tighter damping gives you higher definition and more control. Result: less blur, less listening fatigue. Transient error in a spaced wire or a zip-wire is as much as 1/28th of the immediately preceding signal; our cable design reduces this at least ten times.

The low, benign oxidation is discussed in Ben Duncan's article in Electronics World, February 1996: Modelling cable

Please send for our catalog to see our complete range of cables and connectors, for pro and HiFi!

Jenving Technology AB

Backamo 12800 • S-459 91 Ljungskile • Sweden
Fax: +46 522 23131 Tel: +46 522 23460

Supra Ply has got a big brother, Ply 3.4 £8.00/m for superior bass sonics
We are cable specialists since 1976 with distribution established in 24 countries

CIRCLE NO. 139 ON REPLY CARD

Designing reliable rectifiers

Ray Fautley explains how to design a reliable power supply using optimum components.

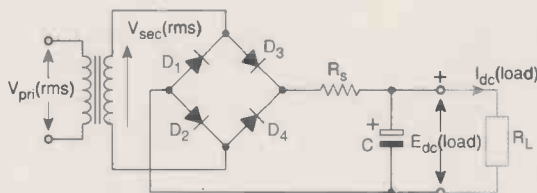


Fig. 1. The full-wave bridge rectifier is not the easiest way of producing dc from ac mains, but electrical stresses are lower than for other rectifier types.

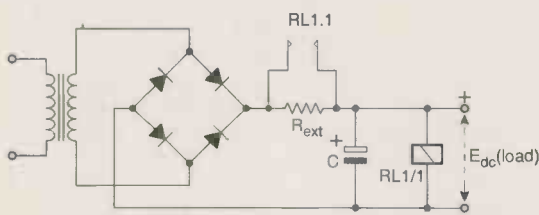


Fig. 2. At switch on, the capacitor present a short to the bridge and can cause diode failure. In this protection circuit, the relay contacts remain open until the capacitor is charged.

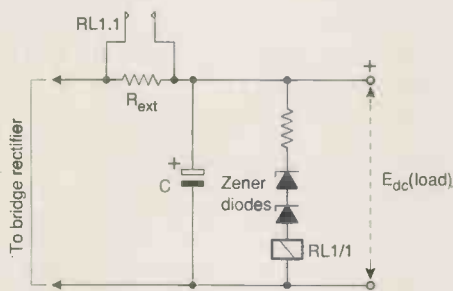


Fig. 3. Zener diodes can be used to operate the protection relay when output voltage reaches about 75% of maximum.

Reliable linear power supplies of many different types are common. But their apparent simplicity can easily lead designers to think that a few components connected to a mains transformer will produce the desired result. It can be disconcerting when at switch-on there is a bang and no output.

Main pitfalls to be avoided are breakdown of rectifier diodes due to excessive pulse current or reverse voltage, and too high voltage or ripple current causing violent demise of the reservoir capacitor.

This article and its successors cover how to design the commonest rectifier circuits, namely half-wave, full-wave centre tap, full-wave bridge and voltage doubler circuits. Design procedures presented are intended to help you design reliable linear supplies with a minimum of effort.

The source of the tabulated figures is a set of curves produced by O. H. Schade for valve type rectifiers. Although originally published over fifty years ago, these figures are still valid and useful!

Because the full-wave bridge is probably the commonest rectifier circuit these days, it is the subject of the first design procedure. It is not by any means the simplest way of providing dc from ac mains, but the electrical stresses on the diodes are less than for other types.

Full-wave bridges

In the full-wave bridge circuit, Fig. 1, alternating voltage is applied to the bridge diodes D_{1-4} , where it is rectified and the output smoothed by the reservoir capacitor C . The fundamental frequency of the ripple voltage superimposed on the dc output is twice that of the supply frequency. So for a 50Hz mains supply the ripple frequency is 100Hz. Resistor R_s represents the resistance of the source of the supply, and R_L the effective resistance of the dc load.

Designing a full wave bridge

To design a full-waver bridge rectifier, follow these steps.

- 1) Specify required dc output voltage at full load $E_{dc(load)}$ (volts).
- 2) Specify required maximum load current $I_{dc(load)}$ (amps).
- 3) Specify maximum ripple voltage acceptable $V_{r(rms)}$ (volts).
- 4) Specify the ac mains supply voltage $V_{pri(rms)}$ (volts).
- 5) Specify the frequency of the ac mains supply f (hertz).
- 6) Determine the value of the equivalent load resistance $R_L = E_{dc}/I_{dc(load)}$ where E_{dc} is the design value of the dc output voltage. It is the voltage drop across the load $E_{dc(load)}$ added to the voltage drop across the rectifiers: E_{dc} equals $E_{dc(load)} + 2V_{rec}$ and V_{rec} is 0.9V, which is the drop across each rectifier diode. So R_L equals $[E_{dc(load)} + 1.8]/I_{dc(load)} \Omega$.
- 7) Determine average current through each diode, I_o . As the bridge has two current branches, half the total average current will flow through each branch and thus also through each diode. Current I_o equals $I_{dc(load)}/2$.
- 8) Determine a value for the source resistance of the supply to the bridge rectifier, R_s .
- 8a) For low resistance loads, ie, low voltage high current supplies, for example 12V at 10A, diode resistance R_{rec} will probably be the largest component of R_s and so must not be forgotten. Resistance $R_{rec} = V_{rec}/I_o$, where $V_{rec} = 0.9V$. As a result, R_s equals $R_{sec} + R_{pri}/N^2 + 2R_{rec}$, where N is $V_{pri(rms)}/V_{sec(rms)}$. The term for rectifier diode resistance is $2 \times R_{rec}$ because in the bridge circuit there are two diodes in series across the transformer secondary winding. The term R_{pri}/N^2 represents the value of the resistance

of the transformer primary winding reflected – or appearing at – the secondary winding. Resistance of the transformer secondary winding itself is R_{sec} . So R_{sec} is transformer secondary winding resistance, R_{pri} is transformer primary winding resistance and N is transformer turns ratio, i.e., $N=V_{pri}/V_{sec}$ or primary-turns/secondary-turns.

If the transformer winding resistances are not known – and this is very likely as the transformer requirements haven't been defined yet – it is fairly safe to assume that $R_{sec}+R_{pri}/N^2$ is about 5% of load resistance R_L . Then R_s is $(R_L \times 5)/100 + (2 \times 0.9)/I_o$.

8b) For high resistance loads, i.e. high voltage, low current supplies (eg, 500V, 100mA) the resistance of the transformer windings will completely swamp the much smaller value of the rectifier resistance. So $R_s=R_{sec}+R_{pri}/N^2$.

As before, if the transformer winding resistances are not known, assume that $R_{sec}+R_{pri}/N^2$ is about 2% to 5% of R_L . Say $R_s=R_L \times 5/100$ (5% of R_L).

9) Calculate the ratio of R_s to R_L as a percentage: $R_s/R_L \times 100\%$.

10) Determine the percentage ripple voltage from the specified maximum ripple voltage and the dc output voltage, $V_r\%$, from $V_{r(rms)}/E_{dc(load)} \times 100\%$

11) From Table 1, determine the value of X required to provide the percentage ripple voltage, $V_r\%$, and $R_s/R_L\%$, as above.

If figures for $V_r\%$ and $R_s/R_L\%$ are not exactly the same as those found in the table headings, then the required value for X must be interpolated. A couple of examples may help.

11a) If $V_r\%=2.5$ and $R_s/R_L\%=2.0$, look for values on each side of those in the example. For $V_r\%=2$ and $R_s/R_L\%=1.0$, then $X=36$, $V_r\%=3$ and $R_s/R_L\%=3.0$, then $X=23$.

Although not absolutely theoretically correct, finding the arithmetical mean value between 22 and 36 will give a good enough approximation of the value for X . The arithmetical mean between a and b is given by $(a+b)/2$. So the arithmetical mean between 22 and 36 is: $(22+36)/2$, which is 58/2, or 29.

11b) If $V_r\%=15$ and $R_s/R_L\%=20$, again look for values on each side.

For $V_r\%=10$ and $R_s/R_L\%=10$, then $X=5.9$, $V_r\%=20$ and $R_s/R_L\%=30$, then $X=2.2$. The arithmetical mean between 2.2 and 5.9 is 4.05, again a good enough working approximation. This method is, of course, applicable to finding in-between values when using the other three tables.

12) Calculate the value of the reservoir capacitor C , required to provide the ripple voltage $V_{r(rms)}$ from $C=X/(2\pi f \times R_L) \times 10^6 \mu F$.

Some of you may wonder why the term used for frequency in the equation for C mentioned earlier is f and not $2f$ (the ripple frequency in a bridge rectifier being twice the supply frequency). It is simply because the figures in Table 1 were calculated to allow for the difference.

Table 1. An aid to finding the value of X

$V_r\%$	$R_s/R_L\%$						
	0.1	0.3	1.0	3.0	5.0	10	30
0.1	771	740	709	679	650	583	463
0.2	381	368	354	340	326	294	233
0.3	257	247	237	228	219	199	158
0.4	195	188	177	170	163	147	120
0.5	154	148	141	135	129	116	95
0.6	128	123	117	112	108	98	81
0.7	110	106	102	98	94	85	69
0.8	97	93	88	85	81	74	61
0.9	86	82	78	75	72	65	54
1.0	78	75	71	68	65	59	49
2	38	37	36	35	33	30	25
3	26	25	24	23	22	20	16
4	19	19	18	17	17	15	12
5	15	15	14	14	13	12	10
6	13	12	12	11.5	11.1	10	8
7	10.6	10.3	9.9	9.6	9.3	8.5	7.0
8	9.1	8.8	8.5	8.2	8.0	7.4	6.0
9	8.0	7.7	7.5	7.3	7.0	6.5	5.3
10	7.1	7.0	6.8	6.6	6.4	5.9	4.9
20	2.9	2.8	2.7	2.6	2.6	2.4	2.2
30	1.6	1.6	1.5	1.5	1.4	1.4	1.2
40	0.9	0.9	0.9	0.9	0.9	0.8	0.7

Table 2. Finding the value of Y, using X

X	$R_s/R_L\%$									
	0.05	0.1	0.5	1.0	2	4	6	8	10	12.5
0.1	0.64	0.64	0.64	0.63	0.62	0.61	0.60	0.57	0.57	0.56
0.2	0.64	0.64	0.64	0.63	0.62	0.62	0.60	0.58	0.57	0.57
0.3	0.64	0.64	0.64	0.63	0.63	0.62	0.61	0.59	0.58	0.57
0.4	0.64	0.64	0.64	0.63	0.63	0.62	0.61	0.60	0.58	0.58
0.5	0.65	0.64	0.64	0.63	0.63	0.62	0.61	0.60	0.59	0.58
0.6	0.65	0.65	0.64	0.64	0.64	0.63	0.62	0.60	0.59	0.58
0.7	0.66	0.65	0.65	0.65	0.64	0.63	0.62	0.61	0.60	0.59
0.8	0.66	0.66	0.66	0.65	0.65	0.64	0.63	0.62	0.60	0.59
0.9	0.67	0.66	0.66	0.66	0.65	0.64	0.63	0.62	0.61	0.60
1.0	0.68	0.68	0.67	0.67	0.66	0.65	0.64	0.63	0.62	0.61
1.5	0.72	0.71	0.70	0.70	0.69	0.68	0.67	0.65	0.64	0.62
2.0	0.76	0.76	0.76	0.76	0.75	0.73	0.71	0.70	0.67	0.64
2.5	0.77	0.77	0.77	0.77	0.76	0.74	0.72	0.71	0.68	0.66
3.0	0.79	0.78	0.78	0.78	0.77	0.75	0.73	0.72	0.69	0.68
4.0	0.82	0.82	0.80	0.79	0.79	0.78	0.75	0.73	0.71	0.69
5.0	0.85	0.85	0.84	0.84	0.82	0.80	0.77	0.75	0.73	0.70
6.0	0.86	0.86	0.85	0.85	0.84	0.80	0.77	0.75	0.73	0.70
7.0	0.88	0.87	0.86	0.86	0.85	0.82	0.78	0.75	0.74	0.71
8.0	0.89	0.88	0.87	0.87	0.86	0.82	0.78	0.76	0.74	0.71
9.0	0.90	0.90	0.88	0.88	0.87	0.83	0.79	0.76	0.74	0.72
10	0.92	0.91	0.90	0.89	0.88	0.84	0.80	0.77	0.75	0.72
15	0.95	0.93	0.91	0.90	0.89	0.85	0.80	0.77	0.75	0.72
20	0.96	0.95	0.94	0.92	0.90	0.86	0.80	0.78	0.75	0.73
25	0.96	0.96	0.95	0.93	0.90	0.86	0.81	0.78	0.75	0.73
30	0.97	0.96	0.95	0.93	0.91	0.86	0.82	0.78	0.76	0.73
40	0.98	0.97	0.96	0.93	0.91	0.86	0.82	0.78	0.76	0.73
50	0.98	0.98	0.96	0.94	0.91	0.86	0.82	0.79	0.76	0.73
60	0.98	0.98	0.96	0.94	0.91	0.86	0.82	0.79	0.76	0.73
70	0.99	0.99	0.96	0.94	0.91	0.86	0.82	0.79	0.76	0.73
80	0.99	0.99	0.96	0.94	0.91	0.86	0.82	0.79	0.76	0.73
90	0.99	0.99	0.97	0.94	0.91	0.86	0.82	0.79	0.76	0.73
100	0.99	0.99	0.97	0.94	0.91	0.86	0.82	0.79	0.76	0.73
200	1.0	0.99	0.97	0.94	0.91	0.86	0.82	0.79	0.76	0.73
300	1.0	0.99	0.97	0.95	0.91	0.86	0.82	0.79	0.76	0.73
1000	1.0	0.99	0.97	0.95	0.91	0.86	0.82	0.79	0.76	0.73

TABLE 2 (continued)

To Find the Value of Y												
X	$R_s/R_L\%$											
	15	20	25	30	35	40	50	60	70	80	90	100
0.1	0.56	0.54	0.51	0.49	0.47	0.46	0.44	0.40	0.38	0.35	0.33	0.32
0.2	0.56	0.54	0.51	0.49	0.47	0.46	0.44	0.40	0.38	0.35	0.33	0.32
0.3	0.56	0.54	0.51	0.49	0.47	0.46	0.44	0.40	0.38	0.36	0.33	0.32
0.4	0.56	0.54	0.51	0.49	0.48	0.46	0.44	0.40	0.38	0.36	0.33	0.32
0.5	0.57	0.54	0.51	0.50	0.48	0.46	0.44	0.41	0.38	0.36	0.34	0.32
0.6	0.57	0.54	0.51	0.50	0.48	0.46	0.44	0.41	0.38	0.36	0.34	0.32
0.7	0.57	0.55	0.52	0.50	0.48	0.46	0.44	0.41	0.38	0.37	0.34	0.32
0.8	0.58	0.55	0.52	0.50	0.48	0.47	0.44	0.41	0.39	0.38	0.34	0.33
0.9	0.58	0.55	0.53	0.51	0.49	0.47	0.45	0.41	0.39	0.38	0.34	0.33
1.0	0.59	0.56	0.53	0.51	0.49	0.47	0.45	0.42	0.40	0.38	0.35	0.33
1.5	0.60	0.57	0.55	0.52	0.50	0.48	0.45	0.42	0.40	0.38	0.35	0.33
2.0	0.63	0.59	0.56	0.53	0.51	0.49	0.46	0.43	0.41	0.38	0.35	0.33
2.5	0.64	0.60	0.57	0.54	0.52	0.50	0.47	0.43	0.41	0.38	0.36	0.34
3.0	0.65	0.61	0.58	0.55	0.52	0.50	0.47	0.43	0.41	0.38	0.36	0.34
4	0.66	0.62	0.59	0.55	0.53	0.51	0.47	0.44	0.41	0.38	0.36	0.34
5	0.67	0.63	0.60	0.56	0.54	0.52	0.48	0.44	0.42	0.39	0.37	0.35
6	0.68	0.63	0.60	0.56	0.54	0.52	0.48	0.44	0.42	0.39	0.37	0.35
7	0.68	0.64	0.60	0.57	0.54	0.52	0.48	0.44	0.42	0.39	0.37	0.35
8	0.68	0.64	0.60	0.57	0.54	0.52	0.48	0.44	0.42	0.39	0.37	0.35
9	0.69	0.64	0.60	0.57	0.54	0.52	0.48	0.44	0.42	0.39	0.37	0.35
10	0.69	0.65	0.61	0.58	0.55	0.52	0.48	0.44	0.43	0.39	0.37	0.35
15	0.69	0.65	0.61	0.58	0.55	0.52	0.48	0.44	0.43	0.39	0.37	0.35
20	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.44	0.43	0.39	0.37	0.35
25	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.39	0.37	0.35
30	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.39	0.37	0.35
40	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.39	0.37	0.35
50	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.35
60	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.35
70	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.35
80	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.35
90	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.35
100												
to	0.70	0.66	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.36
1000												

13) Find the nearest standard or available value for the reservoir capacitor C , close to or preferably just above, the value calculated earlier. If the value different from the one found earlier, call it C_1 and determine a new value for X , called X_1 , using $X_1=2\pi fR_L C_1$ with C_1 in μF , and $X_1=(2\pi fR_L C_1)/10^6$.

14) From the figures in Table 2 determine the value of Y for X in (11) (or X_1 in (13) and $R_s/R_L\%$ in (9)).

15) Determine the transformer secondary voltage $V_{sec(rms)}$ required, from the value for Y in (14),

$$V_{sec(rms)}=E_{dc}/(\sqrt{2}\times Y)=(0.707\times E_{dc})/Y$$

where $E_{dc}=E_{dc(load)}+2V_{rec}$.

16) Determine peak voltage or PIV, or peak inverse voltage, that each of the rectifier diodes must withstand. PIV is $V_{sec(peak)}$, which equals $\sqrt{2}\times V_{sec(rms)}$, or $1.414V_{sec(rms)}$.

17) Find the value of Z from the figures in Table 3 for $2X$ or $2X_1$, where X was found in (11), and for $R_s/2R_L\%$, where $Z=I_{(rms)}/I_o$.

18) From the values for Z found in (17) and I_o in (7), determine the current through each rectifier diode: $I_{(rms)}=I_o\times Z$.

19) Determine recurrent peak current $I_{(peak)}$ through each rectifier diode. From the figures in Table 4 for $2X$ (or $2X_1$) and $R_s/2R_L\%$ find

W , which is $I_{(peak)}/I_o$. Then find $I_{(peak)}=I_o\times W$.

20) Determine initial switch-on current I_{on} . As C (or C_1) will be initially discharged, the load on the rectifier diodes will be nearly a short-circuit at the instant of switch-on, limited only by the source resistance R_s . As a result, I_{on} is $V_{sec(peak)}/R_s$.

This very high current flows for only a very short time, but the rectifier diodes must be capable of withstanding it. If suitable devices with such high pulse current ratings are not available, the source resistance R_s must be increased by adding an external resistor R_{ext} between the bridge rectifier and the reservoir capacitor C (or C_1). The value of R_{ext} to limit the switch-on current to an acceptable lower value $I_{on(L)}$, is determined later in (28).

21) Decide on a suitable rectifier diode type to be used. The device must have all its ratings equal to, or greater than the following: Peak-inverse voltage or $V_{sec(peak)}$, sometimes called V_{RRM} , as in (16):

Initial switch-on current or I_{on} , sometimes called I_{FSM} , as in (20): Average current or I_o , sometimes known as $I_{F(AV)}$, as in (7).

22) Determine rms ripple current, $I_{c(rms)}$, flowing through the reservoir capacitor C (or C_1) using $\sqrt{(2[I_{(rms)}]^2-[I_{dc(load)}]^2)}$.

23) Decide on the specification for the reservoir capacitor to be used. The capacitor

must have ratings equal to, or greater than, the following. Capacitance C (or C_1) see (12) or (13), dc working voltage $V_{sec(peak)}$, see (16), and ripple current $I_{c(rms)}$ see (22).

24) Total transformer secondary current $I_{t(rms)}$ comprises two currents, one in each branch of the bridge, which must be summed using: $\sqrt{([I_{(rms)}]^2+[I_{(rms)}]^2)}$, which is $\sqrt{2}\times I_{(rms)}$.

25) Transformer VA or volt-amp rating T_{VA} determines the size of the transformer: $V_{sec(rms)}\times I_{t(rms)}$.

26) Transformer requirements are volt-Amp rating T_{VA} , see (25), primary winding voltage $V_{pri(rms)}$, see (4), secondary winding $V_{sec(rms)}$, see (15), and secondary current $I_{t(rms)}$, see (24).

27) When a suitable transformer has been chosen, measure the resistance of both windings. If measured source resistance $R_{s(m)}$, or $R_{sec}+R_{pri}/N^2+2R_{rec}$, is less than R_s calculated in (8), then an external resistor calculated using $R_{ext}=R_s-R_{s(m)}$ must be added, see (28), to limit I_{on} to the value found in (20). For low resistance loads, as in (8a), it is unlikely that any external resistance will be necessary as the diode resistance R_{rec} will tend to limit the switch-on current rather than the resistance of the transformer windings.

28) If an external resistor R_{ext} was found necessary in (20) or (27) to be fitted between the rectifiers and the reservoir capacitor C (or C_1) to limit the switch-on current to $I_{on(L)}$, see (20), its value will be $[V_{sec(peak)}/I_{on(L)}]-R_s$.

29) Power P_r , dissipated in R_{ext} (if used) is given by $[I_{t(rms)}]^2 R_{ext}$.

A suitable resistor should have a power rating of about twice the value of P_r for reliable operation.

30) If external resistor R_{ext} is used, and is of high enough resistance to degrade the supply's regulation, it could be shorted out by a switch immediately after switch-on. Either a hand operated toggle switch or, preferably an automatically operated circuit could be used.

Power switch with automatic sensing

Automatic operation could be by a circuit sensing the rise of current through a relay coil. This relay has an operating voltage just below $E_{dc(load)}$ connected and is directly across the dc output. Its contacts are normally open, and connected across R_{ext} .

At the instant of switch-on, with high current charging the reservoir capacitor, the relay contacts are open, so R_{ext} limits the current. As the capacitor charged, the voltage across it rises until it becomes high enough to operate the relay. The relay contacts then close, shorting out R_{ext} , thus reducing the series resistance of the supply and improving its regulation, Fig. 2.

For higher voltage supplies the relay could have a combination of resistance and zener diodes in series. This would enable operation when say, the output voltage reached about 75% of its full value, $E_{dc(load)}$, see Fig. 3.

Implementing the equations

Suppose you want a supply to operate a linear amplifier. Requirements are for an output volt-

age of 13.5V at 10A. Assume that an acceptable ripple voltage is 0.6Vrms and that the supply will operate from the standard mains supply of 240V, 50Hz. Design stages are numbered as previously.

- 1) $E_{dc(load)}$ is 13.5V.
- 2) $I_{dc(load)}$ is 10A.
- 3) $V_{r(rms)}$ is 0.6Vrms.
- 4) $V_{pri(rms)}$ is 240Vrms.
- 5) f is 50Hz.
- 6) $R_L = E_{dc}/I_{dc}$, where E_{dc} is $E_{dc(load)} + 2V_{rec}$. So R_L is $[E_{dc(load)} + 1.8]/I_{dc(load)}$, or $(13.5 + 1.8)/10$, giving 1.53Ω.
- 7) $I_o = I_{dc(load)}/2 = 10/2 = 5A$.
- 8) Using (8a), $R_s = (R_L \times 5)/100 + 2R_{rec}$, where R_{rec} is $V_{rec}/I_o = 0.9/5$, or 0.18Ω and R_s is $(1.53 \times 5)/100 + 2(0.18)$ or 0.437Ω.
- 9) $R_s/R_L \times 100\% = (0.437/1.53) \times 100\%$, giving 0.286 × 100%, or 28.6%.
- 10) $V_r\%$ is $V_{r(rms)}/E_{dc(load)} \times 100\%$, which equals $0.6/13.5 \times 100\%$, or 4.44%.
- 11) From Table 1, the value of X for $V_r\% = 4.44\%$ and $R_s/R_L\% = 28.6\%$, is found to be 11.0.
- 12) $C = X/2\pi f R_L$ is $(11 \times 10^6)/2\pi \times 50 \times 1.53\mu F$ or 22,885μF.
- 13) 22,000μF is a standard value for an electrolytic capacitor and would be a suitable choice.
- 14) The value of Y for $X = 11.0$, and $R_s/R_L\% = 28.6\%$ from Table 2 is 0.59.
- 15) $V_{sec(rms)}$ is $E_{dc}/\sqrt{2} \times Y$, which is $15.3/1.414 \times 0.59$ or 18.34Vrms.
- 16) $\sqrt{2} \times 18.34$ is 25.9V_(peak) or PIV.
- 17) Value of Z , for $2X = 22.0$ and $R_s/R_L\% = 14.3\%$, from Table 3 is found to be 2.0. Here, X is 11.0 in (11) and $R_s/R_L\%$

equals 28.6% in (9).

- 18) $I_{(rms)} = I_o \times Z$, which is 2×5 , or 10A, where $Z = 2.0$ in (17) and $I_o = 5.0A$ in (7).
- 19) Value of W for $2X = 22.0$ and $R_s/2R_L\% = 14.3\%$ from Table 4 is found to be 5.0 and thus $I_{(peak)}$ is $I_o \times W$, which is 25A. Here, $X = 11.0$ in (11) and $R_s/R_L\% = 28.6\%$ in (9).
- 20) $I_{on} = V_{sec(peak)}/R_s = 25.9/0.437 = 59.3A$.
- 21) Diode ratings required are PIV (or V_{RRM}) of 25.9V, I_{on} (or I_{FSM}) of 59.3A and I_o (or $I_{F(AV)}$) of 5.0A. Diode type BYX98-300 is suitable, having a PIV (V_{RRM}) of 300V, an I_{on} (I_{FSM}) of 75A and an I_o ($I_{F(AV)}$) of 10A.
- 22) $I_{c(rms)} = \sqrt{(2I_{(rms)}^2) - I_{dc(load)}^2}$, which gives $\sqrt{2}([10^2] - [10^2])$, or 10A.
- 23) Reservoir capacitor ratings are a capacitance of 22,885μF (22,000μF standard value) a $V_{sec(peak)}$ equal to $V_{DC(wkg)}$ of 25.9V and a ripple current of $I_{c(rms)}$ of 10A.
- 24) Current $I_{t(rms)}$ is $1.414 \times I_{(rms)}$ of 14.14A.
- 25) Transformer T_{VA} is $V_{sec(rms)} \times I_{t(rms)}$, which is 18.34×14.14 , or 259.3VA.
- 26) Mains transformer ratings required are the T_{VA} of 259.3VA, primary winding voltage $V_{pri(rms)}$ of 240Vrms, secondary-winding voltage $V_{sec(rms)}$ of 18.34Vrms and the $I_{t(rms)}$ secondary current of 14.14Arms.

Compared with guessing components, you may find this design process rather laborious – but it does provide you with an elegant and reliable power solution. ■

Further reading

Schade, O. H., 'Analysis of Rectifier Operation', Proc. IRE, Vol. 31, No. 7, July 1943.

PSU rectifier symbols used

C	Capacitance of reservoir capacitor
C ₁	Alternative for C
E _{dc}	Design value for dc output voltage
E _{dc(load)}	DC output voltage across full load
f	Frequency of ac mains supply
I _{c(rms)}	Ripple current through reservoir capacitor
I _{dc(load)}	Maximum current in load
I _{F(AV)}	Same as I _o
I _{FSM}	Same as I _{on}
I _o	Average current through each diode
I _{on}	Current at initial switch-on
I _{on(L)}	Reduced initial switch-on current
I _(peak)	Recurrent peak current through each diode
I _(rms)	Current through each diode (rms)
I _{t(rms)}	Mains transformer secondary current
N	Mains transformer ratio (V _{pri} /V _{sec})
PIV	Diode peak inverse voltage
P _r	Power dissipated in R _{ext}
R _{ext}	External resistance added to source resistance
R _L	Equivalent load resistance
R _{pri}	Resistance of mains transformer primary winding
R _{rec}	Effective resistance of each diode
R _s	Source resistance
R _{s(m)}	Measured source resistance
R _s /R _L %	Ratio of source resistance to equivalent load as %
R _{sec}	Resistance of mains transformer secondary winding
T _{VA}	Mains transformer volt-amp rating
V _{pri(rms)}	Supply voltage applied to mains transformer primary
V _r %	Ratio of ripple voltage to dc output voltage as %
V _{r(rms)}	Maximum ripple voltage acceptable
V _{rec}	Voltage drop across each-rectifier diode
V _{RRM}	Same as PIV
V _{sec(peak)}	Mains transformer secondary voltage (peak)
V _{sec(rms)}	Mains transformer secondary voltage (rms)

Table 3. Finding the value for Z.

2X	R _s /2R _L %										
	0.02	0.05	0.1	0.2	0.5	1.0	2	5	10	30	100
1	1.80	1.80	1.79	1.79	1.79	1.78	1.77	1.77	1.73	1.70	1.66
2	2.03	2.02	2.01	2.00	1.99	1.98	1.97	1.96	1.89	1.77	1.67
3	2.19	2.17	2.16	2.14	2.13	2.11	2.10	2.03	1.95	1.79	1.67
4	2.32	2.30	2.28	2.26	2.24	2.22	2.17	2.08	1.98	1.80	1.68
5	2.43	2.40	2.36	2.32	2.27	2.23	2.19	2.10	2.01	1.82	1.68
6	2.50	2.48	2.46	2.44	2.42	2.40	2.28	2.13	2.04	1.83	1.68
7	2.58	2.53	2.51	2.49	2.47	2.45	2.31	2.16	2.05	1.84	1.68
8	2.66	2.63	2.61	2.60	2.58	2.50	2.35	2.17	2.06	1.84	1.68
9	2.73	2.70	2.68	2.66	2.64	2.57	2.38	2.18	2.07	1.85	1.68
10	2.80	2.78	2.75	2.73	2.70	2.62	2.40	2.19	2.08	1.86	1.68
20	3.30	3.20	3.17	3.15	2.83	2.82	2.53	2.26	2.12	1.88	1.68
30	3.64	3.50	3.40	3.29	3.05	2.89	2.59	2.30	2.15	1.90	1.68
40	3.91	3.72	3.55	3.40	3.13	2.92	2.62	2.32	2.16	1.90	1.68
50	4.08	3.87	3.68	3.48	3.22	2.93	2.64	2.33	2.17	1.91	1.68
60	4.23	3.97	3.78	3.55	3.25	2.94	2.66	2.35	2.18	1.91	1.68
70	4.35	4.03	3.87	3.60	3.27	2.95	2.67	2.36	2.18	1.91	1.68
80	4.45	4.10	3.94	3.65	3.30	2.96	2.68	2.36	2.18	1.91	1.68
90	4.52	4.18	3.98	3.67	3.31	2.97	2.68	2.37	2.19	1.91	1.68
100	4.62	4.23	4.02	3.69	3.32	2.98	2.69	2.37	2.19	1.91	1.68
200	5.03	4.60	4.27	3.86	3.37	3.00	2.69	2.38	2.19	1.91	1.68
300	5.20	4.79	4.33	3.88	3.38	3.00	2.69	2.38	2.19	1.91	1.68
400	5.35	4.86	4.37	3.88	3.38	3.00	2.70	2.38	2.19	1.91	1.68
500	5.45	4.90	4.38	3.89	3.38	3.00	2.70	2.39	2.19	1.91	1.68
600	5.51	4.93	4.38	3.89	3.39	3.00	2.70	2.39	2.19	1.91	1.68
700	5.60	4.96	4.39	3.90	3.39	3.01	2.70	2.39	2.19	1.91	1.68
800	5.67	4.98	4.39	3.90	3.39	3.01	2.70	2.39	2.19	1.91	1.68
900	5.70	4.99	4.39	3.90	3.39	3.01	2.70	2.39	2.19	1.91	1.68
1000	5.75	5.00	4.39	3.90	3.39	3.01	2.70	2.39	2.19	1.91	1.68

Table 4. Finding the value for W.

2X	R _s /2R _L %										
	0.02	0.05	0.1	0.2	0.5	1.0	2	5	10	30	100
1	3.70	3.70	3.70	3.64	3.62	3.60	3.60	3.59	3.58	3.57	3.46
2	4.60	4.57	4.55	4.53	4.52	4.50	4.28	4.20	4.08	3.72	3.51
3	5.50	5.40	5.33	5.30	5.20	5.10	5.00	4.67	4.33	4.00	3.55
4	6.20	6.17	6.13	6.10	6.00	5.98	5.45	5.20	4.95	4.05	3.57
5	7.30	6.95	6.90	6.85	6.80	6.75	6.51	5.60	5.00	4.10	3.62
6	8.00	7.90	7.70	7.60	7.50	7.30	6.90	5.84	5.09	4.19	3.63
7	8.70	8.55	8.50	8.30	8.10	7.82	7.30	6.00	5.10	4.22	3.64
8	9.60	9.50	9.35	9.00	8.50	8.20	7.69	6.15	5.14	4.23	3.64
9	10.3	9.80	9.60	9.50	9.10	8.55	7.72	6.23	5.21	4.25	3.65
10	10.9	10.7	10.5	10.1	9.50	8.64	7.74	6.30	5.28	4.26	3.66
20	16.0	15.0	14.4	13.0	11.1	9.44	7.83	6.47	5.29	4.27	3.66
30	19.7	18.0	16.3	14.3	11.7	9.60	7.92	6.50	5.31	4.27	3.66
40	21.9	20.0	17.3	14.7	12.1	9.64	8.01	6.51	5.33	4.28	3.66
50	23.7	20.8	18.2	15.2	12.2	9.70	8.10	6.51	5.34	4.28	3.66
60	24.9	21.1	18.5	15.4	12.3	9.77	8.12	6.51	5.34	4.29	3.66
70	25.9	21.4	18.9	15.6	12.4	9.84	8.14	6.51	5.34	4.29	3.66
80	26.7	21.8	19.4	15.7	12.4	9.90	8.16	6.51	5.34	4.30	3.66
90	27.5	22.2	19.5	15.8	12.5	9.93	8.18	6.51	5.34	4.30	3.66
100	28.5	22.5	19.7	15.9	12.5	9.96	8.19	6.52	5.35	4.31	3.66
200	30.5	23.0	20.0	16.3	12.6	10.0	8.19	6.52	5.36	4.31	3.67
300	31.6	23.3	20.5	16.9	12.7	10.0	8.20	6.53	5.38	4.32	3.67
400	32.8	23.5	20.9	17.0	12.7	10.0	8.20	6.54	5.40	4.32	3.67
500	33.3	23.8	21.0	17.1	12.8	10.0	8.20	6.55	5.42	4.33	3.68
600	33.8	24.0	21.1	17.2	12.8	10.1	8.20	6.56	5.44	4.33	3.68
700	34.2	24.5	21.2	17.3	12.9	10.1	8.20	6.57	5.46	4.33	3.69
800	34.4	24.9	21.4	17.4	12.9	10.1	8.20	6.58	5.48	4.33	3.69
900	34.5	25.8	21.5	17.5	13.0	10.1	8.20	6.59	5.52	4.33	3.70
1000	34.7	27.0	21.6	17.6	13.0	10.1	8.20	6.60	5.56	4.33	3.70

Take a look inside the ELECTROMAIL catalogue and you're in for a surprise. If you're looking for Electronic Components, Electrical Equipment or Mechanical Tools, with over 60,000 product lines, there's a whole galaxy of choice.

Electromail is one of Europe's largest stockists dedicated to the Home Based Professional and Electronics Enthusiast.

The fully comprehensive catalogue provides detailed descriptions, full technical information and (in most cases) colour pictures of each product to make selection easy.

Our orderline staff are light years ahead in friendly and efficient service and above all, they're committed to helping you find exactly what you need.

You'll find our despatch just as advanced, with a nominal p&p charge and range of delivery options to suit, even a Sonic Screwdriver* won't take an age to materialise.

Simply telephone or fax your order anytime between 8.00am and 8.00pm Monday to Friday Earthtime.

So - whatever your current project, anywhere in the universe, save yourself time, call Electromail.

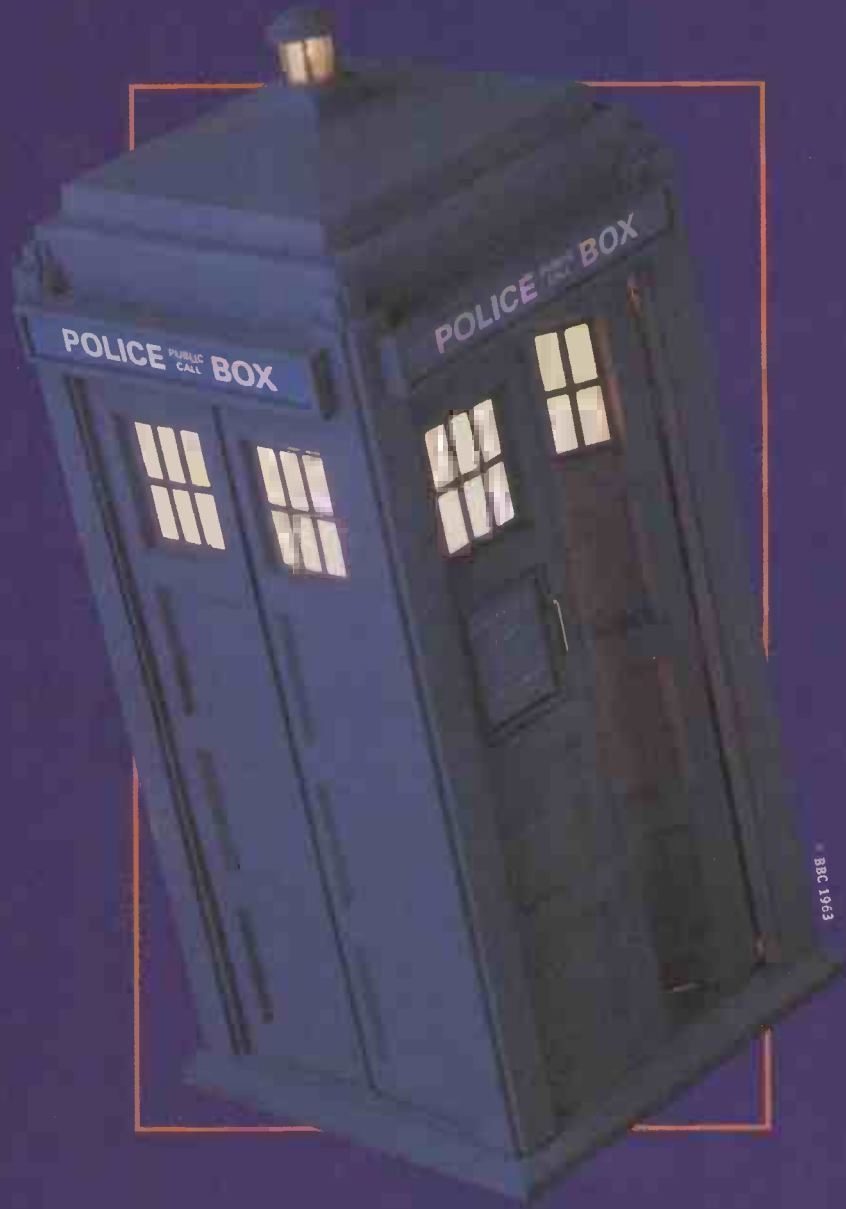
* Not available on this planet

ELECTROMAIL

THE SERVICE FOR HOME BASED PROFESSIONALS
AND ELECTRONICS ENTHUSIASTS

Electromail P.O. Box 33, Corby, Northants, NN17 9EL. Internet <http://www.rs-components.com/rs/>

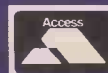
WITH OVER 60,000 PRODUCTS INSIDE



© BBC 1963

YOU'RE BOUND TO SAVE TIME

Telephone 01536 204 555
or Fax 01536 405 555.



Cards accepted when placing an order.

CIRCLE NO. 140 ON REPLY CARD

695

Hands-on Internet

Cyril Bateman discusses new search tools and looks at Spice models and hardware and software support via the World Wide Web.

As the Web grows, so newer, more user friendly search tools become available. Last month I highlighted the 'Infoseek' search engine accessible from Netscape. This is now complemented by A2Z and Accufind¹, making a total of twenty-three search tools accessible from this page.

A development from Lycos, A2Z offers authoritative descriptions of the best Web pages, while Accufind claims its *JavaScript* search engine makes new power available to the user.

The *Java* explosion continues apace. By the time this issue is published, the first *Java* developers' conference – JavaOne – will have taken place in San Francisco 29-31 May, Fig. 1.

On April 25, Dun & Bradstreet Software², in conjunction with Sun Microsystems, announced the release in May of the first enterprise applet allowing local and remote users to complete purchase requisitions electronically.

The IBM Hursley UK port of Java to AIX³, release 1.01, having passed Sun Microsystem's test suite, now has Java-compatibility approval. And IBM Raleigh has released its demo version of WebExplorer-with-Java⁴, available by download.

Security issues

Some of the concerns expressed regarding security aspects of Java have now been remedied. Netscape

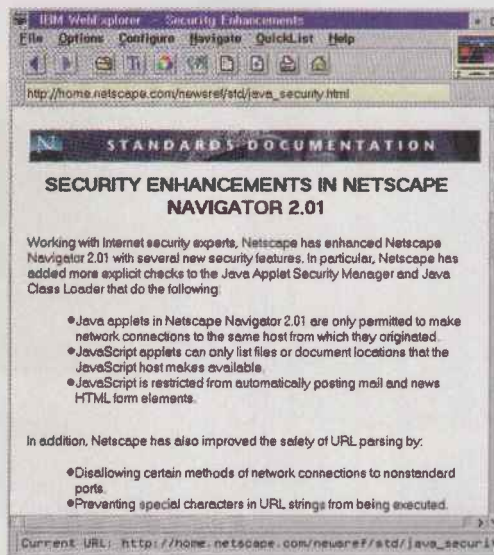


Fig. 2. The need to improve the security of Java used for Web browsers is now official. Those interested are advised to download and print out this two page announcement. Watch Java's space for future announcements.

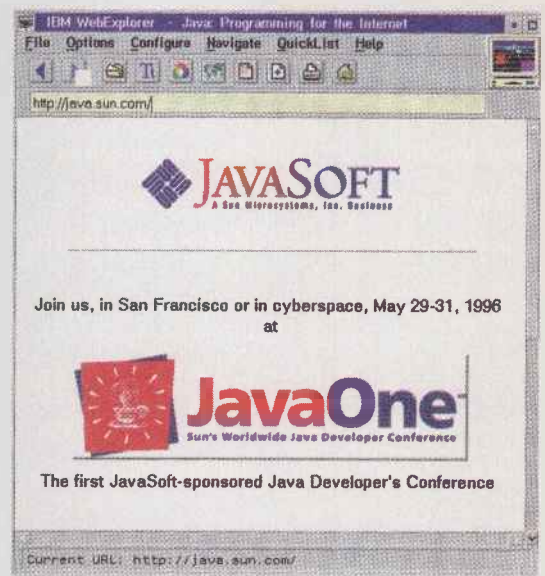


Fig. 1. Web announcement of the first ever Java Developers' Conference. The rush to embrace the Java concept continues to gain pace world wide.

Navigator version 2.01 addresses three potentially vulnerable areas. These are host connection, files or document locations and mail or news postings, Fig. 2.

The desktop operating system clash between IBM and Microsoft continues with both companies offering critiques of the others system, accessible via their Web pages. While the imminent demise of OS/2 Warp had been voiced by some writers, on 23 April, IBM announced that the next OS/2 upgrade – code-named Merlin⁵ and due this year – will include speech recognition software, Fig. 3.

Also, the first low-cost Internet access boxes have arrived⁶. The British company Acorn⁷ is involved, in the production of these, together with Apple, Fig. 4.

Software and hardware support

During a recent visit to a client with my pc, a dos and Windows whizz noticed the 'IBM-Information-Superhighway' folder on my desktop and asked why he might need Internet access. Apart from the topics already covered in this series, perhaps the most relevant for his need is to gain software and hardware support.

Support was brought forcibly to my attention recently

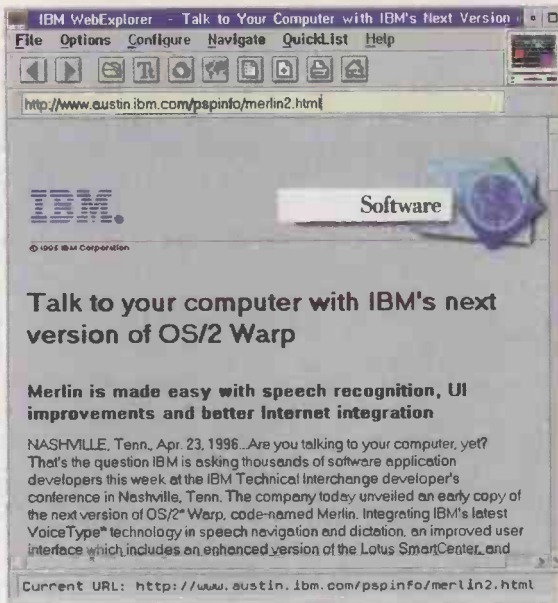


Fig 3. OS/2 – neither dead nor buried, but resurrected maybe under a different name? Some of the published missives from IBM and Microsoft camps reveal weakness in both their systems. Hopefully these processor and memory guzzling operating systems will pass into history.

by two different incidents. Having owned and used a registered copy of Visual Basic 3 for well over a year, I received only promotional literature from Microsoft. During this time I had not used one facet of the program – the company's much vaunted 'Set-up Wizard' – which requires a file not included in the 'packing list'.

On investigation I found this failing was known prior to my purchase and had been published on the Internet. But at that time I had no modem. Microsoft considers that publication on the Internet⁸ or their BBS⁹ covers their obligations. To compound this error, their 'fix-pack' also failed to work when following the included instructions. The outcome was four days lost work and many harsh words.

I recently found time to install OS/2 Warp Connect 'Blue Box', replacing the original Warp 'Red Box' which had served me well for more than a year. Unfortunately the specific version of the S3 video graphics accelerator I use was not supported by the 'shrink wrap', although the required driver was available from the IBM Web page¹⁰, or their BBS¹¹.

This problem of device drivers is common to all current pc operating systems – including Windows 95 – when using non-current hardware. For those of you still afflicted by the 'Prank' virus by the way, help to identify and remove it is available from Microsoft⁸, Fig. 5.

Benefits of modem access

Traditional telephone support is time consuming and expensive after the initial free period. A modem and Internet or Compuserve access makes these problems addressable economically. But more importantly modem access can forewarn you of problems, easily justifying the cost of a modem for all sizes of business.

Hewlett Packard manufactures both semiconductors and simulation systems, offering Spice macro models as well as S parameters. A search on Spice models from their home page revealed more than forty reference documents for download, Fig 6.

Earlier this year, my verbal request for macro models to the

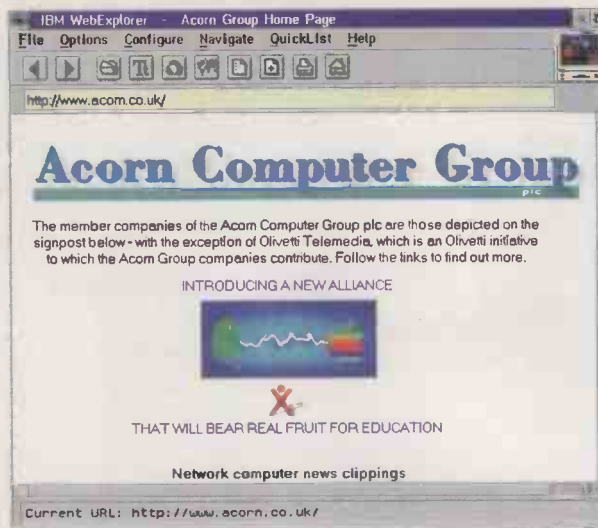


Fig. 4. This Acorn/Apple alliance for education has since been designated Xemplar. In my view, combining these two desk tops must be good for education.

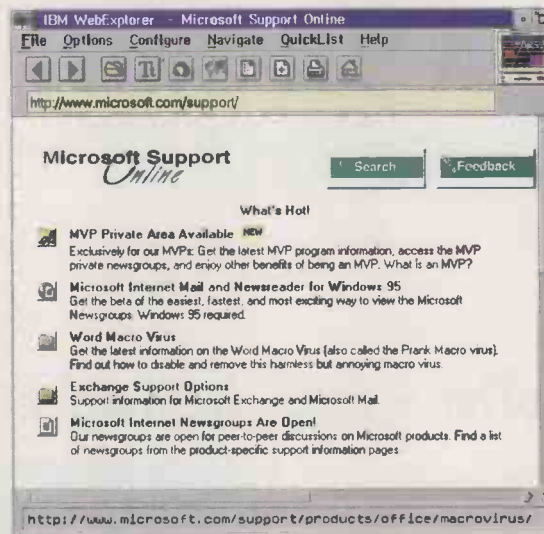


Fig. 5. Part of the Microsoft users' support system. This site's FAQ is essential reading to understand the terminology used and site structure. Not the most intuitive or user friendly, but support is there, given familiarisation. A useful area is the so-called knowledge base, unfortunately indexed by document number.



Fig. 6. As with all Hewlett Packard products, everything works, is user friendly and accessible. Well worth visiting just to view this well organised site.

Fig. 7. A month ago, this site had no Spice macro models. Things update quickly on the Internet. If a first visit to any site is unfruitful, try again shortly.



company's UK office failed. But International Rectifier now offers a zip file of all the company's current models downloadable from IR's Web page. This page also provides applications and literature, Fig 7.

At the moment, Linear Technology Corporation has only a temporary, un-manned, Web page advertisement although an interactive page is in development, Fig 8.

Web sites accessed

1. Netscape
<http://www.netscape.com/escapes/maps/escapes.map>
2. Sun Microsystems Inc. <http://java.sun.com/>
3. IBM Hursley Park UK <http://ncc.hursley.ibm.com/javainfo>
4. IBM Raleigh <http://www.ics.raleigh.ibm.com/ics/give3.htm>
5. IBM Austin <http://www.austin.ibm.com/pspinfo/merlin2.html>
6. First Web PCs Arrive, *Byte* April '96 p 24,25.
7. Acorn Computer Group <http://www.acorn.co.uk/>
8. Microsoft Support Online <http://www.microsoft.com/support>
9. Microsoft BBS UK, 01734-270065
10. IBM Europe Repository <http://www.europe.ibm.com/getdoc/psmmea/progserve/device>
11. IBM BBS UK, 01256-811900

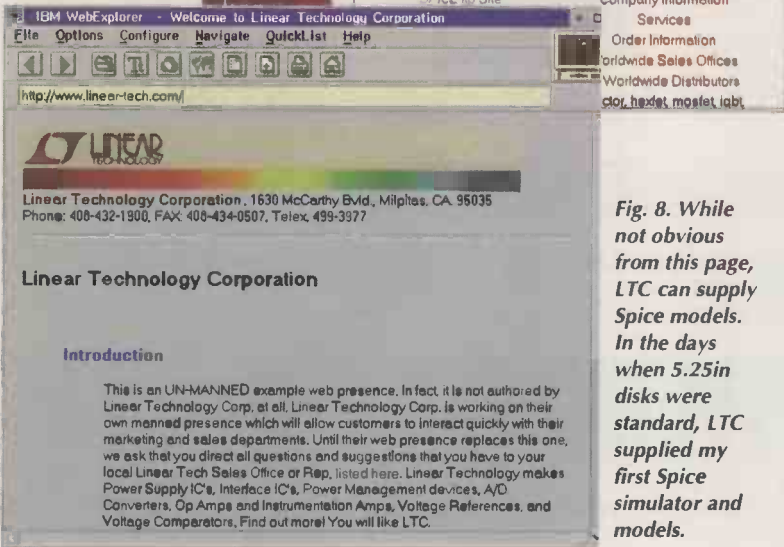


Fig. 8. While not obvious from this page, LTC can supply Spice models. In the days when 5.25in disks were standard, LTC supplied my first Spice simulator and models.

EW reader offer – multi-instrument – discount and free dmm

Maxcom's MX9300 is a four-function multi-instrument featuring,

- 1Hz to 1GHz, 8-digit frequency counter
- 0.02Hz to 2MHz swept function generator
- 3¹/₂-digit DMM with 10A range
- 0 to 30V, 3A-variable psu
- 15V, 1A fixed output
- 5V, 2A fixed output

Normally, this instrument costs £399 excluding VAT and delivery but Vann Draper is making it available to EW readers at the special price of £399 – fully inclusive – and this price includes a **free hand-held digital multimeter**.

Incorporating full overload protection, the MX9300 allows a significant reduction in lab bench space needed while being more convenient than separate instruments. The free 3¹/₂-digit dmm accompanying this offer features 10A dc measuring capability and transistor 0 to 1000 h_{FE} test.



Frequency counter features – wide range, 10s to 10ms gating, 25mV sensitivity at 1GHz, autoranging, 1Hz +1dgt accuracy.

Function generator features – 0.1 to 20Vpp o/p, linear/log 20ms-2s internal or external sweep, sine, square, triangle, skewed sine, pulse, ttl.

DMM features – auto/manual ranging, DCV ACV Ω DCA ACA, 10MΩ input, ±(0.5%+2digit) basic accuracy.

PSU features – variable voltage and current, floating outputs, 2mV max. ripple on all outputs, 0.01% load regulation on 30V output.



Please send a cheque for £399 payable to Vann Draper Electronics, or your full credit-card details including expiry date and card type to Vann Draper Electronics at Unit 5, Premier Works, Canal Street, South Wigston, Leicester, LE18 2PL. Alternatively fax credit card details with your order on 0116 277 3945 or telephone on 0116 277 1400.

Address orders and all correspondence relating to this offer to Vann Draper Electronics.

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 HIGHGRADE 286 **ONLY £129.00** (E)

Optional Fitted extras:	VGA graphics card	£29.00
	1.44Mb 3 1/2" floppy disk drive (instead of 1.2 Mb)	£19.95
	Wordperfect 6.0 for Dots - 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 user, superb small size desktop unit. Fully featured with standard simm connectors 30 & 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 **£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-L 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-55FGR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5 1/4" Teac FD-55F-03-U 720k 40/80 (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 slimline 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" FUJI FK-309-26 20mb MFH 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 R030575 45mb SCSI I/F (Mac & Acorn)	£69.00(C)
3 1/2" WESTERN DIGITAL 850mb IDE I/F Brand New	£185.00(C)
5 1/4" MINISCRIIBE 3425 20mb MFH 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 MFH I/F RFE tested	£69.95(C)
5 1/4" HP 9754B 850 Mb SCSI RFE tested	£89.00(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(C)

Hard disc controllers for MFH, 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 sound specification.
*For cable / hyperband reception Telebox MB should be connected to a cable type service. Shipping code on all Telebox's is (E)

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 PCs in CGA, EGA, VGA & SVGA modes. BBC, COMMODORE (including Amiga 1200), ARCHIMEDES and APPLE. Many features: Etched 'faceplate', text switching and LOW RADIATION MPR specification. Fully guaranteed, supplied in EXCEL-



LENT little used condition. Tilt & Swivel Base £4.75 **Only £119** (E) Order as MITS-SVGA
VGA cable for IBM PC included.

External cables for other types of computers CALL

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 fan controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W114" x H123 1/4" x 15 1/2" 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 1/2" 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, Discos, Clubs, etc. in EXCELLENT little used condition with full 90 day guarantee.

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

SPECIAL INTEREST ITEMS

MITS. FA3445ETKL 14" Industrial spec SVGA monitors	£245
2Kw to 400 kw - 400 Hz 3 phase power sources - ex stock	EPOA
IBM 8230 Type 1, Token ring base unit driver	£950
IBM 53F5501 Token Ring ICS 20 port lobe modules	£750
IBM MAU Token ring distribution panel 8228-23-5050N	£95
AIM 501 Low distortion Oscillator 9Hz to 320KHz, IEEE	£550
Trend DSA 274 Data Analyser with G703(2M) 64 vO	EPOA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & HP3782A Error Detector	EPOA
HP APOLLO RKT700 system units	£950
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP3081A Industrial workstation clw Barcode swipe reader	£175
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£675
HP54121A DC to 22 GHz four channel test set	EPOA
HP7580A A1 8 pen HPGL high speed drum plottter	£1850
EG-G Brookdale 95035CS Precision lock in amp	£650
View Eng. Mod 1200 computerised inspection system	EPOA
Ling Dynamics 2Kw programmable vibration test system	EPOA
Computer controlled 1056 x 560 mm X Y table & controller	£1425
Keithley 590 CV capacitor / voltage analyser	EPOA
Racal ICR40 dual 40 channel voice recorder system	£3750
Fiskers 45KVA 3 ph On Line UPS - New batts Dec.1995	EPOA
ICI R5030UV34 Cleanline ultrasonic cleaning system	£2200
Manly Tally MT645 High speed line printer	£1200
Intel SBC 486/133SE Multibus 486 system, 8Mb Ram	£1150
Nikon Zeta 3220-05 A0 4 pen HPGL fast drum plotters	£1450
Nikon HFX-11 (Ephiphot) exposure control unit	EPOA
Motorola VME Bus Boards & Components List. SAE / CALL	£950
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	EPOA
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3750
Andrews LARGE 3.1 m Satellite Dish + mount (For Voyager)	£950
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
TAYLOR HOBSON Talysurf amplifier / recorder	£750
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)

320 - 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 1/4" 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 MICROTUCH 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 50. 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 9 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-DX33 CPU	£55.00	Intel 486-DX66 CPU £69.00 (A1)

FULL RANGE OF CO-PROCESSOR'S EX STOCK - CALL FOR INFO

FANS & BLOWERS

EPSON D0412 40x40x20 mm 12v DC	£7.95 10 / £65
PAPST TYPE 612 60x60x25 mm 12v DC	£8.95 10 / £75
MITSUBISHI MMF-D6D12DL 60x60x25 mm 12v DC	£4.95 10 / £42
MITSUBISHI MMF-08C12DM 80x80x25 mm 12v DC	£5.25 10 / £49
MITSUBISHI MMF-09B12DH 92x92x25 mm 12v DC	£5.95 10 / £53
PANASKE 12-3.5 92x92x18 mm 12v DC	£7.95 10 / £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 Bus Route
Nr Thornton Heath &
Selhurst Park SR 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. Bond 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 under 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. 141 ON REPLY CARD

LETTERS

Letters to "Electronics World"
Quadrant House, The Quadrant,
Sutton, Surrey, SM2 5AS

Check it out

Your sceptical correspondent Dr Fisher (*EW*, May) will, in the near future, need to double-check his own work rather than maintain his present attitude towards those who regard anomalistic phenomena as challenges to an inquisitive intellect.

He will, for instance, be very surprised to learn that many scientists of international repute are engaged in the study of 'dowsing, ball lightning, free energy and/or anti-gravity'. The majority of these experimentalists are highly skilled mathematicians and cross-check each others' work using a variety of methodologies.

Many phenomena previously considered to be 'paranormal' are now yielding up their secrets, a process which is likely to be accelerated by the redefinition of the phase space of both thermodynamics and information theory. Dr Fisher can work this out for himself by a simple experiment using a gaming die. In this, the die is placed on a sheet of paper orthogonally gridded to match the length of each of its edges. It is then orientated with its 'six' spot in one of the central cells of the grid with its 'two' spot facing him and its 'five' spot facing north. With most dice, the 'four' spot then faces west and the 'three' spot faces east.

The die is then rolled slowly and step-wise over its edges so that the number of spots on the faces of the die which come into contact with successive cells can be recorded in those cells as a form of sequential memory. These number sequences are, in fact, representations of

displaced rotations about the x, y and z axes and correspond to a spinning object in three-dimensional space which is represented in the observer's stationary frame of reference under a condition of projective geometry.

Unfortunately, even this simple procedure demonstrates several surprising errors of omission in Alan Turing's famous 1936 paper entitled 'On computable numbers, with an application to the Entscheidungsproblem' on which much of contemporary computing is based. Perhaps Dr Fisher could work out what these errors were?

Brian Clement
Powys

Proof is in the cable?

I refer to the letter '10mV diode proof?' by Allen Wright, May 1996. A little thought will show that the effect described has nothing to do with putative 10mV diode effects in the speaker cable.

Let's take some approximate figures. In the March 1996 issue, Doug Self refers to a test for the existence of these diodes carried out at 50W/8Ω (ie 20Vrms output) and measures a drop of 140mV across his speaker cable.

Allen Wright refers to a listening level of 'milliwatts'. If we assume 50mW, this implies an output voltage reduced by a factor of $\sqrt{1000}$ or approximately 660mV. The resistance of Allen Wright's RG59 braid won't be much different from Doug Self's cable so we have a voltage drop across the cable of about 5mV. If the

speaker cables are newly made, with freshly soldered or crimped terminations and no broken strands, then even if the strands were insulated from each other along the length of the cable, the voltage difference between them at any point due to random variations in thickness would only be fractions of a microvolt. Clearly, even if Ben Duncan's diodes do exist, they can have nothing to do with the effect described.

What is going on, then? The resistance of 0.25mm diameter wire will be much higher than the braid, and may be helping to swamp the reactive components of the loudspeaker impedance, thus flattening the frequency response. This could easily be tested by wiring a non-inductive resistor of a few ohms in series with the braid, and seeing if the same improvement results.

Additionally, the (unspecified) amplifier will be operating almost entirely in its crossover region, and if it is not in fact free of crossover nasties, may be less able to control a reactive load. At these power levels it would be no problem to knock up a single-ended Class A amplifier to check this one out.

Chris Bulman
Bedford

In the real world

Ben Duncan's piece 'Modelling cable' (*EW* Feb 1996) was a fine demonstration of the capabilities of his circuit simulator. Unfortunately his modelling does not give an accurate view of the real world. Ben has not included the proximity effect in his modelling, although I doubt it would be any more significant than the skin effect – that is, not very.

Also, his assumption that loudspeaker drivers are substantially inductive at high frequencies was not borne out by measurements. I took of five loudspeakers' impedances, using an *HP 4193A* vector impedance meter. At 400kHz – the instrument's lowest working frequency – phase angles measured ranged between 38° and 56°. At 1MHz the range was –62° (capacitive) to 57°. These figures indicate that their Q probably never exceeds two. The speaker that ranged from 38° (400kHz) to –62° (1MHz) was a 10in woofer, and it was self resonant at 600kHz where its impedance was 780Ω. On the basis of this one must doubt the accuracy of Ben's models.

I first saw the idea that copper cables contained oxide diodes over five years ago in the Australian electronics press. At the time I thought the idea sounded plausible so I decided to test it. Checking the dc resistance of a piece of wire revealed it to be as linear as I could measure, so a more sophisticated

method was required. I reasoned that if significant amounts of current were flowing in these oxide diodes then they would reveal their non-linear behaviour by distorting the voltage drop along the cable.

As I was not well equipped to perform a harmonic distortion test with sufficient resolution I decided to try measuring the intermodulation distortion. This way distortion components generated by the wire would not be integer multiples of the test frequencies and the harmonic distortion components from signal sources could be easily identified and ignored, leaving any intermod components sticking out like the proverbial dog's ...errrr, well easy to identify. My partner in this venture was Dr Mark Ballico, who was at the time working towards his PhD in the Dept of Plasma Physics.

A more complete description of the experiment and the results was printed in *Electronics Australia* (Oct. 1990), but briefly the wire used was RS 357-340 'tinned copper stranded 10/0.1mm conductor ... (rated at)... 0.5A¹'. For test signals I used 1.5A 50Hz from the mains, isolated by a transformer and set with a *Variac*, and a 5kHz (approx) signal from a low distortion oscillator.

The higher frequency signal was selected not to be a harmonic of the 50Hz mains but close to 5kHz. Around the high frequency signal the noise floor was at least 65dB down for over a kilohertz, and all frequency spikes that the spectrum analyser displayed were simple harmonics of the test signals – mostly harmonics of the mains. There was no evidence of any intermodulation distortion at all. I could only deduce from this that there were no such diodes, or that they were shunted by sufficiently low impedance, eg. plain metallic copper, that they had no effect.

These results need to be scaled to compare them to the circumstances that exist in an audio system. The cross-sectional area of the wire was less than 0.08mm² – very small and woefully underrated for connecting speakers – the current of 1.5A would generate 18W in the nominal 8Ω load. Normal speaker cables would have at least ten times the cross sectional area, and at the same current density 1.8kW would be delivered to the load, without, it would seem, significant distortion.

Further if less than 10% of the output voltage was dropped across the cable then you would expect that the cable would not produce any distortion products at the speaker greater than 84dB down from the original signal. I have not heard of a hi-fi speaker that produces less than 0.01% IMD, or THD or Doppler distortion, at 1.8kW. Most devices produce more distortion with more power.

Bach in time

In his article on free phasing oscillators for electronic organs, Ian Hickman suggests that one oscillator can be shared between two adjacent semitones. He may not know that this is a very old idea, actually dating back to 1730, when 'fretted' clavichords were constructed that shared one string between two or more semitones. A clavichord works by simultaneously stopping the free length of the string and exciting its vibration by striking it with a wooden tangent. The tangent is directly attached to the key, and thus two adjacent keys can stop different notes on the same string.

The system became obsolete when J. S. Bach began writing keyboard music that occasionally requires the simultaneous sounding of two adjacent semitones. In fact one does not need to look further than the first prelude of book 1 of the "Wohltemperiertes Klavier" (the set of 48 preludes and fugues written in every major and minor key) to find two examples, of a B sounded with a C, and later on, an E with an F.

If Bach found such economies restrictive, surely we should not consider reintroducing them?

Cosmo Little
Cornwall

With regard to the notion that copper cables consist of copper oxide diodes that cause audible distortion, I suspect that Ben Duncan has more closely modelled a fertile imagination than the physical universe that we live in. There are more plausible explanations for why some people believe that one type of cable sounds better than another that require no reference to electronics at all. The poor and variable frequency response of human hearing and its effects on perceived sound would be one of the strongest.

References

1. RS Catalogue, 1995
2. R.A. Greiner, 'Amplifier-loudspeaker interfacing', *J. Audio Eng. Soc.*, Vol. 28, No. 5, 1980 May.
3. Fred E. Davis, 'Effects of cable, loudspeaker and amplifier interactions', *J. Audio Eng. Soc.*, Vol. 39, No. 6, 1991 June.
4. Ben Duncan, 'Modelling cable', *EW* Feb 1996.

Phil Dennis

Sydney, Australia

Did you do your homework?

I was surprised to read the article entitled 'Crossover networks made simple'. I think simple is the operative word and I would suggest that Mr Teleki should do a bit more homework before writing any further articles on loudspeaker networks.

a) Correctly designed networks are specifically designed for predetermined units in a specific cabinet. Every unit has its unique parameters. I have yet to measure differing unit types that have a sufficiently close acoustic and impedance curves to be able to use, optimally, the same crossover network. No unit I know has a flat response and impedance in a practical enclosure.

b) The network has to take into account the acoustic response and acoustic phase of the units involved, mounted in the design cabinet. Hence the electrical network has to take this into account. The thing that matters is the acoustical output of the combined electrical and acoustical signals. The network order is therefore not necessarily the same as the required acoustic order.

c) Because of the above, the acoustic responses of the units in the specified cabinet need to be known along with their impedance curves and preferably their phase response.

d) Networks are available with components ranging from cheap reversible electrolytic capacitors $\pm 20\%$ to $\pm 2.5\%$ Polypropylene, and ferrite inductors with thin copper wire to very large air-cored cores with very thick wire. We have produced air-cored inductors

weighing over 1kg each. The price should take into account some design time, assembly time and component costs. Oh yes, plus hopefully some profit and 17.5% VAT.

e) Both ferrite and air-cored inductors can and should be orientated so that there is virtually no mutual coupling (magnetic interaction) between them. Toroids are not normally used due to their overload characteristics and high cost and size for sufficient power handling.

f) From the above it is obvious that a theoretical network using the nominal impedance of the unit will give nothing like an optimum response, in fact in many cases the response can be more irregular than with no network at all.

g) With regard to cascading high and low pass sections as suggested, this does not even work in theory, due to interaction between the sections. This interaction diminishes with the separation of the two crossover frequencies, but is still significant for normal three-way systems^{1,2}.

$$f_4 = f_3(f_2/f_1 - 1)$$

$$f_5 = \sqrt{f_4 f_2} / (f_2/f_1 - 1)$$

where f_1 and f_2 are the crossover frequencies and f_3 and f_4 are the calculated design frequencies.

Rather than having to buy C(++?) compilers it is simpler to construct a spreadsheet where the frequencies and impedances are in referenced boxes and the various order filter components are in the body of the sheet. Other items such as resonance tuned circuits and Zobel networks can be included.

Finally, 6 decimal places on results?

References

1. Norman Crowhurst, High Fidelity Sound Engineering.
2. M.D. Hull, Building Hi-Fi Speaker Systems.

Malcolm Jones
Norfolk

Hand-crafted Cs

I liked Vladkov's capacitance meter. For it to be of maximum use, one requires small, accurate, reference capacitors. The snag is that in the picofarad region, lead capacitance is significant. Chip capacitors are free of this but even the best ones, such as those provided by ATC, are not tightly toleranced in the pF region.

Microwave cables such as the RG 402 are made to very tight tolerances and this particular item is specified as having a capacitance of 98pF/metre.

Thus it is possible to construct capacitors of a few pF with considerable precision. The lead length can be made very small.

At measurement frequencies up to a few MHz the fact that one's

Historical units

When I saw the reference to 'm.s.c.' in Mr. Owen Davie's letter in the July/August 1996 issue, I recalled my early notes on the origins of logarithmic units of attenuation:

The 'standard cable' referred to, was originally an ordinary 19 AWG-conductor telephone cable, which had constants: 88 Ω , 1mH, 57nF and μ S per loop-mile¹. The capacitance was a little different for some manufacturers. This gave; $f_c=30$ kHz and $\alpha=0.94$ dB (0.106 neper) at 800Hz.

The most used measure was the '800 cycle-mile'². Current or power ratios were expressed as the number of miles of standard cable which gave the same ratio at 800Hz.

Because the power attenuation of a mile of standard cable, at 886Hz, was $10^{0.1}$ and involved common logarithms; this attenuation was adopted as a standard for all frequencies and was called the 'transmission unit'.

In 1923, the American Telephone and Telegraph Company announced this new 'transmission unit' to replace the mile of standard cable. In the following year, the International Advisory Committee on Long Distance Telephony recommended the 'bel' or the 'neper' should be used.

* The adoption of the decibel, as the name for the 'transmission unit', was eventually announced by the Bell System in January, 1929³.

References - 'Electric Circuits and Wave Filters' STARR, Arthur Tisso, 1948 [Pitman] p.180.

2. 'Communication Engineering' EVERITT, William Littell, 1937, (Mc Graw-Hill) p.101,102.

3. 'Decibel'-the name for the Transmission Unit. Martin, W.H., Bell System Technical Journal, January, 1929
T.J. Wynn South Wales

capacitor is a transmission line is irrelevant, though purists may like to form the length of line into a loop and feed it at both ends in parallel.

This is an old trick, of course, but only works with this type of co-ax in short lengths. Try cutting off 2cm of braided outer co-ax accurately.

Nick Wheeler
Surrey

Wait for me

In his response to Chris Bulman's letter in the June issue, Seggy Segaram mentioned BT's plans to enhance the Call Waiting system to allow Caller ID units to display the number of the waiting caller. This service is described in the ETSI specification ETS300-659-2 and could well be introduced in the UK this year.

Allan Edwards
Essex

Clear as a bell?

Bengt Olsson, in his July 1996 letter, says that in speaking of output stages and their devices, one must be clear. Unfortunately, he is not.

The first part of his letter claims that a bipolar transistor is highly non-linear, just because it has high gain. This is of course quite untrue when baldly stated thus. I said myself in 'FETs vs Bipolars: The Linearity Competition' (*EW* May 1995) that on the same graph, transistor collector current vanishes near vertically off the scale, exponentially increasing, before the fet has even begun to conduct. The

raw transconductance (g_m) of a bjt is far higher than for any power fet, so to make the two devices even vaguely comparable one must insert: 0.1Ω into the bipolar emitter as local feedback, reducing its g_m to about $9A/V$, equal to that of the fet at an I_d of 10A.

Adding this emitter-resistor to a bipolar device with high g_m has the happy side effect of making it very linear indeed compared with the fet. The bipolar g_m is now constant over a wide range, ie the gain is linear. The fet, with no spare gain to allow the application of any local feedback, still has g_m that varies linearly with I_d , so that the actual I_d/V_{gs} output characteristic is square-law rather than linear.

I must admit that I thought this was demonstrated beyond all doubt in my article; I hope this makes it clearer.

The second part of the letter seems to deal with the internal negative feedback of the complementary feedback pair output stage; how this is relevant to the linearity of single devices is not obvious to me. The gain quoted (58 dB, not 60) is wholly mysterious as it is not at all clear whether this is supposed to be voltage or current gain; either way it seems to be wrong.

I find that the reference to the linearity of borrowed plumes does little to clarify matters. I wish to reassure concerned readers that no bird products were used in the amplifier experiments I have reported.

Douglas Self
England

MOONSHINE BIBLE 270 page book covering the production of alcohol from potatoes, rice, grains etc Drawings of simple home made stills right through to commercial systems. £15 ref MS1

NEW HIGH POWER MINI BUG With a range of 800 metres or more and up to 100 hours use from a PP3 this will be popular! Bug measures less than 1" square! £28 REF LOT102.

SINCLAIR C6 MOTORS We have a new ones available without gearboxes at £50 ref LOT25

BUILD YOU OWN WINDFARM FROM SCRAP New publication gives step by step guide to building wind generators. Armed with this publication and a good local scrap yard can 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, ref E65.

TRACKING TRANSMITTER range 1.5-5 miles, 5,000 hours on AA batteries, also transmits info on car direction and motion! Works with any FM radio. 1.5" square. £65 ref LOT101

ELECTRIC DOOR LOCKS Complete lock with both Yale lock and 12v operated deadlock (keys included) £10 ref LOT99

GALLIUM ARSENIDE FISHEYE PHOTO DIODES Complete with suggested circuits for long range communications/switching £12 complete.

SURVEILLANCE TELESCOPE Superb Russian zoom telescope adjustable from 15x to 60x! complete with metal tripod (impossible to use without this on the higher settings) 66mm lense, leather carrying case £149 ref BAR69

WIRELESS VIDEO BUG KIT Transmits video and audio signals from a miniature CCTV camera (included) to any standard television! All the components including a PP3 battery will fit into a cigarette packet with the lens requiring a hole about 3mm diameter. Supplied with telescopic aerial but a piece of wire about 4" long will still give a range of up to 100 metres. A single PP3 will probably give less than 1 hours use. £99 REF EP79. (probably not licensable)

CCTV CAMERA MODULES 46X70X29mm, 30 grams, 12v 100mA, auto electronic shutter, 3.6mm F2 lens, COIR, 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! £5.99 ref EF138.

REMOTE CONTROL AND DATA TD1400 MODEM/VIEWDATA Complete system comprising 1200/75 modem, auto dialler, infra red remote keyboard, (could be adapted for PC use?) psu, UHF and RGB output, phone lead, RS232 output, composite output. Absolute bargain for parts alone! £9.95 ref BAR33

9 WATT CHIEFTAN TANK LASERS

Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conduct or lasers and motor drive units for alignment, 7 mile range, full circuit diagrams, new price £50,000? us? £349. 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, five or more units £299 ea, £349 for one. Ref LOT4.

TWO WAY MIRROR KIT Includes special adhesive film to make two way mirror(s) up to 60"x20". (glass not included) Includes full instructions. £12 ref TW1.

NEW LOW PRICED COMPUTER WORKSHOP/HIFI/RGB UNITS Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends it 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!

RADIO CONTROLLED CARS FROM £6 EACH!!!!

All returns from famous manufacturer, 3 types available, single channel (left, right, forwards, backwards) £6 ref LOT1. Two channel with more features £12 ref LOT2.

THOUSANDS AVAILABLE RING/FAX FOR DETAILS!

MAGNETIC CARD READERS (Swipes) £9.95 Cased with flyleads, designed to read standard credit cards! they have 3 wires coming out of the head so they may write as well? complete with control electronics PCB, 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

PANORAMIC CAMERA OFFER Takes double width photographs using standard 35mm film. Use in horizontal or vertical mode. Complete with strap £7.99 ref BAR1

COIN OPERATED TIMER KIT Complete with coin slot mechanism, adjustable time delay, relay output, put a coin slot on anything you like! TV's, videos, fridges, drinks cupboards, HIFI, takes 50p's and £1 coins. DC operated, price just £7.99 ref BAR27.

ZENITH 900 X MAGNIFICATION MICROSCOPE Zoom, metal construction, built in light, shrimp film, group viewing screen, lots of accessories £29 ref ANAYLT.

AA NICAD PACK Pack of 4 tagged AA nicads £2.99 ref BAR34

PLASMA SCREENS 22x310mm, no data hence £4.99 ref BAR67

NIGHTSIGHTS Model TZ54 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, 16 character 2 line, 99x24mm £2.99 ref SM1623A 20 character 2 line, 83x19mm £3.99 ref SM2020A 16 character 4 line, 62x25mm £5.99 ref SMC1640A

TAL-1110MM NEWTONIAN REFLECTOR TELESCOPE Russian. Superb astronomical scope, everything you need for some

serious star gazing! up to 160x magnification. Send or fax for further

WOLVERHAMPTON BRANCH NOW OPEN AT WORCESTER ST WOLVERHAMPTON TEL 01902 72039

details £249 ref TAL-1

CENTRAL POINT PC TOOLS Award winning software, 1,300 virus checker, memory optimiser, disc optimiser, file compression, low level formatting, backup scheduler, disk defragmenter, undelete, 4 calculators, Dbase, disc editor, over 40 viewers, remote computing, password protection, encryption, comprehensive manual supplied etc £25 ref lot 97 3.5" disks.

GOT AN EXPENSIVE BIKE? You need one of our bottle alarms, they look like a standard water bottle, but open the top, insert a key to activate a motion sensor alarm built inside. Fits all standard bottle camers, supplied with two keys. SALE PRICE £7.99 REF SA32.

GOT AN EXPENSIVE ANYTHING? You need one of our cased vibration alarms, keyswitch operated, fully cased just fit it to anything from videos to caravans, provides a years protection from 1 PP3 battery, UK made. SALE PRICE £4.99 REF SA33.

DAMAGED ANSWER PHONES These are probably beyond repair so just £4.99 each. BT response 200 machines REF SA30.

COMPUTER DISC CLEAROUT We are left with a lot of software packs that need clearing so we are selling at disc value only! 50 discs for £4, that's just 8p each!! (our choice of discs) £4 ref EP66

IBM PS2 MODEL 160Z CASE AND POWER SUPPLY Complete with fan etc and 200 watt power supply. £9.95 ref EP67

DELL PC POWER SUPPLIES 145 watt, +5,-5,+12,-12, 150x150x85mm complete with switch, flyleads and IEC socket. SALE PRICE £9.99 ref EP55

1.44 DISC DRIVES Standard PC 3.5" drives but returns so they will need attention SALE PRICE £4.99 ref EP68

1.2 DISC DRIVES Standard 5.25" drives but returns so they will need attention SALE PRICE NOW ONLY £3.50 ref EP69

PP3 NICADS Unused but some storage marks. £4.99 ref EP52

DELL PC POWER SUPPLIES (Customer returns) Standard PC psu's complete with flyleads, case and fan. +12v,-12v,+5v,-5v SALE PRICE £1.99 EACH worth for the bits alone! ref DL1. TRADE PACK OF 20 £29.95 Ref DL2.

GAS HOB AND OVENS Brand new gas appliances, perfect for small flats etc. Basic 3 burner hob SALE PRICE £24.99 ref EP72. Basic small built in oven SALE PRICE £79 ref EP73

RED EYE SECURITY PROTECTOR 1,000 watt outdoor PIR switch SALE PRICE £6.99 ref EP57

ENERGY BANK KIT 100 6"x6" 6v 100mA panels, 100 diodes, connection details etc. £69.95 ref EF112.

PASSEL ACCOUNTS SOFTWARE, does everything for all sizes of businesses, includes word processor, report writer, windowing, networkable up to 10 stations, multiple cash books etc. 200 page comprehensive manual. 90 days free technical support (01342-326009 try before you buy) Current retail price is £129, SALE PRICE £9.95 ref SA12. SAVE £120!!!

COMPLETE PC 200 WATT UPS SYSTEM Top of the range UPS system providing protection for your computer system and valuable software against mains power fluctuations and cuts. New and boxed, UK made Provides up to 5 mins running time in the event of complete power failure to allow you to run your system down correctly. LATEST FAST TO CLEAR AT £49 SAVE £30 ref LOT61

BIG BROTHER PSU Cased PSU, 6v 2A output, 2m o/p lead, 1.5m input lead, UK made, 220v. SALE PRICE £4.99 REF EP7



Check out our WEB SITE

<http://www.pavilion.co.uk/bull-electrical>

RACAL MODEM BONANZA! 1 Racal MPS1223 1200/75 modem, telephone lead, mains lead, manual and comms software, the cheapest way onto the net! all this for just £13 ref DEC13.

4.6mw LASER POINTER. BRAND NEW MODEL NOW IN STOCK!, supplied in fully built form (looks like a nice pen) complete with handy pocket clip (which also acts as the on/off switch.) About 60 metres range! Runs on 2 AAA batteries. Produces thin red beam ideal for levels, gun sights, experiments etc. just £39.95 ref DEC49 TRADE PRICE £28 MIN 10 PIECES

BULL TENS UNIT Fully built and tested TENS (Transcutaneous Electrical Nerve Stimulation) unit, complete with electrodes and full instructions. TENS is used for the relief of pain etc in up to 70% of sufferers. Drug free pain relief, safe and easy to use, can be used in conjunction with analgesics etc. £49 Ref TEN/1

PC PAL VGA TO TV CONVERTER 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 £25 REF SA34

EMERGENCY LIGHTING UNIT Complete unit with 2 double

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

BULL ELECTRICAL

250 PORTLAND ROAD, HOVE, SUSSEX.

BN3 5QT. (ESTABLISHED 50 YEARS).

MAIL ORDER TERMS: CASH, PO OR CHEQUE

WITH ORDER PLUS £3 P&P PLUS VAT.

PLEASE ALLOW 7-10 DAYS FOR DELIVERY/PHONE ORDERS

WELCOME (ACCESS, VISA, SWITCH, AMERICAN EXPRESS)

TEL: 01273 203500

FAX: 01273 323077

E-mail bull@pavilion.co.uk

bulb floodlights, built in charger and auto switch. Fully cased. 6v 8AH lead acid req'd. (secondhand) £4 ref MAG4P11.

YUASHA SEALED LEAD ACID BATTERIES Two sizes currently available this month. 12v 15AH at £18 ref LOT8 and 6v 10AH (suitable for emergency lights above) at just £6 ref LOT7.

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 2 watt. £8.99 REF SA25.

MICRODRIVE STRIPPERS Small cased tape drives ideal for stripping. lots of useful goodies including a smart case, and lots of components. SALE PRICE JUST £4.99 FOR FIVE REF SA26

SOLAR POWER LAB SPECIAL You get 2W 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit SALE PRICE JUST £4.99 REF SA27

RGB/CGA/EGATT/LL COLOUR MONITORS 12" in good condition. Back animated metal case. SALE PRICE £49 REF SA16B

PLUG IN ACORN PSU 19v AC 14w , £2.99 REF MAG3P10

13.8V 1.9A PSU cased with leads. Just £9.99 REF MAG10P3

UNIVERSAL SPEED CONTROL KIT Designed by us for the C5 motor but ok for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 REF: MAG17

PHONE CABLE AND COMPUTER COMMUNICATIONS PACK Kit contains 100m of 6 core cable, 100 cable clips, 2 line drivers with RS232 interfaces and all connectors etc. ideal low cost method of communicating between PCs over a long distance utilizing the serial ports. Complete kit £8.99. Ref comp 1.

VIEWDATA SYSTEMS made by Phillips, complete with Internal 1200/75 modem, keyboard, psu etc RGB and composite outputs. menu driven, autodialler etc. SALE PRICE £12.99 REF SA18

AIR RIFLES. 22As used by the Chinese army for training purposes, so there is a lot about! £39.95 REF EF78. 500 pellets £4.50 ref EF80.

PLUG IN POWER SUPPLY SALE FROM £1.60 Plugs in to 13A socket with output lead. three types available, 9vdc 150mA £1.50 ref SA19, 9vdc 200mA £2.00 ref SA20, 6.5vdc 500mA £2 ref SA21.

VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, videorecorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £25 REF: MAG15 12v psu is £5 extra REF: MAG5P2

***MINIATURE RADIO TRANSCENDERS** A pair of walkie talkies with a range up to 2km in open country. Units measure 22x52x155mm. Including cases and earpieces. 2xPP3 req'd. £30.00 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 £15 REF: EF62 (kit) Transmits to any FM radio.

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

TALKING COINBOX STRIPPER COMPLETE WITH COIN SLOT MECHANISMS originally made to retail at £79 each, these units are designed to convert an ordinary phone into a payphone. The units have the locks missing and sometimes broken hinges. However they can be adapted for their original use or used for something else?? SALE PRICE JUST £2.50 REF SA23

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £12.95 Ref EF82B extra pellets (500) £4.50 ref EF80.

6"x12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. SALE PRICE £4.99 REF SA24.

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

MIXED GOODIES BOX OF MIXED COMPONENTS WEIGHING 2 KILOS YOURS FOR JUST £6.99

4X28 TELESCOPIC SIGHTS Suitable for all air rifles, ground lenses, good light gathering properties £19.95 ref R/7.

GYROSCOPES Remember these? well we have found a company that still manufactures these popular scientific toys, perfect gift or for educational use etc. £6 ref EP70

HYPOTHERMIA SPACE BLANKET 215x150cm aluminiumised foil blanket, reflects more than 90% of body heat. Also suitable for the construction of two way mirrors! £3.99 each ref OL1041.

LENSTATIC RANGER COMPASS Oil filled capsule, strong metal case, large luminous points. Sight line with magnifying viewer. 50mm dia, 86gm. £10.99 ref OK604.

RECHARGE ORDINARY BATTERIES UP TO 10 TIMES! With the Battery Wizard! Uses the latest pulse wave charge system to charge all popular brands of ordinary batteries AAA, AA, C, D, four at a time! Led system shows when batteries are charged, automatically rejects unsuitable cells, complete with mains adaptor. BS approved. Price is £21.95 ref EP31.

TALKING WATCH Yes, it actually tells you the time at the press of a button. Also features a voice alarm that wakes you up and tells you what the time is! Lithium cell included. £7.99 ref EP26.

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! £79.95 ref EP3.

3" DISCS As used on older Amrad machines, Spectrum plus3's etc £3 each ref BAR400.

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

WE BUY SURPLUS STOCK

FOR CASH

BUYERS DIRECT LINE 0802 660377

FREE CATALOGUE

100 PAGE CATALOGUE NOW

AVAILABLE, 50P STAMP OR FREE

ON REQUEST WITH ORDER.

Please quote "Electronics World" when seeking further information

ACTIVE

A-to-D and D-to-A converters

11-bit sampling converter. Analog's *AD7861* four-channel simultaneous sampling a-to-d converter has a four-channel multiplexer for auxiliary inputs, a voltage reference and double-buffered output registers for reading in any sequence. Applications range from motor control and three-phase power systems to cellular telephones and data acquisition. Sample/hold acquisition time is 1.6µs and conversion time 3.2µs. Internal logic operates with a microcontroller to form a low-cost general-purpose data acquisition device. Analog Devices Ltd. Tel., 01932 266000; fax, 01932 247401.

And a 14-bit one. From Datal comes the *ADS-919* 14-bit, 2MHz sampling converter, which is guaranteed to have no missing codes to the 14-bit level over the military temperature range. Signal-to-noise ratio is 77dB and thd -74dB. It is pin-compatible with earlier Datal 1MHz and 2MHz types. Power is ±12V or ±15V and +5V, dissipation 1.8W. Datal (UK) Ltd. Tel., 01256 880444; fax, 01256 880706.

Audio a-to-d converter. From AKM, the *AK5391* 24-bit, 128 times oversampling, stereo, analogue-to-digital converter, which employs a new dual-bit technique for low distortion and wide range. It samples at a maximum rate of 54kHz and exhibits a sinad of 100dB, with a dynamic range of 115dB and s:n ratio of 115dB. Stop-band attenuation is 110dB. The device resets itself after power-up if it loses sync. DIP International Ltd. Tel., 01223 462244; fax, 01223 467316.

Linear integrated circuits

Dual cfa. A dual 250mA, 60MHz current feedback amplifier by Linear Technology, the *LT1207* features a slew rate of 900V/µs, 0.02% differential gain and 0.17° typical differential phase. It has a pin for an optional compensation network for use with large capacitive loads. Micro Call Ltd. Tel., 01844 261939; fax, 01844 261678.

3-port isolated amplifiers. Burr-Brown offers the *ISO250* family of four, three-port isolated amplifiers in

28-pin dips: the *ISO253* buffer; *ISO254* programmable-gain amplifier; instrumentation amplifier *ISO255*; and the *ISO256* operational amplifier, all meant for industrial process control. Each model uses a new modulation-demodulation duty cycle technique for increased accuracy and possesses a 1500V continuous isolation rating (2500V for a minute). Burr-Brown International. Tel., 01923 233837; fax, 01923 233979.

Microprocessors and controllers

Low-cost PICs. New PICs from Microchip are the *PIC16C710* and *711*, which are 8-bit, one-time-programmable microcontrollers for 8-bit a-to-d conversion in low-cost systems. The 711 has 1024word (1K by 14) of eeprom and 68byte of ram for data memory; 710 has 512word of eeprom and 36byte of data memory. Both include 35 single-word instructions, 200ns single-cycle instruction time, 3-6V operating voltage, four analogue inputs and in-circuit serial programming. An internal four-channel a-to-d converter and the brown-out detector help to reduce component count. The devices are supported by the *PICmaster* development system. Arizona Microchip Technology Ltd. Tel., 01628 851077; fax, 01628 850259.

Mixed-signal ICs

SCSI terminators. Both the *UCC5610/5611* 3.3V active terminators by Unirode provide 18 lines of termination for the Small Computer Systems Interface (SCSI) parallel bus. During disconnect, channel capacitance is 1.8pF, minimising the effects on signal of disconnected channels, and supply current is 0.5µA. The devices operate on a supply of 2.75V to 7V and both can be programmed for 110Ω or 2.5kΩ termination. The 5610 is for standard logic, while the 5611 uses reverse logic disconnect. Unirode (UK) Ltd. Tel., 0181-318 1431; fax, 0181-318 2549.

Optical devices

1550nm laser diode. Mitsubishi has the *FU-68PDF-1* distributed-feedback laser diode module, which has a polarisation-maintaining fibre pigtail from the butterfly package. The package also contains a thermal electric cooler and an optical isolator. Maximum impedance is 25Ω and spectral line width 20MHz typical. Optical output from the fibre end is 4mW at a forward current of 150mA. Mitsubishi Electric UK Ltd. Tel., 01707 276100; fax, 01707 278692.



Oscillators

Vcxo. Fordahl's new range of 14-pin, dual-in-line, voltage-controlled crystal oscillators allow a minimum of ±100ppm frequency pulling and ±10ppm stability over the 0-70°C range of temperatures. Output waveforms at 470MHz are ecl logic level and a clipped sine wave. Fordahl GB. Tel., 01703 848961; fax, 01703 846532.

Ovened crystal oscillator. Oscillator 4834 by Oak is available in versions covering 4-10MHz. Temperature stability is ±3x10⁻⁹ over -20°C to 70°C and ageing ±3x10⁻⁸ per year. At 100Hz, phase noise is -140dBc/Hz. Ginsbury (UK) Ltd. Tel., 01634 290903; fax, 01634 290904.

Power semiconductors

Hexfet/Schottky combination. Inevitably known as a Fetky, IR's *IRF7421D1/7422D2* are power mosfet/Schottky diode combinations in an SO-8 small-outline package, the impetus for the design being the recent reduction in mosfet die size and on-resistance obtained using the company's new process. The *7422D2* contains a -20V, 90mΩ p-channel Hexfet and a 30V, 3A Schottky, the other a 30V, 35mΩ n-channel Hexfet and a 30V, 1A Schottky. Fetkys used in dc-to-dc converters should, says IR, reduce battery drain and will reduce power dissipation and heat in the converters in desk-top systems. In both, board space and component counts will be smaller. International Rectifier. Tel., 01883 713215; fax, 01883 714234.

Class D Industrial amplifiers.

Apex's *SA Series* of hybrid amplifiers are 97% efficient and provide up to 20A continuously from 100V, or 2kW into a load. They find application in vibration cancellation, magnetic-coil controls, brush motor control and active magnetic bearings. An analogue input is converted into a variable duty cycle switched signal to the output stage, thereby reducing power dissipation in the device and allowing the use of smaller packages. *SA01*, the 20A one, is in a 10-pin package and switches at 42kHz, while *SA50* and *SA51* in TO-3 give 5A for 16-80V. *SA50* switches at 45kHz and the *SA51* takes an external pwm signal under processor control up to 500kHz. METL. Tel., 01844 278781; fax, 01844 278746.

PASSIVE

Passive components

Mains-rated film capacitors. Arcotronics's *R.41* Class Y2 capacitor is designed for use across the 250V mains line or mains to ground and meets the standards to qualify for the EN132400 mark. It is self-healing and failure leads to open circuit rather than a short. Values are E6 from 0.001µF to 0.1µF. Test over 21 days at 40°C and in 90% humidity gave no breakdown or flashover at 1500Vac for 1 minute. Easby Electronics Ltd. Tel., 01748 850555; fax, 01748 850556.

Please quote "Electronics World" when seeking further information

Non-polar electrolytics. Nitai Series D non-polar electrolytic capacitors are made in nine voltage ratings from 6.3V to 100V and in values from 0.47 μ F to 1000 μ F for the 6.3V range and 0.47 μ F to 100 μ F in the 100V types. Tolerances are \pm 20%, but \pm 10% units are available. Leakage current is less than 3 μ A. The body is pvc sleeved and fitted with tinned copper leads at one end. Europa Components & Equipment plc. Tel., 0181-953 2379; fax, 0181-207 6646.

Rectifiers. ITT has the IN4000G range of glass-passivated plastic rectifiers, which feature a 1V maximum forward voltage and 5 μ A leakage current at 25°C. Peak reverse voltage is 50V to 1000V, depending on which of the range is in use and max. repetitive peak forward current over 15Hz is 10A. Package is DO-41. ITT Semiconductors. Tel., 01932 336116; fax, 01932 33148.

3GHz baluns. Balun transformers from Toko now cover the range of frequencies used in GPS and wireless lans up to 3GHz. They are available in double-balanced mixer, distributor and directional coupler configurations in a range of turns ratios, being bifilar wound for good balance. These devices are pcb or surface mounted. Cirkit Distribution Ltd. Tel., 01992 444111; fax, 01992 464457.

CE-approved switches. EAO's Series 61 push-button switches and indicators carry the CE mark for the European emc standard. The switches mount in a 16mm panel cut-out and are modular in form, having separate lens, actuator and contact block, so that the series provides many variations and options. Contacts are self-cleaning gold or silver, the gold type switching from 10mA at 5V to 250Vac at 6A. EAO-Highland Electronics Ltd. Tel., 01444 236000; fax, 01444 236641.



Connectors and cabling

Formula 1 connectors. Micro AS Series II miniature connectors from Deutsch are lower-cost developments of a type used in racing cars, in which the environment is, to say the least, hostile. Contacts are gold-plated and shells of aluminium alloy finished in conductive black zinc. Anti-vibration locking and seals that are proof against oils, water and many solvents are standard. Rear seals take wires from 0.6-1.37mm diameter. Deutsch Ltd. Tel., 01342 410033; fax, 01342 410005.

Emc-shielded connector.

Framatome's UTGS connector has a twin-ferrule system to ensure 360° electrical continuity for grounding from the cable shield to the plug body. Plugs and receptacles are made of nickel-plated, glass-filled thermoplastic, the plug connectors having a metal PG tube and cable clamp. RM/RC machined contacts, SM/SC formed two-piece types and RMDX/RCDX coaxial contacts can be accommodated. The units are available in 4 to 48-way versions. Framatome Connectors UK Ltd. Tel., 01582 475757; fax, 01582 476203.

Pcb edge connector. Thermodata's new edge connector has spring-loaded clamp terminals for rapid wiring. Edgeclamp connectors come in 20, 56 and 72 ways on a 0.156in pitch and accept wires up to 0.19mm at 5A per way. Thermodat claim that wiring time is reduced by over 60% compared with soldering and still more than 50% compared with screw retainers. Alterations are, of course, much simpler. Thermodata Components. Tel., 01462 811757; fax, 01462 811536.

Long-lasting coax. connectors. 50/75 Ω rf coaxial connectors for test jigs, capable of withstanding many thousands of mating cycles, have been added to the ODU MAC range of modular attachable contacts, which are aluminium frames taking plastic insulation. Bodies are inserted taking

a variety of contacts. ODU UK Ltd. Tel., 01653 600489; fax, 01653 600493.

Displays

Low-profile graphics display. This new compact supertwist lcd module by Hitachi resolves 256 by 64 dots and has a single edge-lit off backlight, providing very good contrast, over 100cd/m² and a wide viewing angle. LMG7380QHFC has 8Kbyte of display ram and a T6963C graphics controller with character generation to show text and graphics simultaneously. Use of a fast-response crystal fluid makes it possible to show animation without ghosting or lag. Hitachi Europe Ltd. Tel., 01628 585163; fax, 01628 585160.

Filters

Active filters modules. These filters from Vicor complement its range of power supplies. The VI-AM input attenuator attenuates conducted emi and a passive/active circuit suppresses transient overvoltages. Common-mode and differential-mode chokes, in addition to the power supply decoupling, reduce noise to meet international standards. VI-RAM is a passive/active filter to reduce output noise and ripple to give ripple as low as 3mV pk-pk from low frequencies to tens of MHz. Vicor UK. Tel., 01276 678222; fax, 01276 681269.

Hardware

Heatsinks for power converters. Aavid produces a range of heatsinks for dc-to-dc converters, these devices being, apparently, particularly prone to heat stroke. The heatsinks are in extruded aluminium with a flat surface for least resistance; they come either unfinished or with anodised or chromate finish. All have six mounting slots, threaded or unthreaded to order. In sizes 4.6 by 2.4in and 2.4 by 2.28in, the units have various fin heights and orientations. A range of Interface pads is also offered to further improve performance. Aavid Thermal Technologies Ltd. Tel., 01279 626161; fax, 01279 626208.

Industrial computer enclosures.

Arcom offers two enclosures for STEbus industrial computer use, called ACE. They are described as 'boot-shaped', with the power supply in the heel, terminations and cable entry in the toe and up to six Eurocards about where the shin might go. These cases take up about half the volume of a 19in rack, many of which house mainly fresh air. The cases are die-cast and provide good noise protection and em compatibility, so that a computer built in this way can be CE self-certified. ACE-28 is for target systems, diskless pcs or

remote i/o nodes, while ACE-42 is wider with 42E space and will take pcs with disk drives. Arcom Control Systems Ltd. Tel., 01223 411200; fax, 01223 410457.

Emc shielding strip. A low-compression emc shielding strip from TBA ECP takes account of small irregularities of mating surfaces, allowing equipment that does not fully compress the common type of strip to meet emi shielding standards, without increasing insertion forces. The strip is pressure sensitive and can be supplied cut to length. Finishes supplied include gold, silver, cadmium, tin/lead and nickel. TBA Industrial Products Ltd. Tel., 01706 47718; fax, 01706 46170.

Card brackets. Vero has a range of nine, nickel-plated steel brackets for use on PCI format expansion cards. They come blank, with 9-way and 25-way D cut-outs, the 9-way type having the cut-out at the top or the bottom and with or without pcb fittings. Vero Electronics Ltd. Tel., 01489 780078; fax, 01489 780978

Rfi/emc shielding. Hughes Wynne offers Practi-Shield, a range of materials and components for rfi and emc protection. On offer are aluminium and copper barrier shielding laminates with an insulating film on both surfaces; elastomeric gaskets from silicone rubber loaded with carbon, nickel and silver-plated glass, or from E-PTFE Gore-Shield; and Mumetal components for magnetic shielding. The company offers a computer-controlled laser profiling service. Hughes Wynne Ltd. Tel., 01932 569700; fax, 01932 569652.

Test and measurement

Isolation amplifier. On offer from Nicolet is the BE1100 modular isolation amplifier which gives 1500Vrms isolation with filtered outputs on up to nine channels in a stand-alone instrument. Four types of amplifier module are available with inputs of 62mV to 1000V and can be mixed in any combination. Inputs are differential and floating, and outputs filtered and short-circuit protected. Nicolet Technologies Ltd. Tel., 01908 679903; fax, 01908 677331.

Digital video measurement. New facilities provided by Tektronix for its 2715 cable spectrum analyser turn the instrument into an rf test set for digital channels. The additions provide measurements of: digital average power across the channel bandwidth; desired:undesired signal power ratio (signal-to-noise and distortion power); channel triple beat and second-order distortion, the level of distortion to average power; and adjacent-channel leakage. There are facilities for unattended operation and

Please quote "Electronics World" when seeking further information

collection of data. Tektronix UK Ltd. Tel., 01628 403300; fax, 01628 403301.

Dummy head measurement. *HEAD* by Head Acoustics is a sound measuring system using an anatomically and auditorily accurate model head (bald, actually) to provide reproducible recordings of sound signatures in noise diagnosis and analysis, product development and architectural acoustics, among other areas. There is a range of measuring and support equipment for the head, including storage, filtering and reproduction using the *HEADphone* playback system. Acsoft Ltd. Tel., 01296 662852; fax, 01296 661400.

Real-time/storage oscilloscope. Hitachi Denshi's *VC-6645* real-time and storage oscilloscope is characterised by a four-channel 100Msamples rate, 100MHz bandwidth, 4Kword instrument with delaying sweep and a 100MHz frequency meter. An RS-232C interface, which is standard, conveys data to a pc using *HIMES* software. Four waveforms may be captured and memorised in a 72h-10day memory. Hitachi Denshi (UK) Ltd. Tel., 0181-202 4311; fax, 0181-202 2451.

Interfaces

Signal conditioners. *ADAM-3000* isolated signal-conditioning modules use optical techniques to provide 1000V dc isolation of input, output and power lines to protect against ground loops and interference. There are models for analogue input and output signal conditioning and for direct sensor conditioning in thermocouples, 4-20mA loops and voltage-output sensors, a 1kHz or 5Hz active low-pass filter giving extra noise rejection. Integrated Measurement Systems Ltd. Tel., 01703 771143; fax, 01703 704301.

Literature

Hitachi microcontrollers. Hitachi's *H8 Power in design* is an overview of the *H8* microcontroller family of 8/16-bit devices. It includes a summary of applications ideas and there is a section on support tools from Hitachi and other companies. Hitachi Europe Ltd. Tel., 01628 585163; fax, 01628 585160.

Production equipment

Desoldering iron. The Weller/Ungar *4024IL-A* desoldering instrument is variable in temperature from 260°C to 540°C and is electronically controlled for printed-board repairs and rework; it has a self-contained pump for desoldering and has a desoldering iron. Control is by zero-switching circuitry, the supply is isolated and the instrument is fully grounded. Cooper Tools. Tel., 0191-416 6062; fax, 0191-417 9421.

Power supplies

Fast chargers. Fast NiCd battery chargers, one for ac and the other for dc input, are announced by Relec. Both are of the switched-mode type and achieve up to 75% efficiency. The *9243* 10-18V dc model delivers a constant fast charge of 700mA to up to 16 cells, while the *8715* ac-powered unit delivers 520mA to 10 cells. The chargers contain circuitry to protect against overcharging; approaching full charge, the fast charge gives way to a trickle charge of 18mA, or 14mA in the ac type. Relec Electronics Ltd. Tel., 01962 863141; fax, 01962 855987.

5V regulator. Zetex's *ZSAT500* 5V positive regulator is particularly meant for satellite receiver low-noise blocks, offering ripple rejection of 65dB up to 22kHz and 40dB to 200kHz. Quiescent current is 350µA and maximum load current 200mA. Zetex plc. Tel., 0161-627 5105; fax, 0161-627 5467.

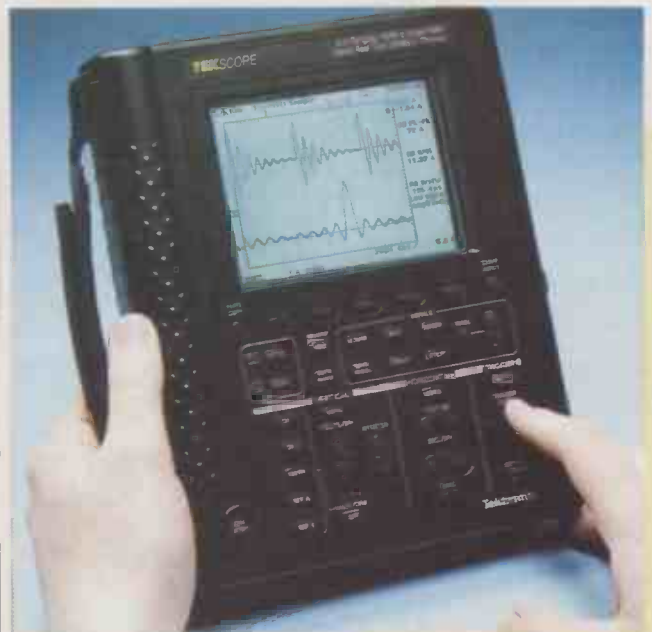
Small psu. Said to be the world's smallest 40W ac/dc supply, the *NLP40* by Computer Products measures 108-by-63.5 by 28.45mm, also meeting the relevant standards for conducted noise and emc and producing 36% more power per unit volume than any other known supply. Input is 86-264V ac and five single-output models give 5, 12, 15, 24 or 48V dc; two duals provide 5/12Vdc or ±12V dc; and two triples give 5/12V dc and 5/±15V dc, all regulated to within ±2%. Computer Products, Power Conversion Ltd. Tel., 01494 883113; fax, 01494 883419.

Surface-mount dc-to-dc converters. Small, self-contained dc-to-dc converters by TOKO may be paralleled together for higher currents. Both step-up and step-down models are available: 12V-to-5V at 600mA and 5V-to-12V at 115mA, with dual-rail types available. Efficiency is 87% and the units are fitted with a on-off control. Package is 14.5mm². Cirkit Distribution Ltd. Tel., 01992 444111; fax, 01992 464457.

High-voltage supply. Advance Hivolt announces the first of a series of high-voltage power supplies giving up to 40kV at 2.5mA, controllable in current or voltage mode by remote potentiometer or 10V analogue voltage. There is a 0-10V output for monitoring. Ripple is 20V maximum, 200ppm variation for ±10% input change and 500ppm output variation for a 0-100% load change. Other modules for outputs of 5-25kV are to be announced. Advance Hivolt. Tel., 01243 841888; fax, 01243 820555.

Radio communications products

Surface-mounted antenna. Meant for use in DECT portable telephones, Murata's *ANCLC* series of antennas



uses a dielectric material and operates over a 60MHz bandwidth centred on 1890MHz. Input impedance is 50Ω and vswr in bandwidth a maximum of 2. Murata Electronics (UK) Ltd. Tel., 01252 811666; fax, 01252 811777.

73kHz amateur receiver. Cambridge Kits points out that it already has a kit suitable for the new 73kHz band – the 60kHz MSF receiver, which is easily modified. It has a built-in directional antenna, a 100Hz bandwidth if, 50dB agc and outputs for an S-meter and headphones or a speaker amplifier. Modification is only a matter of retuning and adding a variable capacitor. Using its internal antenna, the receiver will get HBG in Switzerland, MSF at Rugby and DCF77 in Germany. Cambridge Kits. Tel., 01223 860150.

GPS for telecomms. Motorola has a new GPS receiver for the telecommunications market, in which accurate timing is becoming of greater importance; for example, in simulcast operation. *VP Oncore* provides one pulse/s to a 43ns accuracy and also *T-RAIM*, which prevents faulty satellite data being used in the timing calculation. On Core can be embedded, being the size of a credit card, and an enhanced version is fitted with more memory, a battery, a low-noise amplifier and phase-carrier software. It also has an RS232/ttl interface. Motorola Automotive and Industrial Electronics Group. Tel., 01462 831111; fax, 01462 835602.

Protection devices

Programmable voltage clamp. From Unitrode, the *UC3908* clamp, which is designed to protect the load from power supply overvoltage, sustained or transient. It takes the form of a shunt regulator which, in the presence of overvoltage, keeps the output to a programmed maximum level. In the event of this circuit saturating, excess

Handheld 'scope/multimeter. New from Tektronix, the *THS700* Series of handheld instruments combining the functions of a digital multimeter and a digital oscilloscope with digital, real-time sampling. Maximum sampling rate is 500Msamples in the *THS720*, presenting real-time displays on a 5ns/division, 100MHz timebase, dual digitisers giving full sampling on both channels simultaneously. The instrument's white, backlit lcd gives a brightness of 10foot-lamberts, much brighter than is often found. Thurlby Thandar Instruments Ltd. Tel., 01480 412451; fax, 01480 450409

shunted current or activation of thermal shutdown, the device emits an scr gate signal to crowbar the output. When no untoward state exists, the circuit takes less than 100µA; when it springs into action, it will shunt up to 17A to maintain the output at the maximum programmed limit and sets the flag signal. Unitrode (UK) Ltd. Tel., 0181-318 1431; fax, 0181-318 2549.

Current/thermal fuses. Microtherm offers the *CT* range of fuses, which combine both overcurrent and high temperature protection in one surface-mounted package, handling up to 15A ac with special versions available. Microtherm Ltd. Tel., 01483 450100; fax, 01483 451816.

Fast suppressors. Surface-mounted transient voltage suppressors by Liteon dissipate 400W and exhibit a response time of 1ps. There are 35 types in the range of unidirectional and bidirectional devices, all in SMA style, handling forward currents up to 40A and having leakage current of less than 1µA at more than 10V. Standard breakdown voltage tolerance is 5%, but 10% types are available. Flint Distribution. Tel., 01530 510333; fax, 01530 510275.

Please quote "Electronics World" when seeking further information

Switches and relays

Quad pwm relay driver. UC3702 from Unitrode drives up to four relays from a common bus and does not need secondary regulation of the relay bus voltage. It will drive 9V, 12V and 24V relays from a possibly poorly regulated, ripply, higher bus voltage such as 34V in a power-efficient pwm manner, the coil being used as the inductive element in a switched-mode supply. Unitrode (UK) Ltd. Tel., 0181-318 1431; fax, 0181-318 2549.

TO-5 relays. Magnetic-latching relays in Teledyne's 422 Series are intended for applications in which reliability is vital and have been specified for satellite work. Single-pulse activation also means that no holding power is needed. Frequency handling extends well into the uhf region. Teledyne Electronic Technologies. Tel., 0181-571 9596; fax, 0181-571 9637.

Television components

Comprehensive tv signal processing. Toshiba announces the TB1226N, which performs video, chroma and synchronous processing for Pal, Secam and NTSC, cutting the number of external components by around half. The chip contains the I-H delay circuit and needs only one crystal for the colour carrier base frequency. Toshiba Electronics UK Ltd. Tel., 01276 694600; fax, 01276 694800.

Digital video encoder. VP531 and VP551 represent GEC Plessey's entry

1.3GHz counter. Thurlby Thandar has introduced the PFM1300, a handheld counter capable of measuring signals in the 5Hz-1300MHz range. Sensitivity is 15mV and a low-pass filter can be selected. Period measurement is provided up to 25MHz and, for very low frequencies, reciprocal counting to give readings on inputs down to 0.001Hz. Cost is £99. Thurlby Thandar Instruments Ltd. Tel., 01480 412451; fax, 01480 450409.

to the digital set-top box arena. The two cmos decoder chips are used with the company's bipolar rf tuner and a-to-d converters to give a low-cost core for digital decoders converting the decompressed Y, Cr and Cb MPEG outputs to NTSC or Pal. A unique feature is the provision of genlock, which allows the device to lock to the colour burst phase of an analogue signal and thereby enable digital overlay on an analogue signal in combined systems at lower than usual cost. GEC Plessey Semiconductors Ltd. Tel., 01793 518510; fax, 01793 518582.

Transducers and sensors

Gas microvalve. EG&G IC Sensors offers the Model 4425 silicon microvalve gas controller, a normally closed valve giving proportional control of gas flow in the 0-150cc/min range. A diaphragm forms a bi-metallic actuator and has implanted resistors; by varying the power in the resistors, the bi-metallic diaphragm distorts and moves away from its seat in a controlled manner to allow gas to flow. The device is in a pcb-mounted package and contains filtering to prevent particles in the gas affecting operation. Eurosensor. Tel., 0171-405 6060; fax, 0171-405 2040.

Signal-conditioned accelerometer. Made by EG&G IC Sensors, the Model 3255 is believed to be the smallest signal-conditioned dc-response accelerometer available, mounting flat on a 7.5 by 13.5mm area for hand or reflow soldering. It consists of a silicon sensor and a dedicated asic in the same case, which is hermetically sealed by a gold-plated Kovar lid. The unit was designed for ±50g airbag activation, providing an output of ±40mV/g about a 2.5Vdc reference and there is a digital warning of malfunction, and a self-test facility. Eurosensor. Tel., 0171-405 6060; fax, 0171-405 2040.

Trlaxial accelerometers. Isotron 2258AM2 series piezoelectric accelerometers by Endevco contain the relevant electronics and are designed to measure vibration in

three orthogonal axes in small structures, having output sensitivities of 10mV/g or 100mV/g with a bandwidth of 1Hz-20kHz. Cost of operation is greatly reduced by the use of replaceable transducer elements in case of damage to one of the axes. Only one, four-conductor cable is needed. Endevco UK Ltd. Tel., 01763 261311; fax, 01763 261120.

COMPUTER

Data acquisition

PCMCIA data acquisition. Intelligent Instrumentation's i/o card system is a portable acquisition system to connect to a PCMCIA Type II slot. It consists of a card and a termination pad which provides all analogue and digital i/o on screw terminals. The card has eight differential analogue inputs with 12-bit resolution, 30kHz throughput and external triggering. Unipolar at 0-10V and bipolar on ±5V and ±10V are provided with selectable gain and input ranges. There are four digital input and output channels at ttl levels, a cold-junction compensation circuit for seven thermocouples and an adjustable voltage reference for sensors needing excitation. Intelligent Instrumentation. Tel., 01923 249596; fax, 01923 226720

Development and evaluation

PIC emulator. ICEPIC from Microchip is a low-cost development tool for the 8-bit PIC16C5X and PIC16CXX microcontrollers. The emulator operates under Windows 3.1 to give source-level debugging in assembly or C. Modular in design, the emulator has a motherboard with common logic and a device-specific daughter board. ICEPIC runs with MPASM and the company's MP-C compiler. Arizona Microchip Technology Ltd. Tel., 01628 851077; fax, 01628 850259.

Data logging

Handheld logger. Mitec's AT40 handheld data logger has intelligent inputs to identify the type of sensor automatically and program the instrument accordingly. It has four or eight channels, a 512Kbyte memory and accepts signals of ac/dc voltage or current, resistance, temperature transducers, pulses and time/frequency; a non-contact magnetic probe can be supplied for electrical measurements. An internal processor analyses the data to allow the immediate plotting on a portable inkjet printer and display on the instrument's lcd. Interface to a pc can be direct or by way of a modem. Martron Instruments Ltd. Tel., 01494 459200; fax, 01494 535002

Programming hardware

Debugger for 68HC05/8. Cosmic Software offers the ZAP debugger for



Multimedia

CD-roms for notebooks. Using a PCMCIA slot in a notebook pc, you can now operate a CD-rom drive by means of a single cable. DIP Systems produces dual, quad and six-speed versions of the drive, all being compatible with MSCDEX, Windows and Windows 95 and the six-speed type giving a 900Kb/s transfer rate. The PCMCIA card is a Type 1 to fit any pc card slot and software provided makes for easy installation. The drives will also handle audio CDs and have line output and headphone jacks. DIP Systems. Tel., 01483 202070; fax, 01483 202023.

Motorola 68HC05 and 69HC08 microcontrollers. The debugger works with the Motorola modular evaluation system and with in-circuit emulators from Motorola and Pentica. Cosmic expects that designers will choose the ZAP in preference to the Motorola MMEVS debugger in view of its integration with Cosmic's C compiler. Four standard ZAP configurations form a simulator, monitor, background debugger and in-circuit emulator, so that the same debugger can be used at each stage of the design. Cosmic Software. Tel., 01734 880241; fax, 01734 880360.

Software

Lookout for Windows. National's Lookout industrial automation software is now available in 32-bit Windows 95 and NT versions., giving users a 32-bit, object-oriented, event-driven system for building applications from a simple human interface to supervisory control and data acquisition (Scada) systems, working at a rate almost twice as fast as in a 16-bit version. National Instruments UK. Tel., 01635 572400; fax, 01635 523154.

Data visualisation. HiQ by National Instruments is an interactive package to allow the visualisation of maths and data. It runs as a native, 32-bit application in Windows 95 or NT, uses ole and ActiveX and the OpenGL 3-d graphics library to provide ActiveMaths and visualisation to ActiveX and Microsoft Office applications such as Word and Excel. National Instruments UK. Tel., 01635 572400; fax, 01635 523154.



DC TO DC CONVERTERS

DRM58 input 10-40vdc output 5v 8A £15
 DRM128 input 17-40vdc output 12v 8A £50
 DRM158 input 20-40vdc output 15v 8A £50
 DRM248 input 29-40vdc output 24v 8A £40
 DRS123 input 17-40vdc output 12v 3A £20
 DRS153 input 20-40vdc output 15v 3A £20
 DRS243 input 29-40vdc output 24v 3A £15

SOLID STATE RELAYS

CMP-DC-200P 3-32vdc operation, 0-200vdc 1A £2.50
 SMT20000/3 3-24vdc operation, 28-280vac 3A £4.50
 SMT20000/4 3-24vdc operation, 28-280vac 4A £5.00
 ZRA6025F 28-280vac operation, 28-280vac 25A £7.00

200 WATT INVERTERS Nicely cased units 12v input 240v output 150watt continuous, 200 max. £49 ref LOT62.

6.8MW HELIUM NEON LASERS New units, £65 ref LOT33

COINSLLOT TOKENS You may have a use for these? mixed bag of 100 tokens £10 ref LOT20.

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, no special gimmicks for experimental purposes. Not a toy or for minors! £65/set. Ref FXP1.

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. £45/set Ref F/TKK1.

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. £5/5/ set Ref F/BTC1/LG5.

COPPER VAPOUR LASER PLANS Produces 100mw of visible green light. High coherence 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/ICV1.

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. £6/ set Ref F/VSS9.

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.

MYSTERY ANTI GRAVITY DEVICE PLANS Uses simple concept. Objects float in air and move to the touch. Defies gravity, amazing gift, conversation piece. magic trick or science project. £6/ set Ref F/ANT1K.

ULTRASONIC BLASTER PLANS Laboratory source of sonic shock waves. Blow holes in metal, produce 'cold' steam, atomize liquids. Many cleaning uses for PC boards, jewellery, coins, small parts etc. £6/ set Ref F/JLB1.

ULTRA HIGH GAIN AMP/STETHOSCOPIC MIKE/SOUND AND VIBRATION DETECTOR PLANS Ultrasensitive device enables one to hear a whole new world of sounds. Listen through walls, windows, floors etc. Many applications shown, from law enforcement, nature listening, medical heartbeat, to mechanical devices. £6/ set Ref F/HGA7.

ANTI DOG FORCE FIELD PLANS Highly effective circuit produces time variable pulses of acoustical energy that dogs cannot tolerate £6/ set Ref F/DOD2.

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

LASER LIGHT SHOW PLANS Do it yourself plans show three methods. £6 Ref F/LLS1.

PHASOR BLAST WAVE PISTOL SERIES PLANS Handheld, has large transducer and battery capacity with external controls. £6/ set Ref F/PPS4.

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/TELEGRAB.

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

WOLVERHAMPTON BRANCH NOW OPEN AT WORCESTER ST W'HAMPTON TEL 01902 22039

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/HVMT7/ TCL4.

INFINITY TRANSMITTERS The ultimate 'bug' fits to any phone or line, undetectable, listen to the conversations in the room from anywhere in the world! 24 hours a day 7 days a week! Just call the number and press a button on the mini controller (supplied) and you can hear everything! Monitor conversations for as long as you choose £249 each, complete with leads and mini controller Ref LOT9. Undetectable with normal RF detectors, fitted in seconds, no batteries required, lasts forever!

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 1/ P. Cased, 175x90x145mm. IEC Inlet Suitable for PC use (6 d/drive connectors 1 mboard). £10 ref PSU1.

VIDEO PROCESSOR UNITS?/6v 10AH BATT/12V 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 B? 12v toroidal transformer (main in). Condition not known, may have one or two broken knobs due to poor storage. £17.50 ref VP2

RETRON NIGHT SIGHT Recognition of a standing man at 300m in 1/4 moonlight, hermetically sealed, runs on 2 AA batteries, 80mm F1.5 lens, 20mw infrared laser included. £325 ref RETRON.

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. £7 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! £12 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. £15 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. £14 Ref 1014.

4 WATT FM TRANSMITTER KIT Small but powerful FM transmitter, 3 RF stages, microphone and audio preamp included. £20 Ref 1028.

STROBE LIGHT KIT Adjustable from 1-60 hz (a lot faster than conventional strobes). Mains operated. £16 Ref 1037.

COMBINATION LOCK KIT 9key, programmable, complete with keypad, will switch 2A mains. 9v dc operation. £10 Ref 1114.

PHONE BUG DETECTOR KIT This device will warn you if somebody is eavesdropping on your line. £6 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 £8 Ref 1135.

3 CHANNEL LIGHT CHASER KIT 800 watts per channel, speed and direction control supplied with 12 LEDs (you can fit nics instead to make kit mains, not supplied) 9-12vdc £17 ref 1026.

12V FLOURESCENT LAMP DRIVER KIT Light up 4 foot tubes from your car battery! 9v 2a transformer also required. £8 ref 1069.

VOX SWITCH KIT Sound activated switch ideal for making bugging tape recorders etc, adjustable sensitivity. £8 ref 1073.

***SOME OF OUR PRODUCTS MAY BE UNLICENSEABLE IN THE UK**



Check out our
WEB SITE

<http://www.pavillon.co.uk/bull-eleotrical>

PREAMP MIXER KIT 3 Input mono mixer, sep bass and treble controls plus individual level controls, 18vdc, input sens 100mA. £15 ref 1052.

BULL ELECTRICAL

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

MAIL ORDER TERMS: CASH, PO OR CHEQUE
 WITH ORDER PLUS £3 P&P PLUS VAT.

PLEASE ALLOW 7-10 DAYS FOR DELIVERYPHONE ORDERS
 WELCOME (ACCESS VISA, SWITCH, AMERICAN EXPRESS).

TEL: 01273 203500

FAX 01273 323077

E-mail bull@pavillon.co.uk

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

16 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, lcd 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

FM CORDLESS MICROPHONE This unit is an FM broadcasting station in miniature, 3 transistor transmitter with electret condenser mic-fet amp design result in maximum sensitivity and broad frequency response. 90-105mhz, 50-1500hz, 500 foot range in open country! PP3 battery required. £15.00 ref 15P42A.

MAGNETIC MARBLES They have been around for a number of years but still give rise to curiosity and amazement. A pack of 12 is just £3.99 ref GI/R20

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. £39.99 ref NIK39.

Miniature adjustable timers, 4 pole o/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

9v DC POWER SUPPLY Standard plug type 150ma 9v DC with lead and DC power plug. price for two is £2.99 ref AUG3P4.

COMPOSITE VIDEO KIT, Converts composite video into separate H sync, V sync, and video. 12v DC. £8.00 REF: MAG8P2.

FUTURE PC POWER SUPPLIES These are 295x135x60mm, 4 drive connectors 1 mother board connector. 150watt, 12v fan, iec Inlet and on/off switch. £12 Ref EF6.

VENUS FLY TRAP KIT Grow your own carnivorous plant with this simple kit £3 ref EF34.

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

ROCK LIGHTS Unusual things these. Two pieces of rock that glow when rubbed together believed to cause rain! £3 a pair Ref EF29.

3' by 1' AMORPHOUS SOLAR PANELS 14.5v, 700mA 10 watts, aluminium frame, screw terminals. £44.95 ref MAG45.

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

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

FLYING PARROTS Easily assembled kit that builds a parrot that actually flaps its wings and flies! 50 m range £6 ref EF2.

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! £7.99 ref R/9.

BALLON MANUFACTURING KIT British made, small blob blows into a large, long lasting balloon, hours of fun! £3.99 ref GI/E99R

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

2.5 KILOWATT INVERTERS, Packed with batteries etc but as they weigh about 100kg CALLERS ONLY! £120.

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.

CLEARANCE SECTION, MINIMUM ORDER £15, NO TECHNICAL DETAILS AVAILABLE, NO RETURNS, TRADE WELCOME.

2000 RESISTORS ON A REEL (SAME VALUE) 99P REF BAR340

AT LEAST 200 CAPACITORS (SAME VALUE 99P REF BAR342

INFRA RED REMOTE CONTROLS JUST 99P REF BAR333

CIRCUIT BREAKERS, OUR CHOICE TO CLEAR 99P REF BAR335

MICROWAVE CONTROL PANELS TO CLEAR £2 REF BAR 329

2 TUBES OF CHIPS (2 TYPES OUR CHOICE) 90P REF BAR305

LOTTERY PREDICTOR MACHINE!! JUST £1.50 REF BAR313

HELLA/ROVER ELECTRIC LAMP LEVELLER £2 REF BAR311

SINCLAIR C5 16" TYRES TO CLEAR AT JUST 75P REF BAR318

LARGE MAINS MOTORS (NEW) TO CLEAR AT 75P REF BAR310

MODEMS ETC FOR STRIPPING £2.50 EACH REF BAR324

110V LARGE MOTORS (NEW) TO CLEAR AT 50P REF BAR332

MODULATOR UNITS UNKNOWN SPEC JUST 50P REF BAR323

GX4000 GAMES COSSOL'S JUST £4 REF BAR320

SMART CASE MEMORY STORAGE DEVICE, LOADS OF BITS INSIDE, PCB, MOTOR, CASE ETC. BUMPER PACK OF 5 COMPLETE UNITS TO CLEAR AT £2.50(FOR 5) REF BAR 330.

2 CORE MAINS CABLE 2M LENGTHS PACK OF 4 £1 REF BAR337

PC USER/BASIC MANUALS, LOADS OF INFO. £1 REF BAR304

PCB STRIPPERS TO CLEAR AT 2 FOR 99P REF BAR341

3 M 3 CORE MAINS CABLE AND 13A PLUG. 60P REF BAR325

WE BUY SURPLUS STOCK

FOR CASH

BUYERS DIRECT LINE 0802 660377

FREE CATALOGUE

100 PAGE CATALOGUE NOW AVAILABLE, 45P STAMPS.

Precision preamplifier '96

"Could this be the quietest audio preamplifier design in existence?" asks Douglas Self. Part II concentrates on circuit design, revealing a new concept in hi-fi tone control.

Morgan Jones raised the excellent point of crosstalk in the input-select switching in a recent article*. If the source impedance is significant then this may be a serious problem.

While I agree that Morgan's rotary switch with every other contact grounded may be slightly superior to conventional rotary switches, measuring a popular Lorlin switch type showed the improvement to be only 5dB. I am also unhappy with all those redundant 'mute' positions between input selections, so I instead chose interlocked push-switches rather than a rotary. A four-pole-changeover format can then be used to reduce crosstalk.

The problem with conventional input select systems like Fig. 1a is that the various input tracks necessarily come into close proximity, with significant crosstalk through capacitance C_{stray} to the common side of the switch, ie from A to B. Using two changeovers per input side - ie four for stereo - allows the intermediate connection B-C to be grounded by the NC contact of the first switch section. This keeps the 'hot' input A much further away from the common input line D, as shown in Fig. 1b.

Crosstalk data in Table 1 was gathered at 10kHz, with 10k Ω source impedances. The emphasis here is on minimising inter-source crosstalk, as interchannel (L-R) crosstalk is benign by comparison. Interchannel isolation is limited by the placement of left and right on the same switch, with the contact rows parallel, and limits L-R isolation to -66dB at 10kHz with 10k Ω source impedance.

With lower source impedances, both intersource and interchannel crosstalk is proportionally reduced. In this case, a more probable 1k Ω source gives 115dB of intersource rejection

at 10kHz for the four-pole-changeover method.

Line input criteria

Nowadays the input impedance of a preamp must be high to allow for interfacing to anachronistic valve equipment, whose output may be taken from a valve anode. Even light loading compromises distortion and available output swing. A minimum input impedance is

Table 1. Crosstalk exhibited by four switch arrangements using a 10kHz test signal.

Simple rotary:	71dB
Morgan-Jones rotary:	76dB
2 c/o switch	74dB
4 c/o switch	95dB

Fig. 1a). Input-select switching for audio preamplifiers - the conventional method, with poor rejection of unselected sources due to C_{stray} .

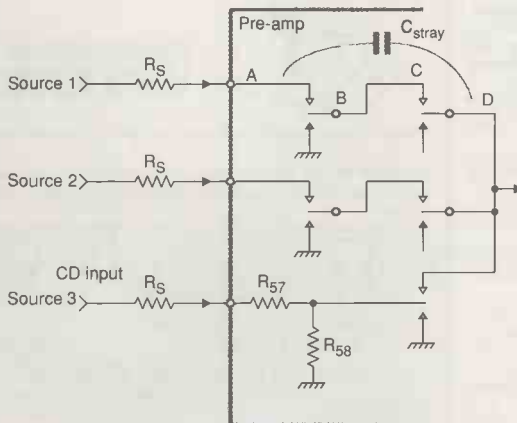
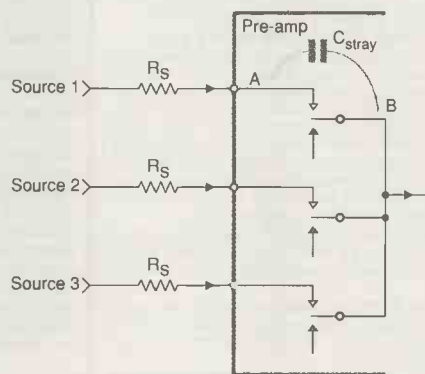


Fig. 1b). Improved input selection using four-pole switching to reduce capacitance between the different sources. The CD input attenuator can be grounded when not selected, so 2-pole switching is sufficient for high isolation of Source 3.

* Valve preamplifiers, Morgan Jones, March and April issues.

100kΩ, which many preamp designs fall well short of.

The CD input stands out from other line sources in that its nominal level is usually 1V rather than 150mV. This is perfectly reasonable, since digital sources have rigidly defined maximum output levels, and these might as well be high to reduce noise troubles. There is no danger of the analogue output section clipping. However, this means a direct line input cannot be used without the trouble of resetting volume and recording-level controls whenever the CD source is selected.

This problem is addressed here by adding a 16dB passive attenuator, as shown for Source 3 in Fig. 1b. The assumption is that a CD output has a low impedance, and that a 10kΩ input impedance will not embarrass it. As a result, resistance values can be kept low to minimise the noise degradation.

Output impedance of this attenuator is 1.4kΩ, which generates -120.9dBu of Johnson noise as opposed to -135.2dBu from a direct 50Ω source. This is still much less than the preamp internal noise and so the noise floor is not degraded. It is now possible to improve inter-source crosstalk simply by grounding the CD attenuator output when it is not in use, so only a two-pole switch is required for good isolation of this source.

The tape-monitor switch allows the replay signal from the tape deck to be compared with the source signal. With three-head machines, this provides a real-time quality check. But with the much more common two-head appliances, where the input signal is looped straight back to the amplifier in RECORD mode, it only provides confirmation that the signal has actually got there and back.

Line input buffering

This stage has to provide a high input impedance and variable gain for the balance control. My last preamp¹ had the balance control incorporated in the tone stage, but this does not appear to be practical with the more complex tone system here.

The vernier balance control alters the relative stage gain by +4.5, -1.1dB - a difference of 6dB - which is sufficient to swing the image wholly from one side to the other. Since the minimum gain of this non-inverting stage is unity, the nominal gain with balance control central is 1.1dB. Maximum gain of the active gain stage, or AGS, is reduced to allow for this. The active nature of this balance control means that the signal never receives unwanted attenuation that must be undone later with noisy amplification. The gain law is modified by R₃₄ to give as little gain as possible in the centre. Maximum gain is set by R₃₅, Fig. 11.

A high input impedance is obtained simply by using a high-value biasing resistor R₃₃, accepting that the bias current through this will give some negative output offset; at -180mV this is not large enough to reduce

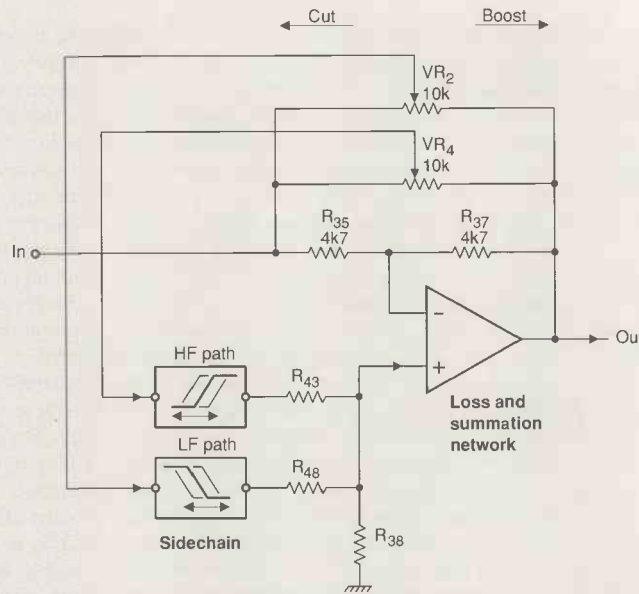


Fig. 2. The basic tone control circuit. The response only deviates from unity gain at frequencies passed by the hf or lf side-chain paths.

headroom. Input impedance is therefore 470kΩ, high enough to prevent loading problems with any conceivable source equipment.

In discussing noise there are fundamental limits that lend perspective to the process. If the external source impedance is 50Ω, which is about as low as is plausible, the inherent thermal noise from it is -135.2dBu in 22kHz bandwidth. This is well below the measuring equipment, (AP System 1) which has an input noise floor 1 measured at -116.8dBu, 50Ω source again.

The noise output of the buffer/balance stage is of the same order and cannot be measured

directly - a good way would be to use the flat moving-coil cartridge stage as a preamp for the testgear². Calculated noise output is -116dBu with balance central.

Controlling tone

I plan to ignore convention once again. I think tone controls are absolutely necessary, and it is a startling situation when, as frequently happens, anxious inquirers to hi-fi advice columns are advised to change their loudspeakers to correct excess or lack of bass or treble. This is an extremely expensive way of avoiding tone controls.

This design is not a conventional Baxandall tone control. The break frequencies are variable over a ten to one range, because this makes the facility infinitely more useful for

correcting speaker deficiencies. This enhancement flies in the face of Subjectivist thinking, but I can live with that. Variable boost/cut and frequency enables any error at top or bottom end to be corrected to at least a first approximation. It makes a major difference, as anyone who has used a mixing console with comprehensive EQ will tell you.

Middle controls are quite useless on a preamplifier. They are no good for acoustic correction: after all, even a third-octave graphic equaliser isn't that much use. Variable frequency mid controls are standard on mixing consoles because their function is voicing - ie giving a sound a particular character - rather than correcting response anomalies.

Certain features of the tone control may make it more acceptable to those with doubts about its sonic correctness. The tone control

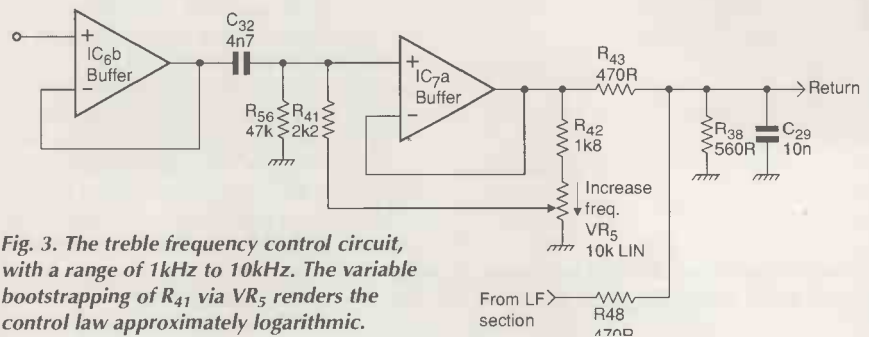


Fig. 3. The treble frequency control circuit, with a range of 1kHz to 10kHz. The variable bootstrapping of R₄₁ via VR₅ renders the control law approximately logarithmic.

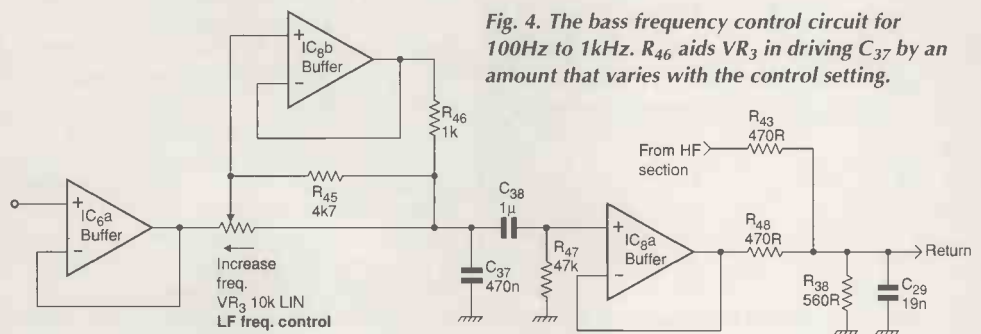


Fig. 4. The bass frequency control circuit for 100Hz to 1kHz. R₄₆ aids VR₃ in driving C₃₇ by an amount that varies with the control setting.

range is restricted to $\pm 10\text{dB}$, rather than the $\pm 15\text{dB}$ which is standard in mixing consoles. The response is built entirely from simple 6dB/octave circuitry, with inherently gentle slopes. The stage is naturally minimum-phase, and so the amplitude curves uniquely define the phase response. This will be shown later, where the maximum phase-shift does not exceed 40° at full boost.

This is a return-to-flat tone control. Its curves do not plateau or shelve at their boosted or cut level, but smoothly return to unity gain outside the audio band. Boosting 10kHz

is one thing, but boosting 200kHz is quite another, and can lead to some interesting stability problems. The fixed return-to-flat time-constants mean that the boost/cut range is necessarily less at the frequency extremes, where the effect of return-to-flat begins to overlap the variable boost/cut frequencies.

The basic principle is shown in Fig. 2. The stage gives a unity-gain inversion, except when the selective response of the side-chain paths allow signal through. In the treble and bass frequency ranges, where the side-chain does pass signal, boost/cut potentiometers $VR_{2,4}$ can give either gain or attenuation. When a wiper is central, there is a null at the middle of the boost/cut potentiometer, no signal through that side-chain, and gain is unity.

If the potentiometer is set so the side-chain is fed from the input then there is a partial cancellation of the forward signal; if the side-chain is fed from the output then there is a partial negative-feedback cancellation. To put it another way, positive feedback is introduced to counteract part of the negative feedback through R_{37} .

This apparently ramshackle process actually gives boost/cut curves of perfect symmetry. In fact this symmetry is pure cosmetics, because you can't use both sides of the curve at once, so it hardly matters if they are exact mirror-images.

Bass and treble

The tone control stage acts in separate bands for bass and treble, so there are two parallel selective paths in the side-chain. These are simple RC time-constants, the bass path being a variable-frequency first-order low-pass filter, and the associated bass control only acting on the frequencies this lets through.

Similarly, the treble path is a variable high-pass filter. The filtered signals are summed and returned to the main path via the non-inverting input, and some attenuation must be introduced to limit cut and boost.

Assuming a unity-gain side-chain, this loss is 9dB if cut and boost are to be limited to $\pm 10\text{dB}$. This is implemented by R_{43} , R_{48} and R_{38} , Figs 2, 3 and 4. The side-chain is unity-gain, and so has no problems with clipping before the main path does. As a result, it is highly desirable to put the loss after the sidechain, where it attenuates side-chain noise.

The loss attenuator is made up of the lowest value resistors that can be driven without distortion. This minimises both the Johnson noise therein and noise generated by op-amp IC_{7b} .

The tone cancel switch disconnects the entire sidechain, ie five out of six op-amps, from any contribution to the main path, and usefully reduces the stage output noise by about 4dB , depending on the hf frequency setting. It leaves only IC_{7b} in circuit, which is required anyway to undo the gain-control phase-inversion.

Unlike configurations where the entire stage is by-passed, the signal does not briefly disappear as the switch moves between two contacts. This minimises transients due to suddenly chopping the waveform and makes valid

tone in/out comparisons much easier.

Having all potentiometers identical is very convenient. I have used linear $10\text{k}\Omega$ controls, so the tolerances inherent in a two-slope approximation to a logarithmic law can be eliminated. This only presents problems in the tone stage frequency controls, as linear potentiometers require thoughtful circuit design to give the logarithmic action that fits our perceptual processes.

Basics of the treble path are shown in Fig. 3. Components C_{32} , R_{41} are the high-pass time-constant, driven at low-impedance by unity-gain buffer IC_{6b} . This is needed to prevent the frequency from altering with the boost/cut setting. The effective value of R_{41} is altered over a 10:1 range by varying the amount of bootstrapping it receives from IC_{7a} , the potential divider effect and the rise in source resistance of VR_5 in the centre combining to give a reasonable approximation to a logarithmic frequency/rotation law, Fig. 5.

Resistor R_{42} is the frequency end-stop resistor. It limits the maximum effective value of R_{41} . Capacitor C_{29} is the treble return-to-flat capacitor. At frequencies above the audio band it shunts all the sidechain signal to ground, preventing the treble control from having any further effect.

The treble side-chain does degrade the noise performance of the tone control stage by 2–3dB when connected. This is because it must be able to make a contribution at the hf end of the audio band. As you would expect, the noise contribution is greatest when the hf frequency is set to minimum, and so a wider bandwidth from the side-chain contributes to the main path.

The simplified bass path is shown in Fig. 4. Op-amp IC_{6a} buffers VR_2 to prevent boost/frequency interaction. The low-pass time-constant capacitor is C_{37} , and the resistance is a combination of VR_3 and $R_{45,46}$.

Capacitors $C_{38,39}$ with R_{47} make up the return-to-flat time-constant for the bass path, which blocks very low frequencies, limiting the lower extent of bass control action. The bass frequency law is made approximately logarithmic by IC_{8b} ; for minimum frequency VR_3 is set fully counter-clockwise, so the input of buffer IC_{8b} is the same as the C_{37} end of R_{46} , which is thus bootstrapped and has no effect.

Turnover

When VR_3 is fully clockwise, $R_{45,46}$ are effectively in parallel with VR_3 and the turnover frequency is at a maximum. Resistor R_{45} provides some extra law-bending, Fig. 6. Sadly, an extra op-amp is required. However, despite its three op-amps, the bass side-chain contributes very little extra noise to the tone stage. This is because most of its output is inherently rolled off by the low-pass action of C_{37} at high frequencies, almost eliminating its noise contribution.

Once the active elements have been chosen – here 5532s – and the architecture made sensible in terms of avoiding attenuation-then-amplification, keeping noise-gain to a mini-

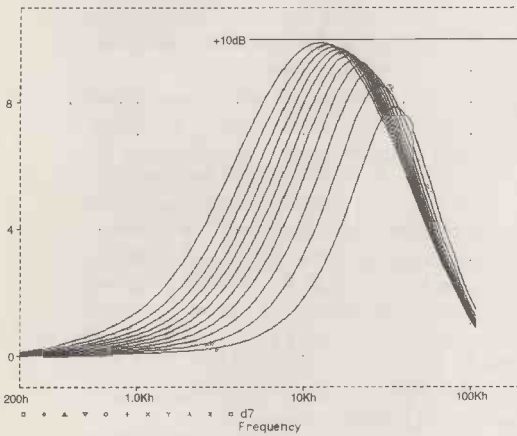


Fig. 5. Treble frequency control law for constant increments of rotation. The curves approximate to linear spacing on the log frequency axis. PSpice simulation.

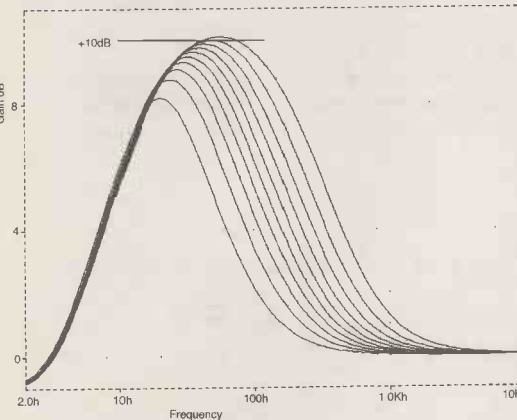


Fig. 6. Bass frequency control law with near-linear spacing on the log frequency axis.

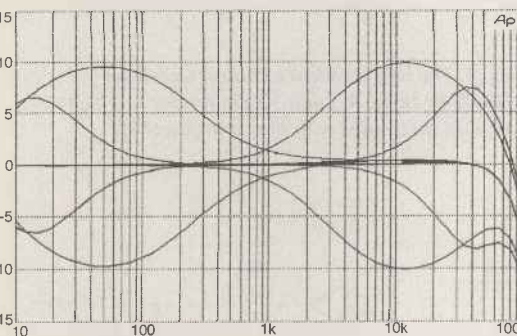


Fig. 7. Tone-control maximum boost/cut curves. (measured)

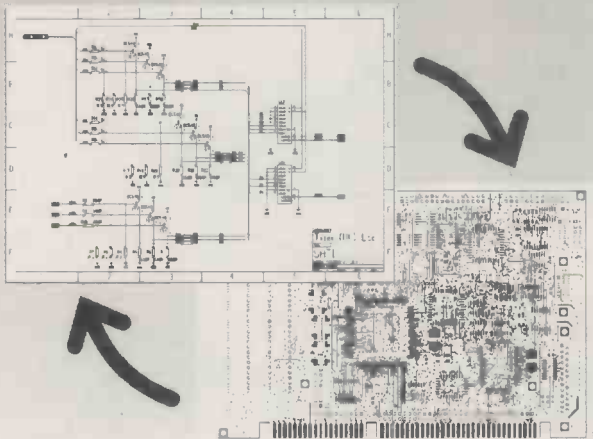
Finally an upgradeable PCB CAD system to suit any budget ...

Board Capture

BoardCapture - Schematic Capture

- Direct netlist link to BoardMaker2
- Forward annotation with part values
- Full undo/redo facility (50 operations)
- Single-sheet, multi-paged and hierarchical designs
- Smooth scrolling
- Intelligent wires (automatic junctions)
- Dynamic connectivity information
- Automatic on-line annotation
- Integrated on-the-fly library editor
- Context sensitive editing
- Extensive component-based power control
- Back annotation from BoardMaker2

£395



Board Maker

BoardMaker1 - Entry level

- PCB and schematic drafting
- Easy and intuitive to use
- Surface mount support
- 90, 45 and curved track corners
- Ground plane fill
- Copper highlight and clearance checking

£95

BoardMaker2 - Advanced level

- All the features of BoardMaker1 plus
- Full netlist support - OrCad, Schema, Tango, CadStar
- Full Design Rule Checking - mechanical & electrical
- Top down modification from the schematic
- Component renumber with back annotation
- Report generator - Database ASCII, BOM
- Thermal power plane support with full DRC

£395

Board Router

BoardRouter - Gridless autorouter

- Simultaneous multi-layer routing
- SMD and analogue support
- Full interrupt, resume, pan and zoom while routing

£200

Output drivers - Included as standard

- Printers - 9 & 24 pin Dot matrix, HPLaserjet and PostScript
- Penplotters - HP, Graphtec, Roland & Houston
- Photoplotters - All Gerber 3X00 and 4X00
- Excellon NC Drill / Annotated drill drawings (BM2)

Contact Tsien for further information on
Tel 01354 695959
Fax 01354 695957



tsien

Tsien (UK) Ltd Aylesby House Wenny Road Chatteris Cambridge PE16 6UT

All trademarks acknowledged

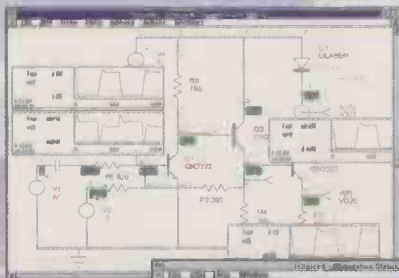
CIRCLE NO. 143 ON REPLY CARD

Interactive SPICE

Stop Waiting for your simulation results!
Experience the power and Immediate Satisfaction of IsSPICE4!

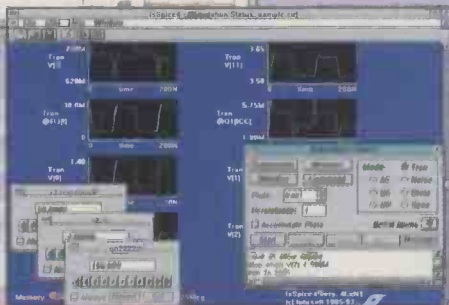


ICAP/4, The Virtual Circuit Design Lab, is a completely integrated system with schematic entry, the IsSPICE4 native analog and mixed mode simulator, extensive SPICE model libraries and powerful graphics post-processing.



Platform Support

- Windows
- Windows 95
- Windows NT (x86, Alpha & MIPS)
- Macintosh
- Power Macintosh
- DOS, NEC



- Analyse and Simulate all types of designs with IsSPICE4, the First and Only Interactive Native Mixed Mode SPICE 3 Simulator
- System, Board, and IC level
- Analog, Digital, Sampled-Data, Mixed Mode, Behavioural elements
- Power, ASIC, RF, Mechanical, Physical, Thermal applications
- AC, DC, Transient, Distortion, Temperature, Monte Carlo, Noise, Sensitivity, Optimisation, and Fourier analyses
- Works with all popular schematic entry systems!
- Graphically Driven and Easy To Use
- Support & Service - FREE, EXPERT, UK BASED AFTER SALE SUPPORT, Web & CompuServe Forums
- Affordable, Prices from £450 to £2,300

Technology Sources Ltd

Falmouth Avenue, NEWMARKET
CB8 0LZ, UNITED KINGDOM
Tel. 01638-561460
Fax 01638-561721
E-mail: aaj74@dial.pipex.com

Ask us for a
FREE Working SPICE Simulation Kit!

The Future Is Interactive!



Specialist in Parts - Broad in Outlook

The 1996 Cirkit Catalogue includes components from these and many other leading manufacturers:

AlliedSignal
ADVANCED MATERIALS

MICROMETALS
HIGH POWER CORES

BULGIN

muRata

COOPER
CooperTools

NEC
Capacitors

F

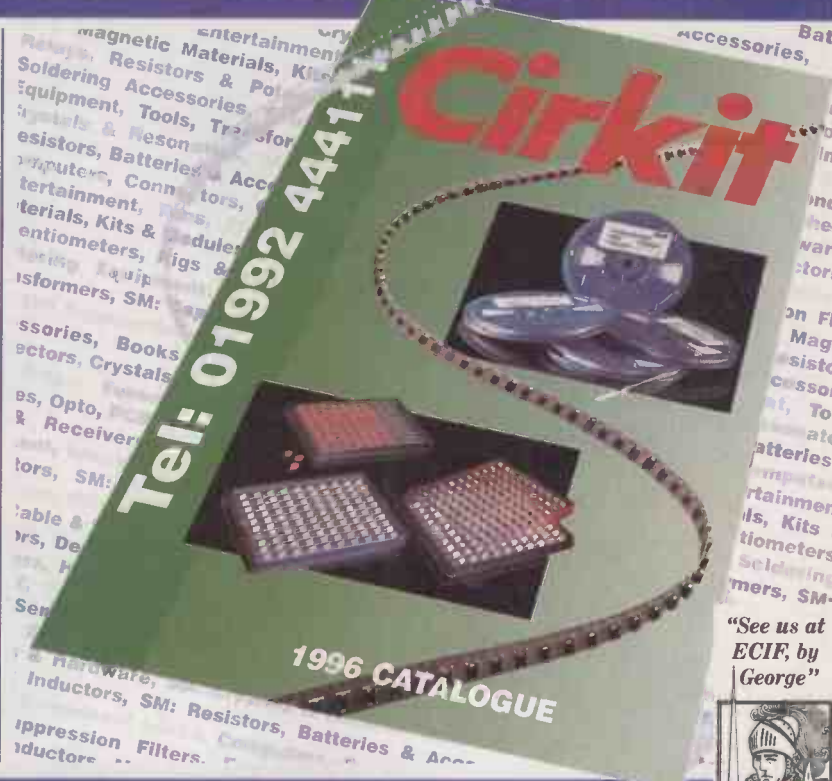
NEOHM

HARWIN

Richco

LORLIN

RETOKO



Tel: 01992 444111 Fax: 01992 464457
E-Mail: sales@cirkit.co.uk
Park Lane Broxbourne Herts EN10 7NQ



CIRCLE NO. 107 ON REPLY CARD

M & B RADIO (LEEDS)

THE NORTH'S LEADING USED TEST EQUIPMENT DEALER

OSCILLOSCOPES	SPECTRUM ANALYSERS	SIGNAL GENERATORS	TEST EQUIPMENT	TELEVISIONS
HP 5411D 500 MHz digital scope (colour display)..... £3000	TEKTRONIX 2710 10 KHz-1.8 GHz..... £4000	HP 8672A 2 GHz-18 GHz synthesized signal generator (new)..... £6000	TEKTRONIX 2901 time mark generators..... £300	HP 3446A 4.5 digit autoringing multimeter..... £200
HP 5411D 100 MHz channel digitizing scope (colour display)..... £2250	TEKTRONIX 2710 10 KHz-1.8 GHz OPT 001/003/014 new unused..... £4950	HP 8683D 2.3 GHz-13 GHz OPT 001/003 solid state generator (new)..... £2950	FLUKE 601A 10 Hz-11 MHz synthesized signal generator..... £90A	HP 3437A 3.5 digit high speed system voltmeter..... £200
TEKTRONIX 2230 100 MHz digital storage scope..... £2250	TEKTRONIX 7L12 10 KHz-1.8 GHz + mainframe..... £3000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	ROHDES & SCHWARTZ APN62 0.1 Hz-260 KHz LF gen (new)..... £2000	HP 3455A 6.5 digit digital voltmeter..... £495
TEKTRONIX 2245 150 MHz 4 channel CP-IB OPT..... £1400	HP 8569A 64 uHz-100 KHz dynamic signal analyser (1 year HP cal)..... £4000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	FARNELL SSG2000 10 KHz-2000 MHz synthesized gen (as new)..... £2000	HP 3468A 5.5 digit multimeter/auto cal (LCD)..... £400
TEKTRONIX 2246 100 MHz 4 channel..... £1400	HP 8903A 20 Hz-100 KHz audio analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	FARNELL DS2 0.001 Hz-110 KHz synthesized (new)..... £200	HP 5005A signature multimeter..... £300
TEKTRONIX 222 10 MHz portable digital storage scope (new)..... £950	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	WILTON 610D/501 1 MHz sweeper..... £750	HP 6032A systems power supply 0-60V/0-50 amp 1000W..... £1000
TEKTRONIX 7844/7A2/7A19/7B92B/7B80 (600MHz/2x 400MHz)..... £1250	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	GIGA GR101A 12 GHz-18 GHz pulse generator (as new)..... £650	HP 6255A dual DC power supply 0-40V/0-1.5 amp..... £185
TEKTRONIX 2215 60 MHz dual trace/delayed TB..... £450	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	POLARAD 1105EL 800 MHz-24 GHz signal generator..... £500	HP 6253A dual DC power supply 0-20V/0-3 amp..... £200
TEKTRONIX 475 200 MHz dual trace..... £495	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	POLARAD 1104ET/1020T 1.8 GHz-4.6 GHz with modulator..... £2000	HP 6825A power supply/amplifier-20v to +20V/0-2 amp..... £250
TEKTRONIX 4658 100 MHz 2 channel..... £435	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	MARCONI TF2019A 80 KHz-1040 MHz synthesized..... £2000	HP 6268B DC power supply 0-40V/0-30 amp OPT 005/010/040..... £500
TEKTRONIX 434 25 MHz 2 channel storage..... £400	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	MARCONI TF2018A 80 KHz-520 MHz synthesized..... £1000	BIRD 43 RF wattmeters..... £100
TEKTRONIX SC504/TM504/DM501 80 MHz scope/DVM..... £450	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	MARCONI TF2018 80 KHz-520 MHz..... £750	BIRD 8323 30db coaxial attenuator 100W..... £200
TEKTRONIX 212 500 KHz handheld battery portable scope..... £200	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	MARCONI TF2008 10 KHz-510 MHz signal generator..... £300	BIRD 8329 30db coaxial attenuator 2000W..... £500
BALLANTINE 1021B 25 MHz microscope..... £225	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	MARCONI TF2016 10 KHz-120 MHz (£250) TF2016A..... £295	FLUKE 3330B prog constant current/voltage calibrator..... £450
PHILIPS 3055 50 MHz dual trace..... £425	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	MARCONI 6055B 850 GHz-2150 GHz signal source..... £225	EXACT 334 precision current calibrator..... £195
PHILIPS 3057 50 MHz dual trace..... £495	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	PHILIPS PMS190 LF synthesizer 1uHz-2 MHz digital..... £375	FLUKE 103A frequency comparator..... £250
PHILIPS 3244 4 MHz 4 channel oscilloscope..... £400	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	ADRETE 2230A 200 Hz-1 MHz synthesized source..... £195	BRADLEY 192 oscilloscope calibrator..... £500
IWATSU 554122 100 MHz 4 channel with cursors..... £400	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	LINSTEAD G1000 10 Hz-10 MHz synthesized oscillator..... £200	ALTECH 533X-11 calibrator (1 HP355C/1HP355D ATT)..... £295
IWATSU 555710 60 MHz 4 channel..... £400	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000	THANDAR TG503 0.005 Hz-5 MHz pulse/function generator..... £225	KEMO DP1 1 Hz-100 KHz phase meter (new)..... £150
LEADER LB0524L 40 MHz dual trace delayed t/b..... £300	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000		WAYNE KERR CT496 LCR meter battery portable..... £75
GOULD OS300 20 MHz dual trace..... £200	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000		RADIO METER TRB11 RLC component comparator..... £150
UNAOMH G508 DT 20 MHz compact dual trace scopes + probes..... £160	HP 8754A 4 MHz-1300 MHz network analyser..... £2000	HP 8620C 1.8 GHz-4.2 GHz sweep..... £2000		AVO 215-L2 AC/DC breakdown/impedance tester..... £400

ALL PRICES PLUS VAT AND CARRIAGE - ALL EQUIPMENT SUPPLIED WITH 30 DAYS WARRANTY

86 Bishopgate Street, Leeds LS1 4BB

Tel: (0113) 2435649 Fax: (0113) 2426881

CIRCLE NO. 147 ON REPLY CARD

mum, and so on, there remains one further means of improving noise performance. This is to reduce the impedance of the circuitry.

The resistances are lowered in value, with capacitances scaled up to suit, by a factor that is limited only by op-amp drive capability. This is another good reason to use the 5534/2.

Two examples of this process as applied to the tone stage are given here. In each case the noise improvement is for the stage in isolation, set flat with high frequency set at minimum:

Firstly, in this sort of stage $R_{36,37}$ are conventionally $22k\Omega$. This was reduced to $4.7k\Omega$, and noise output dropped by 1.3dB. Secondly, the summation/loss network began with $R_{43,48}$ as $4.7k\Omega$, and R_{38} as $5.6k\Omega$. Reducing this by a factor of ten to 470Ω and 560Ω respectively reduced output noise by 0.6dB.

With balance control central and tone cancel pressed, noise output of the tone stage, plus the line/balance buffer before it is $-107.2dBu$. This is 22kHz bandwidth. With tone controls active but set flat, noise output at minimum high frequency is $-104.7dBu$, and at maximum is $-106.7dBu$.

The final tone stage may look rather a mess of pottage, and be afflicted with more buffers than Clapham Junction. This is unavoidable if control interaction is to be wholly eliminated. Sadly, the practical tone circuit is somewhat more complex than Figs 2, 3 and 4, reflecting one of the disadvantages of low-noise op-amps. This is that bipolar input stages mean that the bias currents are non-negligible. They must not be allowed to flow through potentiometers if crackling noises are to be avoided when they are moved.

These bias currents also tend to be reflected in significant output offset voltages, as the source resistances for the two op-amp inputs are not normally the same. All gain-variable circuit stages therefore have their gain reduced to unity at dc. This subject is detailed later.

Figure 7 shows the measured extremes of cut and boost at the frequency extremes. Figure 8 gives the phase-shift at hf while Fig. 9 shows phase-shift at low frequencies. In both cases it is very modest.

Active gain stage

The active gain stage, or AGS, used here as in¹, is due to Baxandall³. Maximum gain is set to +23dB by the ratio of $R_{52,53}$, to amplify a 150mV line input to 2V with a small safety margin.

An active volume-control stage gives the usual advantages of lower noise at gain settings below maximum, and for the Baxandall configuration, excellent channel balance that depends solely on the mechanical alignment of the dual linear potentiometer. All mismatches of its electrical characteristics are cancelled out, and there are no quasi-log dual slopes to induce anxiety.

Note that all the potentiometers are 10k Ω linear types and identical, apart from the question of centre-detents, which are desirable only on the balance, treble and bass boost/cut controls.

Compared with¹, noise has been reduced by an impedance reduction on the gain-definition

network $R_{52,53}$. The limit on this is the ability of buffer IC_{5a} to drive R_{52} , which has a virtual earth at its other end. Figure 10 shows the volume control law for different maximum gain settings; only the very top end of the curve alters significantly.

For the rear section of the preamp – ie that shown in Fig. 11a – the noise performance depends on control settings. The table below gives results for hf frequency at minimum, the worst case, Table 2.

The figures for maximum gain may look unimpressive, but remember this is with +23dB of gain; at normal volume settings the noise output is below $-100dBu$. I think this is reasonably quiet.

Output muting and relay control

The preamp includes relay muting on the main outputs. This is to prevent thuds and bangs from upstream parts of the audio system from reaching the power amplifiers and speakers at power-up and power down. Most op-amp circuitry, being dual-rail (ie outputs at 0V) does not inherently generate enormous thumps, but it cannot be guaranteed to be completely silent. It may produce a very audible turn-on thud, and often objectionable turn-off noise. I recall one design that emitted an unnerving screech of fading protest as the rails subsided...

Electronic muting is desirable, but introduces unacceptable compromises in performance. Relay muting, given careful relay selection and control, is virtually foolproof. The relay must be normally-open so the output is passively muted when no power is applied. The control system must:

- Delay relay pull-in at power-up, to mute turn-on transients. A delay of at least 1 second before the relay closes.
- Drop out the relays as fast as possible at power-down, to stop the dying moans of the preamp, etc, from being audible.

My preferred technique is a 2ms or thereabouts power-gone timer, held in reset by the ac on the mains transformer secondary, except for a brief period around the ac zero-crossing, too short to allow the timer to trigger. When the ac disappears, this near-continuous reset is removed, the timer fires, and relay power is removed within 2ms. This is over long before the reservoir capacitors in the system can discharge, so turn-off transients are authoritatively suppressed.

However, if the mains switch contacts generate an rf burst that is in turn reproduced as a click by the preamplifier, then even this method may not be fast enough to completely mute it.

Fig. 11b shows the practical relay-control circuit. At turn-on, R_{211} slowly charges C_{224} until Tr_{205} and D_{207} are forward biased, ie when C_{224} voltage exceeds that set up by $R_{214,215}$. This is the turn-on delay. Transistor Tr_{206} is then turned on via R_{213} , energising the relays, and LD_{201} is brightly lit through D_{208} and R_{216} . This led is dimly lit via R_{217} as soon as power is applied, but only brightens when

Table 2. Characteristics of the tone-control stage.

	Tone cancel	Tone flat
AGS zero gain	-114.5dBu	-114.5dBu
AGS unity gain	-107.4dBu	-105.3dBu
AGS fully up	-90.2dBu	-86.4dBu

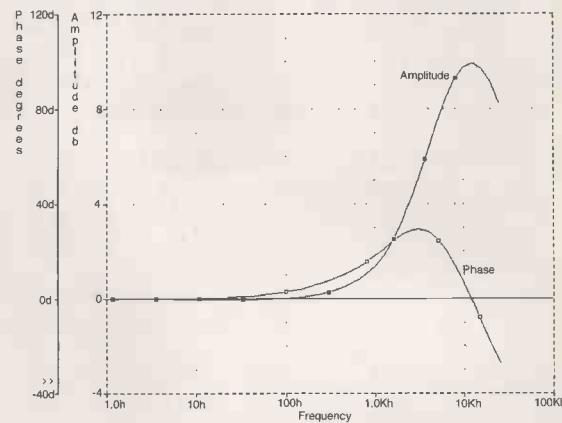


Fig. 8. Tone control phase curve for maximum treble boost. Maximum phase-shift is 29° at about 4kHz. PSpice simulation.

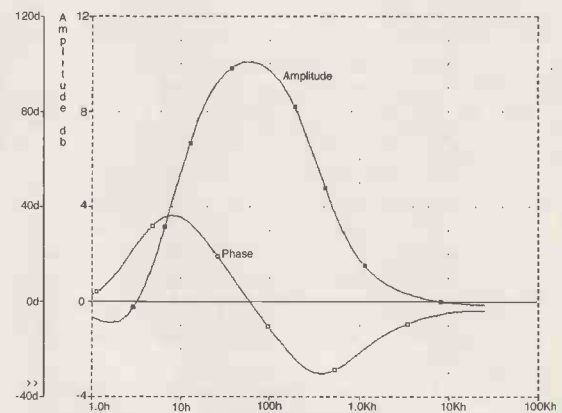


Fig. 9. Tone control phase curve for maximum bass boost. Maximum phase-shift is 31° at 40Hz.

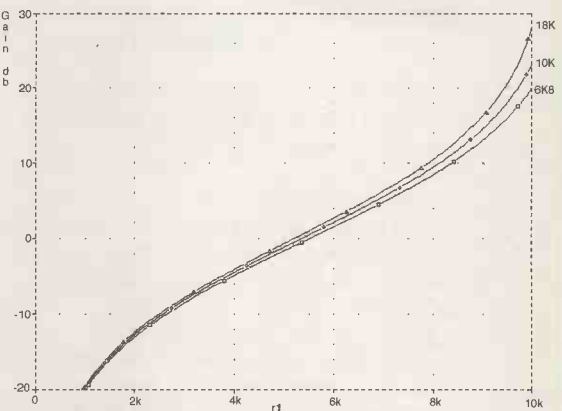


Fig. 10. Plot of the Active Gain Stage volume control law. Varying the maximum gain has little effect except at the top end; the middle curve is the one used in the preamp.

the initial mute period is over.

As long as mains power is applied, Tr_{203} is kept turned on through $D_{205,206}$ by the ac ahead of the bridge rectifier, except during the zero-crossing period every 10ms, when the voltage is too low for Tr_{203} base to conduct. When Tr_{203} switches off, C_{223} starts to charge through R_{208} , but is quickly discharged through R_{207} when the very brief zero-crossing period ends. If it does not end – in other words mains power has been switched off – C_{223} keeps charging until Tr_{204} turns on, discharging C_{224} rapidly via R_{210} , and removing power from the relays almost instantly.

DC blocking and additional details

The preamp circuitry has been described as each stage was dealt with, so this section is confined to dc blocking problems and other odd subjects.

The complete circuit of the line section of the preamp is Fig. 11a. Bias current is kept out of balance potentiometer VR_1 by C_{27} , and dc gain held to unity by C_{28} . Capacitors C_{31} and C_{35} keep bias currents out of $VR_{2,4}$, necessitating bias resistors R_{40}, R_{44} .

The treble frequency law is corrected by bootstrapping through C_{33} , which keeps the bias current of IC_{7a} out of VR_5 . Similarly, C_{34} prevents any offset on IC_{7a} output reaching VR_5 . In the bass path C_{36} keeps IC_{8b} bias out of VR_3 , while return-to-flat components $C_{38,39}$ and R_{47} provide inherent dc-blocking.

Final offsets at the side-chain output are blocked by C_{40} , while IC_{7b} bias is blocked by C_{30} . This is essential to prevent the tone-cancel switch clicking due to dc potentials. Bear in mind that this switch may still appear to click if it switches in or out a large amount of response-modification of a non-zero signal. This is because the abrupt gain-change generates a step in the waveform that is heard as a click. This is unavoidable with hard audio switching.

Capacitor C_{41} keeps IC_{7b} output offset from volume control VR_6 , while C_{42} blocks IC_{5a} bias current from the pot wiper. Capacitor C_{44} gives final dc blocking to protect the following power amplifier.

Many components in this design are the same value; for example, wherever a sizable non-electrolytic is required, 470nF could usually be made to work. This philosophy has to be abandoned in areas where critical parameters are set, such as the RIAA network and tone control stage.

Supplying power

This is a conventional power supply using IC regulators. I strongly recommend that you use a toroidal mains transformer to minimise the ac magnetic field.

Supply rails have been increased from $\pm 15V$ to $\pm 18V$ to maximise headroom. Nonetheless, 15V regulators are specified as they are easy to obtain. Their output increased to 18V by means of $R_{201,203}$, Tr_{201} and $R_{202,204}$, Tr_{202} .

It is common to use a potential divider to 'stand-off' the regulator by a fixed proportion of the output voltage. In the improved version

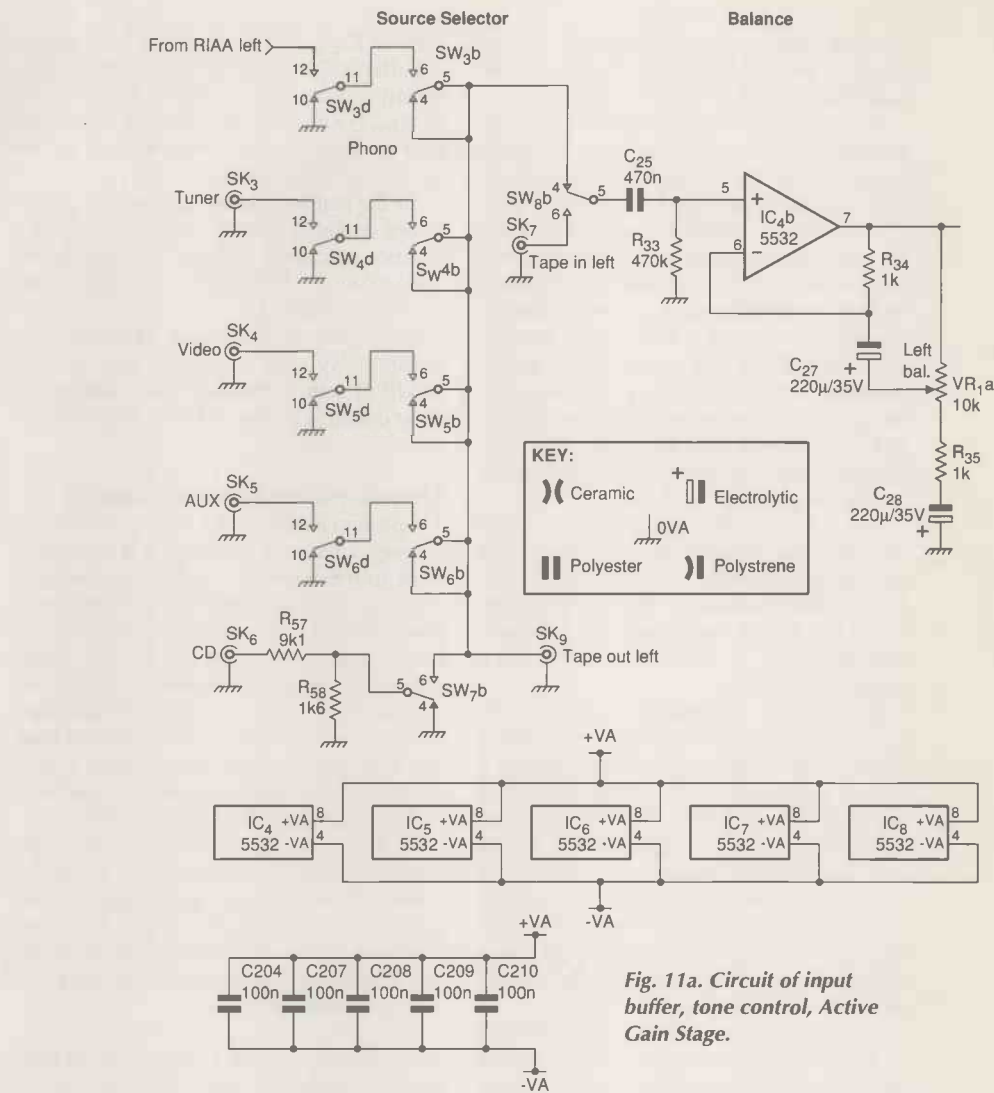


Fig. 11a. Circuit of input buffer, tone control, Active Gain Stage.

here, positive divider $R_{201,203}$ is buffered by emitter-follower Q_{201} . Thus $R_{201,203}$ can be higher in value – saving power – while Tr_{201} absorbs the ill-defined quiescent current from the regulator COM pin.

Choosing the right op-amps

Exotic and expensive op-amps will probably give a disappointing noise performance. The bipolar input of the 5534/32 is well matched to the medium-low impedances used in this preamplifier. For example, an *OP-27* might be expected to be quieter in the moving-magnet cartridge stage; but when measured, or calculated, it is 2dB noisier.

The performance

Figure 12 shows the thd of the flat moving-coil cartridge stage alone, at maximum gain. The rise at extreme lf is due to the integrator time-constant. Figures 13 & 14 give the thd of the moving-magnet cartridge disc input and the entire rear section respectively. Levels involved are ten times those found in real use. Distortion is not a problem here.

Crosstalk performance attained depends very much on physical layout. Capacitive crosstalk can be minimised by spacing components well apart, or by simple screening.

Resistive crosstalk depends on the thickness of the various ground paths.

It would be desirable to specify a grounding topology for optimal results, but this is not so easy. I found that the more tightly the various grounds are tied together with heavy conductors, the better the crosstalk performance. There seemed little scope for subtlety.

As with noise performance, the results depend somewhat on control settings, but under most conditions the prototype gave about -100dB flat across 20Hz-20kHz, with noise contributing to the reading. This was not hard to achieve.

The preamplifier in perspective

In determining what (if anything) has been achieved by this design, we must see if it is capable of any further improvement.

- The moving-magnet stage input noise performance is limited by the electrical characteristics of the cartridge and its loading needs.
- Making the RIAA any more accurate will be expensive.
- Increasing disc input headroom would require the use of higher supply rails, demanding discrete amplifier stages.

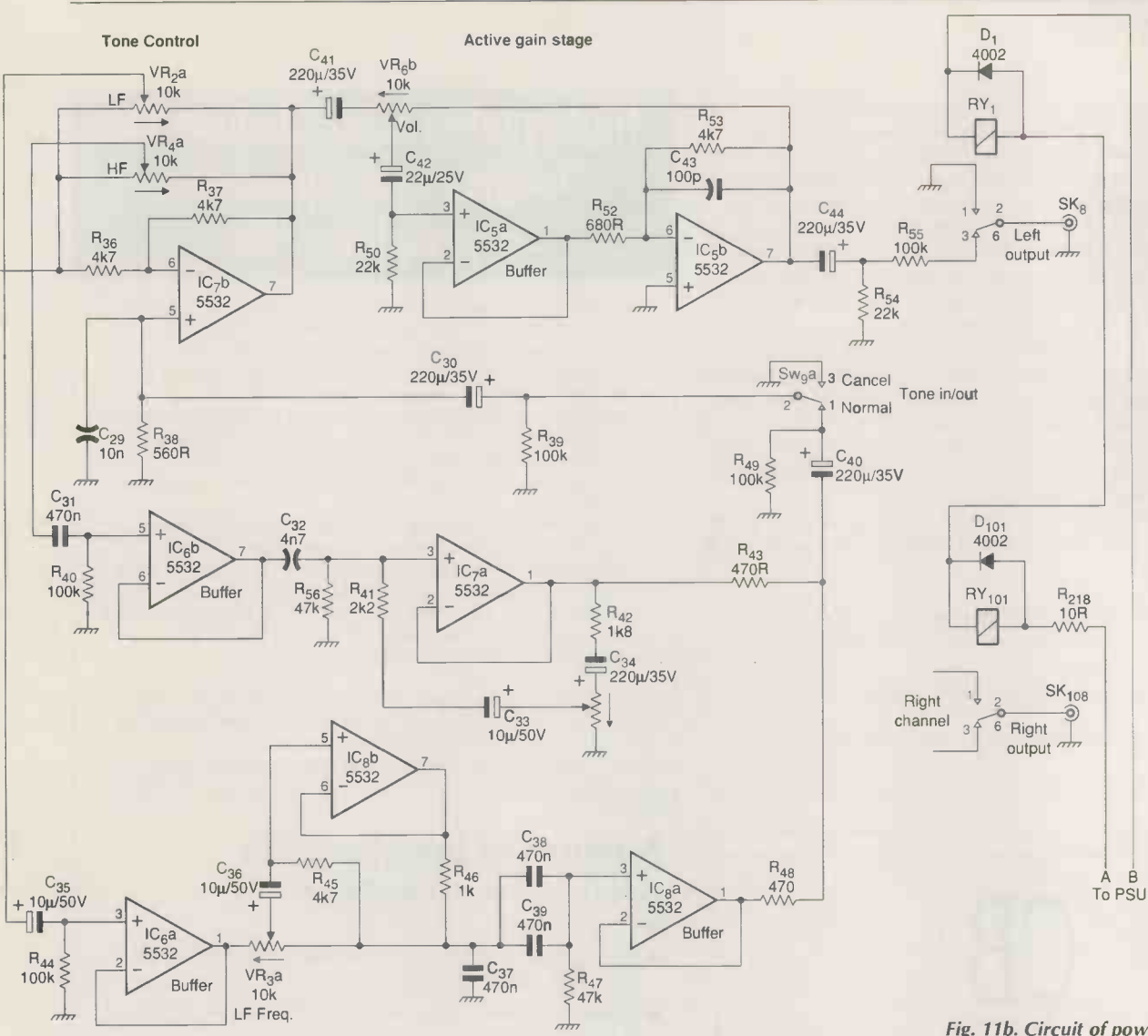


Fig. 11b. Circuit of power-supply and relay controller.

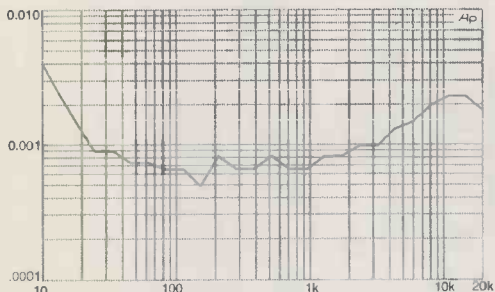
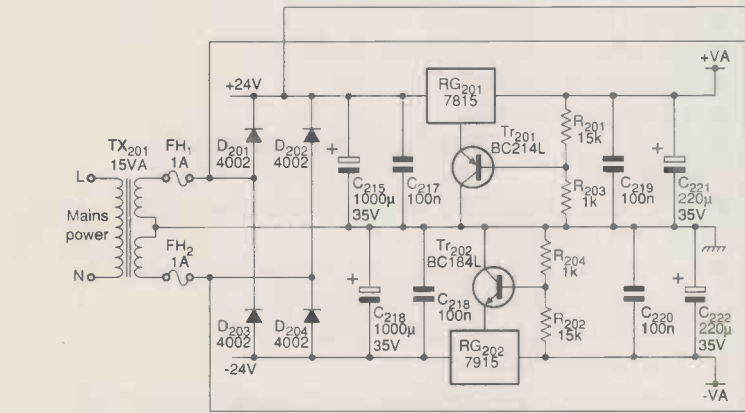


Fig. 12. THD of the moving coil stage alone, at 2.2V_{rms} output. Measurement bandwidth 30kHz.

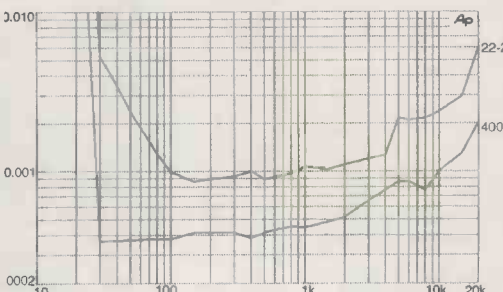
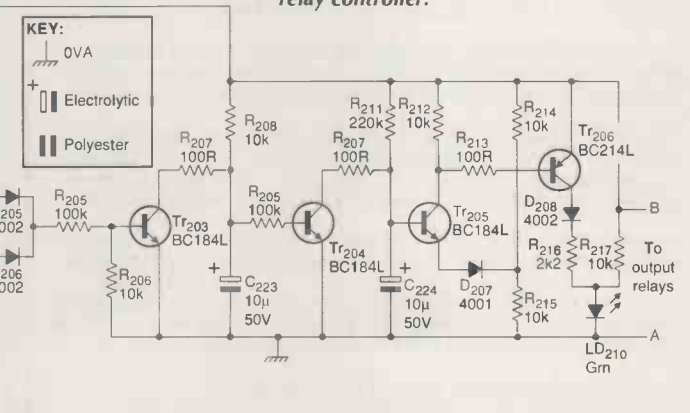


Fig. 13. THD of disc input stage in moving-magnet mode, at 8V_{rms} output. Bandwidth 22-22kHz upper trace and 400-22kHz lower trace, which gives a more valid result as magnetic hum is excluded. Distortion is very low, but rises at hf due to increasing loading.

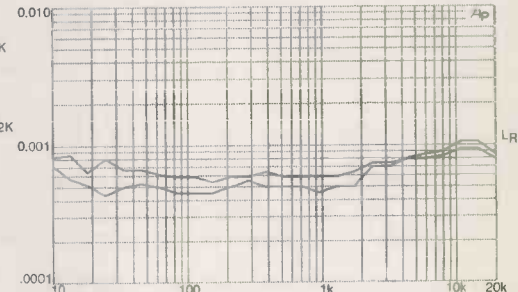
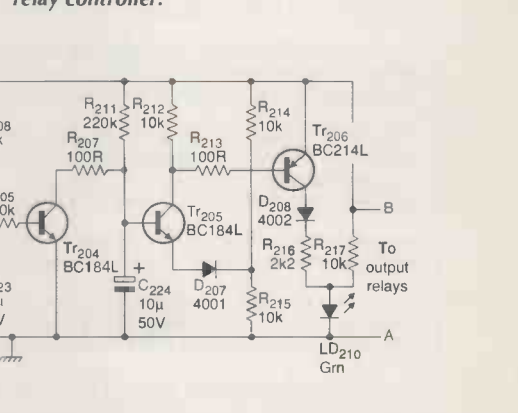


Fig. 14. THD of rest of preamplifier at 8V_{rms} in and out, ie volume control set for unity gain. Tone control set flat, bandwidth 80kHz. Distortion is below 0.001%.

Having gone to some effort to make the preamplifier as noise-free and transparent as possible, we should ask how it compares with other parts of the system. The standard Blameless Class B power amplifier⁴ output noise is -93.5dBu, and the Trimodal⁵ with the low-impedance feedback network reduces this to -95.4dBu. In both cases the source impedance is 50Ω.

Both amplifiers have a closed-loop gain of +27.2dB, and so the equivalent input noise (EIN) is -120.7dBu and -122.6dBu respectively. This can be compared with the source-resistance Johnson noise of 50Ω, which is -135.2dBu. The best power-amp noise figure is therefore 12.6dB, which is some way short of perfection.

In contrast, the noise output from the preamplifier is never less than -114.5dBu with the volume control at zero. Even in this rather useless condition, the preamplifier increases the total noise output, as it produces 8dB more than the Trimodal power amplifier input noise. At mid-volume (in-line mode) the preamplifier noise is -105.3dBu, which is 17dB worse than the power-amp; clearly as far as preamp design is concerned, history has not yet ended.

Even so, serious thought has been given to whether this may be the quietest preamp yet built. Comments and opinions on this are invited. ■

References

1. D. Self, 'A Precision Preamplifier', *Wireless World*, Oct 1983, p31.
2. D. Self, 'Ultra-Low-Noise Amplifiers and Granularity Distortion', *Journ AES*, Nov 1987 pp907-915.
3. P. Baxandall, 'Audio Gain Controls', *Wireless World*, Nov 1980, pp 79-81.
4. D. Self, 'Distortion in Power Amplifiers: Part 2', *Electronics World*, Sept 1993, p736.
5. D. Self, 'Trimodal Audio Power', *Electronics World*, June 1995, p462.



C. Bateman Engineering

EMC/RFI Filter Simulator uses 'Real-Time' Components.

Dedicated EMC Filter Simulation Software for 'Windows'® offers simplest possible 'Net-List' generation and correction for Capacitor-Inductor 'Frequency Dependant' parameters.

All Filter Schematics are Pre-drawn, including Capacitor or Inductor parasitic elements, together with 'Startup' 'Default' values. Simply 'overtyp' the 'Defaults' with required values and click on 'Simulate' Button for instant, realistic, results.

Automatically displays on screen: - 'Return - Loss', 'Group - Delay', and 'Insertion - Loss', - no user configuration needed.

This new and unique Simulator uses 'Real-Time' modelling of components by calculating the 'Frequency Dependant' change of value and loss factor for Capacitors and Inductors.

Unique features of the 'EMC Filter' software:-

- Automatic 'Net-List' Generation - No Learning curve.
- Filter Schematics pre-drawn - with Parasitics and 'Defaults'
- Overtyp 'Defaults' with values desired for simulation.
- Choice of 'Capacitor' and 'Inductor' materials defines losses.
- Select 'Worst Case' or desired 'Source-Load' impedance.
- Automatic 'Return - Loss' plot - Filter/source interaction.
- Automatic 'Group - Delay' plot - Filter/signal interaction.
- Automatic 'Insertion-Loss' plot - Filter/EMC attenuation.

Price:- £100 inc. for the full package with manuals (Software and Filter), as used for *Electronics World* May '96 pp 384-388. An 'Evaluation' disk is available for £7 inc. - refund on purchase. Or visit - <http://ourworld.compuserve.com/homepages/cyri1b>

C. Bateman. Design Consultant. Tel. 01493-750114.
 'Nimrod', New Road, ACLE, Norfolk. NR13 3BD.
 cyri1b@ibm.net 76251,2535@Compuserve

CIRCLE NO. 148 ON REPLY CARD

High-quality circuit boards for Douglas Self's precision preamplifier '96

A high quality double-sided circuit board is available for Doug Self's precision preamplifier, exclusively via *Electronics World*. The board takes the full stereo preamplifier, including all power supply components except the transformer. Its layout is optimised to provide exceptionally low crosstalk.

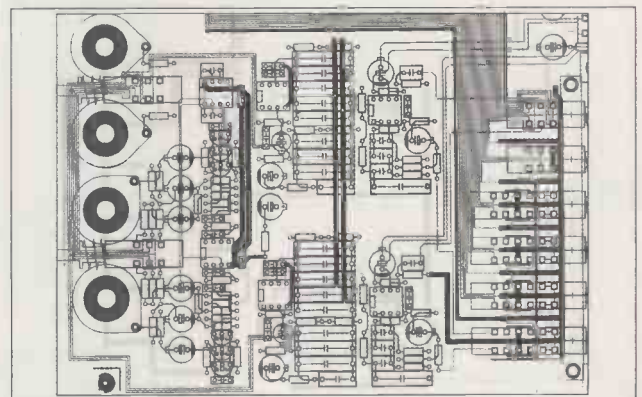
Co-designed by Gareth Connor, the board is glass-fibre with plated-through holes and roller-tinned. It features solder masking and full component identification. Component lists and assembly notes - containing extra information about the preamplifier - are supplied with each order.

Each board is £59 inclusive of package, VAT and recorded postage. Please include a cheque or postal order with your request, payable to Reed Business Publishing. Alternatively, send your credit card details - i.e. card type, number and expiry date. Include the delivery address in the order, which in the case of credit card holders must be the address of the card holder. Add a daytime telephone and/or fax number if you have one.

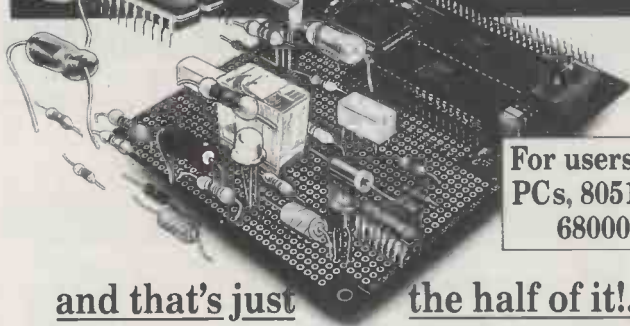
Send your order to Electronics World Editorial, PCBs, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Alternatively fax us on 0181 652 8956 or e-mail a jackie.lowe@rbp.co.uk. Credit card details can be left on the answering machine on 0181 652 3614. Please allow 28 days for delivery.

Features of Douglas Self's precision preamplifier

- Very low noise and distortion.
- Moving-coil - sensitivity switchable 0.1 or 0.5mV, ±0.05dB RIAA accuracy.
- Moving-magnet input with ±0.05dB RIAA accuracy, 5V rms sensitivity.
- Three 150mV line inputs.
- One dedicated compact-disc input.
- Tape-monitor switch.
- Active-balance control.
- Tone control - switch defeatable - with ±10dB range.
- Tone control treble and bass frequencies variable over 10:1 range.
- Active volume control for optimal noise/headroom and enhanced interchannel matching.
- Intelligent relay muting on outputs.
- CD input sensitivity 1V rms.



The MICRO MODULE A NEW LOW COST controller that gives you customisation for as little as **£95** one off + VAT



For users of
PCs, 8051 &
68000

and that's just **the half of it!..**

FEATURES

- 16/32 bit 68307 CPU for fast operation
- Up to 1 Mbyte of EPROM space onboard
- Up to 512Kbyte SRAM space onboard
- 32 Kbyte SRAM fitted as standard
- RS232 serial with RS485 option
- MODBUS & other protocols supported
- Up to 22 digital I/O channels
- 2 timer/counter/match registers
- I²C port or Mbus & Watch dog facilities
- Large Proto-typing area for user circuits
- Up to 5 chip selects available
- Program in C, C++, Modula-2 & Assembler
- Real Time multitasking Operating System
- OS9 or MINOS with free run time license option
- Manufacturing available even in low volumes
- A full range of other Controllers available

P.C. 'C' STARTER PACK AT ONLY £295 + VAT

The Micro Module will reduce development time for quick turnaround products/projects and with the P.C. 'C' Starter pack allow you to start coding your application immediately, all drivers and libraries are supplied as standard along with MINOS the real time operating system all ready to run from power on. The 'C' Starter pack includes: A Micro Module with 128 Kbyte SRAM, PSU, Cables, Manuals, C compiler, Debug monitor ROM, Terminal program, Downloader, a single copy of MINOS. Extensive example software, and free unlimited technical support all for £295 + VAT.



Cambridge Microprocessor
Systems Limited

Unit 17-18, Zone 'D', Chelmsford Road Ind. Est.,
Great Dunmow, Essex, U.K. CM6 1XG
Phone 01371 875644 Fax 01371 876077

TRANSFORMERS FOR BALANCED LINES IN HIGH PERFORMANCE AUDIO SYSTEMS

SOWTER EST. 1941
TRANSFORMERS

E A Sowter Ltd
PO Box 36 IPSWICH IP1 2EL ENGLAND
Tel: +44(1)1473 252794
Fax: +44(1)1473 236188
E-Mail: sowter@tcp.co.uk

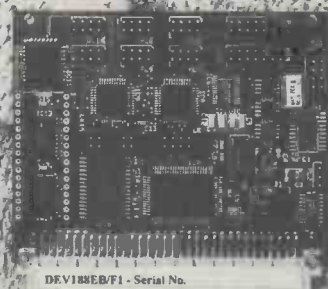
Design and Manufacture
of all types of Audio Transformer using
Nickel and Grain Oriented cores

Free catalogue
Free technical support service
Popular types from stock

CIRCLE NO. 149 ON REPLY CARD

80C188EB Embedded CPU Card

From
£99



- 80C188EB Processor Clocked at 24Mhz
- 128k Battery Backed RAM (512k option)
- 128k Eprom (32k - 512k options)
- 128k 5 volt Flash Eprom (512k option)
- Real Time Clock (On board Battery)
 - Watchdog Timer/Reset with Brownout detection
 - 2 Serial Ports - 1 RS232, 1 RS232/422/485
 - 8 Channel 12 bit ADC (optional)
 - Direct Connection to Alphanumeric LCD Display
 - 48 Digital I/O lines
 - Set-up and Driver routines with Full C Source Code

FAST START - Use our Full ANSI compatible Embedded C Compiler for super fast application development. Supplied complete with Editor, Compiler, Assembler, Linker, Embedded Debug and comprehensive Manual, you can compile and download and be in the Debugger with a single keypress - or back in the editor at just the right place. Generate ROMable Code direct, no struggling with .EXE conversions or messing around with reset code. Just £595.

For further information

Call now - **01379 644285** - Fax **650482**

Please ask for our catalogue

Devantech Ltd - 2B/2C Gilray Road - Diss - Norfolk - IP22 3EU

CIRCLE NO. 150 ON REPLY CARD

PCB Designer

For Windows 3.1, '95 or NT



Amex/Access/Delta/Visa

Looking for the price?
It's just **£49.00** all inclusive!
...no VAT...no postage...
...no additional charges for
overseas orders.

Dealers and distributors wanted.
Phone (01432) 355 414 to order

Internet

See our Web site at www.niche.co.uk for
information and a working demo. e-mail
pcb@niche.demon.co.uk.

- ✓ Produce Single or Double sided PCBs.
- ✓ Print out to any Windows supported printer.
- ✓ Toolbar for rapid access to commonly used components.
- ✓ Helpful prompts on screen as you work.
- ✓ Pad, track & IC sizes fully customisable.
- ✓ No charges for technical support.
- ✓ Snap-to grid sizes 0.1", 0.05" 0.025" and unrestricted.
- ✓ SMT pads and other pad shapes.

Also available from,

South Africa: JANCA Enterprises, PO Box 32131, 9317 Fichardt Park at R299.00. Phone/FAX: (051) 223744

France: Telindel, Quartier Les Pradets, Chemin des Veys, 83390 Cuers. Phone: 94 28 66 67

CIRCLE NO. 151 ON REPLY CARD

Niche Software (UK)

12 Short Hedges Close, Northleach, Cheltenham GL54 3PD

CLASSIFIED

TEL 0181 652 3620

FAX 0181 652 8956

ARTICLES WANTED

WE WANT TO BUY!!

*IN VIEW OF THE EXTREMELY
RAPID CHANGE TAKING PLACE
IN THE ELECTRONICS
INDUSTRY, LARGE QUANTITIES
OF COMPONENTS BECOME
REDUNDANT. WE ARE CASH
PURCHASERS OF SUCH
MATERIALS AND WOULD
APPRECIATE A TELEPHONE
CALL OR A LIST IF AVAILABLE.
WE PAY TOP PRICES AND
COLLECT.*

R. HENSON LTD.

*21 Lodge Lane, N.Finchley,
London N12 8JG.*

5 Mins, from Tally Ho Corner.

TELEPHONE

0181-445-2713/0749

FAX 0181-445-5702

★★WANTED★★

Test equipment, Electronic Scrap,
Valves, Transmitters/Receivers,
Factory & Warehouse Clearance.
Confidentiality Assured.

TELFORD ELECTRONICS

Phone: 01952 605451

Fax: 01952 677978

WANTED

Test equipment, receivers, valves,
transmitters, components, cable
and electronic scrap and quantity.

Prompt service and cash.

M & B RADIO
86 Bishopgate Street
Leeds LS1 4BB

Tel: 0113 2435649

Fax: 0113 2426881

ELECTRONICS VALVES & SEMICONDUCTORS

Phone for a most
courteous quotation

We are one of the largest
stockists of valves etc,
in the U.K.

COLOMOR ELECTRONICS LTD

170 Goldhawk Road,
London W12 8HJ
England.

Tel: 0181 743 0899

Fax: 0181 749 3934

WANTED

TOP PRICES PAID

For all your Test Equipment,
Receivers, Transmitters etc.
Factory Clearance, Prompt
Service and Payment.

HTB ELEKTRONIK

Alter Apeler Weg 5
27619 Schiffdorf, Germany

Tel: 0049 4706 7044

Fax: 0049 4706 7049

VALVES, and CRTs AVAILABLE

ONE MILLION VALVES stocked for Audio, Receiving, Transmitting & RF Heating. Rare brands such as Mullard & GEC available. Also MAGNETRONS, KLYSTRONS, CRTs and SOCKETS.

Large stocks of Russian & Sovtek items.

Please ask for our free catalogues of valves or CRTs.

VALVES, etc. WANTED

Most types considered but especially KT88 (£48), PX4/PX25 (£50), KT66 (£35), KT77 (£15), EL34 (£10), EL37 (£9), 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

! TEST EQUIPMENT WANTED !

SMALL OR LARGE QTY, WORKING OR NON WORKING

WE PAY THE BEST PRICES FOR YOUR EXCESS INVENTORY!

FAX YOUR INVENTORY LIST TODAY FOR AN INSTANT QUOTE

PROMPT PAYMENT AND FAST SERVICE ARE OUR CORPORATE POLICY

LOTHAR BAIER ELECTRONIC TEST EQUIPMENT, MICROWAVE TECHNOLOGY

BLUMENSTRASSE 8 D-95213 MUENCHBERG/GERMANY

PHONE: +49 925192163 FAX: +49 9251 7846

ARTICLES FOR SALE

MEMORY SIMMS

256K £2.50 each Min Qty 4 - £10 512K £5.00 each Min Qty 2 - £10

1MB £14.00 each

DRAM

HY52C256S-10 TMS4256-10R, MB81256-10 MCM256-10, M41254-10

£1.00 each Min Qty 10

FLOPPIES

360K 5.25" £10

1.2K 5.25" £20

720K 3.5" £12

EPROMS

1MB - £2.00 512K - £1.25

256K - £1.00 128K - £0.75

64K - £0.50

1000's of Components in stock, also Flybacks, CRT's, PC Power Supplies

400-500MB Hard Drives - £75.00

17" Colour Monitors - from £175

12" Mono Monitors - £10.00

ALL ITEMS PRE-USED AND TESTED

MINIMUM ORDER CHARGE £10.00

WOODVILLE LTD

Tel: 01923 213350 Fax: 01923 211650

All items exclude VAT @ 17.5% CREDIT CARDS WELCOME

EW + WW PC TELETXT, Aug 1994

PCB, EPROM & DISC with
Terminal Software and Partslist,
£12 to clear! LM1414 £2.50
SN74121 50p P&P Inc.

Citifax Ltd
9 Goose Cote Hill
Bolton BL7 9UQ

Tel/Fax +44 1204 417 210

MARCONI 2022A signal generator for
sale £2,000. Phone: 0956 57 56 72. Fax:
0181 316 5627.

Consider

Your costs to continue to stock
UNWANTED SURPLUS . . . EXCESS . . . OBSOLETE
STOCKS OF:-
ELECTRONIC-ELECTRICAL COMPONENTS &
ACCESSORIES

RELEASE

for

**PAYMENT IN ADVANCE
OF COLLECTION**

contact

K.B. Components,

21 Playle Chase, Gt. Totham, Maldon, Essex, CM9 8UT

Tel:- 01621 893204 Fax:- 01621 893180 Mobile:- 0802 392745

REGISTER TO RECEIVE MONTHLY PUBLISHED STOCK LISTS AT NO CHARGE OF
ALL EXISTING NEW, UNUSED, STOCKS OF ALL COMPONENTS AND ACCESSORIES.

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 0EB, U.K.
Tel: (+44)01243 545111/2 Fax: (+44)01243 542457

CIRCLE NO. 152 ON REPLY CARD



OPERATING & SERVICE MANUALS



CONTACT

Cooke International

ELECTRONIC TEST & MEASURING INSTRUMENTS
Unit Four, Fordingbridge Site, Main Road, Barnham,
Bognor Regis, West Sussex, PO22 0EB, U.K.
Tel: (+44)01243 545111/2 Fax: (+44)01243 542457

CIRCLE NO. 153 ON REPLY CARD

INDEX TO ADVERTISERS

	PAGE		PAGE		PAGE
Adept	671	Equinox	649	Olson	IBC
Anchor	637	Field	622	Quickroute	634
Bamber	684	Halcyon	661	Robinson Marshall	656
Bateman	716	Hart	668	Seetrax	667
Bull	702 + 707	Hitex	682	Sowter	717
Chelmer	688	ICE	657	Stag	688
Cirkit	634	Jenving	690	Stewart	712
CML	640	John's	686	Surrey	661
CMS	717	JPG	712	Technology Sources	711
Conford	662	Kanda	639	Telford	661
Crownhill	680	Kenwood	688	Telnet	667
Danmere	689	Labcenter	674	Those	690
Dataman	OBC	M & B	712	Tie Pie	639
Devantech	717	Milford	IFC	Tsien	711
Display	699	Niche	717	Ultimate	658
Electromail	695	Number One	662	Wood & Douglas	682

SPECTRUM ANALYSERS



- HP3580A 5Hz-50kHz audio frequency spectrum analyser £750 to £1250
- HP8568B high-specification 1.5GHz spectrum analyser £10000
- MARCONI 2386 100Hz-26.5GHz (in 1Hz steps) £15000
- AVCOM - portable, battery operated, to 1000 MHz £2000
- TEKTRONIX 492 21GHz portable spectrum analyser, with options 2 (digital storage and Rack-mount option) £6000 or £7000 with mixers to 60GHz
- TEK7623A/7L18 (1.8GHz) with tracking generator in TMS03 £1750

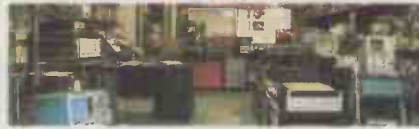
MARCONI INSTRUMENTS



- 2018A synthesized AM/FM signal generator 80kHz-520MHz £1250
- 2019A synthesized AM/FM signal gen 80kHz-1040MHz £2000
- 2828A/2829 digital simulator/analyser £500
- 2955B radio communication test sets - LATEST 'B' MODEL £4000
- 6460/6421 power meter & sensor 10MHz-12.4GHz £350
- 6514 waveguide detector for use with 6500-scalar analyser 26-40GHz £350
- 6960 microwave power meter with 6910 power sensor 10MHz-20GHz £900
- TF2910 TV interval timer £250

ralfe electronics exclusively professional T&M ©
 • 36 Eastcote Lane • South Harrow • Middx HA2 8DB • England •
 TEL (+44) 0181-422 3593 • FAX (+44) 0181-423 4009

EST
41
YRS



DISTRIBUZIONE E ASSISTENZA, ITALY: TLC RADIO, ROMA (06) 871 90254

TEST EQUIPMENT

- BRUEL & KJAER 2023 single channel audio spectrum analyser £2500
- BRUEL & KJAER 2511 vibration meter (field set with 1621 filter) £1500
- BRUEL & KJAER 2307 level recorder £1000
- BRUEL & KJAER 2317 portable level recorder £1500
- BRUEL & KJAER 2308 analogue X-Y pen recorder £750
- CHASE LFR1000 interference measuring receiver 9kHz-150kHz £1000
- DATRON 1061 & 1061A - various, digital multimeter & 1065 - call from £500
- DATRON 1065 digital multimeter all ranges plus IEEE £500
- FARNELL PSG2400A signal generator 100kHz-2.4GHz £3500



**ISO9002 ACCREDITED STOCKIST
MEASUREMENT & TEST EQUIPMENT**

- PHILIPS PM5167 1mHz-10MHz function generator £275
- RACAL 9008 automatic modulation meter £350
- RACAL-DANA 9300 milli-voltmeter £400
- RACAL-DANA 9301A true RMS RF milli-voltmeter £350
- TEKTRONIX P6201 FET PROBE £350
- WANDEL & GOLTERMANN WM30 level tracer £500
- WANDEL & GOLTERMANN PJM-45 Jitter meter for SOMET & SDH £5500
- WAVETEK 23 synthesized function generator 0.01Hz-12MHz £1250
- WAVETEK 1067 opt 522 1-500MHz sweep generator £500
- WAYNE KERR 3220 20A bias unit (for 3245 inductance analyser) £1250
- TEKTRONIX 1502B/03/04 short-range metal-cable tdr tester £3500

HEWLETT PACKARD



- 1640B serial data generator £500
- 3561A dynamics signal analyser (opt 01) £5500
- 3764A digital transmission analyser £1500
- 3335A synthesizer/level generator £2000
- 3400A voltmeter, analogue 10Hz-10MHz £250
- 3235A switch/test unit £1000
- 3324A synthesized function generator £2000
- 3325A synthesizer/function generator, 21MHz £1750
- 3580A audio frequency spectrum analyser £750 to £1250
- 3581C selective voltmeter £1250
- 3779D primary multiplex analyser £5000
- 4140B pA/meter, DC voltage source £4000
- 4339A high resistance meter c/w lead set 16117B £2000
- 4275A multi-frequency lcr meter £3500
- 435B microwave power meter, analogue £400
- 5386A 3GHz frequency counter £1500
- 54100A 1GHz digitizing oscilloscope £2250
- 8007B pulse generator 100MHz £950
- 8018A serial data generator £1000
- 8082A pulse generator 250MHz £2000
- 8111A pulse generator 20MHz £1250
- 816A slotted line 1.8-18GHz with 809C & 447B probe £500
- 8444A tracking generator with option 059 £1000
- 8656B synthesized signal generator to 990MHz £3000
- 87510A gain-phase analyser 100kHz-300MHz £6500
- 8901A modulation analyser with option 02/010 £3500
- J2215A FDDI portable multimode test set £1500
- J2219A 486-based, colour option main-frame £1000
- J2219A/J2171A 486-based colour screen option network advisor £3000

**SEND FOR LATEST STOCK LIST. WE FAX LISTS
AND SHIP WORLDWIDE. ALL FULLY
LAB-TESTED AND NO-QUIBBLE GUARANTEED**

CIRCLE NO. 154 ON REPLY CARD

ELECTRONIC UPDATE

Contact Malcolm Wells on
0181-652 3620

A regular advertising feature enabling
readers to obtain more information
on companies' products or services.

Section 1 Price List & Ordering Information
Section 2 Electronic Training Equipment
Section 3 Microprocessor Training Equipment
Section 4 Test & Measurement Equipment
Section 5 PC Cards



**New Flight Electronics
International Catalogue Set**

- ★ You now have access to the world's latest:
- ★ Electronics Training Equipment
- ★ Microprocessor Training Equipment
- ★ Test and Measurement Equipment
- ★ PC Cards

via "Flight's" latest catalogue set.

We are specialists in the provision of innovative top quality electronics trainers, breadboards, test and measurement, PC cards and microprocessor evaluation equipment.

Our extensive range covers every need, call today for your free catalogue set.

CIRCLE NO. 155 ON REPLY CARD



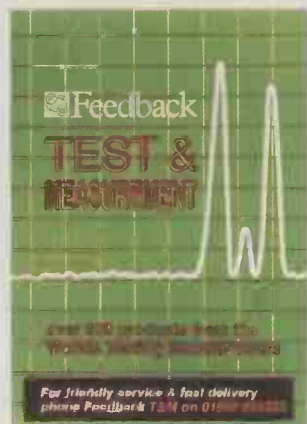
FREE DEMO DISK

The LabWindows/CVI Demo Disk is a free evaluation copy of LabWindows/CVI. You can follow instructions to build Windows applications using GPIB, VX1, Serial, and plug-in DAQ instrumentation. The guide illustrates code-generation techniques, GUI development tools, event-driven programming techniques, instrument drivers, debugging and editing tools.

NATIONAL INSTRUMENTS
For your Free Demo Disk call,
01635 523545

CIRCLE NO. 156 ON REPLY CARD

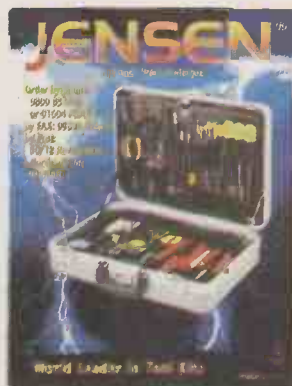
**Feedback
TEST &
MEASUREMENT**



**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. 157 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. 158 ON REPLY CARD

OLSON

®

For all your Power Distribution
Olson offer a varied choice

OLSON Distribution Units

OLSON ELECTRONICS LIMITED

OLSON DISTRIBUTION PANELS
FUSED, WITH R.F. FILTER
AND R.C.D. PROTECTION

OLSON ELECTRONICS LIMITED

OLSON FUSED WITH RCD
PROTECTION
AND DOUBLE POLE
SWITCHED SOCKETS

OLSON ELECTRONICS LIMITED

OLSON "The Rack Range" of
mains distribution panels
for 19" rack mounting

OLSON ELECTRONICS LIMITED

OLSON Office Furniture
Cable Management
Manufactured to BS 6396

OLSON ELECTRONICS LIMITED

OLSON Mains Distribution
Panels with
Non Standard Sockets

OLSON ELECTRONICS LIMITED

OLSON FUSED SUPER SLIM
CONDUIT AND DOUBLE
POLE SWITCHED SOCKETS

OLSON ELECTRONICS LIMITED

OLSON Earth Leakage
Distribution
Units

PORTABLE UNIT
Type BEL 3

WALL MOUNTED UNIT
Type BEL 2

BENCH UNIT
Type BEL 1/4

OLSON ELECTRONICS LIMITED

OLSON Distribution
Units

OLSON ELECTRONICS LIMITED

OLSON PANELS WITH 10AMP
CEE22/IEC
SHUTTER SOCKETS
FUSED, DOUBLE FUSED WITH R.F.
FILTER AND RCD PROTECTION

OLSON ELECTRONICS LIMITED

OLSON "The Rack Range" of
Mains Distribution
Panels WITH AMERICAN
SOCKETS 125V 15A

OLSON ELECTRONICS LIMITED

OLSON Mains Distribution
Panels
INTERNATIONAL RANGE

OLSON ELECTRONICS LIMITED

OLSON FUSED SUPER SLIM
WITH ELECTRIC PLUG,
CONDUIT AND DOUBLE
POLE SWITCHED SOCKETS

OLSON ELECTRONICS LIMITED

OLSON DATA PROTECTOR

10 AMP DOUBLE FUSED WITH R.F. FILTER,
OVER CURRENT AND TRANSDIENT SUPPRESSION

OLSON ELECTRONICS LIMITED

OLSON INDUSTRIAL RANGE
16 AMP 110V AND 240V
TO BS 4343/IEC 309

OLSON ELECTRONICS LIMITED

OLSON Distribution
Units

OLSON ELECTRONICS LIMITED

OLSON 19" FAN TRAYS

OLSON ELECTRONICS LIMITED

OLSON The Rack Range
CEE22/IEC
SOCKETS

OLSON ELECTRONICS LIMITED

OLSON SERVICE PILLAR FOR
THE OPEN-PLAN OFFICE

OLSON ELECTRONICS LIMITED

OLSON Distribution
Units

FRANCE, GERMANY, ITALY, SWITZERLAND

OLSON ELECTRONICS LIMITED

OLSON®

ELECTRONICS LIMITED

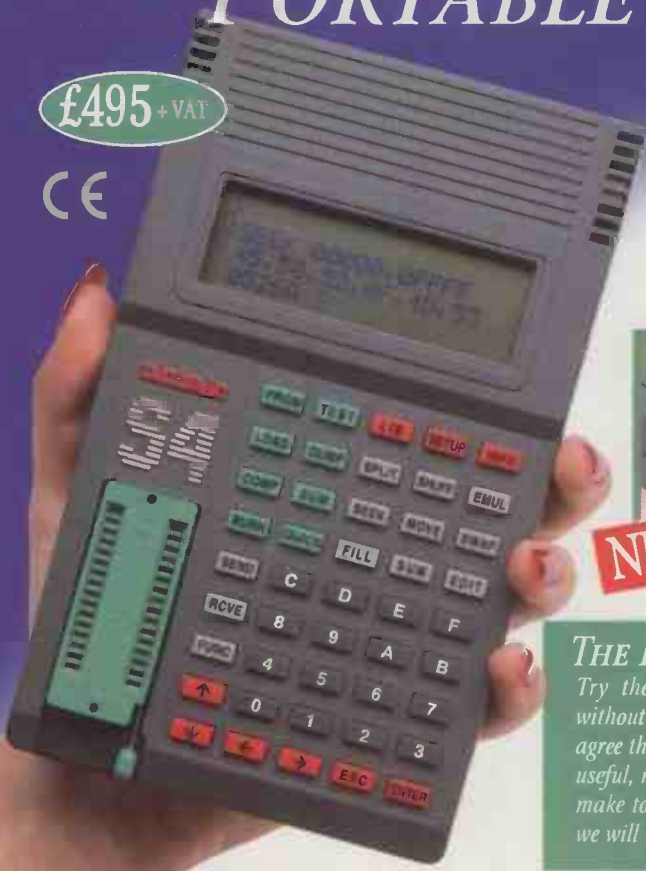
FOUNTAYNE HOUSE, FOUNTAYNE RD., LONDON N15 4QL
TEL: 0181-885 2884 FAX: 0181-885 2496

CIRCLE NO. 103 ON REPLY CARD

CB

THE WORLD'S MOST POWERFUL, PORTABLE PROGRAMMERS

£495 + VAT



S4 GAL module

Programs a wide range of 20 and 24 pin logic devices from the major GAL vendors. Supports JEDEC files from all popular logic compilers.

£195 + VAT



NEW

THE DATAMAN CHALLENGE

Try the Dataman S4 or Dataman-48 without obligation for 30 days. If you do not agree that these are the most effective, most useful, most versatile additions you can make to your programming toolbox, we will refund your money in full.

The current device library contains over 1800 of the most popular logic and memory devices including GALs, PALs, CEPALs, RALs, 8 and 16-bit EPROMs, EEPROMs, PEROMs, FLASH, BOOT-BLOCK, BIPOLAR, MACH, FPGAs, PICs and many other Microcontrollers. We even include a 44-pin universal PLCC adaptor.

If you need to program different packaging styles, we stock adaptors for SOP, TSOP, QFP and SDIP. The Dataman-48 is also capable of emulation when used with memory emulation pods.

Order your Dataman programming solution today via our credit card hotline and receive it tomorrow. For more detailed information on these and other market leading programming products, call now and request your free copy of our new colour brochure.

Dataman S4

Compare the Dataman S4 with any other programmer and you'll see why it's the world's undisputed number one.

S4 is capable of programming 8 and 16-bit EPROMs, EEPROMs, PEROMs, 5 and 12V FLASH, Boot-Block FLASH, PICs, 8751 Microcontrollers and more. S4 also emulates ROM and RAM as standard!

S4 is the only truly hand held programmer that ships complete with all emulation leads, organiser-style manual, AC charger, spare library ROM, both DOS and Windows terminal software, and arrives fully charged and ready to go! Who else offers you all this plus a three year guarantee?

Customer support is second to none. The very latest programming library is always available free on the Internet, and on our dedicated bulletin boards. Customers NEVER pay for upgrades or technical support.

Dataman-48

Our new Dataman-48 programmer adds PinSmart® technology to provide true no-adaptor programming right up to 48-pin DIL devices. Dataman-48 connects straight to your PC's parallel port and works great with laptops. Coming complete with an integral world standard PSU, you can take this one-stop programming solution anywhere!

As with S4, you get free software upgrades and technical support for life, so now you don't need to keep paying just to keep programming.



£795 + VAT

DATAMAN

Dataman Programmers Ltd, Station Road, Maiden Newton, Dorset DT2 0AE. UK
Telephone +44/0 1300 320719 Fax +44/0 1300 321012 BBS +44/0 1300 321095 (24hr)
Modem V.34/V.FC/V.32bis Home page: <http://www.dataman.com>
FTP: <ftp.dataman.com> Email: sales@dataman.com

hotline
01300 320719



Orders received by 4pm will normally be despatched same day.

Order today, get it tomorrow!

CIRCLE NO. 104 ON REPLY CARD

C4