TRAC winner – a new AM demodulator

ELECTRONICS WORLD

INCORPORATING WIRELESS WORLD

JULY 1998 £2.45

Austria Asch. 68.00
Denmark DKr. 69.00
Germany DM 18.00
Greece Dra.1300.00
Holland Dfl. 12.50
Italy L. 9000.00
Malta Lm. 1.65
IR £3.30
Singapore S$7.50
Spain Pts. 900
USA $6.50

A REED BUSINESS PUBLICATION
SOR DISTRIBUTION

Linsley-Hood on the gain stage

Analysing capacitors

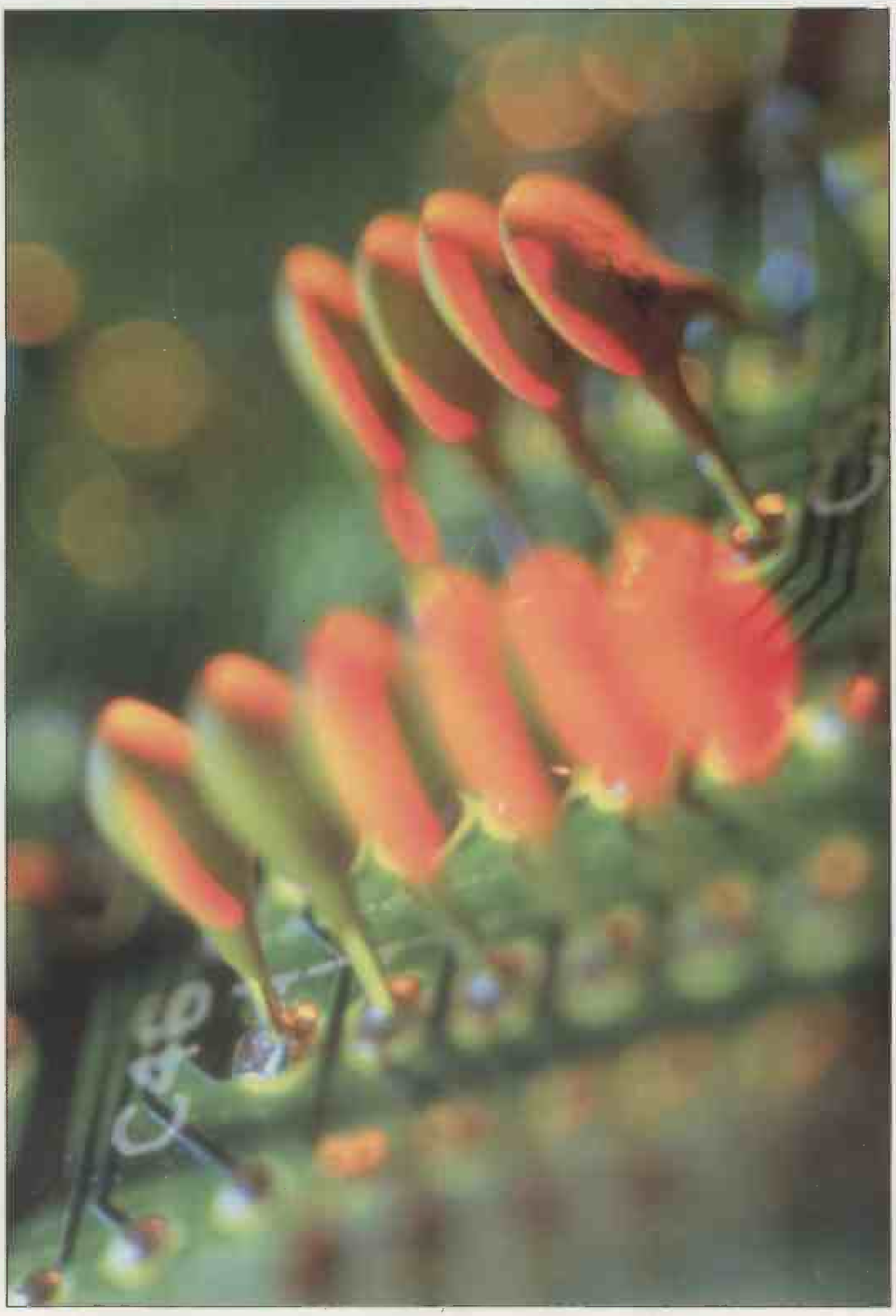
Millivoltmeter for VHF

Phones and phantoms

Reviews: Edwin and Circuitmaker

Heat-sink interfacing

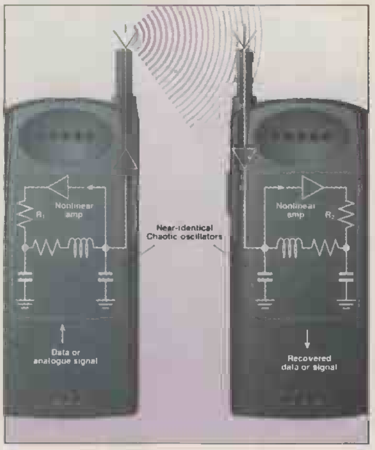
Prototyping pcbs



07>
9 770959 833035

Contents

Photography John W Banagan



Chaotic transmitter and receiver. Find out how they make communications secure on page 544.

Nick Wheeler's vhf millivoltmeter exploits surface-mount components to achieve 2pF or less input capacitance – page 604.

Audio buff? Read the small print:

Next month: Giovanni Stochino's remarkable 300V/μs power amplifier drives 100W into 8Ω and features 0.003% distortion at 5V pp, 1kHz output, falling to 0.0026% at 80V.

AUGUST ISSUE ON SALE 25 JUNE

OLSON®

THE IEC 320 CONNECTION

BUY DIRECT!

VISA MasterCard SWITCH

24 HOUR DELIVERY SERVICE
MASTERCARD AND VISA
CREDIT CARDS ACCEPTED

QM S
ISO 9002
REGISTERED FIRM
GB 1907

OLSON® ELECTRONICS LIMITED

CIRCLE NO. 106 ON REPLY CARD

OLSON HOUSE, 490 HONEYPOT LANE,
STANMORE, MIDDLESEX HA7 1JX
TEL: 0181-905 7273 FAX: 0181-952 1232

EDITOR
Martin Eccles
0181 652 3128

CONSULTANTS
Ian Hickman
Philip Darrington
Frank Ogden

EDITORIAL ADMINISTRATION
Jackie Lowe
0181-652 3614

E-MAIL ORDERS
jackie.lowe@rbi.co.uk

ADVERTISEMENT MANAGER
Richard Napier
0181-652 3620

DISPLAY SALES EXECUTIVE
Joannah Cox
0181-652 3620

ADVERTISING PRODUCTION
0181-652 3620

PUBLISHER
Mick Elliott

EDITORIAL FAX
0181-652 8111

CLASSIFIED FAX
0181-652 8938

NEWSTRADE ENQUIRIES
0171 261 7704

ISSN 0959-8332

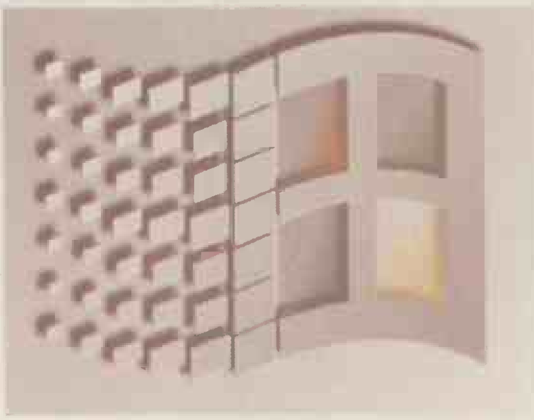
SUBSCRIPTION HOTLINE
01622 778000

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

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

REED BUSINESS INFORMATION

Monopoly for Windows



Windows 98 is upon us, and many Windows 95 and 3.1 users will be looking closely at what Microsoft's new product has to offer them. But even the most casual observer can see that all is not well in the pc world. Letters and editorials even in this magazine have expressed disquiet at the turn of events. However, few of these complainants seem to know what to do about it.

The nub of the problem with pc operating systems is maintaining compatibility with other pc users. Everybody wants to use the operating system everybody else is using because they want to stay compatible.

In the days of dos, this problem hardly existed at all, because a program for PC dos usually ran just as well as on MS dos or Compaq dos. But now there is little common ground between the various operating systems. I am sure that some of this non-compatibility is deliberate.

In a well-regulated industry, compatibility between pc operating systems would have been maintained. However, without political intervention, this ideal is difficult to achieve. In our economic system in the West, monopolies are frowned on and competition is encouraged, and this runs counter to the philosophy of compatibility, which implies co-operation rather than competition.

The trouble is, Windows is set to become the *de facto* standard – i.e. a monopoly – in the near future unless something is done.

Most of the fault here must lie not just with the politicians, many of whom are probably unaware of the situation, but with the third party program producers. For example, despite being given encouragement by IBM to write for 0S2/Warp in the form of development tools, they have almost universally jumped onto the Windows band-wagon, with many software firms *only* supplying products for Windows. This is leading to an anti-competitive situation, where eventually Microsoft will be able to impose its own conditions on the very firms supporting it.

Already, firms are being made to jump through a hoop before getting Windows 95 approval for their programs. It seems likely that this will be extended in other directions in future.

And this is likely to apply to hardware as well as software. For example, Microsoft has announced it will not in future support PCs with the ISA bus. So with the new generation of PCI-only machines that is bound to ensue, no-one will be able to transfer any ISA cards from their existing machines when they buy a new pc.

Of course, program writers have only themselves to blame if this *de facto* monopoly cause them trouble In the future. As the saying goes, they have been given enough rope to hang themselves. They could have produced products for more than just one operating system as they have done in the past, and maintained a balance that worked in their favour. But they didn't.

To use another adage, the writing had been on the wall for a long time and the recent case between the American Dept of Justice and Microsoft simply confirmed what others had been concerned about for years.

My point is this; we have political controls over other monopolies, either to prevent their monopolistic excesses, or to encourage competition to stop them becoming true monopolies in the first place. So perhaps it is time for a political initiative to produce a more level playing field in the pc drones.

Although not impossible, it would be very difficult at this late stage to assemble a conference on o/s compatibility and agree a compatibility standard, and perhaps even more difficult, technically speaking, to implement it.

A more viable and much easier alternative would be to legislate that every piece of application software offered for general sale had to be written for at least one other operating system – other than Microsoft Windows – and sold at the same price. This would prevent a true Microsoft monopoly because there are still sufficient numbers of users of other systems around who would be pleased to take advantage of such legislation.

The only people who would not be pleased would be the software writers – but they are the ones who are mainly to blame for the approaching monopolistic quandary.

Of course, for this to work, Microsoft would have to be prevented from buying up any more third-party application companies. More radical action than this has already been suggested by others, i.e. that Microsoft should be broken up into smaller pieces like Bell was under the USA's anti-trust laws. Many would applaud such action.

Even the most optimistic observer must query the wisdom of the current lemming-like rush into a Microsoft, Windows-only situation. Our own Prime Minister, fresh from his recent meeting with Bill Gates, is an excellent position to take the initiative on this. ■

Simon Wright

Electronics World is published monthly. By post, current issue £2.45, back issues (if available £3.00). Orders, payments and general correspondence to **L333, Electronics World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS**. Tlx:892984 REED BP G. Cheques should be made payable to Reed Business Information Ltd

Newstrade: Distributed by Marketforce (UK) Ltd, 247 Tottenham Court Road London W1P OAU 0171 261-5108.

Subscriptions: Quadrant Subscription Services, Oakfield House Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone 01444 445566. Please notify change of address.

Subscription rates 1 year UK £34.00 2 years £54.00 3 years £68.00. Europe/Eu 1 year £49.00 2 years £78.00 3 years £98.00 ROW 1 year £59.00 2 years £94.00 3 years £119

Overseas advertising agents: France and Belgium: Pierre Mussard, 18-20 Place de la Madeleine, Paris 75008. United States of America: Ray Barnes, Reed Business Publishing Ltd, 475 Park Avenue South, 2nd Fl New York, NY 10016 Tel; (212) 679 8888 Fax; (212) 679 9455

USA mailing agents: Mercury Airfreight International Ltd Inc, 10(b) Englehard Ave, Avenel NJ 07001. Periodicles Postage Paid at Rahway NJ Postmaster. Send address changes to above.

Printed by BPCC Magazines (Carlisle) Ltd, Newtown Trading Estate Carlisle. Cumbria, CA2 7NR

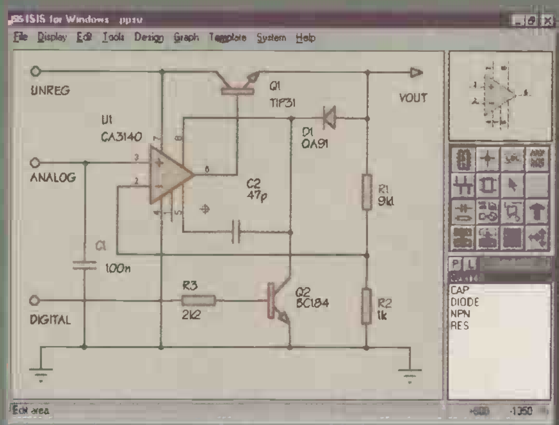
Typeset by Marlin Imaging 2-4 Powerscroft Road, Sidcup, Kent DA14 5DT ,

PROTEUS

The IV th Generation

Schematic Capture

NEW Version IV



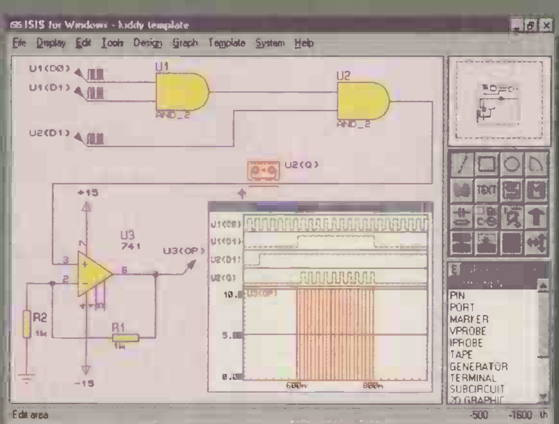
●Produces attractive schematics like you see in the magazines. ●Netlist, Parts List & ERC reports. ●Hierarchical Design. ●Full support for buses including bus pins. ●Extensive component/model libraries. ●Advanced Property Management. ●Seamless integration with simulation and PCB design.

New Features

Component Auto-Placer
Pinswap/Gateswap Optimizer
Background Regeneration of Power Planes
Enhanced Autorouting with Tidy Pass
Full Control of Schematic Appearance
Extensive New Component Libraries

Available in 5 levels - prices from £295 to £1875 + VAT.
Call now for further information & upgrade prices.

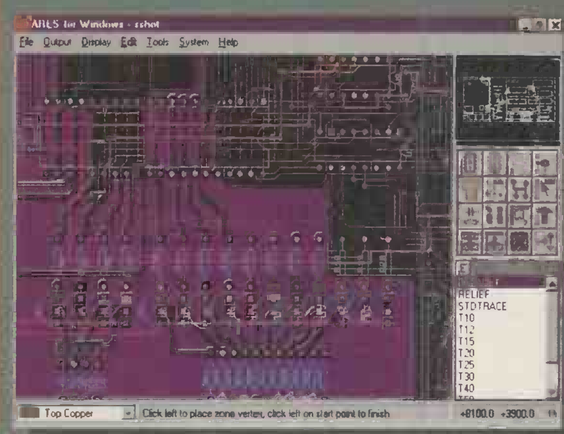
Simulation



●Non-Linear & Linear Analogue Simulation. ●Event driven Digital Simulation with modelling language. ●Partitioned simulation of large designs with multiple analogue & digital sections. ●Graphs displayed directly on the schematic.

PCB Design

NEW Version IV



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

"PROTEUS is particularly good with its rip-up-and-retry autorouter"

EWW January 1997

labcenter
Electronics

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

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

UP DATE

Fire Wire bus on its way from Oxford

Oxford Semiconductor of Abingdon is moving on the IEEE-1394 FireWire market. First silicon using the high speed consumer interface bus is due in mid-summer.

FireWire is an interface fast enough to allow the continuous streaming of video. Consequently it is useful in 'opening up the fuel line' between pcs and equipment like camcorders or DVD players. It is expected to become the key consumer electronics bus for the 1999 market and beyond.

Oxford Semiconductor has completed the interface design and is readying several application specific devices incorporating the 1394 macro. "We've done the macros. They are all ready and fully simulated and we are building them into applications," says Jalil Oraee, Oxford co-founder and technical director.

The company now has three projects going: two for customers and one for an in-house proprietary chip. "We're looking at mid-summer for working silicon," added Oraee. The bulk of the FireWire market is still a year or two away.

The chip which Oxford is developing for its own product portfolio is a 3 to 6 port PHY (physical layer)with a 1394A bus. That is just the start. "We'll be addressing all aspects from low level physical to high level protocol," said Oraee.

The company is taking orders for custom chips which require the FireWire interface. Although the company is still mainly a design house – completing 40 Asic designs last year – its aim is to become a standard chip, own-brand company of the fabless model. It expects to reach a 50/50 custom/standard product split by 2001.

Luminous materials become more than a gimmick

There are two realistic ways to produce light-emitting paint. Combining a phosphor with a radio-isotope is one. This has the advantage of producing light continuously, and at a predetermined level of brightness.

However, handling radioactive compounds in production needs special precautions and radioactivity is not exactly a marketing plus.

The other route to glow-in-the-dark behaviour is to use a material that absorbs electromagnetic energy and re-emits it slowly at a visible wavelength. This is the approach taken in toys. It is non-radioactive, but luminosity with traditional ZnS:Cu materials decays quickly with time, and light output is low.

But now a Japanese chemical company Nemoto has produced a new material called *LumiNova*.

Nemoto set out, and succeeded, to produce a luminous material that is ten times brighter and glows ten times longer than ZnS:Cu.

The company will not disclose the chemistry behind *LumiNova*, except to say that is based on metal oxides. It is possible that it uses rare-earth chemistry like that used in cathode ray tube phosphors, but this is only speculation.

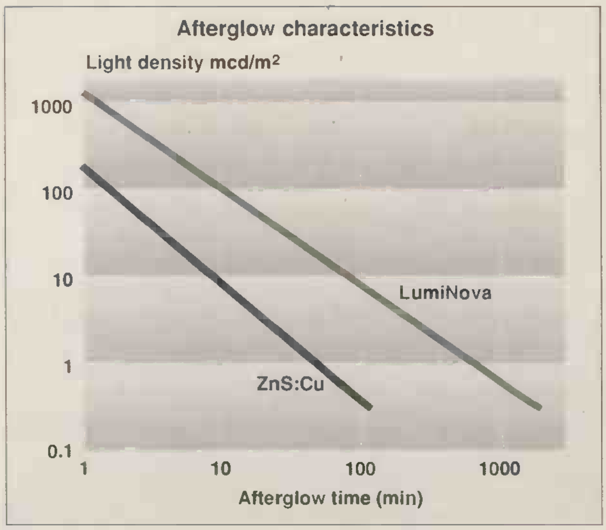
Although *LumiNova* is bright by luminous paint standards, it is not dazzling, producing a creditable 1cd/m^2 one minute after exposure, decaying logarithmically to 1mcd/m^2 after ten hours.

Nemoto's representative in the UK is display company Densitron. It sells *LumiNova* in sheets, doped into plastics, and as custom printing.

"We can see a lot of applications for it, replacing lcd backlights in some circumstances and for legends on and around controls," said Densitron spokesman Nick How. Experiments at Densitron show that a couple of hours in sunlight will fully saturate the material, even through the displays polarisers.

As little as five minutes is required to charge the material in direct sun light.

Signs, camping equipment and low-level safety lighting are other non-electronics applications that are foreseen.



Luminova is a non-radioactive luminous material glows ten times brighter for ten times longer than ZnS:Cu

TV has pc interface

Samsung is claiming a first by adding an IEEE-1394 interface to a tv. This enables the Web browser equipped TV to communicate with digital audio/video products and computers.

"We think digital tv is the most important new technology related to information appliances," said a Samsung spokesperson.

The 1394 interface is said to allow real-time exchange of sound and picture data among various products such as multimedia pcs, set-top boxes, digital vide recorders and digital video disc players.

The specific functions of each connected product are recognised automatically by the digital tv, which displays them through its on-screen menu.

Smartcards for commuters

London Transport is on the verge of signing a £1bn contract for a contactless smartcard system for its six million daily passengers.

The contract with a consortium headed by Electronic Data Systems will be the most important smartcard development in Britain so far and the biggest ever deal under the government's Private Finance Initiative.

It will allow interchange travel throughout LT's network of underground, buses and mainline rail services.

The Transys consortium which will announce the deal next month consists of EDS, ICL, Cubic Corporation and WS Atkins. Payment will be based on performance but the whole deal is expected to net the partners more than £1bn over the next 20 years.

The first stage will be to equip all London's buses, its 273 underground stations and the mainline rail stations with electronic readers at a cost of £180m over four years.

With the cards readable at a distance – or even in a pocket, handbag, or wallet – without the necessity to insert it into a special reader, it should dramatically cut queues and speed up access to and exit from stations and buses.

The cards – which will be able to mix season ticket status with stored value of up to £100 and will be available from multi-lingual touch screens to help both commuters and tourists – should also cut LTs £30m fraud bill.

Rival bidders for the contract; BT, IBM and Olivetti have already withdrawn.

The Department of Environment is also sensitive that the technical details are right, with one source saying: "We've got to get it right. We don't want to appear before the Commons Public Accounts Committee in three years time."

US foreign worker plan may be blocked

The Clinton administration says it may block proposed laws to bring significant numbers of foreign high-tech professionals to the US.

John Fraser, a senior official with the US Labor Department, told a hearing of the immigration subcommittee that ralsing the visa numbers should be a last resort, and not the first response to the IT skills shortage.

The Clinton administration wants any laws that raise annual visa numbers to include protections for local workers. US high-tech companies argue that they desperately need to recruit staff from abroad, while critics say it's because companies want to pay lower wages.

Proposed US laws seek to raise visa caps from the current 65 000 level to 115 000, potentially sparking a brain drain in Europe.

In Brief

Hard drive bonanza

Demand for hard drives is expected to explode over the next few years as storage requirements for low cost computers and large network servers continue to rise, says US market research firm Trendfocus.

Globalstar is on line

Globalstar successfully launched another four satellites in its bid to have low earth orbit network of 48 satellites offering low priced voice and Internet communications worldwide. There are now 8 satellites in orbit.

BT cool over digital tv despite broadband ban lift

BT sees no early boom in its broadband to the home network building plans despite being allowed to offer entertainment services over its national telephone network as early as 2001.

The development of digital tv services make it unlikely that BT will move quickly to provide broadcast entertainment over its network. "In many senses the market has changed a lot since the restriction. Digital tv is on the horizon for this time next year and that is the most efficient way for broadcasting," commented a BT spokesman.

The adsl trial this summer for 2500 BT customers will continue as planned, unaffected by the government changes.

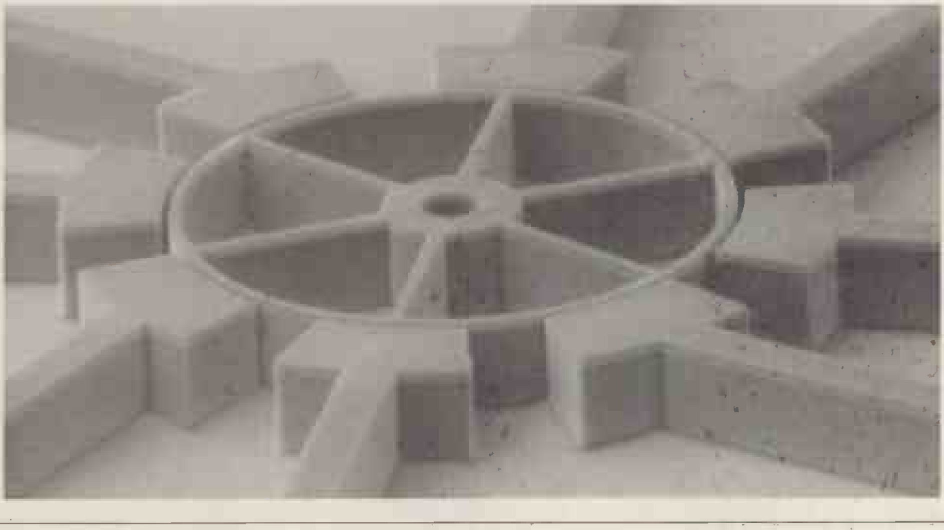
BT's managing director Bill Cockburn said: "BT will now be better able to plan for the implementation of multimedia services to the home."

The government is lifting restrictions on public telecoms operators that prevent them from providing broadcast services over their networks. The ban is removed immediately from areas where there are currently no cable operators and will be lifted completely from 1 January 2001.

"It's not unexpected. The good side is it's an end to uncertainty," added the BT spokesman.

The restriction was originally introduced to enable cable operators to have a free run at setting up their business without head on competition from established companies. Its removal will be a major blow to the country's struggling cable communications sector, which is already facing competition from satellite services.

BT has always maintained that it needed to know that the restriction would end, in order to plan network investment in new broadband to the home technologies such as adsl.



Deep and crisp

Surface Technology Systems of Newport has won a Queen's Award for Technological Achievement for its anisotropic etching system that can etch deeper than ever before while retaining crisp vertical features. The process has already been licensed to several organisations and has been used to make air-bag sensors, fuel atomising nozzles and fluid flow measuring heads. The company claims that, contrary to previous approaches, the system utilises non-toxic, non-corrosive, environmental gases.

Microsoft Internet Explorer

File Edit View Go Favorites Help

Back Forward Stop Refresh Home Search Favorites History Channels Print Font Edit

Address http://www.tiepie.nl Links

PLUG IN AND MEASURE

STORAGE OSCILLOSCOPE
SPECTRUM ANALYZER
VOLTMETER
TRANSIENT RECORDER

TiePie introduces the HANDYSCOPE 2
A powerful 12 bit virtual measuring instrument for the PC

'he HANDYSCOPE 2, connected to the parallel printer port of the PC and controlled by very user friendly software under Windows or DOS, gives everybody the possibility to measure within a ew minutes. The philosophy of the HANDYSCOPE 2 is:

"PLUG IN AND MEASURE".

Because of the good hardware specs (two channels, 12 bit, 200 kHz sampling on both channels simultaneously, 32 KWord memory, 0.1 to 80 volt full scale, 0.2% absolute accuracy, software controlled AC/DC switch) and the very complete software (oscilloscope, voltmeter, transient recorder and spectrum analyzer) the HANDYSCOPE is the best PC controlled measuring instrument in its category.

The four integrated virtual instruments give lots of possibilities for performing good measurements and making clear documentation. The software for the HANDYSCOPE 2 is suitable for Windows 3.1 and Windows 95. There is also software available for DOS 3.1 and higher.

A key point of the Windows software is the quick and easy control of the instruments. This is done by using:
- the speed button bar. Gives direct access to most settings.
- the mouse. Place the cursor on an object and press the right mouse button for the corresponding settings menu.
- menus. All settings can be changed using the menus.

Some quick examples:
The voltage axis can be set using a drag and drop principle. Both the gain and the position can be changed in an easy way. The time axis is controlled using a scalable scroll bar. With this scroll bar the measured signal (10 to 32K samples) can be zoomed live in and out.

The pre and post trigger moment is displayed graphically and can be adjusted by means of the mouse. For triggering a graphical WYSIWYG trigger symbol is available. This symbol indicates the trigger mode, slope and level. These can be adjusted with the mouse.

The oscilloscope has an AUTO DISK function with which unexpected disturbances can be captured. When the instrument is set up for the disturbance, the AUTO DISK function can be started. Each time the disturbance occurs, it is measured and the measured data is stored on disk. When pre samples are selected, both samples before and after the moment of disturbance are stored.

The spectrum analyzer is capable to calculate an 8K spectrum and disposes of 6 window functions. Because of this higher harmonics can be measured well (e.g. for power line analysis and audio analysis).

The voltmeter has 6 fully configurable displays. 11 different values can be measured and these values can be displayed in 16 different ways. This results in an easy way of reading the requested values. Besides this, for each display a bar graph is available.

When slowly changing events (like temperature or pressure) have to be measured, the transient recorder is the solution. The time between two samples can be set from 0.01 sec to 500 sec, so it is easy to measure events that last up to almost 200 days.

The extensive possibilities of the cursors in the oscilloscope, the transient recorder and the spectrum analyzer can be used to analyze the measured signal. Besides the standard measurements, also True RMS, Peak-Peak, Mean, Max and Min values of the measured signal are available.

To document the measured signal three features is provided for. For common documentation three lines of text are available. These lines are printed on every print out. They can be used e.g. for the company name and address. For measurement specific documentation 240 characters text can be added to the measurement. Also "text balloons" are available, which can be placed within the measurement. These balloons can be configured to your own demands.

For printing both black and white printers and color printers are supported. Exporting data can be done in ASCII (SCV) so the data can be read in a spreadsheet program. All instrument settings are stored in a SET file. By reading a SET file, the instument is configured completely and measuring can start at once. Each data file is accompanied by a settings file. The data file contains the measured values (ASCII or binary) and the settings file contains the settings of the instrument. The settings file is in ASCII and can be read easily by other programs.

Other TiePie measuring instruments are: HS508 (50MHz-8bit), TP112 (1MHz-12bit), TP208 (20MHz-8bit) and TP508 (50MHz-8bit).

Convince yourself and download the demo software from our web page: http://www.tiepie.nl.
When you have questions and / or remarks, contact us via e-mail: support@tiepie.nl

Total Package:
The HANDYSCOPE 2 is delivered with two 1:1/1:10 switchable oscilloscope probe's, a user manual, Windows and DOS software. The price of the HANDYSCOPE 2 is £299.00 excl. VAT.

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

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

Internet zone

CIRCLE NO. 108 ON REPLY CARD

Chaos for secure communication

Chaotic communications sounds like just the sort of activity the military would wish to avoid. Yet the US army has just awarded a research contract to investigate just that.

Chaos theory promises the ultimate in secure communications, enabling signal transmissions which are indistinguishable from background noise.

While the US military is interested in secure communications, the motivation for the research is more fundamental:to explore how non-linear dynamics, and chaotic techniques in particular, can be applied to common communication tasks like signal encoding, encryption and modulation.

Moreover, the theory will also be practically applied in the form of a basestation demonstrator using chaotic techniques for wireless and optical communications.

The research is being undertaken at the University of California, San Diego and University of California, Los Angeles and at California-based Stanford University.

"Chaotic techniques promise low cost, low power transmitters and receivers, combined with more efficient use of available bandwidth," said Henry Abarbanel, a physics professor involved in the research at the University of San Diego's Institute of Non-linear Science. The low cost comes from feeding the data or analogue signals to be sent into a simple chaotic oscillator made from resistors, capacitors, inductors and a non-linear device such as a diode," said Abarbanel.

The more efficient bandwidth usage stems from the underlying broadband nature of chaotic signals. Like with code division multiple access, or cdma, the transmissions use all the channel's bandwidth while the dynamic range is shared between the signals.

Abarbanel describes chaotic signals as having a structure in 'multidimensional space'. "Continuous wave signals have amplitude and phase; chaotic signals typically have three, four or five dimensions, but always more than two," he said.

A chaotic communication system requires that the receiver has an identical, or near-identical, structure to the transmitter. Communication is possible because the transmitter and receiver are auto-synchronising (see box) – the receiver adopts the state of the transmitter and follows deviations caused by the transmitted input message. Distortion on the received signal represents the modulation – ignoring channel distortion.

The research project is a three-year one, with the option for a two-year extension. ■

Roy Rubenstein, *Electronics Weekly*

Why does it work?

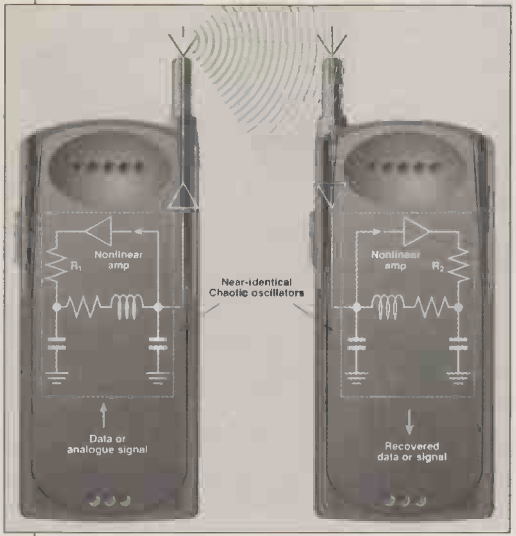
Synchronisation between transmitter and receiver is key if a communications system - and a chaotic one at that - is to work. Otherwise all the careful signal encoding and modulation counts for nothing.

Characterised by its irregular and unpredictable nature, chaos and synchronisation appears at first a contradiction. However, the essential feature is that chaotic oscillators are auto-synchronising.

"There are directions in multidimensional space that are stable and those that are not," said Professor Abarbanel. "Operation relies on the signal in the receive system being drawn back into synchronisation if it starts to drift. And when it is not drifting, it is inherently unstable. It is this instability that gives the wide bandwidth and offers the potential for enhanced security."

The suggested enhanced security is because instability implies non-periodicity and any noticeable pattern to a transmission helps in its uncovering.

Also the combination of stable and unstable directions is unique to non-linear algorithms and no one has yet come up with ways of cracking them, claims Abarbanel.



Outline circuit diagram of two coupled chaotic generators. Each circuit comprises a non-linear gain block and a linear feedback loop. If the circuit parameters in the two are matched, the two circuits evolve into perfect synchronisation. If the parameters differ slightly, as they will do in practice, the circuits remain synchronised in a general sense, with small chaotic deviations that are seen as system noise.

Could fast fpgas oust cplds?

Actel's new *SX* field-programmable gate arrays combine the attributes of both cplds and field-programmable gate arrays claims the company due, it says, to its architecture and use of antifuses.

Fpgas tend to be too slow when used to implement combinatorial logic functions like address decoders. Complex programmable logic devices thrive in such applications, but lack the register structure and gate count to swallow large logic blocks.

With a fast input pin to output pin delay of 6.6ns, the *SX* family is capable of taking on address decoding and other tasks normally reserved for cplds.

At least part of the performance increase comes from reducing its die sizes.

Moving from 0.45μm to 0.35μm processing has contributed, but much of the gain comes from moving the antifuses away from the silicon surface and up to between metal layers two and three. This has removed the need for tracking lanes in the silicon and allowed logic blocks to be packed tightly.

The logic blocks are arranged on the die like an Asic, described by Actel as a 'sea of modules'. Two types of cell, one register based and one combinatorial, are available. This regular construction and the availability of some 4000 functions from a cell make the architecture synthesis friendly.

Very fast interconnect between adjacent cells of 0.1ns, and fast connections of 0.4ns between groups of neighbouring cells, allow quick address decoding. Internally a 25-bit wide decode takes 2ns.

The regular structure also lends the devices to the datapath functions best implemented in fpgas.

The clock-to-out speed is just 4ns. Maximum clock rates are 320MHz. Actel says the chips can implement a full speed 66MHz PCI-bus controller. The first device, the 16000 gate *A54SX16*, could fit in functions currently served by a 5000 gate fpga and five 32-macrocell cplds.

Richard Ball, *Electronics Weekly*

Telnet

Tel: 01203 650702

Quality second-user test & measurement equipment

Hewlett Packard

8920A R/F Comms Test (various options)	£4995
8922 BGH G.S.M. Test	£POA

Rohde & Schwartz

CM5 54 Radio Comms service monitor (0.4 to1000MHz)	£6250
CMTA94 GSM Radio Comms Analyser	£7500

Schlumberger - Stabilock

4031 Radio comms test (0.4 to 10.00MHz)	£4995
4040 'High accuracy' Radio comms test	£3500

Wandel & Goltermann

PFJ-8 Error & jitter test set (All options fitted)	£12500
PCM4 PCM Channel measurement set	£POA

Marconi

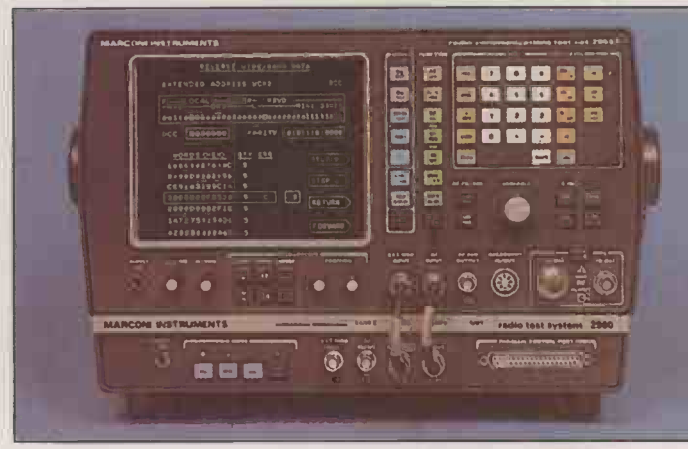
2305 Modulation Meter	£1995
2041 Low noise signal generator (10KHz - 2.7GHz)	£7500

Racal

6111 GSM test sets	£POA

Marconi

Radio Communications Test Sets



2955	£2250
2955A	£2500
2958 (TACS)	£2750
2960 (TACS + Band III)	£2750
2960A (TACS)	£2950
2955B	£4000
with 2960B added	£4250

TELNET

Fax 01203 650 773

OSCILLOSCOPES

Beckman 9020 - 20MHz - Dual channel	£150
Gould 05245A/250/255/300/3000/3351/4000	from £125
Gould 4074 - 10MHz - 4 channel D.S.O. with Printer	£2750
Hewlett Packard 541100D - IGHz Digitizing	£2750
Hewlett Packard 54200A - 50MHz Digitizing	£500
Hewlett Packard 54201A - 300MHz Digitizing	£1500
Hitachi VI52/V212/V222/V302B /V302F/V353F/V550B/V650F	from £125
Hitachi VI I00A - I00MHz - 4 channel	
Intron 2020 - 20MHz. Dual channel D.S.O. (new)	£450
Iwatstu SS557 10/S55702 -	from £125
Kikusui COS 5100 - 100MHz - Dual channel	£350
Kikusui COS 6100 - 100MHz - 5 channel - 12 Trace	£475
Lecroy 9450A - 300MHz/400 MS/s D.S.O. 2 channel	£2250
Meguro MSO 1270A - 20MHz - D.S.O. (new)	£450
Philips 3055 - 50MHz .Dual channel	£450
Philips 3335 - 50MHz - D.S.O. Dual channel	£1500
Philips 3295A - 400MHz - Dual channel	£1750
Panasonic VP574 I A - 100MHz D.S.O. Dual channel	£1750
Tektronix 455 - 50MHz - Dual channel	£275
Tektronix 465 - I00MHz - Dual channel	£350
Tektronix 464/466 - I00MHz - (with AN. storage)	£350
Tektronix 475/475A - 200MHz/250MHz -	from £450
Tektronix 468 - I00MHz - D.S.O.	£650
Tektronix 2213/2215 - 60MHz - Dual channel	from £400
Tektronix 2225 - 50MHz - Dual channel	£450
Tektronix 2235 - I00MHz - Dual channel	£650
Tektronix 2221 - 60MHz - Dual channel D.S.O	£1500
Tektronix 2240 - 300MHz/500 MS/s D.S.O.	£3750
Tektronix 2445A - 150MHz - 4 channel	£1500
Tektronix 7000 Series (I00MHz to 500MHz)	from £250

SPECTRUM ANALYSERS

Advantest 4131B 10KHz - 3.5GHz	£4750
Advantest 4133B 10KHz - 20GHz	£7250
Ando AC 821 1 - 1.7GHz	£2500
Avcom PSA-65A - 2 to I000MHz	£995
Anritsums 62B - 50Hz to 1700MHz	£2500
Anritsums 610B 10KHz - 2GHz	£4750
Advantest/TAKEDA RIKEN - 4132 - I00KHz - I000MHz	£2500
Hewlett Packard 3585A 20Hz - 40MHz	£5000
Hewlett Packard 8591A - 9KHz - 1.8GHz	£5995
Hewlett Packard 8754A - 2.6GHz - Network Analyser	£3500
Hewlett Packard 8505A - 1.3GHz - Network Analyser	£2500
Hewlett Packard 8753A - 3GHz - Network Analyser	£7995
Hewlett Packard 8756A/8757A Scaler Network Analyser	from £1500
Meguro - MSA 4901 - 30MHz - Spec.Analyser	£995
Meguro - MSA 4912 - I MHz - IGHz Spec.Analyser	£1495
Wiltron 6409 - 10-2000MHz R/F Analyser	£2000

MISCELLANEOUS

HP 436A Power meter + lead + sensor various available	from £995
HP 435A + 435B Power meters	
HP 8656B Synthesised signal generator	£2950
HP 3562A Dual channel dynamic signal analyser 64MHz - 100KHz	£6250
HP 8757A Scalar network analyser	£2250
Philips PM 5193 Synthesised Function Gen 50MHz	£1500
Leader 3216 Signal generator 100KHz - 140MHz - AM/FM/CW with built in FM stereo modulator (as new) a snip at	£995
Tektronix 1721 PAL Vectorscope	£1000
Tektronix 1741A PAL Waveform/Vector Monitor	£1600
Tektronix 1751 PAL Waveform/Vector Monitor	£2200
Tektronix 495P Spec analyser prog. - 1.8GHz	£5000

All equipment is used - with 30 days guarantee.
Add carriage and VAT to all goods.
Telnet, 8 Cavans Way, Binley Industrial Estate,
Coventry CV3 2SF

Tel: 01203 650702 545

Fax: 01203 650 773

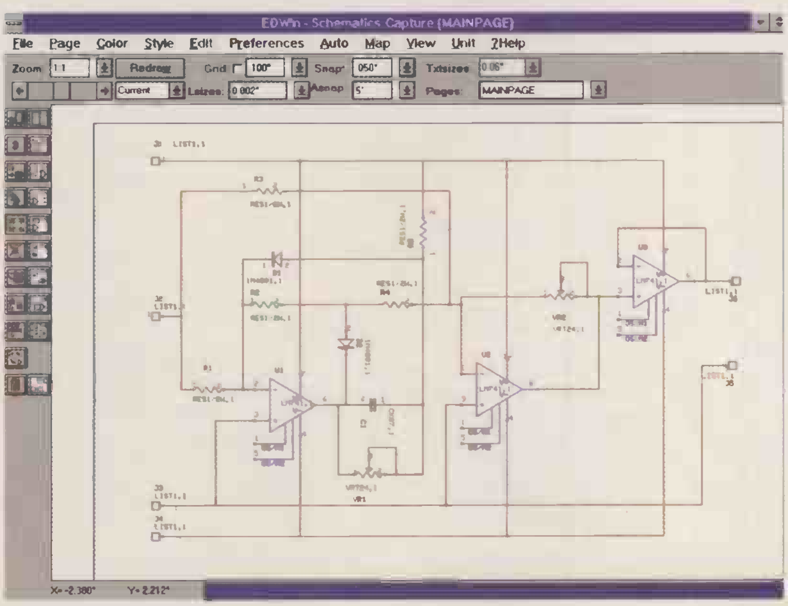
This month Rod Cooper reviews two pcb CAD packages – the heavyweight with a low price tag *EDWin*, and the user-friendly *Traxmaker/Circuitmaker* combination.

The route to pcb cad

This package – *EDWin* – is an integrated schematic drawing/capture and pcb layout program with autorouter and mixed-mode simulator. Considering all this is included in the price, the most salient feature of *EDWin* must be its remarkably low cost. The commercial price of this is £3500.

Visionics has targeted the individual designer and small firm with a bargain version of its full program. The *EDWin* literature says there is no difference in the software between this version and the full commercial version, except in the operating licence. The licence needs to be read carefully. This low cost version is in effect being subsidised by large-scale industry.

Fig. 1. The test circuit drawn in EDWin schematic section. Some of the text, which rotates when symbols are rotated, has not been un-rotated, to show the effect this has.



A further Spice simulator is available for an extra £49 and thermal analysis for £19.

As a buyer, the question you should ask yourself is whether you want an industrial-strength program. You may think that having lots of features and options is a good thing, but as I mentioned in the introductory article, this complexity introduces a very steep learning curve. However, there are programs that are much more difficult to learn than *EDWin*, and if you have had even a modicum of experience of pcb-CAD then it may well interest you.

EDWin requires Windows 3.1 or higher and a minimum of 8 MB of RAM. It occupies 18.5Mb of disk space, but needs 40MB for the installation procedure. The main *EDWin* program comes on a cd, but on its own this can only perform as a demonstration version. To get the cd to work fully a 3.5in licence disk is needed. Two further floppy disks contain the simulators.

A common database

With *EDWin*, schematic capture, simulation and pcb routing are set around a common database, where the jobs-in-hand and completed work are stored. To work on a particular job, you need to invoke the database before you can start any of the other parts of the program such as schematic drawing or pcb layout.

This differs from some of the other programs in this

EDWin

Maker; Visionics
UK supplier; Swift Eurotech Ltd, Twankhams Alley, 160 High Street, Epping, Essex CM16 4AQ,
Tel; 01992 570006, fax 01992 570220.
Price; EDWinNC De Luxe £115
E-mail visionics.eu@dial.pipex.com

review, where typically you start the schematic design program and then extract the schematic file you want to work on from the schematic library, or you start the pcb layout program and then look for the layout file.

The central database is emphasised throughout, for example where most programs just have the instruction 'save' in the file menu, *EDWin* has 'save database'. One of the advantages claimed for this system is that it benefits forward and backward annotation.

Users will sometimes find the terminology and method of working noticeably different in many respects from the other programs in the review. This may be explained by the fact that *EDWin* was first developed for the designer's own use rather than for being sold to end users.

There is a single slim volume entitled 'Getting Started' to initiate the user. The main manual and other documentation is on the cd. Considering the price and nature of *EDWin*, it would be unreasonable to expect bound manuals to be provided. However, these are large volumes and take a considerable time to turn into hard copy – not to mention printer costs. On a *Brother HL 8E* laser printer it took me half a day.

The material is not a native English work, but the translation is generally good. Some of the grammar and phraseology is a little odd here and there, but the text is understandable. There is an option to buy the manuals if you do not want to print them off.

Windows-style help is available, as is a system of windows with topical advice. This activates when anything major is attempted by the operator, and can be used in the early stages of learning. It can be turned off when one is up to speed. I found this a useful method of initially getting to grips with EDWin.

In addition, there is a reminder at the bottom of the screen of what each button does on the various button bars. This is essential as there are too many button functions to remember.

Drawing a schematic

The nominal drawing area is 8.5in by 5.5in on a 14in screen. Although this is about average for a Windows program, it can be improved by turning off some functions.

As **Fig. 1** shows, icons for common procedures such as placing components, delete, rotate etc are collected on the left hand of the screen in the form of a toolbox. This can be toggled off if more screen space is required, which is a good idea – especially for people with smaller monitors.

Most of these functions are replicated in the menus activated from the top menu bar. Directly underneath this menu bar is an area devoted to drawing-screen parameters. This area can also be toggled off after setting-up is complete, to increase working area further. Again, this is good practice.

To start a fresh schematic, you first have to specify the size of sheet, A4, A1, etc, from the edit, page size menu. To place components, you can either select the edit menu then click on 'components' or use the toolbar. If you click

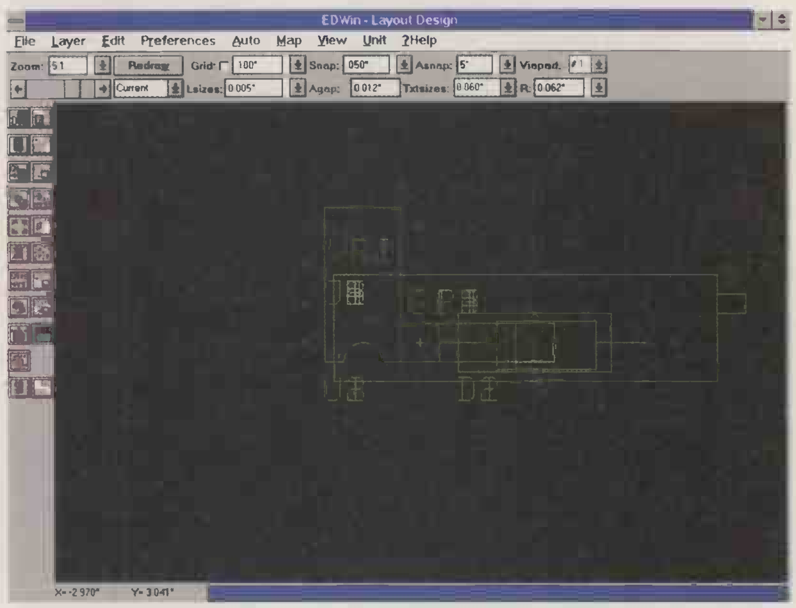


Fig. 2. Component outlines from schematic capture are initially placed in a heap in the pcb layout section.

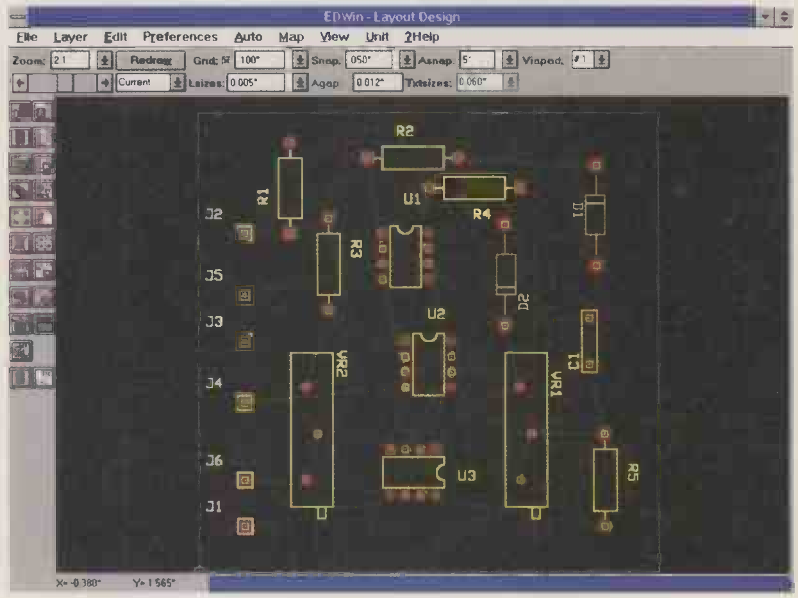


Fig.3. Rat's nest from the screen shot above after the autoplacer has been activated and then interactively arranged, shown with pads and outlines actual size.

Previous review subjects

PCB Designer: Niche Software Ltd, tel 01432 355414 – reviewed September 1996.
PIA:AW Software Ltd, Germany tel +49 89 6915352 – reviewed September 1996.
Easytrax: Protel International pty, Australia. Available from PDSL, tel 01892 663298 – reviewed September 1996.
Ranger 2: Seetrax CAE Ltd, tel. 01705 591037 – reviewed October 1996.
Electronics Workbench: Interactive Image Technologies Ltd Canada, tel. 00141 69 775 550 – reviewed October 1996.
CircuitMaker: MicroCode Engineering USA, UK agent Labvolt, tel 01480 300695 – reviewed November 1996.
Quickroute 3.5 Pro+: Quickroute Systems Ltd, tel 0161 449 7101 – reviewed December 1996.
Propak: Labcenter Electronics, tel 01756 753440 – reviewed December 1996.
Proteus: Labcenter Electronics, Schematic capture and pcb design – reviewed January 1997.
EasyPc Pro XM: Number One Systems, tel 01480 461778 – reviewed January 1997.
Challenger: Ultimate Technology, Tel 01594 810100 – reviewed June 1998.
Ranger 2: Seetrax CAE Ltd, Tel 01730 260062 – reviewed June 1998.

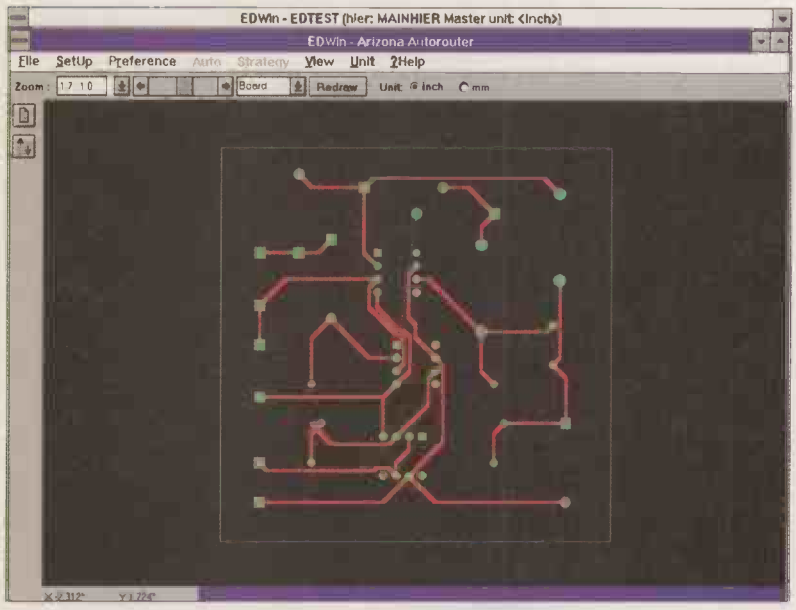


Fig. 4. Results of single-sided autorouteing rat's nest of Fig. 3 using the external Arizona autorouter. Note the incomplete rat line.

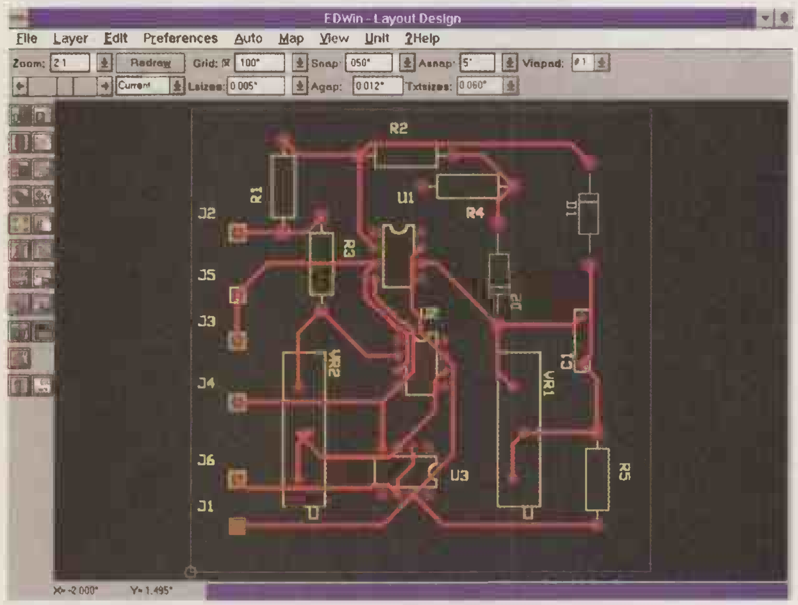


Fig. 5. Results of transferring the autorouter results back to Edwin. Note the incomplete ratline is translated as a missing trace on R4.

in the drawing area you are then presented with the library. You can either select a library volume and then a component, or you can specify a component and let the library search for you.

Generally, I found library access and symbol placing was good. At 11 000 components in 25 volumes, the library is very well stocked. You have the choice of ANSI or IEC symbols as default, this being selected during installation.

Unusual C & R libraries

The capacitor and resistor libraries are unusual. In most programs you get half dozen generic pcb footprints for resistors, but in *EDWin*, the resistor library contains 74 types. The capacitor library contains 85 types. This covers just about every resistor and capacitor package you are likely to come across.

Unfortunately, the size and pad spacing of any particular component type selected during schematic drawing does not appear when you want it – i.e. at symbol selection time. A resistor labelled RC07 is not a resistor on a 0.7in spacing but actually a 0.5 W resistor on a 0.5in spacing. The only means to get this information is to select the library viewer option and look at each individual resistor or capacitor reference. Only then do you get to see what the size and spacing is for that component.

This is not a very user-friendly system and needs reforming, but you can do this yourself by renaming the devices to make them relate more to physical reality.

Alternatively, you could make a note of the most common types you are likely to use and keep it to hand while drawing. Then, you only need to refer to the library viewer when you come across an unusual type. As resistors and capacitors are the most frequently used components in many circuits, the time spent doing this needs considering if you are thinking of buying *EDWin*.

There is no permanent on-screen parts bin, but a 'local library' performing the same function can be generated from the main library and stored in the database. Alternatively a circuit can be built by simply returning to the library and reselecting symbols.

But there is a repeat function for placing several identical components without returning. Generally, I found operating this system straightforward, albeit a little slow. Placing and moving symbols around was easy, but rotating a symbol also rotated symbol text. Un-rotating text is a time-consuming and tedious task. Text can be moved independently of symbols for tidying-up the circuit.

The rotation function for text and components is unlike that used in Ultimate's Challenger system, components being cranked round a fixed point. Many angles can be selected instead of the more usual 90°.

If you wish to use generic symbols – as you might if you were just experimenting with a circuit – an alternative symbols-only option is available. This does not carry pcb footprint information. Graphics quality in schematic drawing is good.

Wiring up

When wiring up components, the system can be set for orthogonal or freehand wiring, and there is an adjustable snap-to system. An adjustable dot-matrix grid can be turned on or off to assist placement.

To start a connection, you click on a component terminal, but to terminate a wire, it is necessary to press F4, making wiring up a continually two-handed operation. As an alternative to F4, you can select the end-wire button from the tool bar. Either way, wiring up is slightly slower and less smooth than most of the other programs in this review.

There is positive confirmation of connectivity, in that a small square appears on device pins when you make a good connection. There is no inhibition of 'bad' connections as in the the *SmartWire* system in *CircuitMaker*.

I discovered that it is comparatively easy to miss a connection and fail to make a net when working quickly. It is possible to draw lines in space i.e. missing connections altogether. You have to delete these mistakes manually. Bearing this in mind, it is worth checking netlists visually before working on pcb layout.

Panning can be done with the right mouse button, or via the scroll bars. Some people prefer to use scroll bars for panning instead of the mouse, as it is one of the few advantages of Windows.

In this case, the right-hand mouse button is not fully utilised; other programs make much better use of it.

However, one benefit of using the right mouse button in this way, if you have a small monitor, is the possibility of turning off the scroll-bars to increase workable screen area. To assist panning, a small map called here the 'viewport' can be turned on to show where the circuit is in relation to the screen area, so it is then not so easy to get lost.

Many other features are available; adjustable autosave, multipage schematics, auto junction dots, auto package, and an excellent incremental zoom feature. In fact, there are more than the usual number of controls for adjusting or tweaking the various functions.

There are too many to mention here, but as an example, the Toolbox Editor enables you to set up a toolbar of your own selection of functions, bypassing the standard menu selection. It is possible to customise *EDWin* more than other programs, but the cost of this is complexity.

Pcb layout

This is practically the same in style and method to the schematic drawing program, with a few obvious changes to the tool bar icons.

For purely manual layout, components can be selected and traces drawn in a similar manner to the schematic. This can be assisted by a dot-matrix grid. Imperial and metric units are supported.

For more automated use in conjunction with schematic capture, on starting the layout program, components from capture are dumped initially inside a defined area ready for autoplacement. The rat's nest is not shown at this stage but can be switched on from the menu bar.

The auto-placement feature can then be used to sort out the components into a more orderly arrangement. There is a certain amount of configuration that can be exercised over placement. Typical results are shown in **Fig. 2**. Manoeuvring the components interactively into their final positions was not difficult.

There is a good design rule check which can be seen as an error list or flagged on the routed board. There is also an unusual feature for auto-renumbering of components. This puts the component numbers – which are of course mixed up after layout – into a more acceptable sequence for manufacturing purposes.

Autorouteing

An autorouter, the '*Arizona*', is provided with this package. It has no rip-up and retry strategy and although it can be configured to do a single-sided board, it could not complete the test circuit. This puts it into category C.

The router is external to the main program so it is necessary to reload the database into it to start work, and return to *EDWin* when finished. Only the pads of the components are visible in the autorouter. I found this disconcerting as it was then unclear which components were which. The component outlines only re-appear when the job is sent back to *EDWin*.

This autorouter needs considerable input from the operator and requires resetting and re-running several times with different configurations to get acceptable results. Expect to do some manual routing to complete boards.

Artwork hard copy is produced from Windows printer drivers. There is a comprehensive set-up procedure, including a mirror function, and quality from laser printing is good. There is no dedicated plotter driver. The usual Gerber in/out is provided.

In summary

EDWin has several good points. It's a complete integrated suite of schematic capture, autoplacer and autorouter, with all the features you would expect in such a program, with an unusually comprehensive library; it has no size or pin restriction, and it has an integrated simulator to boot. It's more than usually flexible in use. But foremost of these good points is the price – £114 is very attractive for such a product – especially one running under Windows.

However, there is no doubt you have to work relatively hard at *EDWin* to get results. It is an intricate product with plenty of controls to play with, so be prepared to spend much longer than usual learning how to work it.

Operation is logical, but a little slow even when conversant with the system. In schematic drawing and layout, consistent care is needed to produce acceptable results. Because of these factors I would hesitate to recommend *EDWin* as a first-time purchase. But someone with pcb-CAD experience, working up the pcb-CAD ladder and looking for an inexpensive all-in program could well be interested. Plotter owners will not like the absence of a dedicated driver.

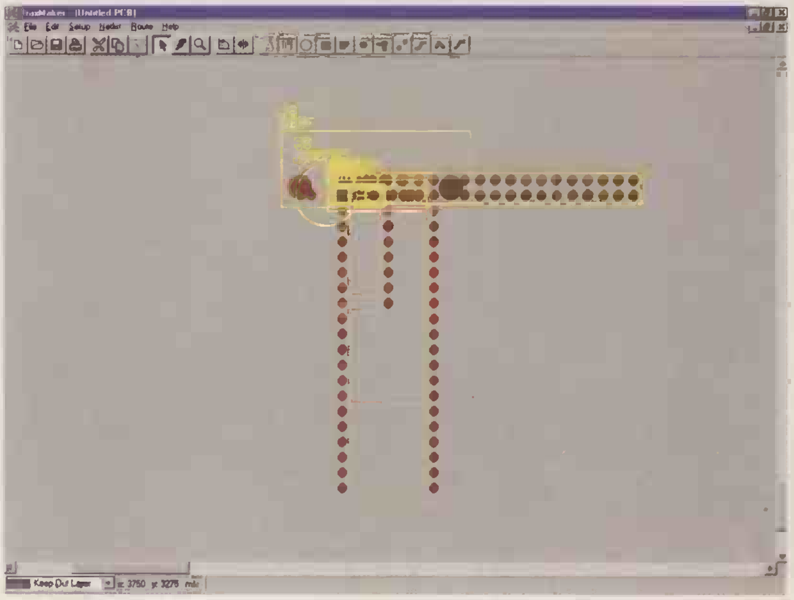
The *Arizona* autorouter is not very powerful compared to other autorouters in this review. If you do only double-sided boards of small to medium size this may not bother you. If you fall outside this category, then you should look for another compatible autorouter.

EDWin has an interface for the *Specctra* autorouter from Cooper and Chyan. One version of this powerful autorouter has been reviewed already in *Electronics World* October '96. There is also an interface for *Maxroute*. Note that both these autorouters cost many times the price of *EDWin*.

Traxmaker

These two programs go hand-in-hand to make a complete schematic capture/pcb layout/ simulation suite. They have both been up-graded since I reviewed them in November '96. Not much has changed in the schematic capture part of *CircuitMaker*. Indeed, the schematic drawing program hardly needs more development as it is already one of the best in this review (see the original review *EW* No 1727). Note that the libraries have been increased to 4000 devices – a welcome expansion.

Fig. 1. Initial imported netlist from CircuitMaker appears as an overlapping rat's nest dump, before autoplacement.



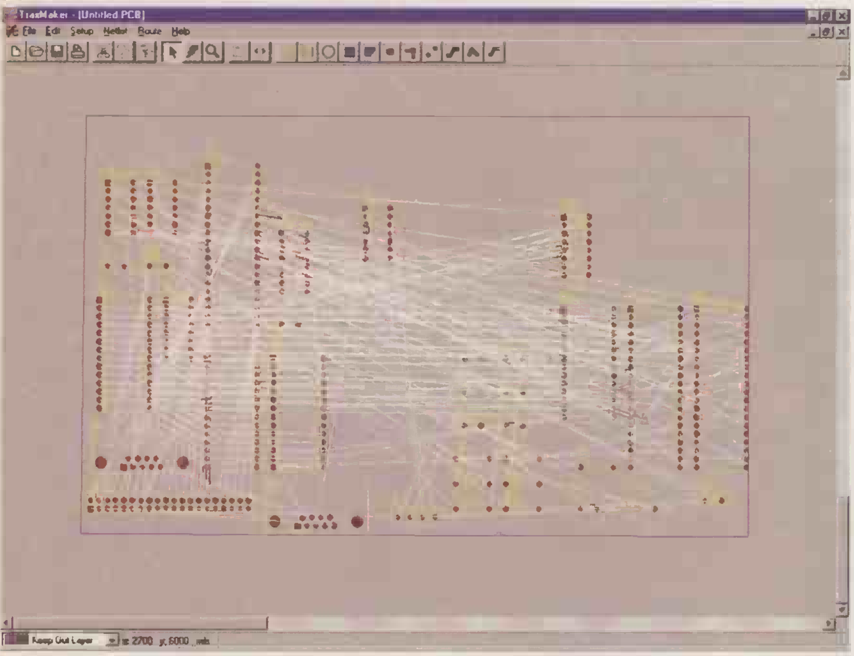


Fig. 2. The same rat's nest dump as Fig. 1 after autoplacement and some manual editing.

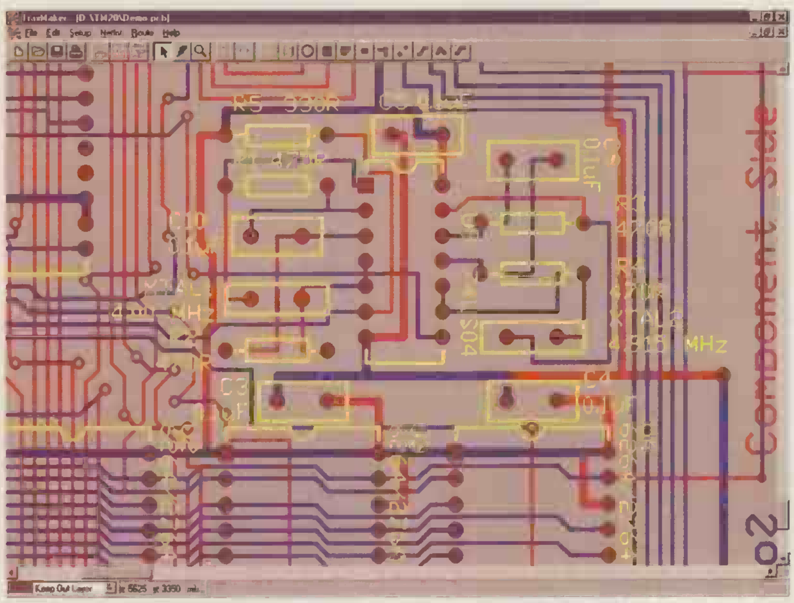
On the other hand, a lot of work has been done on *TraxMaker*, which is the pcb layout and autorouteing section. It originally ran in Dos, while *CircuitMaker* ran in Windows. This made transferring a netlist to *TraxMaker* from *CircuitMaker* cumbersome.

TraxMaker has now been made into a Windows program, making the netlist transfer simple, exactly as you would expect between two Windows programs from the same stable. Much of the original character of the Dos version has been retained so if you up-grade there is not much to re-learn.

The user manual for *TraxMaker* is well-written and easy to follow. It does not use jargon without explaining what it means – unlike some of its competitors – and it follows a logical sequence. This manual is a commendable introduction to using pcb layout and autorouters – a model of clarity that other writers should note. It includes an unusually good explanatory section on Gerber photoplotting.

CircuitMaker needs Windows 3.1 with WIN32S, or Windows 95 or NT 15Mb disk space to install. Program size; 10 Mb, supplied on 6 3.5" disks. TraxMaker occupies 2.5 Mb and is supplied on 3 disks.

Fig. 3. Close-up of an autorouted double-sided board showing the quality of track you can expect



Pcb layout

Available screen area for pcb layout is about 9.5in by 6in on a 14in monitor, which is good for a Windows program. The format is in conventional Windows style as **Fig. 1** shows. Layout of the screen is a relatively plain design – a single menu bar and a single tool bar with just two dozen buttons – making it easy to learn. The buttons have pop-up help text.

The nominal sheet area is 32in by 32in with an adjustable dot grid, and panning is done by scroll-bars. There is no map showing where you are on the sheet, but *Traxmaker* allows you to set a temporary origin for layouts. This is quickly found using the 'find origin' function. Metric or imperial units can be selected but there is no autosave.

Although a relatively uncomplicated program, *Traxmaker* can handle a board design of up to six signal layers with mid-layer power and ground planes. Moving between layers is easily achieved from the button at the task bar, Fig. 1.

Manual layout is straightforward. Access to the library of components via the toolbar is easy, so is selection and placement.

Configuring and placing the traces was also easy. Traces already placed will rubber-band if the components are subsequently moved. To re-route these tracks, there is a re-route tool which allows you to rubber-band traces manually into their new position. Personally, I would rather delete such tracks and start again: it's often quicker.

A pad-to-pad router is provided. To use this, you click and drag the mouse pointer from one pad to another, and on release the track will be automatically inserted for you, complete with vias. It can also be set to route on a single layer with no vias at all.

There is also the option of manual routing from a rat's nest, using the rubber-banding technique. This is, in fact, the suggested method for finishing any layout that the autorouter could not complete. If you don't get on well with rubber-banding, you should note this.

To generate a rat's nest, there is an auto-placement feature, which is very useful to commence a board layout. A small amount of configuration is available to adjust auto-placer performance. Overall, the autoplacer is easy to use and effective.

Routeing

The autorouter provided with *Traxmaker* has much the same performance as the Dos version already reviewed. It has no rip-up-and retry, no push and shove, no autoneck and no track-spread option. It really needs all four strategies to keep up with the competition. *TraxMaker* therefore falls into category C.

To get this router to complete a board it is necessary to work hard at component-placing during the rat's nest stage.

A fair degree of flexibility is provided for setting up this autorouter, but it is not at all hard to understand. A design rule checker confirms any errors during routing i.e. on the fly, or it can produce a list of errors on completion. Errors are not automatically flagged on the routed layout itself, but are listed, and can then be highlighted interactively.

Traxmaker relies on using the Windows drivers for making hard copy. Although this is not a problem for printers, it raises difficulties for those who prefer pen-plotters. This subject was dealt with in the review introduction in the May 98 issue and will be of particular interest to those who want to use the direct-to-copper plotting method for making prototypes.

When *Traxmaker* was in Dos, it had its own plotting program, *Traxplot*, which gave excellent plotter control. It is hard to understand why this has been left out. Other programmers have acknowledged that CAD plotters need special consideration in Windows and most of them have kept their separate drivers; clearly, the maker *MicroCode* has not realised this.

Having said that, the *TraxMaker* interface with the printer drivers is good, including the ability to mirror the output.

In summary

This version of *Traxmaker* is certainly better integrated and thus easier to use with *Circuitmaker*. Viewed overall, the *CircuitMaker*-plus-*TraxMaker* package has one of the easiest learning curves. It is pleasant to operate, and is certainly one of the most understandable.

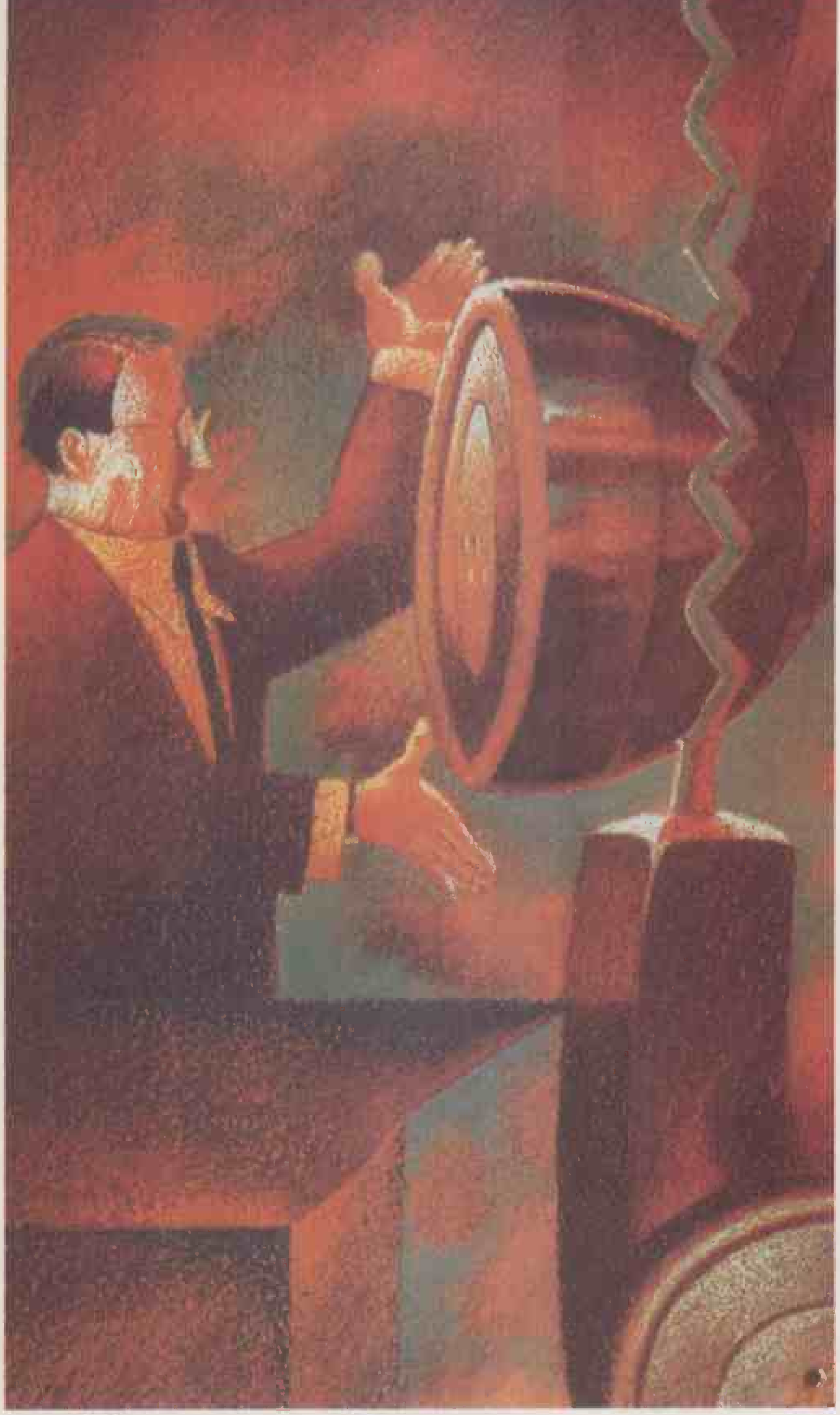
However, the autorouter lacks in routeing power compared to similar-priced products. It needs much more development. Also, the lack of a good pen-plotter driver will displease plotter owners.

There is of course nothing to stop you combining *CircuitMaker* with another Windows-based pcb layout package, providing the netlist (*Tango/Protel*) was compatible. Until *TraxMaker*'s autorouter is made more powerful, this is what I would suggest.

If *TraxMaker* ever gets the extra strategies it needs, it will be a strong contender for the title of "best product" when combined with *CircuitMaker*. ■

Traxmaker & Circuitmaker
Maker; MicroCode Engineering Inc, U.S.A.
UK Supplier; Labvolt (UK) Ltd, 28 Stephenson Road Ind. Estate, St. Ives, Cambs. PE17 4WJ
Tel; 01480 300695
Prices; *CircuitMaker* £199, *TraxMaker* £199

Next, Rod reviews the new Windows version of Easy-PC from No 1 Systems and presents a round-up.



The phantom of the phone

Ian Hickman has been delving into the technical archives again, looking at the transmission of information over wires, both voice and data. Both LANs and WANs use wires to transmit data over various distances. Can we learn anything from the experience of yesteryear's telephone engineers that might help in that sphere?

Man has always sought ways of communicating at a distance, by varied and ingenious means. These include shouting, megaphones, smoke signals – their use was described by Aeschylus in the Agamemnon – tom-toms, beacon fires – which signalled the arrival of the Armada in 1588 – and flag signals for ships, designed by the future James II while Lord High Admiral.[1]

Later advances include semaphore. Ingénieur-Télégraph M. Chappe installed an extended system in France that became operational in 1794. And an electric telegraph was proposed in detail in the *Scots Magazine* as early as 1753. It used twenty six wires, static electricity at the send end and pith ball sensors at the receive end.

But a really practical telegraph system awaited the work of Cooke and Wheatstone for the railways in the 1840s. Wireless communication came at a rather later date, but with a subsequent explosive growth of applications.

Telephony

Though not the earliest, Graham Alexander Bell's telephone, patented in 1876, was the first practical system.

Initially demonstrated operating over a short distance – the room next door – it was soon developed, with the aid of manual exchanges, to allow any two local subscribers to talk to each other.

Inter-urban lines followed, but only when a means of holding the increased attenuation to manageable proportions had been introduced. These used very thick copper wires for trunk circuits, such as the first between London and Birmingham. Fortunately, technology has advanced since then – otherwise the installed capacity of lines between those two cities now would require more copper than has ever been mined.

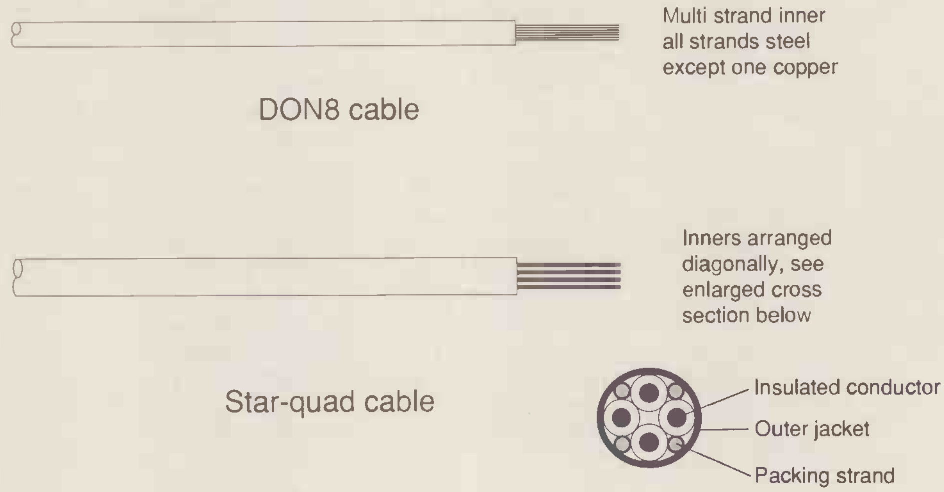
While civilian telephone systems are permanent installations, in the fluctuating situation in a battlefield, installing and maintaining telephonic communications presented some difficulties – like tank tracks chopping up the lines.

However, due to the limitations of wireless communications – vulnerability to jamming and 'exploitation' (eavesdropping) – telephonic and telegraphic traffic held an important role for the military. Consequently, linesmen will run out anything from a few hundred metres to a few miles of Don 8 wire, or star quad cable, to provide a line or two between any two given points, as necessary.

Clearly, for convenience and economy, it is handy if a line can carry more than one circuit, and ways of achieving this were sought, long before carrier systems were invented. The need was particularly pressing wherever Brigade set up its Field HQ, as its thirst for communications is insatiable.

One line, two circuits

Particularly in rear areas, large numbers of circuits are frequently required between different HQs. Installing several lines involves a great deal of time and a large volume of stores, so any scheme to provide more than one circuit per physical pair is of great potential benefit.



Outline make-up of the two types of cables referred to here

One scheme involved direct series connection of a telegraph instrument with a field telephone. This worked, provided the telephone was largely unaffected by the dc and low frequency signals used by the telegraph, and if the latter could pass unhindered the voice frequency components of the phone circuit. The only suitable telegraph machine was the 'Fullerphone' – a telegraph, despite its name.

A further limitation was that the system could not be used with phone circuits that superimposed dc on the line, either for powering the remote handset (central battery, or CB, exchanges) or for ringing (CBS, or central battery signalling exchanges).

Enter the phantom of the phone

A more satisfactory arrangement, providing two telephone circuits over one physical pair involved the use of a 'phantom' circuit. The arrangement is shown in Fig. 1, reproduced from reference 2.

Here, the go current of the instrument on the 'physical circuit' travels down one wire and back along the other. Because the send voltages are balanced about earth, no current flows in either of the routes to ground.

On the other hand, the instrument on the phantom circuit sends half of its signal current equally over each of the two wires of the physical pair. These currents therefore produce no voltage across either the (floating) send or receive end of the physical circuit, the return path being through the earth. This arrangement is known, not surprisingly, as an earth-return phantom circuit.

There is usually no appreciable interference between the physical and phantom circuits on a pair. However, due to the earth return, the phantom circuit tends to pick up noise and interference. If used on a very long line, this can excessive, rendering the phantom unsuitable as a high grade speech circuit. Nevertheless, subject to this limitation, one physical pair can provide two effective circuits.

Names galore

This is probably a good point to clarify some of the terminology used, since workers in different fields tend to call

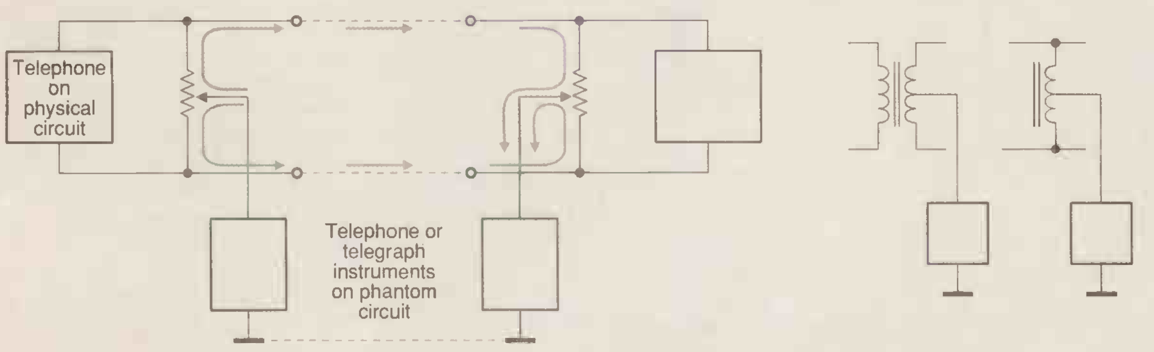


Fig. 1. Two telephone circuits over one physical pair. Earth-return phantom superposing is on the left. Phantom connections are on the right.

the same thing by different names. In UK telephone parlance, balanced signals such as those due to the instrument on the physical pair in Fig. 1 are known as transverse signals. In the USA they are known as signals metallic, in audio parlance as push-pull signals and in instrumentation as normal mode signals.

Correspondingly, the unbalanced currents and voltages in the phantom circuit, shown by the dotted arrows in Fig. 1, are known as longitudinal signals, signals-to-ground, push-push signals and common mode signals respectively.

Often, instead of a single pair using, say, Don 8 wires, a circuit would be provided using star-quad cable. This, as the name implies, was a four-core cable, the overall outer cover retaining the wires in position so that, in cross section, their centres were at the corners of a square. The two wires of each pair were diagonally opposite each other, so that due to the stray wire-to-wire capacitances being balanced, cross talk was cancelled.

With two physical pairs at one's disposal, a full phantom circuit can be realised, **Fig. 2**. The two physical pairs carrying the phantom are known as 'side circuits'. By avoiding the potentially noisy earth return path, this arrangement provides three high-quality speech circuits over the two pairs, even over long distances.

Big phantoms have little phantoms...

Given a full phantom working on its associated side circuits, it would be a pity not to wring the ultimate capacity from the arrangement. This can be achieved by using by using an earth-return super-phantom, **Fig. 3**.

Due to noise, over a long route this might do service as a lower grade speech circuit. If too bad even for that, alternatively it could at least be pressed into service as a telegraph circuit. Either way, given two physical pairs, a total of four effective communications circuits can be engineered.

Given four physical pairs, e.g. two star quad cables, two full phantoms are available. A full super-phantom can then be run between the two full phantoms. And for good measure, an earth-return super-super-phantom can be run over the full super-phantom.

Thus, given four physical pairs, a total of eight effective circuits can be engineered. The general rule is that 2^n physical pairs can provide 2^{n+1} communication circuits.

Telephony makes use of hybrids, to combine the four wire go-and-return interface to mike and earpiece onto a two wire line. Thus a telephone circuit works 'full-duplex', i.e. transmits speech or other information in both directions simultaneously – except over some very long routes, where echo suppressors may be used.

Thus in terms of basic one way A to B 'simplex' circuits, 2^n physical pairs can provide 2^{n+2} connections.

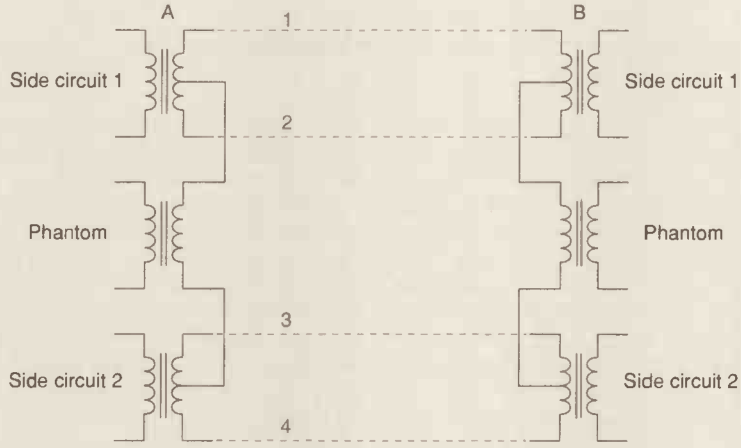


Fig. 2. Side and phantom circuits providing three high quality speech circuits over two pairs.

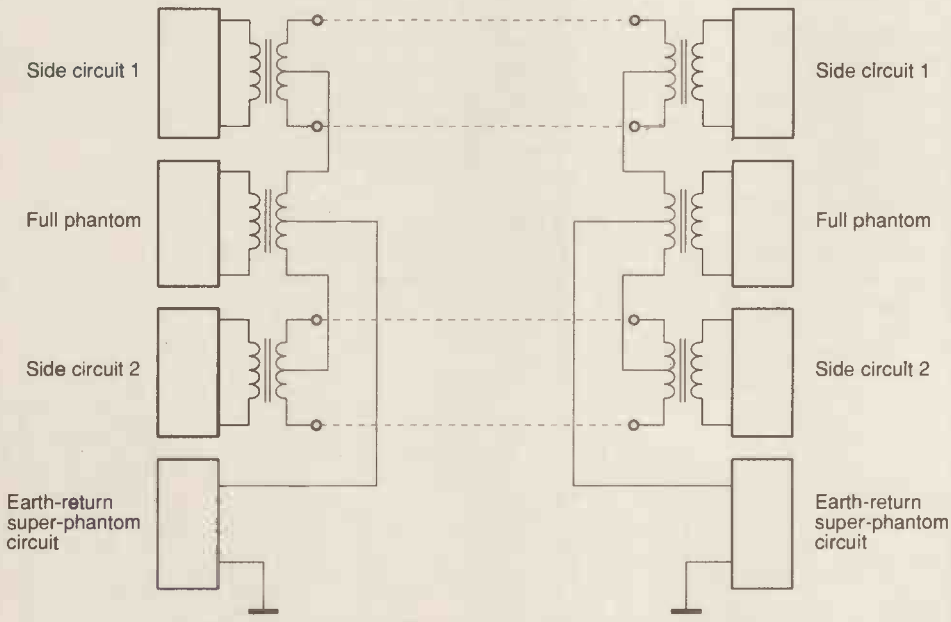


Fig. 3. Full phantom working, with earth-return superphantom circuit, adds yet another channel.

Loading

As with civilian telephone networks, the army had to resort to loading of lines in some cases. This was done in order to obtain a reasonably flat frequency response and low attenuation over the required bandwidth for the service in question – be it speech or carrier operation.

Without loading, the attenuation of lines increases with frequency, due to the excessive capacitance. This is because the ratios of the line parameters differ from those needed to fulfil the distortionless condition.

The deficiency can be remedied, to a close approximation, by increasing the inductance of the lines. The extra inductance does not need to be applied continuously, like the coiled inner of a wideband delay cable. Continuous loading of the conductor, by winding round it either iron wire or mumetal tape, has been used on some submarine cables. But generally, lumped loading is adequate.

For example, reference 3 quotes a typical loading arrangement as "19H88-50". Translated, this comes out as No. 19 gauge wire with H (6000 feet) spacing between loading coils. These coils are of 88mH each for the regular or side circuits, but 50mH each for the phantom circuits.

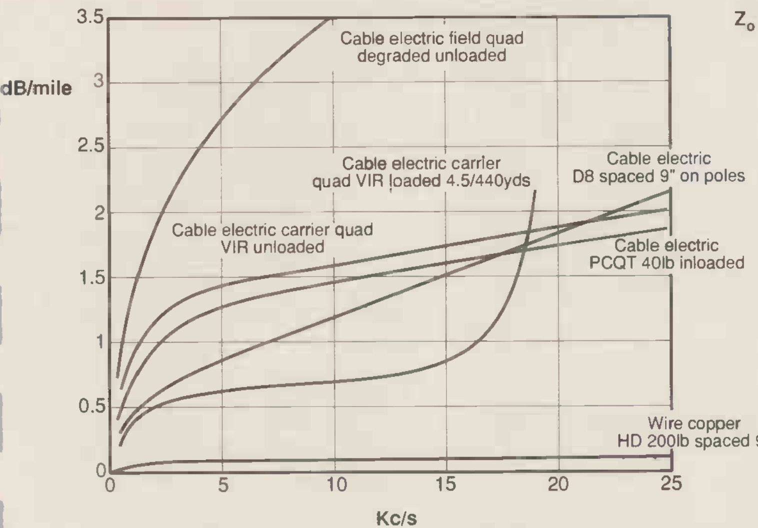


Fig. 4. Variation of attenuation with frequency for some army lines.

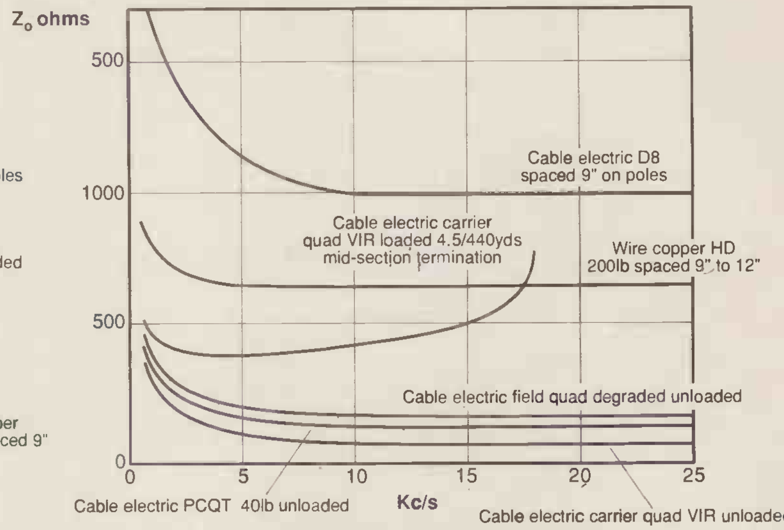


Fig. 5. Army line variations of |Zo| against frequency.

Without loading, the attenuation over a circuit of 12000 feet might be six or seven decibels greater at 3000Hz than at lower frequencies. With H88 loading, this is reduced to less than 2dB, though with this loading, the attenuation increases rapidly beyond 3kHz; due to the lumped nature of the loading, the circuit becomes in effect a low-pass filter.

Figure 4 shows the attenuation in decibels per mile for various lines, both loaded and unloaded, including both D8 and field quad, as a function of frequency. **Figure** 5 shows how the characteristic impedance of various lines varies with frequency.

Note the tendency for the characteristic impedance to climb toward infinity as the frequency approaches 0Hz. This is because the reactance of the inductance *L* and the capacitance *C* per unit length, tend to zero and infinity respectively.

Impedance is now determined by the in-phase components *G* and *R*. At 0Hz, the characteristic impedance Z_0 is given by $Z_0 = R/G$, where *R* is the loop resistance per unit length of line, and *G* is the conductance between the conductors, per unit length.

As *R* is definitely finite, while leakage *G* tends to be negligible – except perhaps in the case of open air lines on a wet day – Z_0 tends to increase almost without limit at low frequencies.

Pots to the rescue

While the characteristic impedance of an unloaded line is constant, at least at higher frequencies, the attenuation increases with frequency, due to the imbalance of the *L* and *C* components per unit length.

So loading coils, or 'pots' – so called because the wound toroidal cores are usually enclosed in standard size steel pots – are inserted at intervals, as mentioned above.

Figure 6a) shows the winding arrangement for a loading coil for use on a regular or side circuit. Due to the winding arrangement, the fluxes due to the go and return currents of the balanced signal, in all four winding, add. But the currents in the lines due to a phantom circuit flow left to right in both legs, and produce no net magnetising ampere-turns, and hence no flux. The loading coil is transparent to the phantom circuit, and might as well not be there.

So a phantom uses a modified loading coil, as shown in Figure **6b)**.

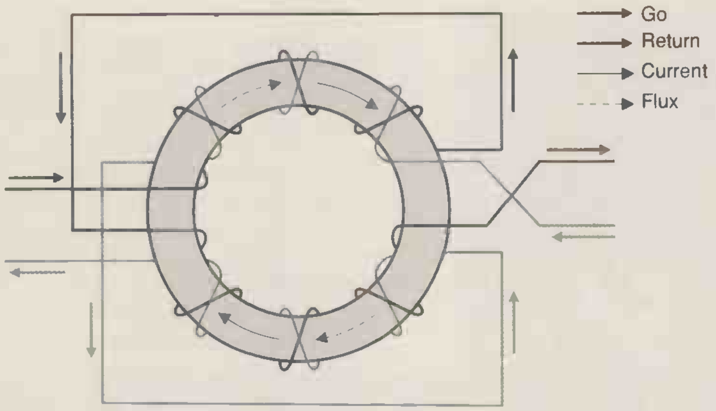
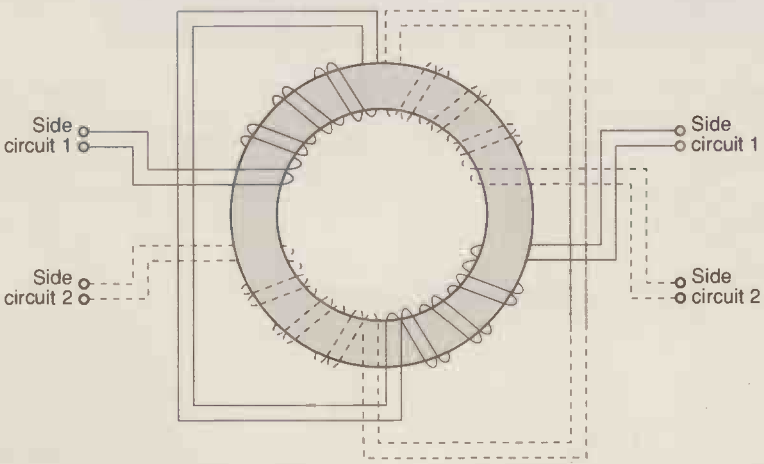


Fig. 6a). Winding of single loading coil, showing directions of current and flux.



b) Windings of a phantom circuit loading coil.

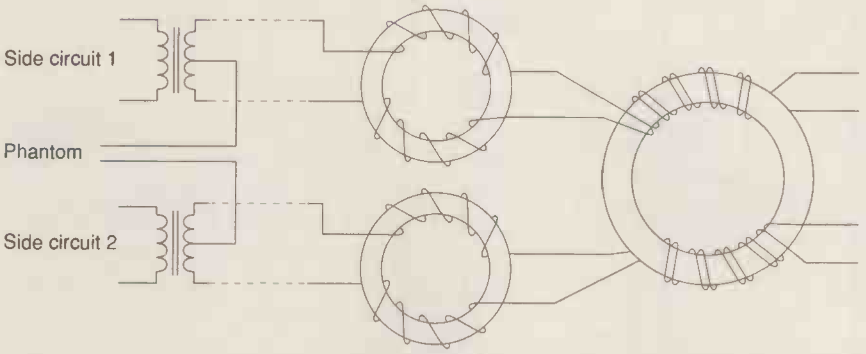


Fig. 7. Arrangement of side and phantom loading coils providing equalisation for all three circuits.

While this is effective for the phantom, it is transparent as far as the side circuits are concerned. So each circuit has its own appropriate form of pot. These are connected as in **Fig. 7**, providing the necessary equalisation for all three circuits.

And nowadays?

I am not sure to what extent the military still uses field telephones, D8 and/or field quad etc. in these days of satellite communications and jamming-resistant radios using frequency hopping or direct sequence spread spectrum.

While the security offered by digital radios makes exploitation difficult, thanks to encryption with regular frequent key changes, there nevertheless remains the aspect of security against jamming. Wireless links operating in the absorption band can provide security, but then so can landlines, and nowadays these can offer almost unlimited bandwidth if engineered with optical fibre technology.

But line communications are still very important in the civilian workplace nowadays, not only for telephony, but for digital traffic of all sorts, including LANs and WANs. I am experimenting with ways to transmit several independent digital data streams over one or two pairs, and hope to report results soon. Watch this space. ■

Acknowledgments

Most illustrations in this article are reproduced from the Handbook of Line Communication, Vol. I, with permission.

References

1. A Short History of Technology, Terry & Williams, Oxford at the Clarendon Press, 1960.
2. Handbook of Line Communication, Vol. I, HMSO London, 1947.
3. Transmission Systems for Communications, Bell Telephone Laboratories Inc, 3rd Ed. 1965.

Cool solutions

Peter Davies of Warth explains how to get the most out of modern high-performance alternatives to the traditional mica and grease solution.

Good heat sink design is important since, quite simply, the cooler electronics components run, the longer they last. For heatsinks to perform optimally, the temperature difference between the heatsink and the surrounding air must be at a maximum. If there is a continual supply of new cooled air passing over the sink, the maximum temperature differential will be maintained.

It is equally important to ensure that the heat being generated in the device flows through to the heatsink efficiently so the heatsink temperature as closely as possible matches that of the device – again maximising the temperature differential between it and the surrounding air.

Historically, to provide electrical isolation, mica insulators were used with thermal grease to mount transistors to heatsinks – a time-consuming process which had several problems. The mica was prone to cracking and grease often migrated, causing contamination. The grease could also become age hardened. But the development of thermally conductive interface materials like *Kool-Pads*, from Warth International, has changed that.

Heat flow mechanisms

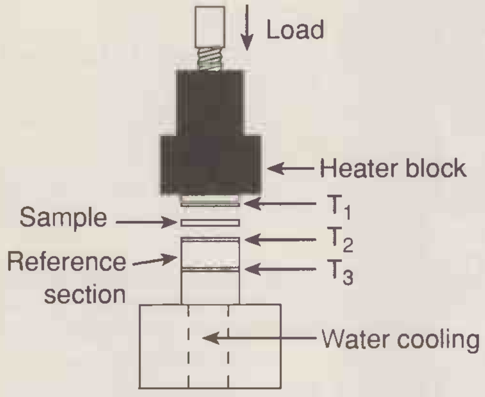
For thermal energy to be able to travel from the power dissipating device it has to cross several interfaces, each having its own resistance to this flow. These are:

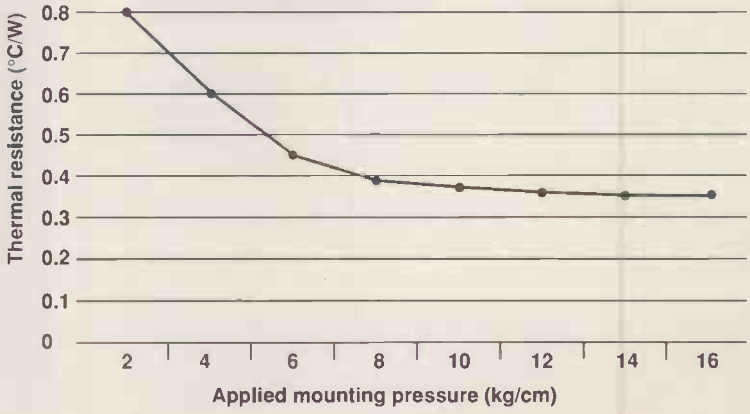
- Device junction to case resistance. This is a function of the design of the device and will be specified by the manufacturer.
- Case-to-heatsink resistance. This is the point that the heatsink and the device meet and is variable.
- Heatsink-to-air resistance. This is the heatsink's ability to dissipate heat to air and is determined by the heatsink selected and is also variable.

Each one of these interfaces has its own thermal resistance figure.

The junction-to-case figure is predetermined by the device manufacturer and so can be only influenced by the device selection. Consequently, as the thermal performance of a device cannot be changed, the design engineer must focus on the other two interfaces. Both of these interfaces will have a critical effect on system reliability.

Fig. 1. Test jig for evaluating thermal conductivity of Warth Kool Pads, top, and curve showing how pressure affects thermal conductivity.





Often, the case of the device that needs cooling needs to be electrically insulated from the heat sink. The insulating material used to provide this insulation determines the second figure – case-to-heatsink resistance. Note that case-to-heatsink conductivity can also be improved by adding the right interface material since it removes thermally insulating air pockets.

The better the thermal interface, the easier the flow of thermal energy to the heatsink. It is vitally important to select a thermal interface pad with performance criteria matching the requirements of the application.

The third interface is determined by the heatsink selection. This is not as simple as it sounds. The obvious solution is to put the biggest heatsink available on the device, but space restriction becomes ever more important as electronic equipment continues to get smaller and smaller.

For design engineers, accurate calculation of thermal conductivity, thermal resistance and mounting pressure is crucial to optimum performance and product reliability. Warth has devised a series of formulae to be used in conjunction with its products to optimise accurate calculation.

Calculating thermal conductivity

Thermal conductivity is the measure of the ability of a material to allow heat to flow through it. It is normally expressed as $Wm^{-1}K^{-1}$. The higher the figure quoted, the better a material will perform.

All Warth calculated figures are achieved by clamping a 2.54cm^2 sample between two isothermal layers, as shown in the **Fig. 1**. Here, pressure is maintained accurately with a ram air cylinder.

The temperature differential across a calibrated stainless steel reference, T_1 and T_2, is compared to the differential across the sample T_2 and T_3 when the materials are in series and equilibrium is attained.

These figures are calculated from the ideal conditions with uniform pressure and one-dimensional heat flow, and are not effected by material thickness and other application variations.

Thermal resistance calculations

Thermal resistance is a measure of the resistance of a material to heat flow through it and is normally expressed in °C/W. The lower the quoted thermal resistance, the better the thermal conductivity.

For a given material, thermal resistance is also proportional to voltage breakdown; consequently high voltage breakdown material often has a higher thermal resistance due to increased thickness and material composition.

In general, thermal resistance is a more practical measure of thermal performance as it is proportional to the thickness of the material. This means that it can be more easily worked into thermal management calculations as heatsink and component thermal performance is normally expressed as a measure of thermal resistance.

Warth calculates its figures by using an aluminium heatsink and TO-3 transistor powered to 20W. An aluminium spacer is placed between the transistor and the heatsink which spreads the heat over the whole test area and distributes the pressure evenly. Thermocouples are embedded in all three components.

The transistor mounting screws are torqued to 0.7Nm giving a mounting pressure of 15kg/cm^2. Thermal resistance is calculated from the temperature difference across the insulator divided by the power dissipated, **Fig. 2**.

To calculate the thermal resistance of a Warth Kool-Pad used with any other component package style, the following equation should be used, **Fig. 3**.

Thermal resistance can be used to calculate the expected junction temperature of a device using, **Fig. 4 & 5**.

Mounting pressure

The mounting pressure used in any application has a significant effect on the thermal resistance of the *Kool-Pads*. As the mounting pressure is increased, pockets of air are eliminated and the *Kool-Pad* fully conforms to the surface of the transistor and heatsink.

After this point, any further increase in pressure has no beneficial effect. In some instances, where packages styles like TO-220 and TO-3P are used, the thermal resistance could actually increase. This is due to the single mounting screw being located at one end of the transistor and causing a cantilever effect. These package styles are best mounted with a clip specially designed for use with the *Kool-Pads*.

For custom Kool-Pads, the following equation can be used to calculate the recommended mounting pressure, **Fig. 6**.

Take care when assessing the required pressure, as surfaces with rough finishes or burrs can cause cut-through and a breakdown in insulation.-

■

Figs 2-6. Equations needed for evaluating the performance of thermally-conductive component-mounting material.

Thermal resistance $\dfrac{T_S - T_R}{W}$

Where:

T_S is spreader temperature
T_R is heatsink Temperature
W is= power dissipated is watt

Selected Kool-Pad thermal resistance $\theta_{kp} = \dfrac{\theta_s \times K}{A}$

Where:

θ_s is thermal resistance of kool-pad material for standard TO-3 package
K is surface area conversion factor constant of 6.45)
A is component contact surface area (cm^2)

Junction temperature $T_j = (\theta_{jc} + \theta_{kp} + \theta_{sa})Q \times T_a$

Where: θ_{jc} is Junction-to-case Thermal Resistance
θ_{kp} = Kool-Pad thermal resistance
θ_{sa} is heatsink thermal resistance
Q is power dissipated in watts
T_a is Ambient temperature

TO-220 transistor with junction to case thermal resistance	θ_{jc} =1.5°C/W
Heatsink thermal resistance	θ_{sa}=6°C/W
Kool-Pad thermal resistance for standard TO-3 package	θ_s =0.07°C/W
Ambient temperature	T_a =30°C
Mounting surface area of TO-220 case	A =1.5cm^2
Power dissipated	Q =10W
$\theta_{kp}=\dfrac{0.07\times6.45}{1.5}$	θ_{kp}=0.3
T_j=(1.5+0.3+6)×10+30	T_j =108°C

$P = \dfrac{T \times N}{0.2 \times D \times A}$

P is pressure is N/m^2
D is fastener diameter
T is torque is Nm
A is contact surface area
N is number of fasteners
friction factor is 0.2.

Details of this month's free cover-mounted sample*

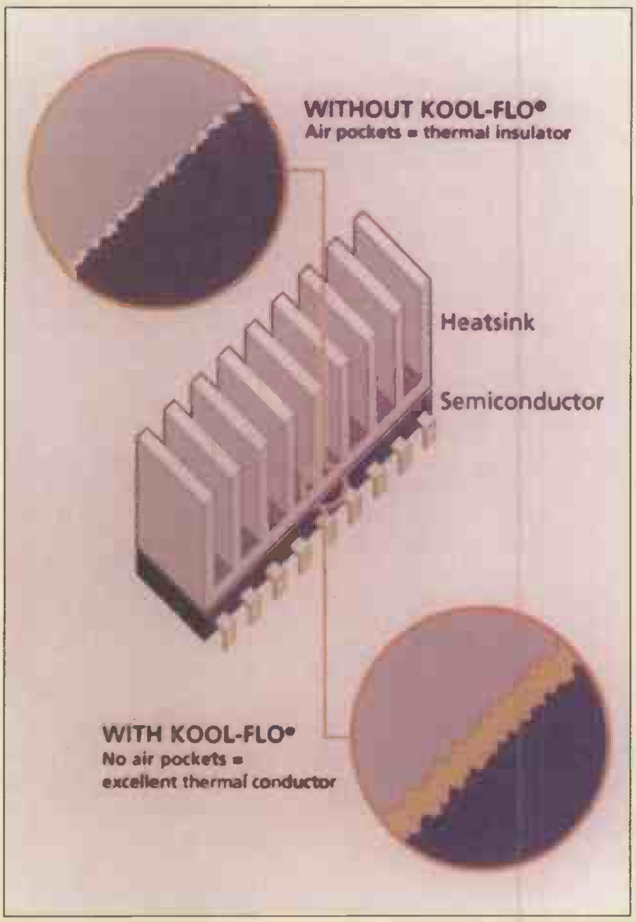
Warth's *K230* thermally-conductive insulating pads

K230 is made from silicone-coated fibreglass cloth in which the silicone is loaded with thermally conductive particles.

It is the type and concentration of the loading that dictates thermal and voltage performance. The greater the loading of particles, the better the thermal resistance and conversely, the lower the voltage breakdown. *K230* is loaded with thermally conductive particles including boron nitride which gives it very low thermal resistance while maintaining a high voltage breakdown. These characteristics make it ideal for applications which need to meet demanding VDE voltage specifications but still require very good thermal performance such as power transistors in high voltage power supplies.

Warth's conducting fillers give a more conformable product so that optimum performance can be achieved with low mounting pressures. This makes the material ideal for applications where transistor mounting clips can be used such as the Warth 'Gull wing' range.

Warth *K230* material attached to the front of this journal has been recently reformulated to give a 10% improvement in thermal performance whilst maintaining its high breakdown voltage.



Air is an excellent insulator. Adding a thermally-conductive pad improves heat transfer between the component and its heat sink by removing the air pockets.

And where insulation isn't needed?

K230 and its family of products are ideal for applications that require electrical isolation. But for applications not requiring isolation, the interface material only needs to take up any irregularities and air gaps existing between the heat generating device and its heatsink. This is because air is a very poor heat-conducting medium and will have a detrimental effect on the performance of the device.

Historically, this type of application would be addressed using thermal grease. But Warth's *CM20* and *Kool-Flo* materials will give excellent consistent heat transfer without the difficulties and silicone contamination associated with using grease.

Kool-Flo – the latest grease replacement product from Warth – is a phase change material which at room temperature is a dry film. When heated to 50°C though, it softens – 'goes through a phase change' – allowing it to flow, filling any voids between the two surfaces.

CM20 is a soft, comfortable graphite sheet which again fills voids, giving a consistent, exceptionally low resistance heat path. It is ideal for high power applications.

Technical support

Based in East Grinstead, the British company Warth International manufactures a wide range of thermally conductive insulators and a multitude of rfi shielding solutions.

Whether for a clip mount processor type application, automotive, telecoms or medical equipment, Warth can solve most thermal interface problems wit standard or custom product.

Warth *Kool-Pads* are available in a comprehensive range of standard package profiles such as TO-3, TO-220 and TO-3Ps or can be quickly and easily cut to any shape required.

You can contact Warth on 01342 315044,

Visit Warth on the Web: **http://www.warth.uk**

Over £600 for a circuit idea?

New awards scheme for circuit ideas

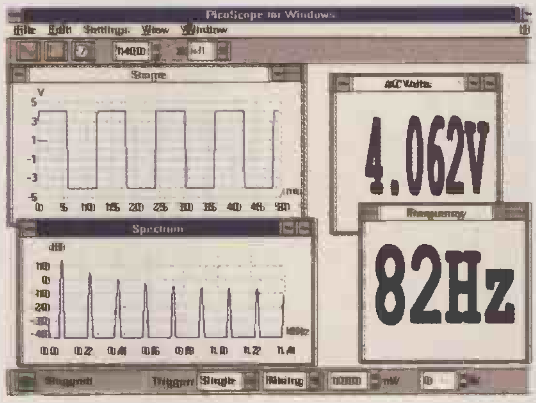
- Every circuit idea published in *Electronics World* receives £35.
- The pick of the month circuit idea receives a Pico Technology ADC42 – worth over £90 – in addition to £35.
- Once every six months, Pico Technology and *Electronics World* will select the best circuit idea published during the period and award the winner a Pico Technology ADC200-50 – worth £586.

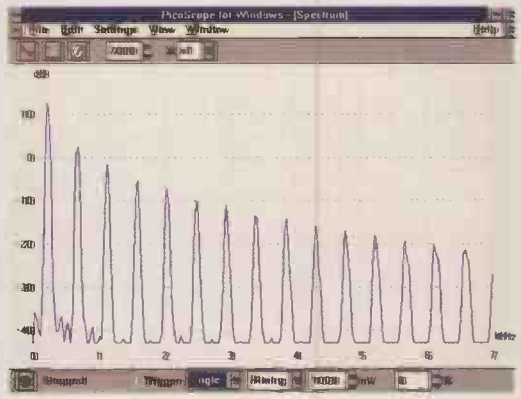
How to submit your ideas

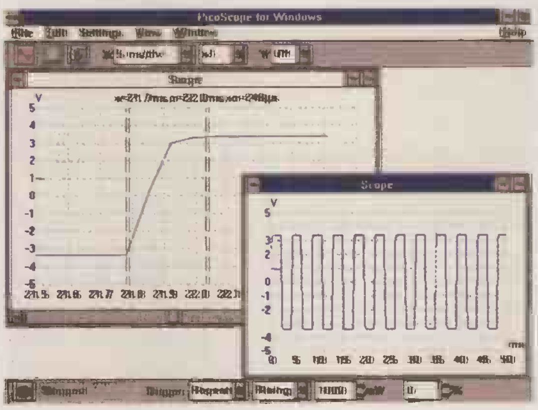
The best ideas are the ones that save readers time or money, or that solve a problem in a better or more elegant way than existing circuits. We will also consider the odd solution looking for a problem – if it has a degree of ingenuity.

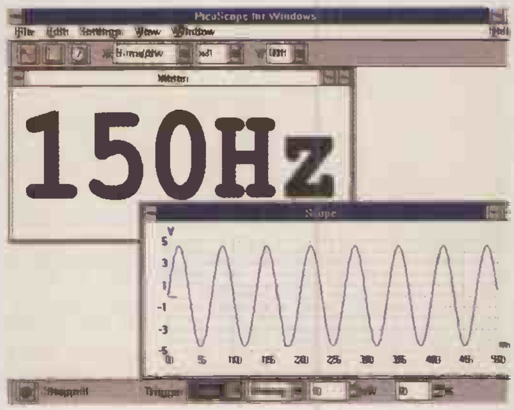
Your submission will be judged on its originality. This means that the idea should certainly not have been published before. Useful modifications to existing circuits will be considered though – provided that they are original.

Don't forget to say why you think your idea is worthy. We can accept anything from clear hand writing and hand-drawn circuits on the back of an envelope. Type written text is better. But it helps us if the idea is on disk in a popular pc or Mac format. Include an ascii file and hard-copy drawing as a safety net and please label the disk with as much information as you can.









Turn your PC into a high-performance virtual instrument in return for a circuit idea.

The ADC200-50 is a dual-channel 50MHz digital storage oscilloscope, a 25MHz spectrum analyser and a multimeter. Interfacing to a pc via its parallel port, ADC200-50 also offers non-volatile storage and hard-copy facilities. Windows and DOS virtual instrument software is included.

ADC42 is a low-cost, high-resolution a-to-d converter sampling to 12 bits at 20ksample/s. This single-channel converter benefits from all the instrumentation features of the ADC200-50.

Variable corner-frequency Sallen & Key low-pass filter

Two analogue switches controlled by a pulse-width-modulation amplifier vary the effective resistance in a Sallen and Key low-pass filter to vary the corner frequency almost down to zero. Switching frequency of the pwm amplifier is far greater than the maximum corner frequency.

In the diagram, $R=R_1=R_2$ and $C=C_2=C_1/2$ and the corner frequency is given by

$f_0=\sqrt{2}/(4\pi RC)$.

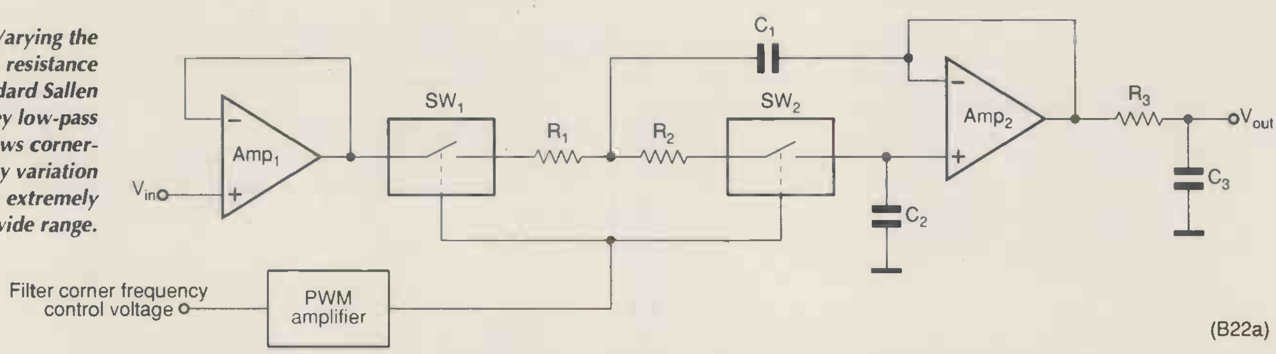
Switching the resistances in and out of circuit at a high frequency by means of the pwm waveform, with a period p and duty cycle d gives an effective resistance $R_{eff}=Rp/d$, which is clearly variable between R and infinity. Substituting R_{eff} for R gives the corner frequency $f_0=\sqrt{2}d/(4\pi RCp)$.

Assuming a linear pwm amplifier, d/p is equivalent to $V_c/V_{c(max)}$, where V_c is the control voltage, so that $f_0=KV_c$ – a linear relationship.

Output components R_3 and C_3 remove high-frequency switching noise.

Andy Little
Penzance
Cornwall
B22

Varying the effective resistance in a standard Sallen and Key low-pass filter allows corner-frequency variation over an extremely wide range.



Replacing an obsolete ram

Faced with the need to replace the ram in equipment, not really all that old, and finding that the ram is no longer available, you have two choices: use an expensive electrically-programmable logic device or use a newer ram with the necessary logic to make a pin-compatible replacement.

This circuit replaces a *74LS189* 16-by-4 bipolar ram, which has been out of production for a year or so, with a 1K-by-4 *7C149* static ram and a 74LS240 octal, tri-state, inverting buffer. No cuts or straps are needed on the original board and the cost is about one-tenth that of an epld method.

Four main points must be mentioned.

- Since the *149* has common i/o lines as opposed to the *189*, which uses separate ones, bus contention on the processor bus during read/write operations is a possibility, if the equipment is a microprocessor-based design.

- Data from the non-inverting *149* must be inverted, to match that from the inverting *189*; hence the use of the inverting buffer.

- Outputs must match. Both types of ram are of the tri-state type and the requirement is therefore met.

- Access time of the *149*, with a typical buffer delay of 10ns, is about 35ns, which is within the 50ns of the *189*.

Address lines A_{0-3} of the 149 address the memory locations, while input lines D_{0-3} from the microprocessor bus are buffered and inverted by the *240*, and then go to the I/O_{0-3} inputs of the *149* whose chip-select and read/write signals come from the original board, as before. Outputs come from the *149* i/o pins.

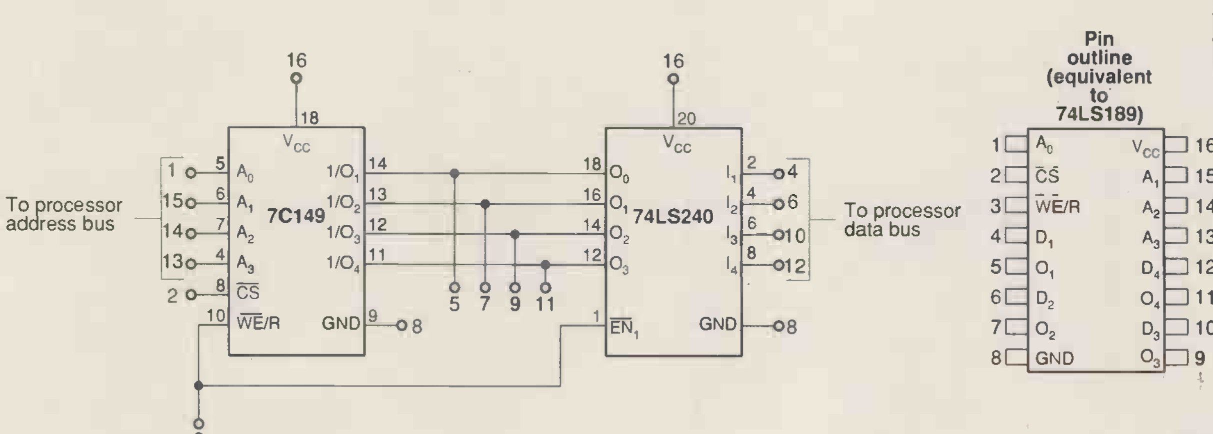
When Write to both chips is low (active), they are enabled and the buffer presents its inverted data to the *149* i/o pins. During a Read, the buffer is disabled and data in the ram is read from pins 11-14. Chip select is low, i.e. active, during both operations.

Both chips are on a card measuring 10 by 8cm – the minimum to allow the use of dil ics. Connections are mapped onto a 16-pin dil package outline equivalent to that of a *189*.

I have successfully used this *74LS189* replacement in a number of designs, including those using microprocessors. It costs much less than an equivalent using a programmable device and is about the same size.

V Lakshminarayanan
Bangalore
India
B20

Replacement for an out-of-production 74LS189 bipolar ram. There are other methods, but this one is inexpensive and may be made on a pin-compatible card. Inputs and outputs are of the same form and access time is lower.



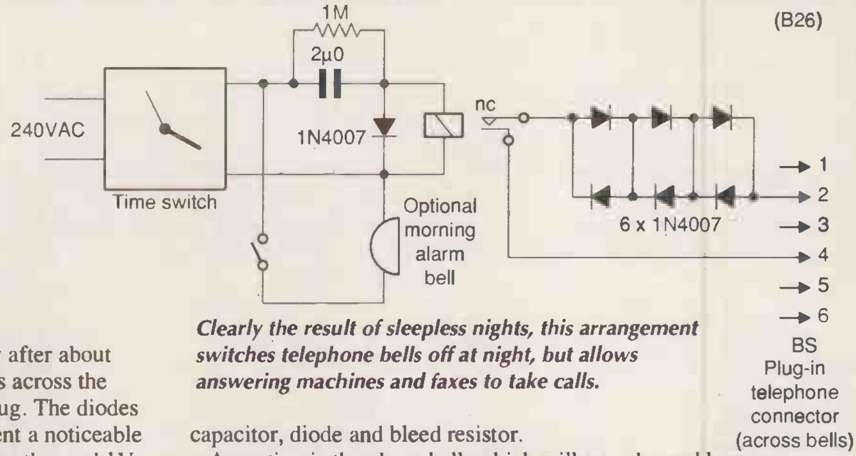
Stop the night-time ringing, but allow the telephone calls

This arrangement stops the telephones ringing at night, but lets fax and answering machines function normally.

A time switch energises the normally closed relay after about half-past eleven and places the two strings of diodes across the "bells" or tone-callers via the standard telephone plug. The diodes clamp the voltage to about 2V, low enough to prevent a noticeable sound but high enough for speech and fax, which mostly need 1V peak. As the relay is wired, no power is needed to silence all the bells, although it may be advisable to adopt the reverse arrangement. Since mains-powered relays are hard to come by, the 12V dc relay takes its power from the 240V ac by way of a capacitor, diode and bleed resistor.

An option is the alarm bell, which will sound – and keep on sounding – when the telephones are enabled in the morning.

HT Wynne
Glasgow
B26



Clearly the result of sleepless nights, this arrangement switches telephone bells off at night, but allows answering machines and faxes to take calls.

ADC42 WINNER

Adjustable lf crossover filter and equaliser

This circuit, using three *MC33172* op-amps, provides as wide a range of lf boost and equalisation as is likely to be needed for speaker crossover use and is both simple and adjustable. All parts of the circuit are familiar in form, but the direct use of a bridged-Tee filter as a crossover component is unusual. It is followed here by a 100Hz, second-order hf filter and a single-section *RC* lf filter.

Useful values are shown in the circuit diagram, with node numbers to assist users of a network simulator; this is much the easiest way to investigate performance, although the band-pass *Q* is pretty optimistic when compared to measured results, which are shown in **Fig. 2**, with the band-pass centre frequency at a nominal 25Hz.

The curves are for the circuit shown, with $R_{(5,0)}$ (i.e. the resistor between nodes 5 and 0) varied from zero to give maximum boost to 1kΩ, 2kΩ, 4kΩ, 8kΩ and 16kΩ. You can vary the band-pass centre frequency by using a dual-gang pot, for $R_{(3,4)}$ and $R_{(4,6)}$, while maximum boost is proportional to the ratio of $C_{(4,5)}$ to $C_{(3,6)}$, modified by the effect of the output l-p filter. During testing, $R_{(0,9)}$ and $R_{(9,10)}$ were open and shorted respectively; gain is slightly increased with them in circuit.

Although response falls quickly below the boost frequency, avoiding the need for an active lf filter to protect the speaker against large vlf input, speaker specifications may not be valid below about 100Hz.

From a 9V rail, the circuit draws about 400µA.

JT Tiernan
Slough
Berkshire
B25

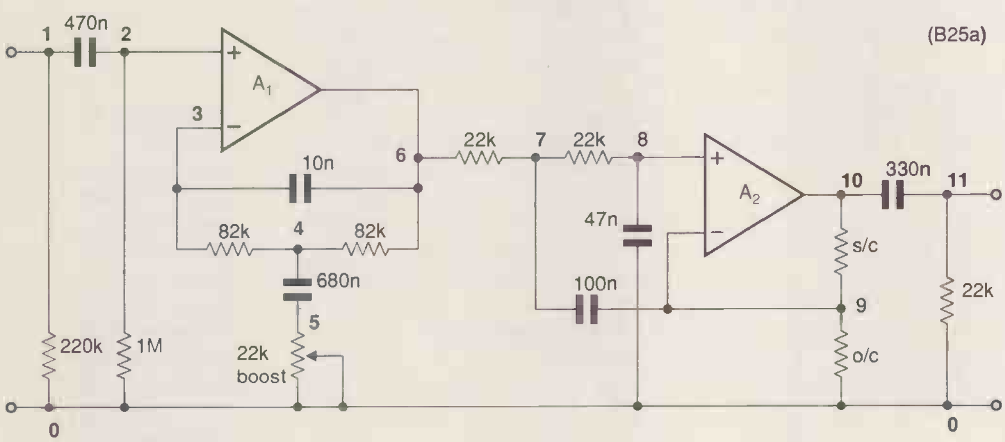
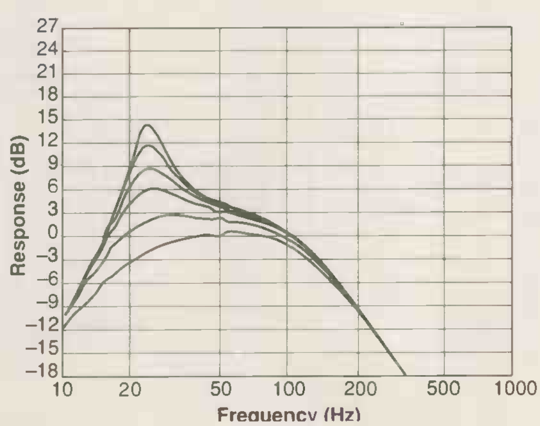


Fig. 1. A bridged-Tee filter is responsible for the boost at a 25Hz centre frequency in this speaker crossover/equaliser, which is adjustable for gain and boost frequency.



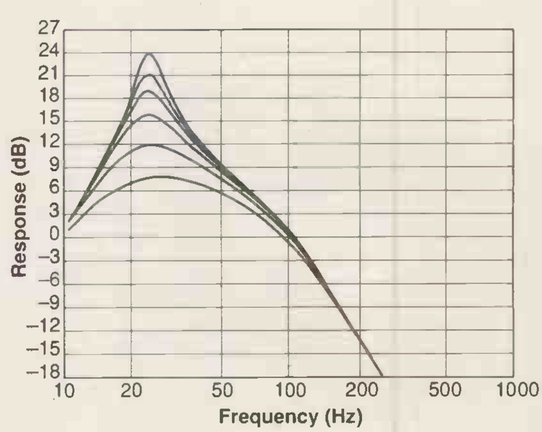
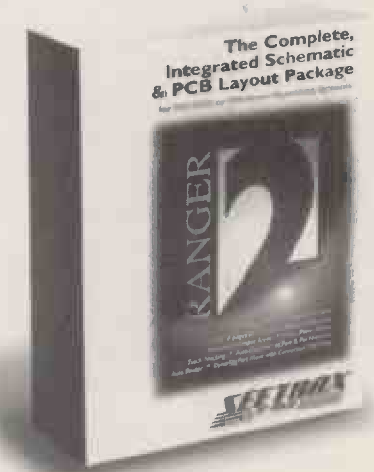


Fig. 2. Measured responses of the Fig. 1 circuit, with variation in the boost potentiometer.

NOW AVAILABLE

RANGER 2 for Windows 95™

Demo Software - available from our Web Address



The Complete, Integrated Schematic & PCB Layout Package

Windows Ranger 2
For Windows 95 & NT

- New Hierarchical Circuit
- Split Devices • Gate & Pin Swap
- New Edit Devices in Circuit
- Copper Fill • Power Planes
- Autorouter • Back Annotation

£350

Ranger 2 Outputs:
Full Windows Outputs
Plus - HP-GL
Gerber
NC Drill
AutoCad DXF

Windows Ranger 2 with Specctra SP2 £600
Ranger & Specctra Autorouter provide the most cost effective PCB Design system available. A powerful, intuitive system at an outstanding price!

Windows Ranger 2 Upgrade £150
Upgrade your existing PCB Package to Windows Ranger 2.

SPECIAL OFFER **Ranger 2 Lite £35** (Prices exc VAT/P&P)

Demo Software -download from **http://biz.ukonline.co.uk/seetrax**

Call 01730 260062

Fax 01730 267273 Old Buriton Limeworks, Kiln Lane, Buriton, Petersfield, Hants. GU31 5SJ

SEETRAX CAE
Advanced Systems & Technology for PCB Manufacture

CIRCLE NO. 115 ON REPLY CARD

TOROIDAL TRANSFORMERS

High Quality Low Prices

In addition to our standard range we will be pleased to quote for your special requirements.

PRICE LIST

VA	Mail Order	Quantity Price Excluding VAT & Carriage 2+	10+	25+	50+	100+
15	14.59	10.21	7.69	5.69	5.52	5.35
30	16.04	11.23	8.45	6.25	6.06	5.89
50	17.83	12.48	9.40	9.95	6.74	6.53
60	18.02	12.61	9.49	7.02	6.82	6.61
80	17.98	12.60	9.49	7.02	6.81	6.60
100	21.07	14.74	11.11	8.21	7.96	7.72
120	21.54	15.08	11.35	8.39	8.15	7.89
150	25.98	18.19	13.70	10.12	9.82	9.53
160	23.83	16.68	12.56	9:28	9.00	8.73
225	30.10	21.07	15.87	11.73	11.39	11.04
300	34.32	24.02	18.09	13.38	12.98	12.58
400	46.19	32.32	24.35	17.99	17.47	16.94
500	50.48	35.34	26.61	19.67	19.09	18.51
625	53.09	41.36	31.14	23.02	21.24	20.57
750	58.39	44.23	33.30	24.62	23.89	23.17
1000	78.80	55.16	41.54	30.70	29.80	28.89
1200	82.45	57.72	43.46	32.12	31.17	30.23
1500	105.10	73.63	55.40	40.94	39.74	38.53
2000	114.45	96.13	72.39	53.51	51.93	50.36
2500	163.04	114.13	85.94	63.51	61.64	59.79

These prices are for 240volt primary and two equal secondaries with 8" colour coded fly leads.
Each transformer is supplied with a mounting kit (steel dish washer pads, nut and bolt)
Mail order prices include vat and postage.
Please do not hesitate to telephone or write with your particular requirements.

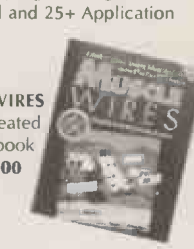
Airlink Sales Co
16 Knight Street, Sawbridgeworth, Herts CM21 9AT
Tel: 01279 600139 Fax: 01279 726379

CIRCLE NO. 116 ON REPLY CARD

CONTROL & ROBOTICS *from* Milford Instruments

BASIC Stamps-
reprogrammable stamp sized computers
Easy to use BASIC language
- 8 or 16 Input/Output lines each 20mA capability
- 80 or 500 Program lines
- Re-programmable thousands of times from PC or Mac
- 5-12vDC Supply. Stamps from **£25.00** each.

Development Kits including programming software, Stamp, Cable, Project Board and 25+ Application notes from **£79.00**.



MUSCLE WIRES
Wires that contract approx 5% when heated (eg 250mA current) -120 page Project book and 3 one metre lengths of wire. **£40.00**

STAMP BUG
Autonomous roving insect using the BASIC Stamp as its "brain". Approx 300mm overall length.
KITS FROM **£29.00**

LYNX ARM
5 Axis robot arm kit; approx size 300mm.
Control from any serial comms port or Stamp.
Includes software to run from PC. KITS FROM **£85.00**

All prices exclude VAT and shipping.
For a full catalogue of the above items and other products, please call or fax Milford Instruments at 01977 683665; Fax 01977 681465.

CIRCLE NO. 137 ON REPLY CARD

Unconventional digital capacitance meter

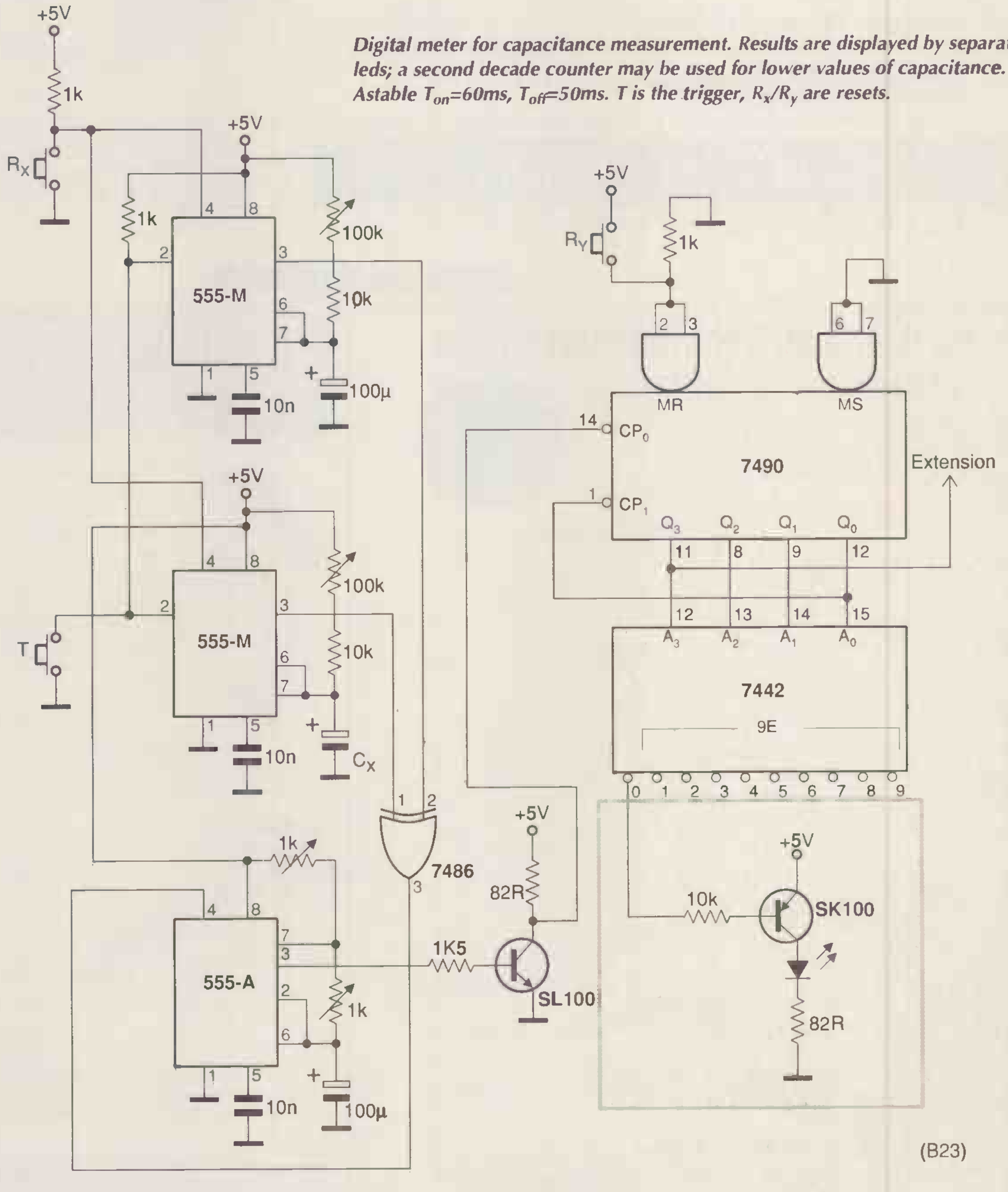
This capacitance meter provides a digital indication and, although the time interval over which pulses are counted is obtained by analogue circuitry, it is easily zeroed for continuing accuracy.

Two *555* monostable flip-flops receive a trigger pulse at the same time by means of a switch. One has a *CR* of 1.1s and the other's timing components are the unknown capacitor and a nominal 110kΩ, so that connecting a 100μF capacitor to the unknown position gives the same output pulse from each flip-flop, after zeroing by means of the pot.

To measure, the unknown is connected and the two output pulses are exclusive-or gated to give the time difference between the two, the resulting pulse gating the third 555 used as a 9.09Hz oscillator. This output is counted down by one *7490*, or possibly two, and the result displayed by the leds after decoding in the *7442*.

If, say, the pulse width of the fixed flip-flop is 11s and the unknown is 95μF, giving a width from the variable flip-flop of 10.45s, the gate time is 11–10.45 = 0.55s. During this time, five pulses from the oscillator are counted down to give 100–5=95μF, the "5" led glowing. Before each reading, the counter and monostables must be reset by the switches; pressing the trigger switch starts an operation.

V Gopalakrishnan
National Aerospace Laboratories
Bangalore
India
B23



Digital meter for capacitance measurement. Results are displayed by separate leds; a second decade counter may be used for lower values of capacitance. Astable T_{on}=60ms, T_{off}=50ms. T is the trigger, R_x/R_y are resets.

ADC42 WINNER

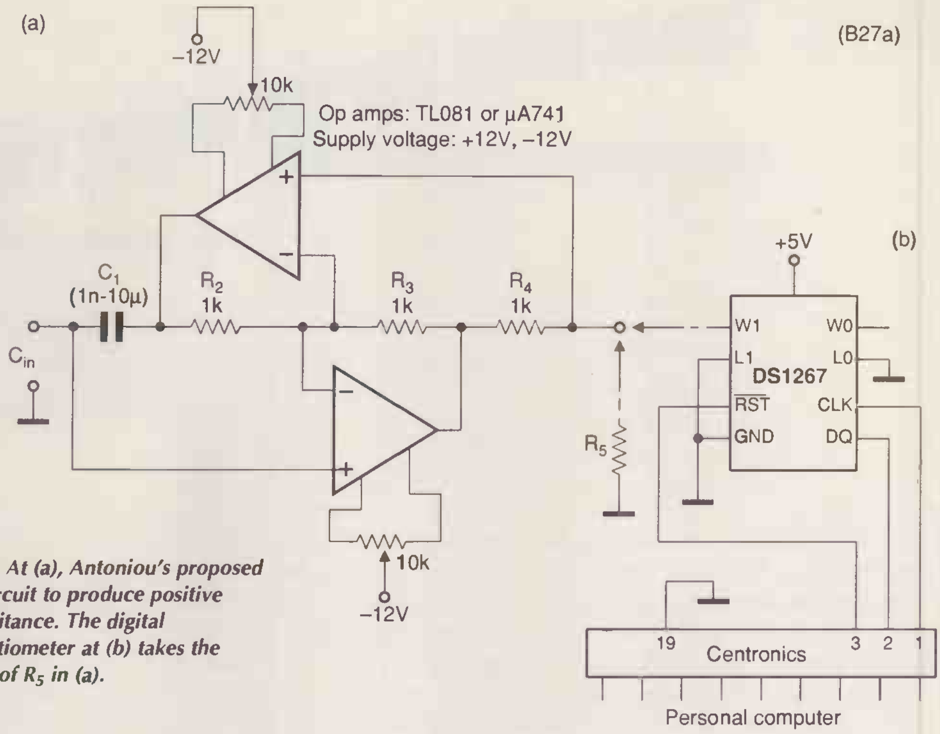


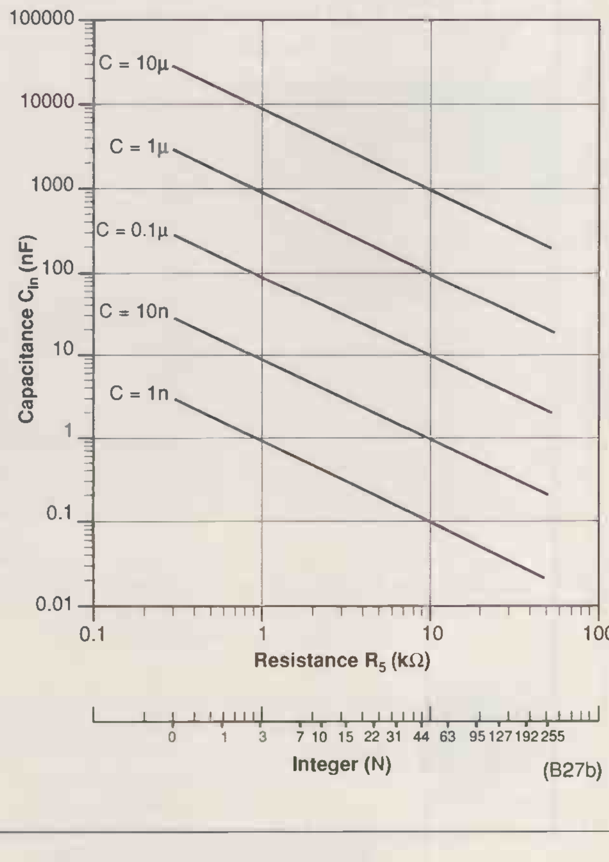
Fig. 1. At (a), Antoniou's proposed gic circuit to produce positive capacitance. The digital potentiometer at (b) takes the place of R_5 in (a).

Digital programming of capacitance

Fig. 2. Effective input capacitance for varying values of C_1 against the value of R_5 and the digital input to the DA1267 from the pc.

Variable capacitance proposed by Dunn[1] and a development described as bipolar programmable capacitance by A R Al-Ali and M T Abuelma'atti[2] are highly sensitive. The arrangement described here, using the generalised impedance converter circuit by Antoniou[3], produces a positive capacitance with a sensitivity of unity.

In the circuit of **Fig. 1**, input capacitance is



determined by

$$C_{in}=C_1R_2R_4/R_3R_5 \qquad (1)$$

Half of the dual digital potentiometer *DS1267/50kΩ* simulates R_5, control being applied over three wires \RST, DQ and CLK from a pc, the resulting resistance in ohms between pins W_1 and L_1 being calculated by

$$R_5=N(50000/256)+300$$

in which N is an integer between zero and 256 placed in the *DS1267* register by the pc. **Figure 2** shows the theoretical result; the largest value obtained was 2000pF.

Using both halves of the *DS1267*, the circuit may be used to tune biquad filters, the resonant frequency of which is,

$$\omega_0 \Rightarrow 1/\sqrt{(C_aC_bR_aR_b)},$$

and

$$Q \Rightarrow \sqrt{(C_a/C_bR_aR_b)},$$

C_a and C_b being connected to W_0/L_0 and W_1/L_1 respectively. If C_a/C_b is kept constant, ω_0 may be varied while Q remains constant.

Lech Tomawski
University of Silesia
Katowice
Poland
B27

References

1. Dunn, J. 'Vary capacitance to positive or negative,' *Electronic Design*, Vol.5, 1991, p. 113.
2. Al-Ali, AR and Abuelma'atti, MT, 'Bipolar programmable capacitor,' *Electronics World and Wireless World*, July, 1995, p. 602.
3. Antoniou. A, 'Realisation of gyrators using operational amplifiers,' *Proc. IEEE*, vol. 116, 1969, p. 1838.

Delivering DVB to the viewers

Digital video broadcasting

1998 is being seen by UK broadcasters as a key year for digital video broadcasting, with satellite DVB expected to be launched shortly and terrestrial DVB this autumn. Pat Hawker examines the techniques and problems faced in delivering DVB signals to the viewers.

With the technical standards for DVB now established and millions of pounds already committed, the entire broadcasting industry is facing its biggest gamble since the change from 405-line vhf monochrome to 625-line uhf PAL. But in the need to ensure a rapid take up of DVB by the public, there is a real danger that expectations of the benefits of DVB may be oversold and the majority of viewers remain committed to their PAL receivers for many years to come.

If the new digital channels are to be taken up rapidly there remain formidable difficulties for those charged with devising marketing strategies that will convince the public that it is worth investing in a new black box which, unless subsidised by broadcasters, industry or government is unlikely initially to cost less than £500.

Marketing surveys suggest that the public may be increasingly reluctant to spend more than about £200. Will anyone be willing to subsidise black boxes to the extent of some £300 per unit?

Digital HDTV is on the back burner

The DVB Project has already put the concept of DVB-HDTV firmly on the back burner, awaiting the development of large 'picture on the wall' displays at reasonable cost, but remains convinced that 'wide screen,' i.e. 16:9 aspect ratio, will have significant appeal despite the large number of UK viewers using small screen sets. Such viewers do not take kindly to the black bars at the top and bottom of their small pictures. Indeed it seems likely that British broadcasters will tend to transmit mainly 14:9 or 4:3 pictures rather than use the full 16:9 provided by the DVB standards.

My previous article 'Digital Video Broadcasting' in the

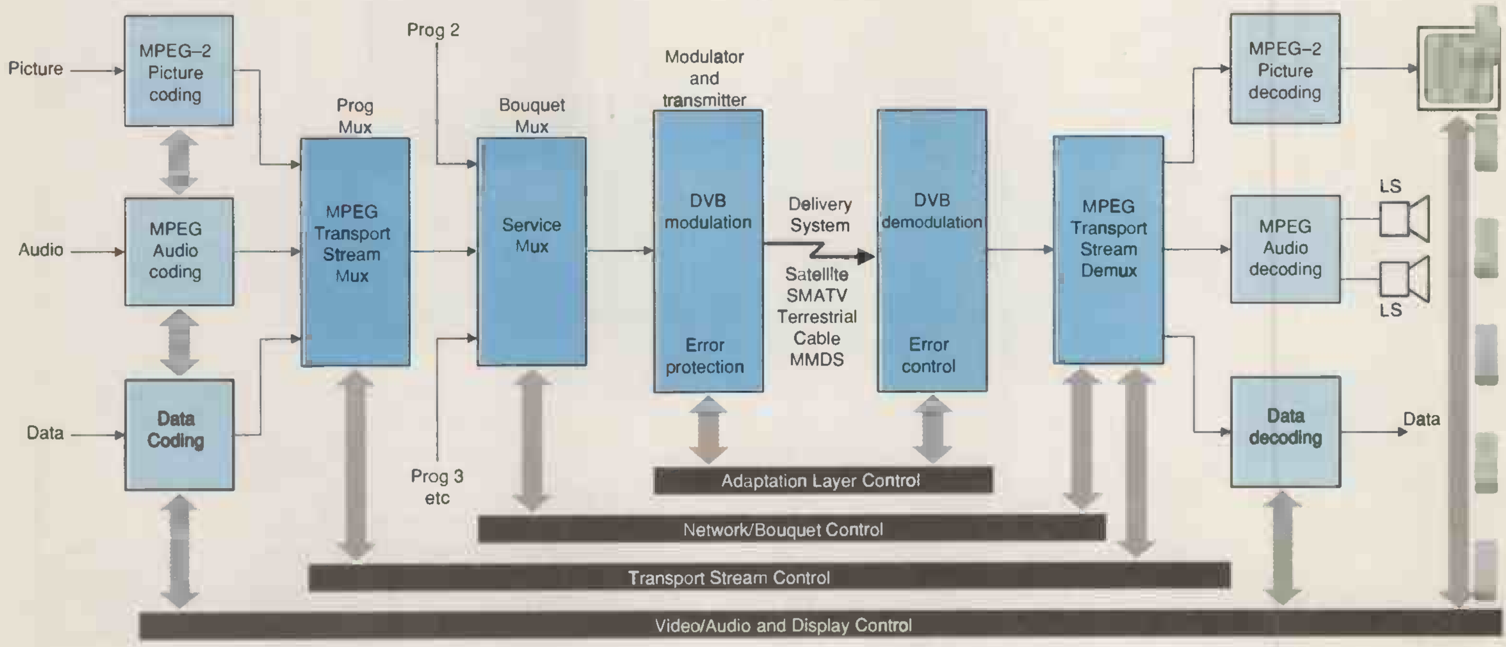


Fig. 1. Overall view of the European digital video broadcasting systems.

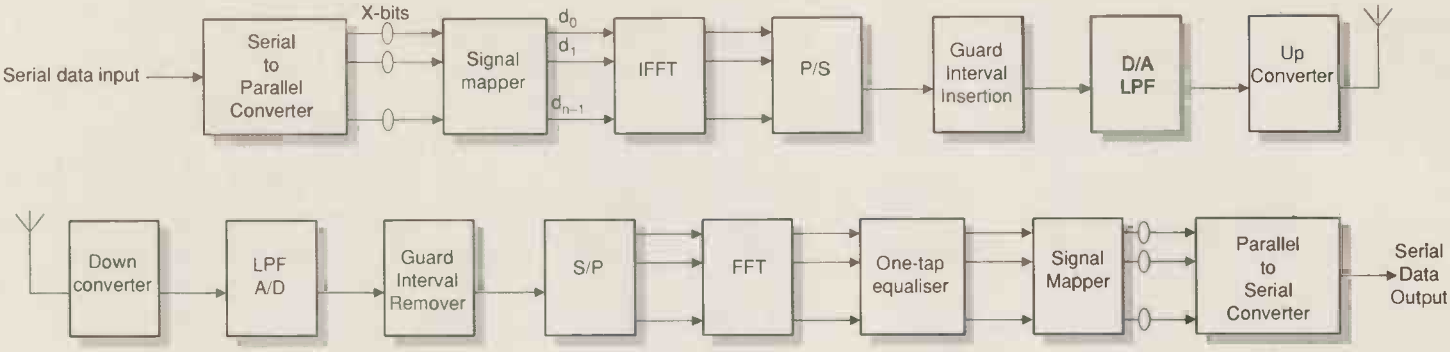


Fig. 2. Basic orthogonal frequency-division multiplexing based on fast-Fourier transform.

September 1997 issue outlined the background to the DVB Project and the attempt to achieve world standardisation for the system. In practice, the committees failed to reach a universal agreement that would have allowed viewers to use the same tv in any part of the world.

What has been standardised, is the use of the MPEG-2 video and audio compression systems discussed in the earlier article. The differences between the European and the American approaches were outlined and remain formidable. This article is primarily concerned with the European systems.

Background

For convenience, Fig. 1., providing an overall view of the European digital video broadcasting systems is shown again although here we are concerned primarily with the delivery of the digital data to the viewer.

MPEG-2 coding, service information and some error correction processes are common to terrestrial, satellite and cable DVB but the way in which digital signals are conveyed to the receiver differs. This is to take account of the different channel bandwidths, signal-to-noise-ratios, potential interference and multipath conditions.

Both DVB-S and DVB-C modulate single carriers. Satellites use conventional qpsk, or quadrature phase shift keying, while cable systems use quadrature-amplitude-modulation, i.e. QAM, 16, 32 or 64 levels. Terrestrial DVB-T uses multi-carrier coded orthogonal frequency division multiplex, or COFDM, with each carrier using 4, 16, or 64 QAM.

Transponder bandwidth of current BSS and FSS satellites in Europe ranges from 26 to 72MHz. The next generation of satellites for direct-to-home television should generally use 33MHz transponders.

The bit-range that can be supported by a 33MHz transponder will depend on the extent of forward error-correction rate, varying from about 24Mbit/s with a rate of 1/2 to 41.6Mbit/s with the 7/8 rate. For a 33MHz transponder, the system with a 2/3-rate inner code has a bit rate of about 34.368Mbit/s after Reed Solomon coding (RS 204,188), corresponding to a standard telecommunications bit rate.

Multipath considerations

The satellite channels are relatively clean and free of multipath propagation, with only moderate variation in signal strength due to rain attenuation. This permits a high data rate of up to about 40Mbit/s with eight-level QPSK modulation of a single carrier.

For terrestrial channels of 7 or 8MHz bandwidth, a digital multiplex of about 20Mbit/s has to be delivered in the available channels – often those 'taboo' to existing PAL networks – subject to significant multipath, co-channel and adjacent-channel interference. European broadcasters have decided that these problems can best be overcome by the use of COFDM.

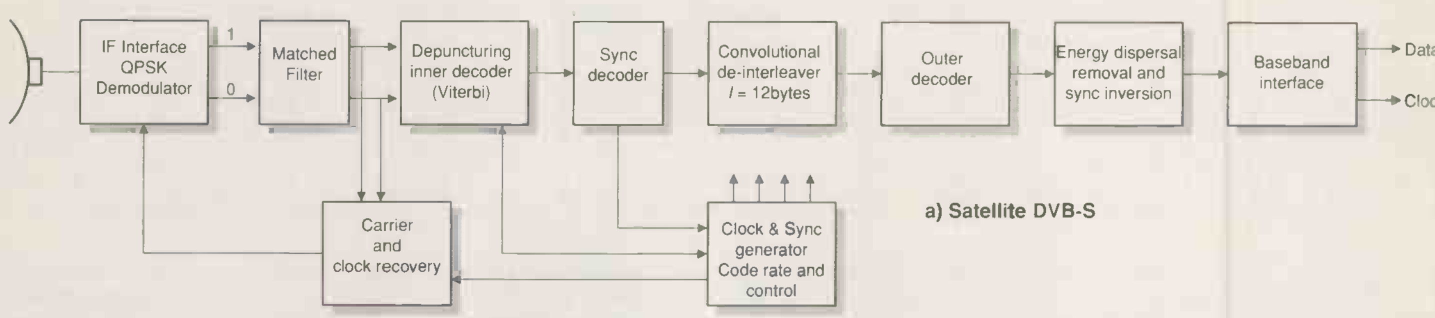
Versions of OFDM have been used for several decades for data transmission and the technique has been adopted in Europe for digital audio broadcasting. Its use for digital television has resulted from a series of European experimental projects including SPECTRE from IBA/NTL, HD-DIVINE from the Nordic countries, dTTb via the European Commission and STERNE and DIAMOND from France.

American broadcasters have taken a different route in settling on single-carrier eight-level vestigial sideband, or

Table 1. Summary of specifications for DVB-S, DVB-T and DVB-C – with main options.

System	DVB-S	DVB-T	DVB-C
ETSI standard	ETS 300 421	ETS 300 744	ETS 300 429
Frequency	11/12GHz	UHF Bands IV/V	8MHz channels
Modulation	Single-carrier	Multi-carrier OFDM (2K/8K)	Single-carrier
Mode	QPSK (6-QAM)	4/16/64 QAM	16/32/64 QAM
Inner code	Convolutional Viterbi decode 1/2, 2/3, 3/4, 5/6, 7/8		None
Inner interleaving	None	PRSB	None
Equalisation	not strictly necessary	guard interval & channel extender 1-tap equaliser per carrier	Important
Symbol rate, R_s	Selectable	About 1kHz for 8K, about 4kHz for 2K	Selectable
Signal spectrum	Square-root raised cosine roll-off 35%	Rectangular signals, unfiltered carriers	Square-root raised cosine roll-off 15%
Total bandwidth	$1.35\times R_s$	7.61MHz	$1.15\times R_s$

Notes: DVB-CS transmission via SMATV: ETS 300 429.DVB-SI service Information:
ETS 300 468.DVB-TXT fixed format teletext: ETS 300 472.PSRB = pseudo-random binary source.



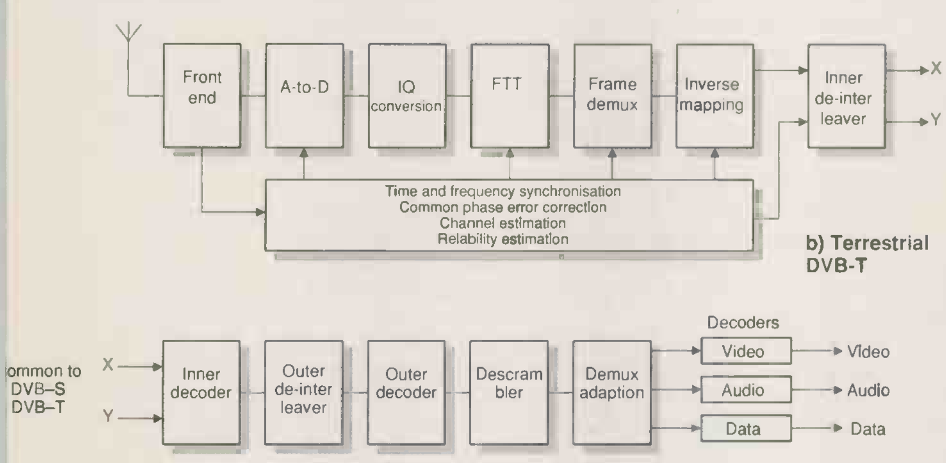


Fig. 3. Digital video broadcasting receiver concepts.

8VSB, modulation which has a spectral efficiency roughly equivalent to 64QAM COFDM but is more vulnerable to multipath and interference.

The basic concept of OFDM for telegraphy dates from the sixties. The use of parallel data transmission and frequency division multiplexing with overlapping subchannels avoids the need for high speed equalisation and combats impulsive noise and multipath distortion. The Foreign Office 'Piccolo' multitone radioteleprinter system, US military systems KINEPLEX, ADEFT and KATHRYN were early examples.

Towards cheaper OFDM

As the number of subchannels is increased, arrays of sinusoidal generators and coherent demodulators become too costly and complex. In 1971, Weinstein and Ebert showed that the discrete Fourier transform, or DFT, could be applied to parallel data transmission systems as part of the modulation and demodulation processes. This eliminated the banks of subcarrier oscillators and coherent demodulators formerly required.

With modern vlsi technology, a complete OFDM system can be implemented using high-speed, large-sized fast Fourier transform (FFT) and inverse FFT chips at acceptable cost. **Figure 2** shows a basic OFDM system.

A parallel data transmission system overcomes many of the problems encountered with high-speed serial data. It not only slows the rate of each data stream but has the advantage of spreading out a frequency selective fade over many symbols. This effectively randomises burst errors, permitting reconstruction of most symbols without forward error correction.

Orthogonal FDM is thus basically a means of transmitting a high data-rate bit-stream by modulating many carriers in parallel, each at a comparatively low data rate. The carriers are modulated by symbols comprising 'square pulses' resulting in a sin x/x-spectrum for each individual carrier. Carrier frequencies are chosen to mutually orthogonal over the symbol period, i.e. an integer number of cycles of the carrier fit into the symbol period.

The spectra of the modulated carriers overlap, resulting in a near-rectangular spectrum with a spectral efficiency theoretically the same as that of an equivalent single carrier system.

Separating orthogonal signals

Orthogonal signals can be separated at the receiver by correlation techniques so that intersymbol interference among channels can be eliminated. This is achieved by carefully selecting carrier spacing, including letting the carrier spacing equal the reciprocal of the useful symbol period. With a guard interval between successive symbols, carrier selectivity and multipath propagation need cause no inter-symbol interference.

If the guard interval is sufficient it becomes possible for all transmitters carrying a specific multiplex to use the same frequency. This is called single-frequency network or SFN. In short, OFDM is a form of multicarrier modulation where the carrier spacing is carefully selected so that each subcarrier is orthogonal to adjacent subcarriers.

The DVB-T standard offers a range of options, both in modulation and inner code rate, **Table 1**. The OFDM frame structure consists of 68 symbols. Each symbol comprises a set of 1705 carriers in the '2K mode' and 6817 carriers in the '8K mode'.

For a national DVB-T SFN based on existing sites – ie with main transmitters spaced about 60km apart and transmitting the same programmes – a guard interval of about 260μs is needed. This can be achieved in an OFDM system with a carrier separation of about 1kHz in an 8MHz channel, roughly 8000 carriers. For the 8K system, the guard interval is 224μs and is suitable for large-area SFNs with transmitter separation distances of some 40 to 60km.

Regional or national?

However, tv broadcasting in the UK has traditionally been based on a regional rather than a national basis, with regional opt-outs for commercial purposes even on channels nominally transmitting a nationwide programme. Consequently, the UK has chosen the '2K mode'.

With 2K the maximum guard interval is 56μs and is thus suitable only for gap-filling relay transmitters separated by not more than about 10-20km; the UK specification has a guard interval of only 7μs.

Within the UK, the DVB-T COFDM systems will be based on the following sub-set of ETS 300 744: Number of carriers 1705 ('2K'); carrier spacing 4464Hz; modulation 64 QAM;

Digital television glossary

ACATS – Advisory Committee on Advanced Television Systems (USA)
ATV – advanced television
BAT – bouquet association table (part ofSI)
BER – bit error rate
B-pictures – bidirectionally predictive pictures (motion compensation)
BRR – bit-reduction rate.
CA – conditional access
CAT – conditional-access table (part of SI)
COFDM – coded orthogonal frequency-division multiplexing
CPE – common phase error
DAB – digital audio broadcasting
DBPSK – differential binary phase-shift keying
DCT – discrete cosine transform
DPCM – differential pulse-code modulation
DTT – digital terrestrial television
DVB – digital video broadcasting, suffixed S for satellite, C for cable, T for terrestrial, CS for SMATV, TXT for fixed-format teletext and MS for MMDS.
EBU – European Broadcasting Union
EIT – event information table (part of SI)
EPG – electronic programme guide
ETS – European Telecommunication Standard
ETSI – European Telecommunication Standards Institute
FEC – forward error correction
FFT – fast Fourier transform
GOP – group of pictures (motion compensation)
IBC – International Broadcasting Conference
ICI – inter-carrier interference
IDCT – inverse discrete cosine transform
IEC – International Electrotechnical Commission
I-pictures – intra pictures (motion compensation)
IRD – integrated receiver decoder
ISO – International Standardisation Organisation
ITU – International Telecommunication Union
MMDS – multichannel, multipoint distribution system, alternatively, multipoint microwave distribution system
MPEG – video bit-rate reduction systems determined by the Moving Picture Experts Group
NIT – network information table (part of SI)
OFDM – orthogonal frequency division multiplexing
PAT – programme association table (part of SI)
PMT – programme map table (part of SI)
P-pictures – predictive pictures
PPV – pay-per-view
PRBS – pseudo random binary sequence
PSI – programme-specific information (part of SI)
PSP – programme service provider
QAM – quadrature amplitude modulation
QEF – quasi-error-free
QPSK – quadrature phase-shift keying
RLC – run-length coding
RS – Reed Solomon error protection
RST – running status table (part of SI)
SDH – synchronous digital hierarchy
SDT – service description table (part of SI)
SFN – single-frequency network
SI – service information, or housekeeping details added on to the video, audio and/or multi-media data stream
SMATV – satellite master antenna television
SMS – subscriber management system
ST – stuffing table (part of SI)
TDT – time and data table (part of SI)
TOT – time offset table (part of SI)
TPS – transmission-parameter signalling
TS – transport stream
VLC – variable-length coding

outer coding (R_c) 2/3; duration (T_u) 224μs; guard interval (delta/T_u) 1/32; duration of guard interval (delta) 7μs; symbol duration (T_s=T_u+δ) 231μs; value of carrier k_{min} 0; value of carrier k_{max} 1704; spacing between carriers k_{max} and k_{min} 7.61MHz.

Figure 3 shows how receivers for DVB-S satellite and terrestrial DVB-T digital video broadcasting might be implemented. A fully integrated set for terrestrial, satellite and cable DVB would need three front-ends, although the main digital processing circuits would be common.

Potential problems

Despite the extensive field trials carried out for the early digital terrestrial projects such as SPECTRE, it remains to be seen whether consumer receivers based on low-cost vlsi chip sets will in practice prove entirely satisfactory for the reception of 64 QAM which demands high stability and very low phase-noise of the oscillators.

Again, while COFDM provides a measure of protection against the sharp boundary between the 'go' and 'no-go' of conventional digital systems, there may still be sudden drop outs of synchronisation of the coherent demodulators in fringe areas during severe conditions of 'tropolift,' etc. Past experience of the reception of teletext and NICAM signals shows that problems can arise with high-speed data signals which COFDM will need to overcome.

A significant problem will arise if dealers sell DVB to viewers outside the recommended 'service area' of the local DVB transmitter. Whereas the long-established UHF PAL service areas have required that the signal-to-noise ratio, or snr, at the receiver should be at least 40dB to achieve a substantially noise-free picture, digital transmissions can provide a noise-free picture with an snr of l0dB.

Theoretically, this feature of digital transmissions allows the transmitter power to be 1000 times lower. In practice, DVB service areas are being based on an snr of about 15dB to provide a margin for the inevitable diurnal and seasonal changes in uhf propagation. These are due to things like foliage and temperature, tropospheric lift, and seasonal changes.

Past experience however suggests that retailers competing for sales will result in DVB receivers often being installed outside the intended service areas, provided that on installation they achieve the bare 10dB or so snr.

Will DVB get a bad name?

Whereas with analogue PAL out-of-area reception usually results with propagation variations only in an increasingly noisy picture or co-channel interference patterning, with DVB it will lead on some days at some times in some seasons to complete loss of synchronisation and total absence of picture. This could result in DVB-T soon acquiring an unfortunate reputation for unreliability.

Even if dealers steer viewers away from installing out-of-area DVB-T sets – an unlikely event in a competitive market – there is still the problem that viewers move houses taking their sets with them.

One of the marketing strategies likely to be evident is that with OFDM, the use of simple indoor antennas will not result in the bad ghosting so often present in such circumstances with PAL signals. But this freedom to use 'rabbit ears' antennas will still require strong signals and will not be universally applicable. Viewers expecting to be able to use set-top aerials in weak signal areas will be disappointed.

Interference issues

Potentially even more serious is the likelihood that DVB-T transmissions in the 'taboo' UHF channels will cause interference to the reception of existing PAL transmissions – particularly to NICAM signals.

Remember that in Europe, virtually every uhf channel is already in use by many hundreds of transmitters. It has been reported that a survey carried out by the ITC estimates that over 60% of the planned DVB-T transmissions could potentially affect existing channels in their fringe (out of area), despite the much lower powers of the digital transmitters.

While, as in the case of the Channel 5 retuning of video recorders, it may prove possible to eliminate the interference in all but a tiny minority of cases, nevertheless it could present a difficulty initially. The problem may be much reduced by the use of 'offset' frequencies at the transmitters, although agreement has yet to be reached on the optimum offset.

You may recall that when teletext data test transmissions were initiated from 1972 onwards, broadcasters received many complaints from viewers of visible interference to pictures due primarily to frame fold-over in some receivers, or intermodulation in transmitters or their re-broadcast (RBR) links.

High-speed digital data transmission in telecommunications has frequently resulted in unforeseen problems. It is an open secret that digital distribution links for television have not always achieved 100% reliability.

In the February 1997 issue of *RF Design*, editorial director Don Bishop wrote:

> *"Digital modulation holds the promise to solve all electronic communications problems, from telephones to television to computer networks and beyond. Or does it? Support for digital comes in a shout; criticism of digital comes in a whisper... Expectations have been quietly revised downwards..."*

By the December 1997 issue, the same writer was reflecting increasing American scepticism of DVB:

> *"Digital television faces obstacles. Maybe [American] broadcasters only cooked up DTV as a way to fend off competing industries from sharing unused [American] UHF-TV channels. It worked but at a price. One form of DTV, high-definition TV received FCC attention. The FCC assigned. channels and set a timetable for conversion. Manufacturers have had to plan for possible HDTV receiver sales, yet sales of current-technology receivers fell as consumers worried about obsolescence. Broadcasters saw a capital-equipment, cash-eating monster that would produce no extra revenue. HDTV and its cousin, multichannel DTV, started going nowhere, fast. No one seems to have a workable business plan."*

The situation is far less pessimistic in Europe although some doubts remain. Broadcasters hope that more "pay-as-you-view channels" may result in significant extra revenue. Governments still see future potential in freeing uhf spectrum that could then be 'sold' to other telecommunications services – although there can be little real expectation of this happening for many years to come. Industry seeks a new opportunity to market high-cost consumer electronics to counter the longevity of current tv receivers, now often lasting 15-20 years or so. There is the belief that "digital" is still a sellable technology, with analogue considered obsolete by the public, even if secretly recognising that the digital pictures will in practice show little or no improvement over current PAL pictures received in strong signal areas, and in some respects may be worse.

The major uncertainty

But the major uncertainty facing DVB broadcasters is the time it will take for the majority of viewers to equip themselves with digital set-top units or integrated digital satellite/terrestrial receivers.

Do viewers really want much more choice? After more than a decade of satellite and, cable – and with video recorders in most homes – only a quarter of UK viewers have opted for the additional choice offered on the air-waves or by cable.

A far greater proportion have adopted the video recorder. Will they want the even greater choice offered. by going digital – unless virtually forced to do so by finding whole classes of programming, such as sport, available exclusively on digital pay-tv channels? Or by a government edict that analogue transmissions must cease by a given date?

It will take a brave government to tackle such a politically explosive question until the vast majority of viewers are watching DVB. Always present at the back of the minds of the industry is the commercial failure of MAC and the whole concept of HDTV which for the past 15 years was hailed as the way ahead.

Above all, programming rather than technology rules the television roost. And more does not necessarily mean better.

Acknowledgments and further reading

Information for this article and also for "Digital tv broadcasting" (*Electronics World*, September 1997), has been drawn freely from the Draft ITC Rules of Operation on the use of the DVB-T Specification (31 October 1996) and from articles in *EBU Technical Review* No 266 Winter 1995 by D Wood, Dr S R Ely, J Sessena and L Grete Moeller; from an article in *ABU Technical Review* No 165, July-August 1996 by Dr Mario Cominetti & Dr Alberto Morello; from *"COFDM: An Overview"* by William Y Zou & Yiyan Wu (*IEEE Trans Broadcasting*, March 1995; and *"Performance Evaluation of MPEG-2 Video Coding for HTITV"* Daniel Lauzon et al, Communications Research Centre, Ottawa (IEEE Trans Bcstg, June 1996). Also acknowledged is the 1998 Annual Lecture of the IEETE/IPRE *"Digital television - the technology and the impact on the viewer"* by Jim Slater, consultant to the Digital Television Group.

575

SPEAKERS CORNER

Loudspeakers are doomed to be inefficient and heating will frequently be an issue. Here John Watkinson considers what can be done to prevent and remove it.

Moving air to make sound usually requires some kind of diaphragm. The problem with air is that its density is so low that the mass of the diaphragm swamps the mass of the air affected.

Consequently most of the energy used by a loudspeaker goes into accelerating the diaphragm and the sound produced represents a very small percentage of the input. For this reason loudspeakers are doomed to be forever inefficient.

Some years ago, when amplifier power was limited, all kinds of tricks were used to improve efficiency – many of which did nothing for fidelity. Today, audio amplification is almost free with the power supply so the efficiency issue is less important, except in battery powered equipment.

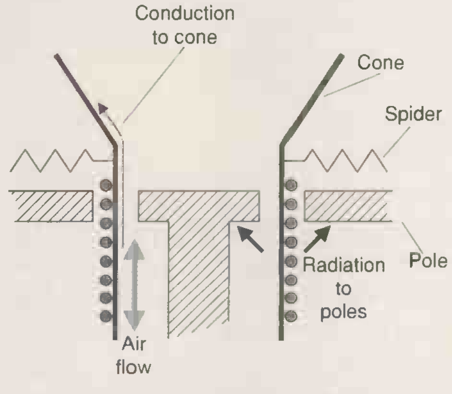


Fig. 1. Loudspeaker voice coil cooling mechanisms.

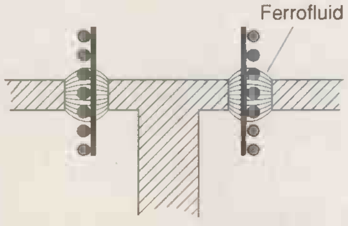


Fig. 2. Ferrofluid is a magnetic colloid which is held in the gap by the working magnetic field.

In any inefficient device, the wasted power almost always shows up as heat and the loudspeaker is no exception. The way the heat is dissipated depends on the kind of loudspeaker. In the electrostatic loudspeaker there is no dissipation mechanism in the speaker itself apart from a negligible dielectric loss. The speaker has a high capacitance and the amplifier has to swing charge in and out of that capacitance in order to cause a voltage swing.

Thus in an electrostatic speaker the heat is dissipated in the amplifier and the amplifier cooling has to reflect that. In an active electrostatic hybrid speaker, the panel amplifier could easily dissipate more than the woofer amplifier.

Why is heat a problem?

In the moving coil loudspeaker, most of the energy loss appears as heat in the coil. This is generally detrimental as the coil is well enclosed within the speaker drive unit and is not easily cooled. There are two issues with coil heating. The first – and most obvious – is that excessive heat can do damage. The second is that heating increases the resistance of the coil. This has the effect of reducing the sensitivity of the speaker.

The effect is known as compression. It is most noticeable on transients, where the dynamic temperature rise of the coil actually modulates the current and so distorts the waveform. To an extent, a moving coil speaker is self regulating because as the coil temperature and resistance go up, less power is drawn from a voltage source type amplifier. Consequently your 200 watt cold rated loudspeaker may actually only be working at 100 watts when the coil has fully warmed up.

In conventional voltage driven loudspeakers there is no solution, but in current drive the problem is eliminated. This does, of course, require a specially designed amplifier and is only possible in active speakers. It should be clear that compression is absent in electrostatic speakers, whose distortion proportion is independent of level. In fact where low distortion is a criterion, the electrostatic can be louder than the moving coil.

"Eventually, something gives..."

If the coil cannot cool itself adequately, the temperature has to rise. Eventually something will give. This could be the coil insulation, the glue holding the coil to the former, or the former itself. Although recent developments in former and adhesive materials have allowed coils to run at higher temperatures, this only allows an improvement in reliability. Unfortunately, however, the improved heat resistance of a coil is often used to raise the power rating. This results in even greater thermal compression effects. Consequently a precision loudspeaker for monitoring purposes does not actually need high temperature coil technology except to survive abuse.

It follows that for quality reasons moving coil drivers must be designed with effective cooling measures so that the coil temperature excursion is minimised. **Fig. 1.** shows that the coil can shed heat by radiation and by conduction. Conduction is limited because the coil former is only attached to the cone and the spider. Most spiders are thermal insulators, as are most cone materials, with the notable exception of aluminium cones, which contribute significantly to coil cooling.

Pumping air

Heat can be lost to the air around the coil, but if this is static, the air temperature will simply rise. Some ventilation of the coil area is necessary. The pumping action of the cone or spider or both can be used, but this must be approached with caution. With large excursions, the air flow may become turbulent, resulting in 'chuffing', where the speaker produces program modulated noise. Air passages act in a non linear fashion and partially rectify. At high level, a poorly designed speaker may act as a pump and displace its own neutral point.

Radiation loses heat to the pole pieces and these can be advantageously blackened to improve their absorption. Ultimately, the magnet assembly must shed the heat and this can be assisted with external fins.

The ultimate cooling method is ferrofluid, a magnetic liquid shown at **Fig. 2.** which is retained in the magnet gap by the magnetic field itself and conducts heat to the pole pieces. Loudspeakers cannot use ferrofluid indiscriminately; they must be designed to use it. A speaker designed to use cone pumping for cooling cannot use ferrofluid as the fluid would block the air path. The pumping action would force bubbles through the ferrofluid and make noises. ■

John Linsley-Hood has been taking an in-depth look at the voltage gain and impedance conversion stage of the audio power amplifier, and its effect on overall performance. Included here is a table comparing distortion from four common configurations.

Gain stage investigations

The conventional circuit layout of a solid-state audio power amplifier consists of a voltage amplifier stage followed by an impedance conversion stage, of the general form shown in **Fig. 1**.

Because the input-output linearity of such a design will be less good than desired, negative feedback, or 'NFB', will normally be employed to improve its performance. This will usually take form of an overall output/input feedback path enclosing both the input voltage amplifier and the output impedance conversion stage.

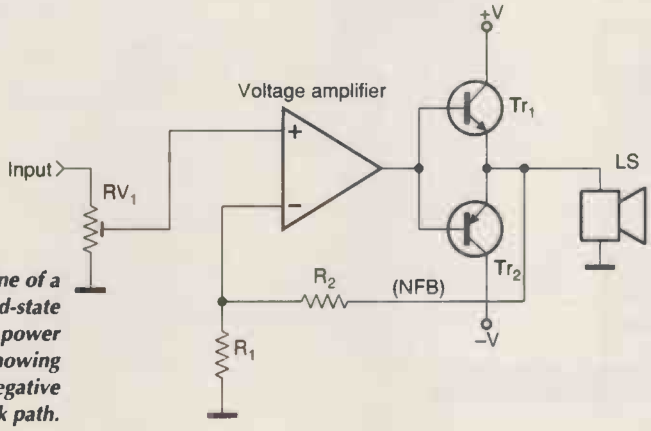


Fig. 1. Outline of a typical solid-state audio power amplifier, showing the negative feedback path.

If the output impedance conversion stage consists of a symmetrical pair of emitter – or source – followers, a fairly typical arrangement, these will, by the nature of their connection, also generate a local negative feedback component. This additional feedback would help lessen the non-linearity due to the output impedance conversion stage.

However the overall linearity of such a system using negative feedback will depend, among other things, on the amount of negative feedback which can be applied. In turn, this will depend on the amount of open-loop gain of the voltage amplifier stage, and the extent to which this exceeds the input to output (closed-loop) gain required from the system.

Feedback and stability

Unfortunately, the application of negative feedback to an amplifier stage can lead to instability, because of unwanted phase shifts in the feedback loop. This phase error, and the consequent likelihood of instability, becomes greater as the number of gain elements in the voltage amplifier section is increased. As a result, it is normal practice to try to obtain the necessary open-loop gain from a two stage amplifier such as that shown in **Fig. 2**. This has simple and predictable phase/frequency characteristics, and can usually accept overall loop negative feedback without introducing instability.

There is, however, some difficulty in obtaining high gain levels from such a simple gain stage, mainly in respect of the sensitivity of arrangements of this kind to the type of output load which is applied. This has sometimes led design engineers to choose voltage amplifier layouts in which the necessary gain is achieved by the use of multiple gain stages. These are connected in cascade within the negative feedback loop. But this solution leads to much more complex hf gain/phase characteristics.

The additional phase shifts will, in turn, require much more elaborate phase compensation arrangements if the final circuit is to be stable. A noteworthy example of a practical circuit of this kind is that due to Lohstroh and Otala (AES 44th Convention, Rotterdam 1973, ref. H6), **Fig. 3**, but this is unusual.

Note that a major consideration in this design was that the high-frequency phase compensation arrangements used should not lead, so far as this is possible, to high-frequency slew-rate limiting. Otala called this 'Transient intermodulation distortion' and it is an inherent design problem in the majority of wide bandwidth power amplifier layouts.

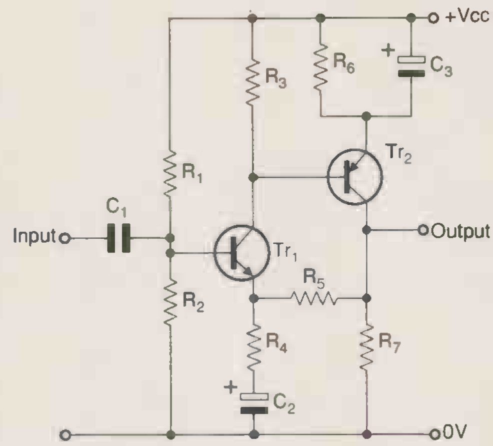


Fig. 2. Simplified dual-transistor gain stage. This configuration has simple and predictable phase-versus-frequency characteristics.

The use of a long-tailed pair as the input layout also allows some simplification of the circuit. However, the gain of this stage is only some 4400. If it were used as the voltage-amplifier stage of a power amplifier, it would not allow much negative feedback to be used.

The main reason for the low open-loop gain of this circuit at medium frequencies, is the low impedance collector load

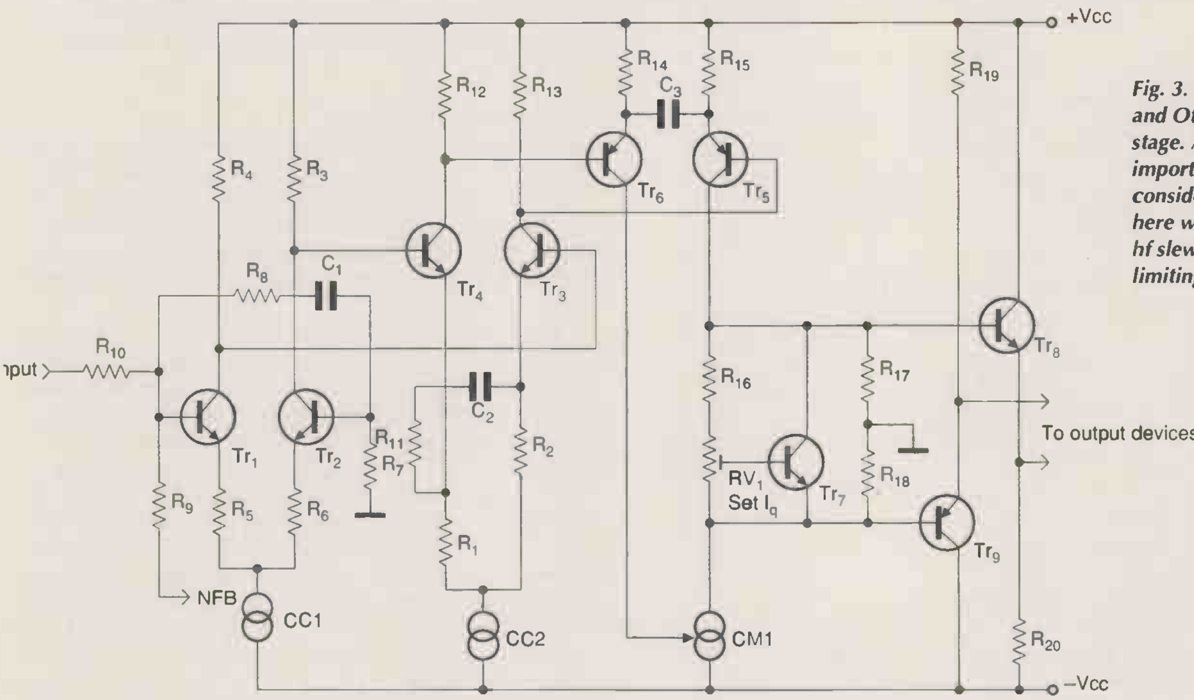


Fig. 3. Lohstroh and Otala gain stage. An important design consideration here was to avoid hf slew-rate limiting.

Alternative gain-stage layouts

In practice, all modern amplifier outputs connect to the speaker without any dc-blocking coupling capacitor. This requires that there is no significant residual dc voltage across the loudspeaker output terminals.

The easiest way of assuring minimal residual dc in a transistor operated audio amplifier is to operate the amplifier between a pair of (+/-) power supply rails, with the signal path balanced about the 0V mid point of this supply arrangement. This will normally be done by the use of an input gain stage using a 'long-tailed pair' or ltp. An example, by Lohstroh and Otala, is the circuit of Tr_1 and Tr_2 in Fig. 3.

It is possible to rearrange the simple two-transistor gain stage shown in Fig. 2 to use an input ltp as shown in **Fig. 4**. Here, the dc feedback path from Tr_3 collector to Tr_2 base gives a dc gain of near unity. This operates to reduce the output dc offset to near zero.

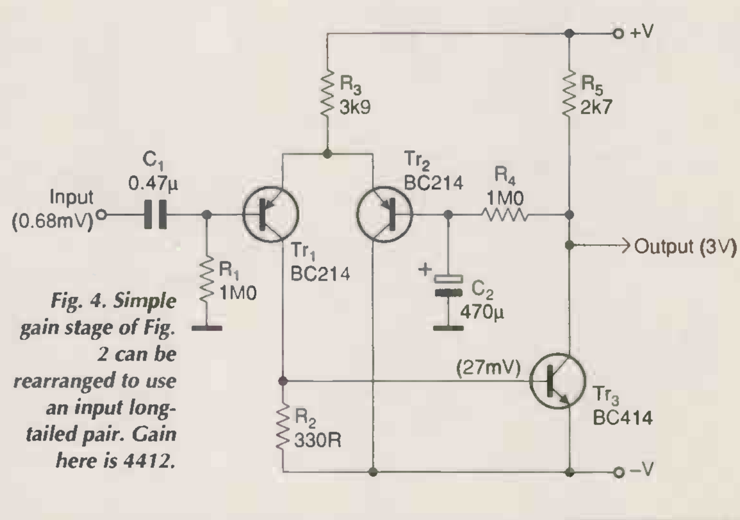


Fig. 4. Simple gain stage of Fig. 2 can be rearranged to use an input long-tailed pair. Gain here is 4412.

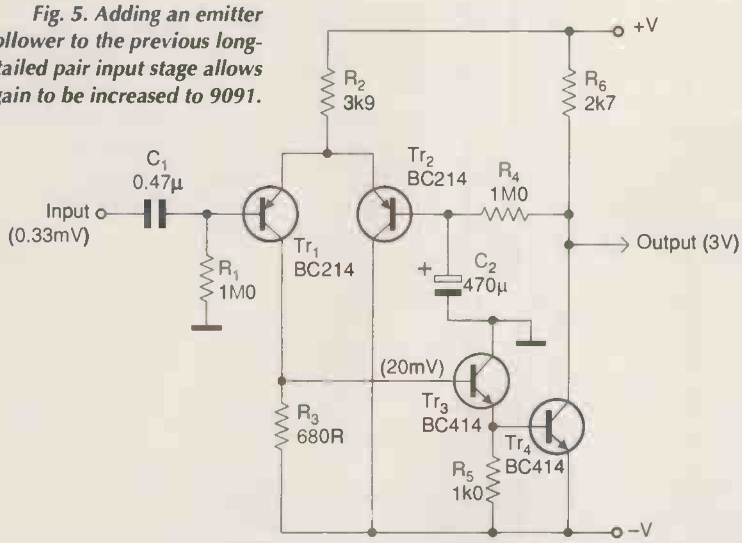


Fig. 5. Adding an emitter follower to the previous long-tailed pair input stage allows gain to be increased to 9091.

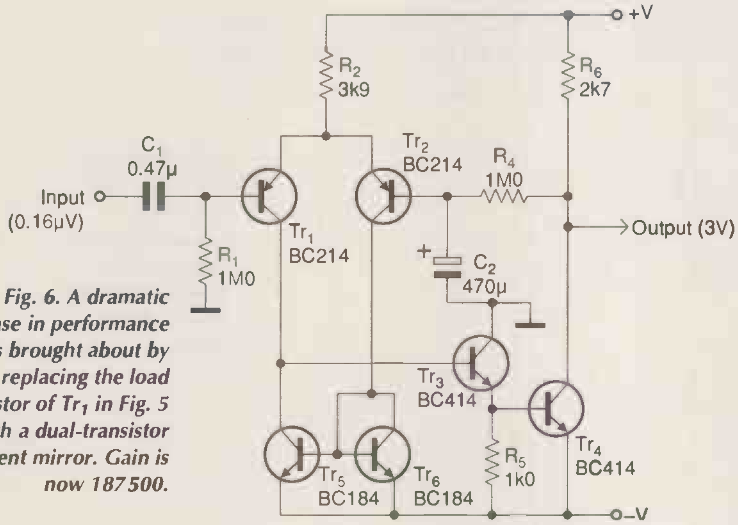


Fig. 6. A dramatic increase in performance is brought about by replacing the load resistor of Tr_1 in Fig. 5 with a dual-transistor current mirror. Gain is now 187500.

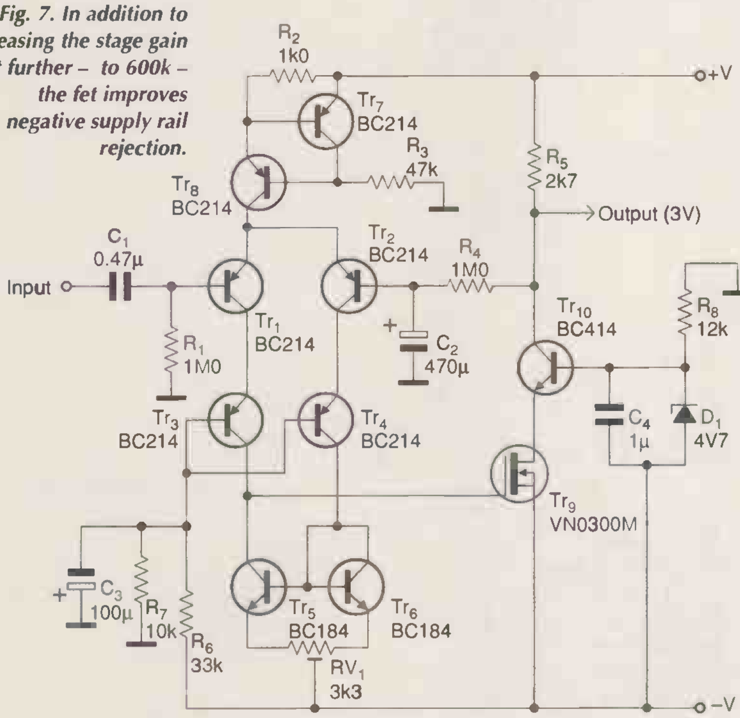


Fig. 7. In addition to increasing the stage gain yet further – to 600k – the fet improves negative supply rail rejection.

presented to Tr_1 by R_2 in parallel with the input impedance of Tr_3. As shown, the large value of C_2 effectively removes all negative feedback at audio frequencies.

An improvement can be made in this respect by replacing Tr_3 with a Darlington pair, Tr_3/Tr_4. This doubles the required value of Tr_1 load resistor and increases the gain to about 9000. I have shown, in brackets, the signal levels at 1kHz, for a 3V rms output, at various stages of the circuit.

The relatively low gain of the circuit in the forms shown so far is due to the low impedance collector load provided for Tr_1. Because of this, if the current flow through Tr_1/Tr_2 is reduced, say, by increasing the 'tail' resistor – R_2 in **Fig. 5** – to 47kΩ, then Tr_1 load resistor, R_3, can also be increased to 12kΩ, without altering the dc balance. Gain will now increase to about 11500.

A dramatic improvement in the performance of this circuit can be brought about by replacing the collector load resistor of Tr_1 in Fig. 5 with a two transistor 'current mirror', Tr_5/Tr_6 in **Fig. 6**. This not only allows the current through Tr_1 to be restored to the original 75μA level of Fig. 5, which will improve its high-frequency gain. It also combines the output signals of Tr_1 and Tr_2 – previously that from Tr_2 was wasted – to form a high impedance active load for Tr_1.

The result of these changes is to increase the open-loop gain of this circuit block to 187 500 – a gain level which would allow a useful amount of negative feedback to be applied while still allowing a sensible amount of closed-loop amplifier gain.

Supply-line isolation

A weakness of all the circuit layouts shown so far is that the relatively low resistance of the 'tail' only allows a limited degree of rejection of unwanted signal components from the positive rail. This can be remedied, with a small additional improvement in open-loop stage gain to 270 000, by replacing the tail resistor with a two transistor constant current source, Tr_7/Tr_8 in **Fig. 7**.

The Darlington pair, Tr_3/Tr_4 of Figs 5 and 6, can also be replaced, with advantage, by a high impedance field-effect device as shown in Fig. 7. In addition to increasing the stage gain still further – to some 600000 – this improves the negative rail signal rejection. Since junction fets are mainly only available in limited supply voltages and power dissipation levels, I have shown a small-signal mosfet in this position.

A further refinement to the circuit is to use cascode isolation of both the input long-tailed pair Tr_1/Tr_2, and the output mosfet, Tr_9 in Fig. 7. In addition to improving the supply rail rejection factor even more, this lessens the loss of gain at higher audio frequencies due to the Miller effect due to the collector/base capacitances in Tr_1/Tr_2, and the drain/gate capacitance in Tr_9.

The final stage gain of the circuit shown, at 3V rms output using ±30V supply rails, was 300000× at 1kHz and 90000× at 20kHz. Surprisingly, in spite of the huge increase in gain from the 4000× figure given by the simple circuit of Fig. 4, the overall phase/frequency characteristics of the Fig. 7 circuit are not significantly more complex than those of Fig. 4. You could expect, therefore, to be able to use this as the gain stage of an amplifier as outlined in Fig. 1 without having much difficulty making the system stable at high frequencies.

One way by which the amplification of all of these gain stages could be increased would be to use a higher impedance output load than the 2.7kΩ last stage collector load I have chosen for all these designs.

The reason why I have used such a low load resistor value is that, in all practical audio applications, an output impedance conversion stage will be interposed between the voltage amplifying stage and the loudspeaker. I think that 2.7kΩ is a reasonable value to assume as the input impedance of this output stage.

Adding a power output stage

To a first approximation, the distortion D' of an amplifier using negative feedback will be the open-loop distortion D_0 divided by the feedback factor $1+\beta A_0$, where A_0 is the open-loop gain and β is the proportion of the signal which is fed back.

This yields a rough and ready rule of thumb: if the open-loop gain is high enough, distortion will be reduced by the application of negative feedback to the same extent as the feedback reduces the gain, i.e.

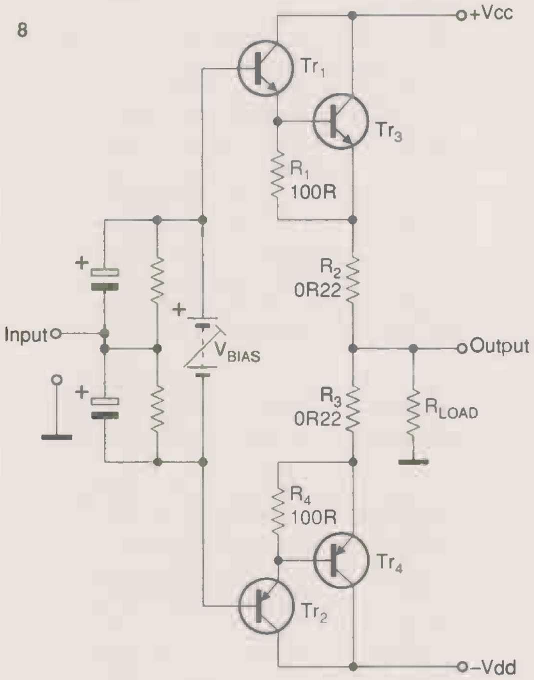
$$D'/D_0=A'/A_0$$

or

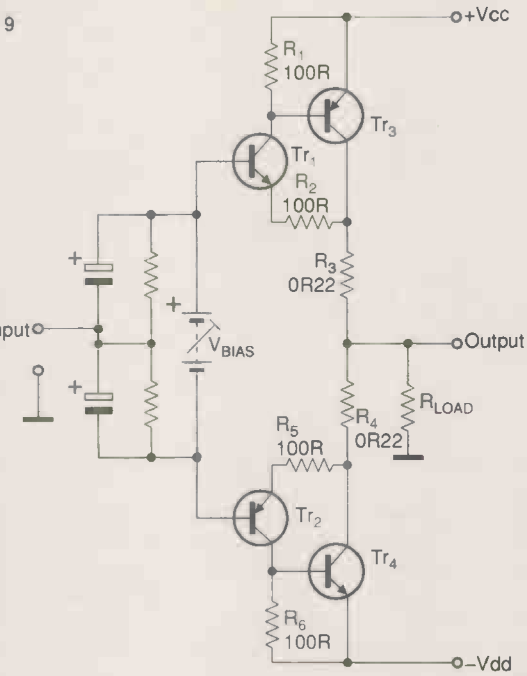
$$D'=D_0\times A/A_0 \qquad (1)$$

Figs 8-11. Four output configurations, typical distortion performance of which is listed in the table. Top left is the Darlington pair output, next to it compound emitter followers, bottom left uses mosfet source followers and bottom right is a bipolar/mosfet combination.

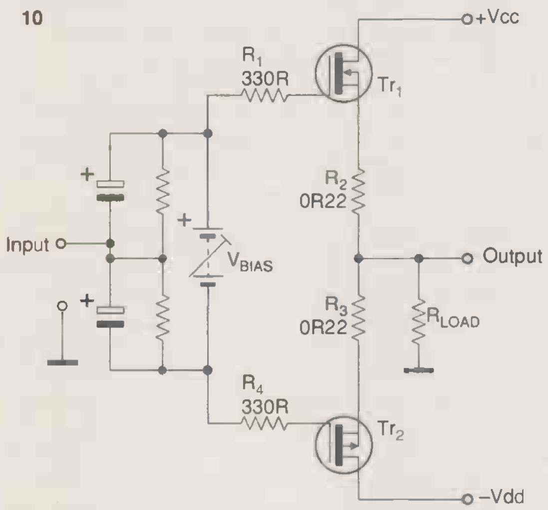
8



9



10



11

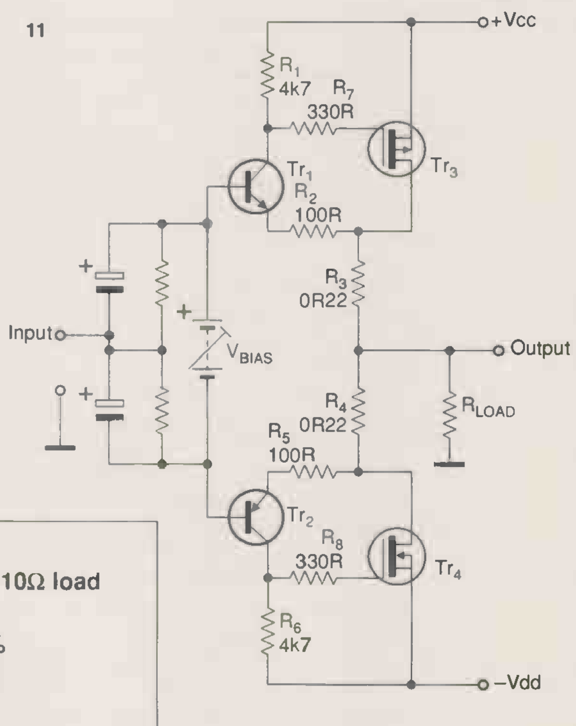


Table. Distortion characteristics of output push-pull pairs.

Configuration	$I_{q(opt)}$	THD, 5kΩ load	THD, 10Ω load
Darlington pair, as **Fig. 8**	60mA	<0.02%	2.2%
Compound e/follower, as **Fig. 9**	60mA	<0.02%	1.15%
MOSFET s-follower, as **Fig. 10**	100mA	0.02%	2.1%
MOSFET pair, as **Fig. 11**	100mA	0.015%	1.0%

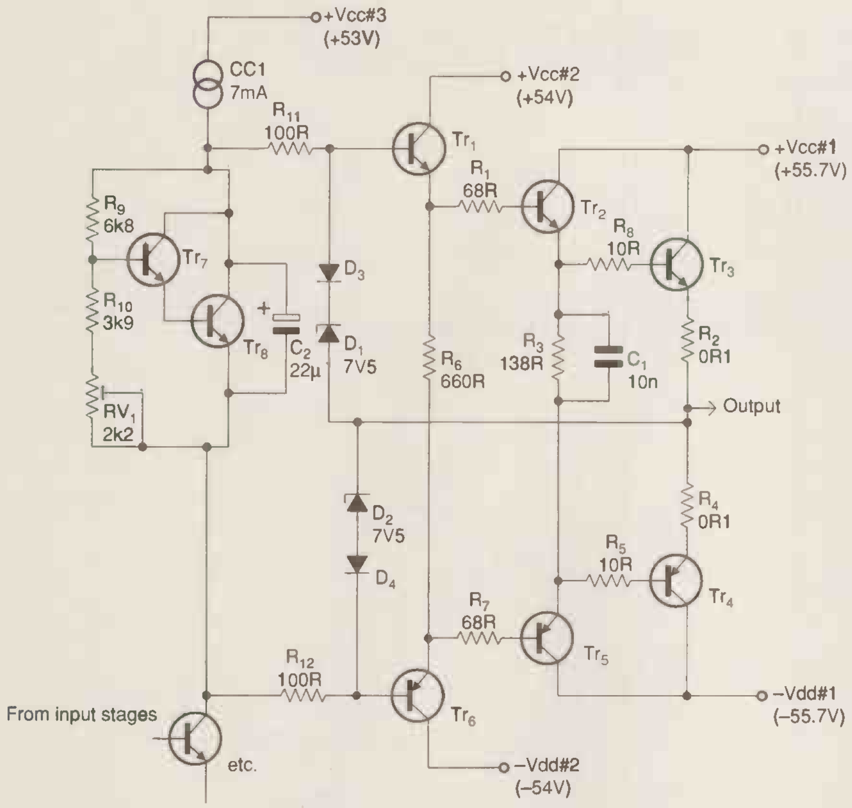


Fig. 12. Typical output stage layout (Marantz PM-16), illustrating how in many amplifiers, the returns of the input drive resistors R_3/R_6 are cross connected to help remove stored charges.

where A' is the gain after the application of negative feedback.

Unfortunately, a number of factors lessen the effectiveness of feedback in reducing distortion. You can only say that the equation above represents the most favourable outcome. Using negative feedback will most probably reduce the distortion, but it will never do so to a greater extent than this.

So, what orders of total harmonic distortion can be expected from an amplifier built using a gain stage of the kind shown above?

Voltage amplifier stage distortion

Because the stage gain of the designs shown above is very high, the input voltage excursion required to provide an output within the permissible output voltage excursion range – mainly determined by the rail voltages – will be very small. As a result, the distortion due to the curvature of the input characteristics will therefore be very small. This is because the input device will only be required to operate over a very small part of its inevitably curved transfer characteristic.

Output stage layout effects

In practice, the output devices available to the audio amplifier circuit designer are the bipolar junction transistor or the power mosfet.

A hybrid device – the insulated gate bipolar transistor, or igbt – has also been introduced by various manufacturers. This has the high input impedance characteristics of the mosfet, coupled with the ruggedness and low forward voltage drop of the bipolar junction transistor, and is aimed mainly at high power, high speed switching applications.

However, its internal phase characteristics are rather complex, and this makes the application of high amounts of negative feedback difficult, except over a restricted bandwidth. I feel that, in general, it is less suitable as an audio amplifier output device than either the bipolar or mos transistor.

Where, as is normal, the output impedance conversion stage is configured as a unity gain layout, the circuits used will generally be one or other of the forms shown in Figs 8-11. In the particular case of the circuit shown in Fig. 8, most of the transistor manufacturers offer Darlington connected output emitter followers. With these, Tr_1/Tr_3 and Tr_2/Tr_4 are formed on the same chip, and sold in a single encapsulation. This saves costs, and allows this kind of output transistor to be offered at a price which is significantly lower than that of the separate, discrete transistors, specifically for use in low to medium grade 'high-fidelity' amplifiers.

And for high-performance designs?

For higher quality units, the discrete component layout of Fig. 8 would be preferred because it is easier to arrange for compensation for the change in the output transistor turn-on voltage as the device warms up in use. When the driver transistors Tr_1/Tr_2 are formed on the same chip as the output devices, they suffer the same changes in junction operating temperature during use.

The circuits of Figs 8-11 have been simplified. I did this deliberately, to allow measurements of the distortion of the output (impedance conversion) stage to be made under conditions where the results would not be modified by the characteristics of the preceding (voltage amplifier) stage.

For the purposes of these measurements the circuits, as shown, were driven directly by a low output impedance, low distortion signal generator. The drive signal was made high enough to provide 5V rms output at 20kHz, into either a 5kΩ or a 10Ω resistive load. Results from these trials are shown in the **Table**.

The choice of 20kHz for the test frequency was made to show up any lack of high-frequency symmetry in the nominally complementary n-p-n/p-n-p or n-channel/p-channel devices.

In a typical audio amplifier layout, the forward bias on the output emitter-follower pairs will be provided by a simple voltage-drop generating arrangement, such as a resistor or transistor or diode network. This will be inserted in the current path from the output of the final driver transistor to the appropriate supply rail.

Also, in practical audio circuits the returns of the input drive resistors R_3/R_6 are frequently cross-connected, as for example, in the Marantz *PM-16* audio power amplifier outlined in Fig. 12. This helps remove stored charges which slow down recovery in bipolar junction transistor circuits when the output stage is driven heavily.

This circuit also shows the elaboration of the simple Darlington pair of Fig. 8 into a cascade-connected triplet – again in the interests of greater power output. But this does not significantly alter the output emitter follower distortion figures given by the layout of Fig. 8.

Output device characteristics

In 'class B' or 'class AB' operating characteristics, there are two major differences between bipolar devices and mosfets. One is that the bipolar transistor requires a lower forward (turn-on) voltage than the mosfet. In addition, the bipolar transistor's turn-on voltage characteristic is more abrupt.

In the case of an output emitter- or source-follower circuit – particularly if it is biased into a near 'class B' (zero quiescent current) operating mode – there will always be a degree of crossover-type distortion. This is because the two halves of the turn-on curves do not add to give the ideal straight line input voltage *versus* output current characteristics. There is also a different type of harmonic distribution in the distortion residues between bipolar devices and mosfets.

This lack of 'crossover' linearity has been the subject of a considerable amount of theoretical analysis, apparently mainly aimed at justifying the use of bipolar rather than mosfet transistors as output stage devices. Such theoretical analysis has demonstrated that bipolar devices have lower distortion in this application.

I find this curious because, in my experience, mosfet based power amplifiers usually have very similar low to mid-frequency distortion characteristics to those based on bipolar devices. On the other hand, bipolar designs offer less good performance at higher frequencies where, for devices of comparable ruggedness, the mosfet has a much higher gain transition frequency. Consequently it has a lower internal phase shift at higher frequencies, facilitating the stable application of loop negative feedback.

I made the experimental measurements shown in the Table to see what the actual output stage distortion characteristics of such output impedance conversion circuits were, when freed from the influence of the other parts of the circuits.

In practice

Taking the case of a typical 100 watt into 8Ω audio power amplifier, for a nominal '0VU' input signal level, i.e. 0.77V rms, the closed-loop gain of the amplifier must be 36.5×.

For a voltage amplifier stage having, say, a gain of 100 000 – a typical (1kHz) value for a commercial gain stage using a circuit similar to that of Fig. 6 when 'hf compensation' has been applied – the theoretical reduction of the distortion in the amplifier will be 100000/36.5=2740×. If, therefore, the only distortion in the system is that due to the output impedance conversion stage, and this is, say, 2%, at medium power levels, then the anticipated – and somewhat optimistic – value for closed-loop distortion will be 2/2740, which equates to 0.07%.

Unfortunately there are many factors which will worsen this figure. One of these – the output load that the amplifier is required to drive – is immediately apparent.

The results quoted in the Table demonstrate the way in which increasing the load resistance will reduce the output stage distortion – what I think of as the 'Sandman effect'. The converse is also true – a low impedance load, such as that presented by many loudspeaker systems, will worsen it.

Also, an assumption implicit in equation 1 is that the gain of the system is constant over the whole frequency range, which would not be true, even if there was no deliberate high-frequency roll-off of the gain to ensure the closed loop stability of the amplifier. It is also assumed that the phase of the feed-back signal remains in the first quadrant over the working frequency range.

In conclusion

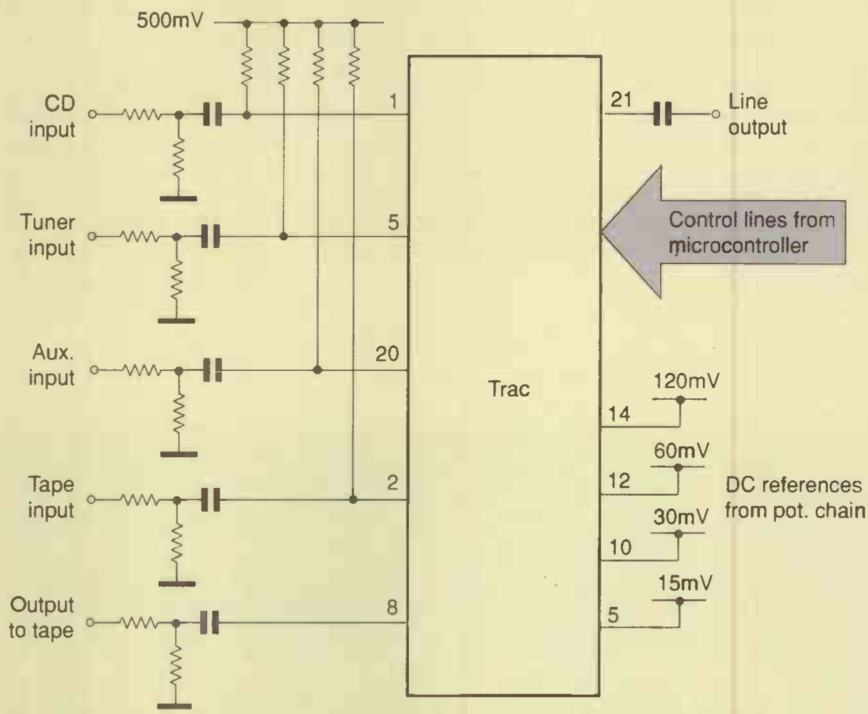
Finally, as anyone who has sought to measure low levels of harmonic distortion will have discovered, there is a host of minor aspects of the system which will degrade the results. These aspects start with the actual points between which one seeks to sample the signal. This undermines my faith in the validity of published performance figures which include total harmonic distortion values below 0.001%.

The results given in the Table, and some of the illustrations, were published in my book 'Valve and Transistor Audio Amplifiers' and have been reproduced by kind permission of Butterworth-Heinemann. ■

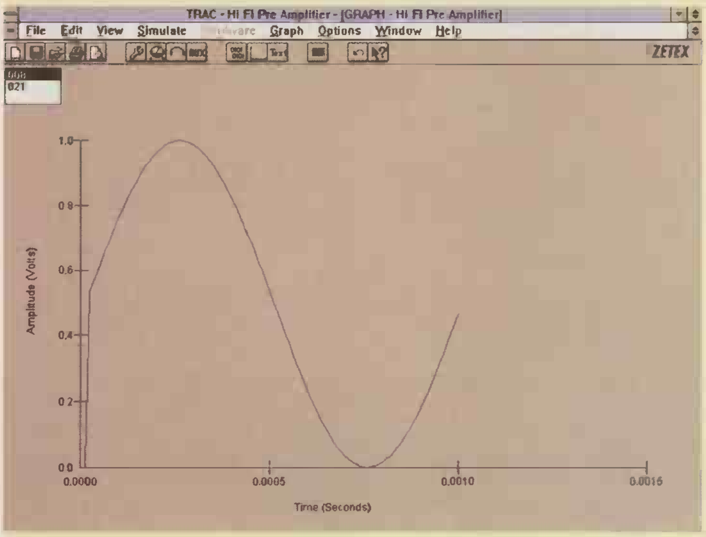
Trac competition winners

Two more TRAC designer's kit winners – a preamplifier with digital gain and input selection, and a new idea for implementing amplitude modulation.

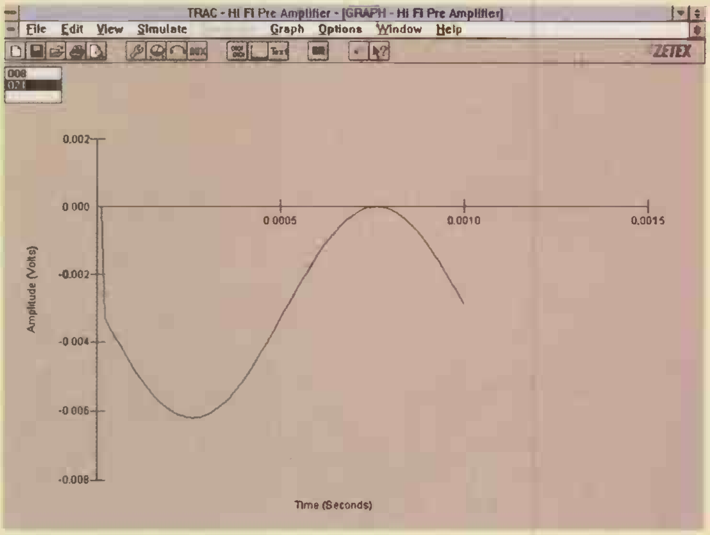
Andrew Wilkes' digitally-controlled audio amplifier is a further winning entry from the Fast Analog Solutions design competition. This circuit demonstrates how *TRAC*'s analogue function blocks can be configured to produce digitally-selectable gain level and source switching.



One channel of the programmable-gain audio amplifier showing the offsets and reference voltages.



Pin 8 is the tape recorder output. Compare this with the diagram for the line-output signal on pin 21. Note that the 1V pk-pk signal has a 500mV dc offset.



Simulation of the output voltage on pin 21 with the cd player selected and the volume control set to –44dB. Output voltage is 6.2mV pk-pk, input is 1V pk-pk and attenuation is 20 log(6.2/1000)=–44dB.

Using one *TRAC* per channel, I was able to realise a four input-source stereo preamplifier with tape deck support and a 4-bit – i.e. 16 logarithmic steps – volume control.

The most obvious advantage of this configuration is that mechanical parts such as input selectors and volume and balance controls are redundant. This eliminates ageing effects such as crackling when the volume is changed, and audio degradation due to switch contact impedance. Pick-up in wiring is also avoided.

A microcontroller would be programmed to configure the *TRAC* devices according to the volume level, balance and signal source selections. To connect a source, an interface would be summed appropriately and applied to the volume control circuit. Balance would be easily achieved by applying different volume settings to each *TRAC* device. ■

Simulation conditions for the audio preamplifier.

Pin	Signal	Amplitude	Frequency
1	Sinewave	0.5Vpk(max)+0.5V dc	1000
2	Sinewave	0.5Vpk(max)+0.5V dc	1500
5	Sinewave	0.5Vpk(max)+0.5V dc	2000
7	Constant	0.015	0
10	Constant	0.03	0
12	Constant	0.06	0
14	Constant	0.12	0
20	Sinewave	0.5Vpk(max)+0.5V dc	1500

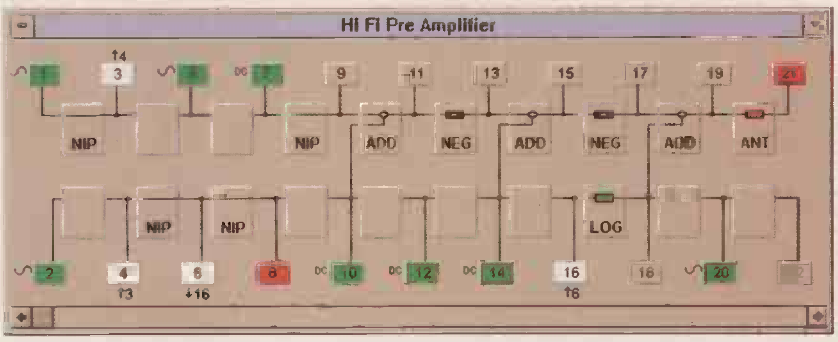
Cell links

From pin		To pin	
3	CD source	4	Source input node
6	Source output node	16	Volume control i/p node

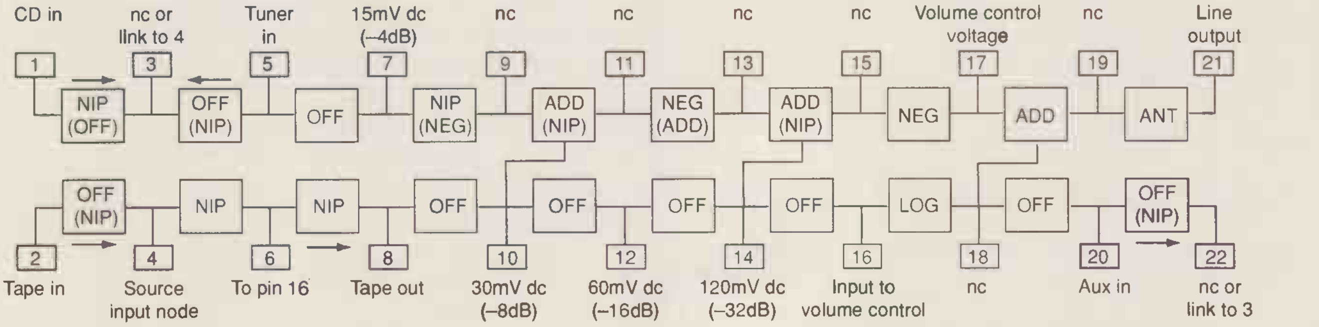
Notes

All sinewave inputs have a 500mV dc offset. For tape monitoring, pin 16 becomes an input from the source to record and pin 3 links to pin 16 for monitoring of the tape record level. The volume control has 16 steps. The four reference voltages combine to give the desired attenuation. In my simulation, I used 15mV+30mV+120mV to give 44dB.

Step	Attenuation (dB)	Sum of pins connected to pin 17
0	0	0 (pins 15-17 off)
1	–4	7
2	–8	10
3	–12	10+7
4	–16	14–12
5	–20	14–10–7
6	–24	14–12+10
7	–28	14–10+7
8	–32	14
9	–36	14+7
10	–40	14+10
11	–44	14+10+7
12	–48	14+12
13	–52	Not possible
14	–56	14+12+10
15	–60	Not possible



Channel switching is achieved by reprogramming the TRAC using some form of controller, hence the alternative functions in brackets. Attenuations are also in brackets.



Novel amplitude modulator

Here, Franck Bigrat demonstrates how an equation for a function, namely that of amplitude modulation, translates directly into *TRAC* circuitry. He uses two *TRAC*s to form an easy-to-implement amplitude modulator. It needs no trimming and uses few components.

The formula for an amplitude modulator is,

$$s(t) = (a \times i(t) + b)\sin(2\pi ft) = A\sin(2\pi ft)$$

Layout of a modulator based on this equation and implemented in two *TRAC* devices is shown in **Fig. 1**.

Designing the modulator was a challenge, but *TRAC* makes implementing an amplitude modulator simpler. The design needs no trimming, it has fewer components and it saves you having to search for special demodulation integrated circuits, which can be difficult to find and use.

The alternating input on pins 1 and 24 is i(t) while the ac input on pin 7 is P(t). There is also a dc input, called named E, on pins 2, 14 and 23.

The functions on pins 1-4, 6, 7, 9, 11, 12 and 13 produce a multiplier,

$$S_1 = \log[i(t) + E] + \log[p(t) + E]$$

$$S_1 = \log[(i(t) + E) \times (p(t) + E)]$$

The result on pin 13 is,

$$S_1 = \log\left[i(t) \times p(t) + E \times i(t) + E \times p(t) + E^2\right]$$

The dc terms E and E^2 must now be removed. This is done via a logarithm function, log(E) subtracted from S_1,

$$S_2 = \log\left[i(t) \times p(t) + E \times i(t) + E \times p(t) + E^2\right] - \log(E)$$

$$S_2 = \log\left(\frac{i(t) \times p(t) + E \times i(t) + E \times p(t) + E^2}{E}\right)$$

Finally, the result on pin 19 is,

$$S_2 = \log\left(\frac{1}{E} i(t) \times p(t) + i(t) + (p)t + E\right)$$

An antilog function gives,

$$S_2' = \frac{1}{E} i(t) \times p(t) + i(t) + p(t) + E$$

Removing the unwanted dc signal i(t) and the unwanted dc E gives,

$$S_3 = \frac{1}{E} i(t) \times p(t) + i(t) + p(t) + E - [i(t) + E]$$

which relates to pins 23, 24, 25 and 28, and finally,

$$S_3 = \frac{1}{E} i(t) \times p(t) + p(t)$$

on pin 29 which can be written,

$$S_3 = \left(\frac{1}{E} i(t+1)\right) p(t)$$

Input and output waveforms associated with the design are presented in **Fig. 2**. ■

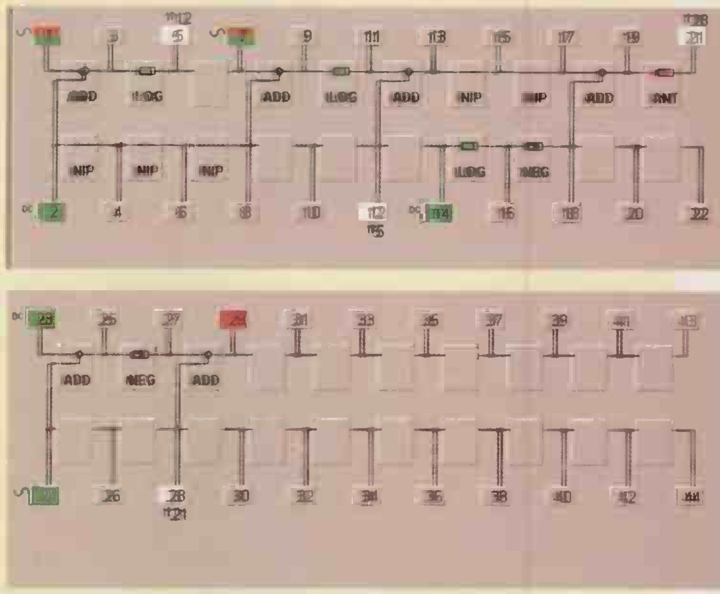


Fig. 1. Amplitude modulator using two TRAC devices needs no trimming.

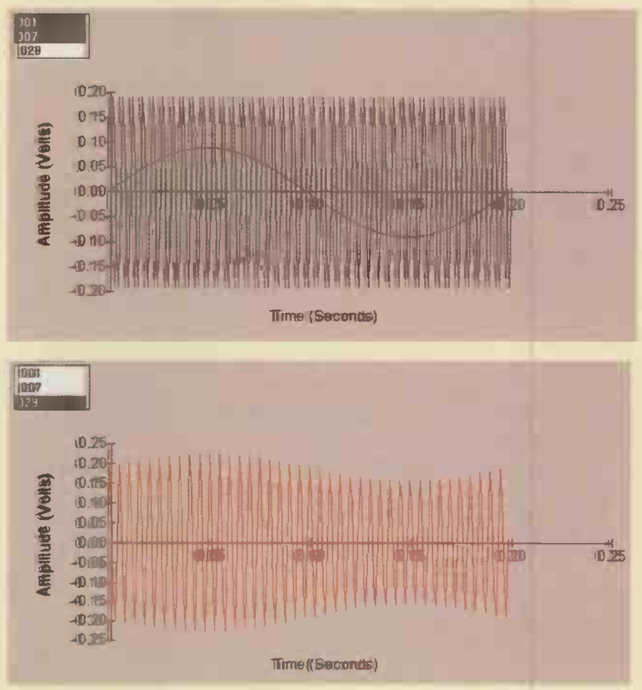


Fig. 2. Simulations showing the carrier, on pin 7, together with the modulation input on pin 1 in the top diagram, and the modulated carrier on pin 29 in the bottom diagram.

Pin assignments for the amplitude modulator.

Pin	Type	Amplitude	Frequency	Amp offsets
1	Sine wave	0.09	5	0
2	Constant	0.5	n/a	n/a
7	Sine wave	0.2	200	0
14	Constant	0.5	n/a	n/a
23	Constant	0.9	n/a	n/a
24	Sine wave	0.09	5	0

Hands-on Internet

Cyril has spotted more free year 2000 test software and has applications news including a novel notch filter.

For the next two years, *Pentium II* compatible computers are expected to make up the lion's share of the pc market. According to a report by News.Com,[1] AMD may now have a legal route to manufacture microprocessors that use the "P6" system bus.

While AMD has apparently acknowledged that P6 technology is within its grasp, the company has denied planning to adopt this bus standard. Coincidentally, as I began writing, Bloomberg Television announced Intel was planning a workforce reduction of some 3000 employees.

Still under pressure by the Department of Justice, as reported by News.Com, Microsoft has offered free copies of Windows NT4 and related server software,[2] to Internet Service providers, if they can convert sufficient subscribers to Internet Explorer software over the next few months.

Is 2000 a leap year?

Interest in the year 2000 problems now dominates much of Internet activities. A simple search against "Y2K" using the Northern Lights search engine turned up more than 21 000 hits. While many listed sites have an obvious commercial interest, a wealth of advice and information is available from Government and other non-commercial sources.

Fig. 1. Visit this site to find the truth about the Millennium Bug.

Perhaps the best starting point is the 'year2000.com'[3] information centre, which in March alone received over 450000 visitors. Sponsored by Peter de Jager, one of the first to alert people outside the technical community about the problem, this site provides a wealth of information and useful links, **Fig. 1**.

To emphasise the need for urgency, year2000.com displays a count down of days remaining in which to resolve any problem. Most authorities advise implementing all corrective actions you might need, before 31 December 1998, leaving 1999 as a proving trial period.

While much has been published about a potential year 2000 scenario, perhaps, like me, you have so far assumed it is a problem only affecting timed business transactions, large database and networked users who depend on maintaining many years data, and accountancy records. Surely a stand-alone single user pc running mainly word-processing, CAD and circuit simulation software packages will find few problems?

Maybe you plan to replace your computer hardware, expecting the replacement will be fully year 2000 compliant. But unless your new motherboard incorporates one of the very latest real-time clock chips, which provide four digits for year data, you could still have a problem.

A dos/windows pc uses two date and time clocks. The real time clock is battery backed hardware which runs continuously, even when the computer is switched off.

The system clock is a 24 hour virtual clock. This is simply a counter incremented 18.2 times each second, so it has no concept of time or date. This counter is then converted by the operating system into hours, minutes and seconds. As for date, the operating system reads it from the real time clock, but only as the computer powers up.

While the computer remains powered, the operating system tracks time and date changes as the system clock 'rolls over' each 24 hours. Since the real time clock is accessed only when a pc boots up, the method used by the bios to convert the real time clock data into date and time for the system clock, is important. Equally important are the exact routines used by software applications when accessing this time and date.

Three quite different aspects of this problem need evaluating by all computer users. These are their computer hardware, their operating systems and all software packages they intend to use after 1 January 2000.

Obviously, if the hardware is not year 2000 compatible, then its operating system and software cannot be compatible. So this month, using four free software programs downloaded from Internet, I tested my own personal hardware, with some good news, some not so good.

For those of you with no Internet access, all four programs invite further copying and distribution. NSTLonline,[4] a division of McGraw-Hill, provides its YMARK2000 test program.

This 35Kbyte program is claimed to have been used by the Canadian Government and many major corporations. It tests the BIOS and real time clock functionality while set to year 2000, which is a leap year, and the clock chip for true *MC146818* compatibility.

Many computer real-time clocks store only two year digits. These then interpret a year coded '00' as 1900, which was not a leap year, while 2000 certainly is.[5] Some computers using a two digit year clock provided a method for storing the century. YMARK2000 concluded that my system could not 'rollover' its date to 2000, but as 2000 and subsequent leap years were being correctly detected, I could manually update my real time clock on 1 January 2000.

Computer Experts' Millennium Bug Toolkit[6] has been reported as a good commercial software package. The company offers two free demos for download. 'Killer.exe' is a small DOS program running from Windows. It displays the behaviour of your real time and system clocks, as at the end of 1999 and at the start of the Millennium. It also includes background information, on any problem it finds.

The Millennium Bug Toolkit demo, 'Setupmbt.exe', from the same company is a slightly smaller dos-only program which runs eight of the ten tests provided in the full commercial package. For my machine it suggested their commercial TSR program be installed to update my real time clock functions.

One possible test not included in these packages is to make sure that manually updated dates to 2000 are retained after powering down and re-booting.

'Test2000.exe' from The RightTime Company[7] first performs similar tests. Having set your real time clock into the year 2000, it automatically re-boots your computer and checks that correct time and date are retained after re-booting.

Also in its documentation, are details of Dallas Semiconductor's new *DS12887*[8] – the first fully 2000 compliant real time computer clock – which is pin compatible with the older *MC146818B* or *DS1287* chips, Fig. 2.

DISC is part of the British Standards Institute.[9] It has published its PD2000-1 a Definition of Year 2000 Conformity Requirements and PD2000-2 Managing Year 2000 Conformity. These documents are based on the requirements of four easily understood and clearly defined rules, which you should comply with, to ensure Y2000 conformity, Fig. 3.

Fig. 2. Can your obsolete real-time clock be upgraded? Visit Dallas Semiconductors to find more details.

Fig. 3. Perhaps you prefer to rely on more formal information. The year 2000 definition is free and on-line; the Code of Practice is printed and costs £14.95.

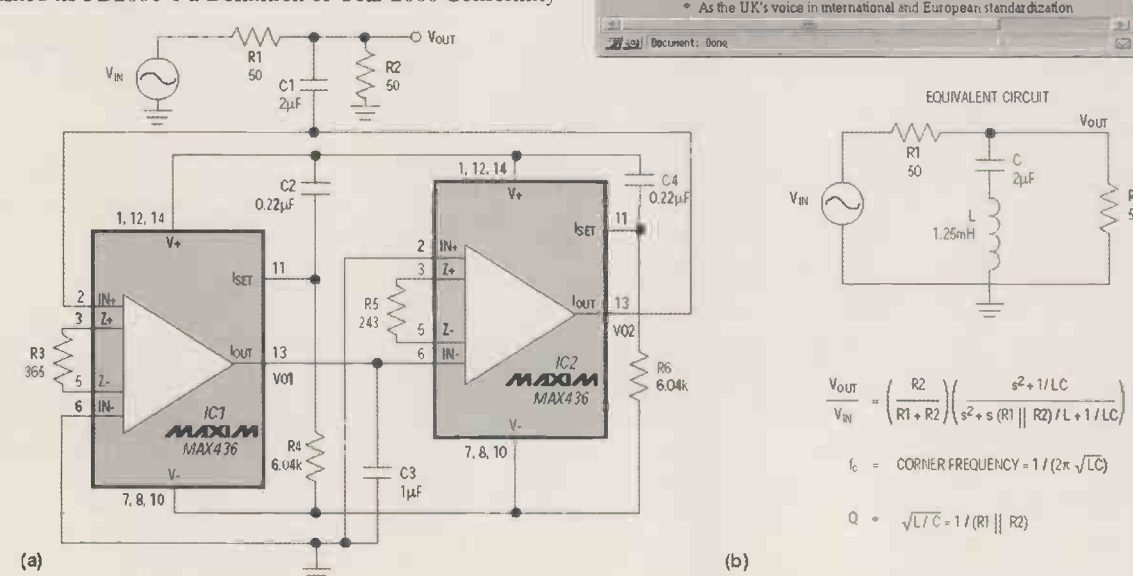


Fig. 4. This dc-accurate notch filter circuit uses a synthetic inductor, together with a passive equivalent circuit filter.

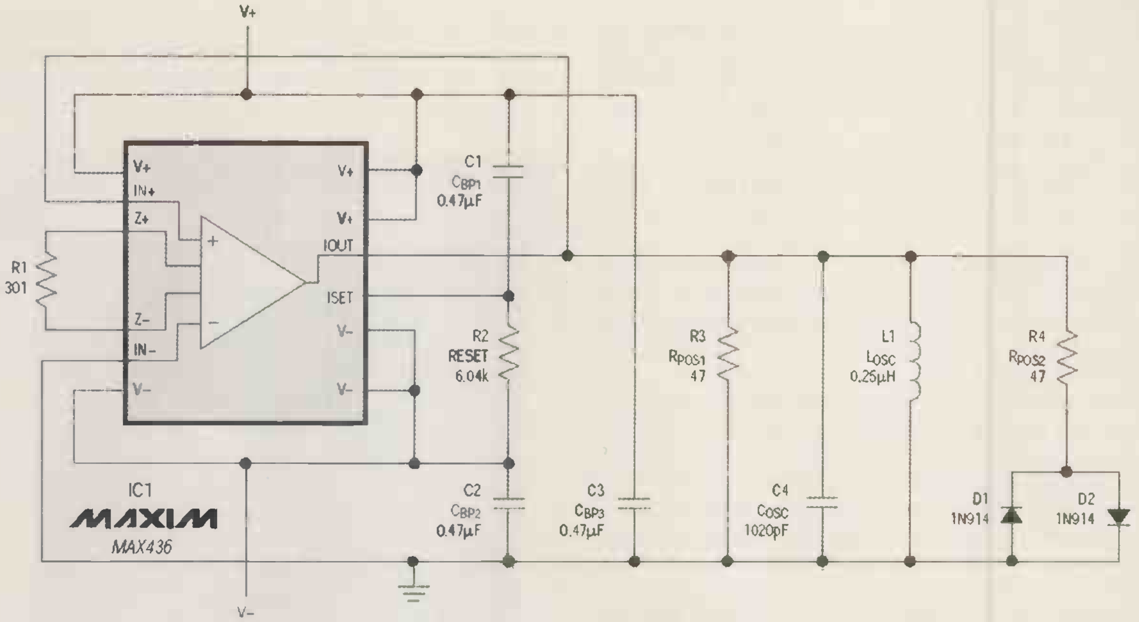
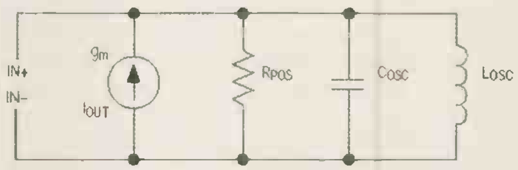


Fig. 5. An easily built high frequency oscillator offers less than 1% distortion at 9.3MHz.

EQUIVALENT CIRCUIT:



This 9.3MHz oscillator includes a wideband transconductance amplifier (IC1), whose negative resistance counters losses in the L1/C4 tank circuit.

Applications

Transconductance amplifiers frequently offer alternative solutions for circuit functions. The *MAX435 and 436*[10] are wideband, true differential amplifiers with relatively high input impedance.

Their unique architecture provides accurate gain without needing negative feedback, eliminating closed loop phase shift which can cause oscillations in conventional amplifiers. This ability to drive large capacitive loads allows easy control of bandwidth. Loading the output with a 6.8nF capacitor to ground and a 25Ω shunt resistor reduces bandwidth from 100MHz to 1MHz while maintaining 6dB gain.

Many instrumentation amplifiers use a single gain setting resistor between two pins. These transconductance amplifier versions have their gain set by the value of an impedance between their two 'Z' input pins. This impedance may be a single resistor or even a tuned circuit. It allows these amplifiers to be used as both high-speed instrumentation amplifiers and as high-speed, high-gain, bandpass filters.

Of the five Maxim application notes for this chip, two caught my attention. The dc-accurate notch filter, downloadable as A2013.PDF, could be most useful for many measurements. Most active-filter circuits generate noise and distortion, and some dc offset. This offset is avoided in this circuit, which completely separates the ac and dc signal paths.

While this function could be performed using a series *LCR* network to shunt any unwanted signal to ground, the inductor used could pickup unwanted noise. This active circuit uses a simulated inductor, avoiding a source of noise, **Fig. 4**

The second circuit, A1616.PDF, was for a high-frequency oscillator having less than 1% distortion. This application uses the transconductance amplifier to synthesise sufficient negative resistance to overcome losses in the parallel tuned circuit. Amplitude control then can be arranged simply by using two back to back diodes in series with a 47Ω resistor, to increase the tuned circuit losses, as needed.

While the example shows a 9.3MHz oscillator, the *MAX436* has a 200MHz bandwidth, so higher frequencies are possible, **Fig. 5**.

Simulation

Microsim,[11] makers of the PSpice simulation software, has recently merged with OrCAD Inc. A new Web page, headed OrCAD Microsim, also promotes the new release 8 of *DesignLab*, which runs under Windows.

I tried to request a copy of the release 8 evaluation cd, but living in UK was not able. The registration

Where to surf

1	AMD can do Pentium II, P6 chip.	http://www.news.com/News/Item/0,4,20993,00.html
2	Microsoft buys IE users with NT.	http://www.news.com/News/Item/0,4,20978,00.html
3	Year2000 Information Center.	http://www.year2000.com
4	National Software Testing Laboratories.	http://www.nstl.com/html/ymark_2000.html
5	National Institute of Standards & Technology	http://www.nist.gov/y2k/
6	Computer Experts (UK) Ltd.	http://www.computerexperts.co.uk/pc2000
7	The RighTime Company, Miami.	http://www.RighTime.com
8	Dallas Semiconductor Corp.	http://www.dalsemi.com/TechBriefs/tb8.html
9	British Standards Institute – DISC	http://www.bsi.org.uk/disc
10	Maxim Integrated Products.	http://www.maxim-ic.com/AppNotes.htm
11	Orcad - Microsim Inc.	http://www.microsim.com
12	Intusoft	http://www.intusoft.com/demos.htm
13	Helsinki University of Technology.	http://www.aplac.hut.fi/aplac/version.main.html

page refused to process my request, insisting on entry of my US State, despite its acceptance of England as a country.

After several failed request attempts, in desperation I sent an e-mailed request, which after being repeated with extra explanations, was accepted. This farce reminded me of the European Microsoft request page, which when I ticked the box to inhibit its replying to me by Fax, insisted on first being fed with a fictitious fax number.

Many other established simulation packages are now being updated, but only for use on Windows 95 or NT. The OrCAD merger statement claimed that 1998 would see an accelerating use of the Windows NT operating system for all electronic design software.

Intusoft's *ICAP/4*[12] has also been upgraded to version 8. This 6Mbyte demo, which also contains comparisons of the *ICAP/4*, *ICAP/4RX* and other ICAP products, is available to download, **Fig. 6**.

The Aplac simulator,[13] from Helsinki University, which I much admire, has also been upgraded. In the process, the previous Windows 3.1 version has been discontinued, so Aplac is now only available for Unix on a mainframe or Windows95/NT on a pc.

The Aplac program files are quite large – more than 6Mbyte – but sub-divided to fit on five floppy discs. The schematic editor, Nasse185.exe is an additional 1Mbyte. While these files include on-line help, the help files are abbreviated compared to the manuals. The full Aplac manuals are available for postscript printers by downloading a single 4Mbyte file.

Downloads from Helsinki are often very slow. I gave up on the manuals four or five times before finding a good day. These manuals must be downloaded using a browser, which also tends to make matters worse with large files.

The program files though can be obtained using an FTP client. These can be sub-divided into smaller files, making downloading even quicker. ■

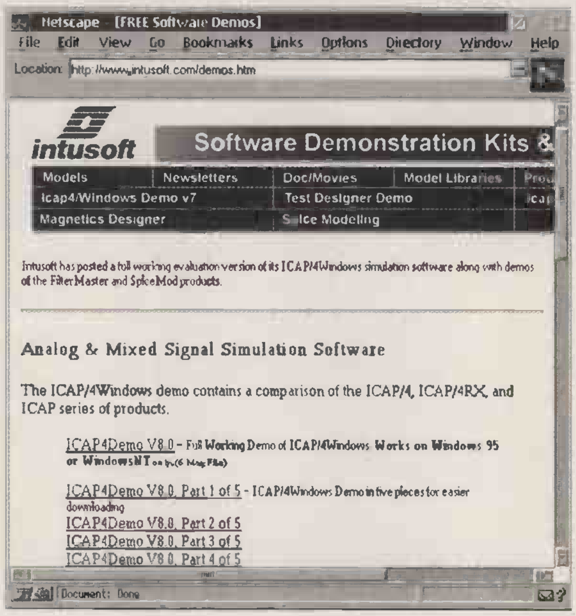


Fig. 6. Version 8 of Intusoft's ICAP/4Windows offers designers a subtly different circuit simulation software package.

In this two-part article, Cyril Bateman reveals how to analyse capacitors with a view to detecting and preventing failures.

Understanding capacitor

When I first started to learn about capacitors, my engineering manager's favourite instruction was, "Measure to gain understanding." This dictum remains just as true today, despite improvements in both equipment and capacitor manufacture.

With many new capacitor product ranges continuously being introduced, and rather fewer ranges becoming obsolete, most component catalogues now omit various performance characteristics. And many main-stream component distributors no longer sell capacitor makers' data books.

Over-stressed or miss-applied capacitors are directly or indirectly involved in most circuit failures. All components deteriorate with time, but miss-applied capacitors can fail extremely quickly. Worse still, before a capacitor fails, it can directly contribute to semiconductor failures, masking the prime failure mechanism.[1]

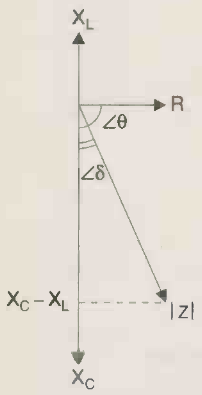


Fig. 1. Vector representation of the interaction between the inductive, X_l and capacitive, X_c reactances which determine measured capacitance value. As the series resistive term R increases, so does the tangent of the angle 'δ' called tanδ, increasing the magnitude of impedance, |Z| but capacitance remains unchanged.

Manufacturers' measurements

Makers' measurements comprise two main categories. Some measurements are applied to every capacitor produced while others are periodic or qualification measurements for national and international approval ratification.

All capacitor production is tested 100% for four major characteristics – capacitance, dissipation factor, voltage proof and leakage current. Regular quality samples will subjected to additional inspections.

End-of-production tests will be supplemented by in-line quality inspections of samples, both electrical and physical, at each manufacturing stage. The results are analysed as part of a statistical process control to optimise yield.

When a manufacturer has gained formal approval to a national or international standard, a program of additional periodic destructive tests, required to maintain this approval, will be agreed. Many makers explain these test requirements in their data books. If you need more information, copies of the specifications can be obtained through national quality supervision bodies.

Supplementary measurements, of interest both to the capacitor maker and circuit designer, will also be performed. Being outside the formal performance claims though, these results will be classified as 'typical'. Such 'typical' measurements centre on measuring capacitance and equivalent series resistance or esr under various conditions or frequencies.

Table 1. Clear demonstration of how esr changes significantly with frequency. Measured results of a high quality 10 nF polystyrene foil/film capacitor using a Wayne Kerr 6425 precision component analyser.

Frequency (Hz)	C (nF)	Tanδ	Q	esr (Ω)
100	9.9982	0.00010	9000	17.0
1k	9.9988	0.00005	20000	0.80
10k	9.9986	0.00015	6000	0.26
100k	10.000	0.0005	3000	0.05

What is ESR?

Having neither resistance nor self inductance, a perfect, loss-free capacitor sustains a voltage in quadrature with the applied current. Analysed on a polar display, voltage would be at –90° and current 0°, so the complementary phase angle δ would be zero. Having no resistive element, this perfect capacitor cannot lose or dissipate energy.[1]

Any self inductance results in a voltage at +90° which subtracts magnitude from the capacitive vector, increasing the apparent capacitance value which is measured.

All practical capacitors exhibit resistance which, appearing in series with the capacitive reactance, degrades this –90° angle to a lesser value, increasing the complementary angle δ. This change of phase angle represents the resistive element which will dissipate energy as heat in the capacitor.

With capacitors, it is usual to refer only to the delta loss angle, described as tanδ, **Fig. 1**.

The resistance acting in series with the capacitor's reactance is called esr. It is the net sum of actual series resistances and any parallel leakage resistances converted to their series equivalents. This leads to the mathematical description of a capacitor's impedance, **Fig. 1**, as,

$$|Z| = R \pm jX,$$

where,

$$jX = j(X_c - X_l)$$

$$X_c = \frac{1}{2\pi f C}$$

$$X_l = 2\pi f L$$

$$\tan\delta = abs\frac{R}{X}$$

$$\theta = \tan^{-1}\frac{X}{R}$$

A near ideal capacitor would have a phase angle, hence tanδ, that remained constant with frequency. Since by definition a capacitor's reactance X_c is totally frequency dependent, so also must be the capacitor's equivalent series resistance, **Table 1**.

These frequency dependent effects can be summarised[1] into the general equivalent circuit of a capacitor, **Fig. 2**.

Any alternating current passing through the capacitor, reacts with this esr, dissipating power as heat and the capacitor temperature rises. Heat increases capacitor leakage current which, according to Arrhenius's law, roughly doubles or halves for each 10°C increase.

Increased temperature, both ambient and self heating, reduces a capacitor's useful life. Additionally every capacitor has a safe internal 'hot-spot' temperature which must not be exceeded.

Measurement of this temperature rise provides a direct correlation between capacitor esr and capacitor through current. There's more on this in the panel entitled Temperature rise.

Measuring capacitance and esr

Many excellent and precise *LCR* meters are now available. These are detailed later. Unfortunately though, such equipment is not usually available on rental.

This article presents measurement methods available using commercially available equipment, as well as lower accuracy, lower cost methods. For brevity, I will concentrate principally on measuring capacitance and esr, since all other desired parameters can then be easily calculated. See the panel entitled Conversions and equations.

Traditionally, all capacitor measurements made by an 'approved' manufacturer have been monitored by independent inspection engineers, either from national standards institutes or the defence quality assurance boards. While these bodies monitored products destined for 'release certification', in practice, identical standards were applied to all products.

Twenty years ago, provided the inherent accuracy of the measuring instrument used was at least a factor of ten better than that claimed for the capacitor, the measured values were accepted. Using the best precision bridges then available, capacitance could be measured to this accuracy. But loss factor of the better COG ceramics, low-loss glass, porcelain, polypropylene and polystyrene capacitors could not.

Since then the accuracy of the best *LCR* meters has improved dramatically, especially for loss factor measurement. See the panel entitled Capacitor test instruments.

Insetting results. Formal approvals require measured values for capacitance and loss factor to be traceable to national standards. This means that the equipment used must be maintained in a calibration system. Test limits used must be 'inset' from those actually claimed for the product. This means that the inaccuracy or uncertainty of the measurement instrument and any test leads or jigging used is taken into account.

Test frequencies and voltages. Traditionally, capacitance and loss factor of electrolytic capacitors was measured at 100Hz. All other capacitor types were measured at 1kHz, except for low capacitance values, which were measured at higher frequencies, usually 100kHz or 1MHz. Before pocket calculators were common, 1592Hz was often substituted for the 1kHz measurements, making ω approximately equal to10000 to simplify calculations.

Similarly, the ac test voltage applied to the capacitor being measured has also become standardised. For example, IEC 68-1 for plastic film capacitors specifies a test voltage of 0.03 times the capacitor's rated voltage should be used, subject to an overriding maximum of 5V.

Ceramic capacitors are treated differently. They should first be pre-conditioned by heating to de-age the dielectric, then allowed to stand for 24 hours at standard atmospheric conditions. Measured values, made using an ac test voltage of a volt or less are then adjusted to the '1000-hour value' by applying the appropriate ageing factor.

Aluminium electrolytic capacitors are usually measured at 0.5 volts or less at 100Hz. Obviously, with large capacitance values, considerable generator current may be needed to develop 0.5V, so a much lower test voltage may be needed.

While loss factor is usually specified as tanδ, esr or equivalent series resistance provides an easier insight into a capacitor's performance – especially power handling limitations.

Since both capacitance and tanδ or esr are frequency dependent, maker's test frequencies and voltages should be

Temperature rise

When subjected to current flow, the esr of a capacitor causes its temperature to rise. With simple, repetitive waveforms, given the capacitor's esr by frequency data, calculation of power dissipation is straightforward.

With many complex waveforms though, the only reliable method to ascertain acceptable power dissipation might be direct measurement of temperature rise with the capacitor in circuit.[5]

With physically large electrolytic capacitors, measurement of temperature rise is a simple task, easily performed using a small diameter wire thermocouple in contact with the base of the aluminium capacitor case.

With small surface mounted components, measurement of temperature rise is very difficult. Depending on the printed board used, whether single sided, double sided, proximity of other components and or tracks, often makes assessment of temperature rise either inaccurate or impossible.

While infra-red measurements of temperature might be possible, physically small components require an expensive instrument having telescopic, or macro object lenses.

Thermochromic inks are available with suitable temperature ranges, but unless the component has been pre-coated with a black ink, identification of the many colour temperature bands is difficult. Coating a small component with black ink, changes its infra-red emissivity and thus its temperature rise, introducing significant errors.

While the thermocouple approach can be used, with small components, even the thinnest available leadout wires conduct significant heat at elevated temperatures, reducing the component's temperature rise.

One method I have used successfully combines using thermochromic ink with a thermocouple. With constant power applied to the test component, thermochromic ink can be used to determine component temperature reduction when a thermocouple is attached. Subsequent thermocouple-only measurements, can then be corrected for this loss, giving improved accuracy of the measured temperature.

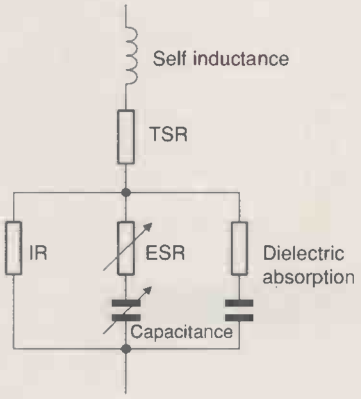


Fig. 2. General equivalent circuit applicable to all capacitors at small signal levels, up to the series resonant frequency. Note however at larger signal levels, as described in the June issue, an enhanced circuit should be applied to electrolytic capacitors.

Conversions and equations

Subject to an ac voltage, an ideal capacitor resists or impedes the passage of current according to its reactance value,

$$X_c = \frac{1}{2\pi fC}$$

developing a voltage which lags the current by 90°.

In practice, every capacitor has a resistive component. Expressed using conventional series equivalent notation, this resistance further impedes the passage of current.

$$|Z| = \sqrt{R^2 + X_c^2}$$

Each practical capacitor also includes an inductive element, which incorporated in the above provides the full equation for impedance, Fig. 1,

$$|Z| = \sqrt{R^2 + (X_c - X_l)^2}$$

where,

$$X_c = \frac{1}{2\pi fC}$$

$$X_l = 2\pi fL$$

At any frequency the term $X_c - X_l$ can be simplified into its series equivalent $\mathbf{j}X_s$ giving the vector equation $Z = R_s \pm jX_s$. This results in the magnitude/angle expressions

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

$$\angle\theta = \tan^{-1}\frac{X_s}{R_s}$$

In the above expressions, the R_s term represents the equivalent series resistance of the capacitor, while the X_s term represents the series reactive component. When viewed as a vector diagram, a polar plot, or on a Smith chart, this X_s term has a negative value for capacitors, Fig. 1.

The commonly used expressions

$$C = \frac{-1}{2\pi fX_s}$$

and,

$$\tan\delta = \text{abs}\frac{R_s}{X_s}$$

also apply.

While the above series equivalent expressions are the most helpful for larger capacitance values, many *LCR* meters default to the equivalent parallel expressions when measuring small capacitance values. Conversion between series and parallel values is simply performed.

$$R_p = \frac{R_s^2 + X_s^2}{R_s}$$

and,

$$X_p = \frac{R_s^2 + X_s^2}{X_s}$$

One benefit of parallel values is to express them in the form of admittance and susceptances, particularly helpful when calculating combinations of networks in parallel.

$$Y = \frac{1}{R_p \pm jX_p} = Gp \pm jB_p$$

$$G_p = \frac{R_s}{R_s^2 + X_s^2}$$

and,

$$B_p = \frac{X_s}{R_s^2 + X_s^2}$$

The conversion from parallel impedance back to series impedance format is equally simple:

$$R_s = \frac{R_p \times X_p^2}{R_p^2 + X_p^2}$$

and,

$$X_s = \frac{R_p^2 \times X_p}{R_p^2 + X_p^2}$$

applied for all subsequent correlation measurements.

To understand why these different frequencies were chosen, consider some measured values. A typical 10 000µF power supply electrolytic at 100Hz has an impedance of 150mΩ and esr of 11mΩ. At 1kHz, its impedance reduces to less than 20mΩ and esr to 10mΩ.

This 1kHz impedance and esr may be less than the impedance of many test leads or jigs. At higher frequencies, the capacitor's esr dominates the measured impedance, increasing measurement difficulties.

The impedance of a 0.1µF foil and polypropylene capacitor at 100Hz would exceed 15kΩ but its esr would be only 2Ω – a most difficult combination to measure and one subject to noise pickup. At 1kHz, its impedance reduces to some 1600Ω and esr to some 0.25Ω, which is a slightly easier measurement task.

Similarly a 100 pF capacitor's impedance makes measurement at 1kHz extremely difficult. Increasing frequency to 1MHz produces an impedance of around 1600Ω and esr of near 1Ω for COG ceramic or polystyrene film.

Test lead or test jig inductance reduces the measured impedance value, so artificially inflates the measure capacitance. More importantly – especially for low loss capacitors – any test lead or jig resistance increases the measured esr value. This results in inflated loss factor measurements.

Both effects can be minimised by using the shortest possible test leads and the most appropriate method to connect the test capacitor to the measurement instrument. By way of example, two-terminal measurement of a 1nF capacitor at 1MHz via a total lead inductance of 1µH overstates the true capacitance by 4%, Fig. 1.

Conventional two-terminal measurements are acceptable when measuring capacitive impedances of more than 1kΩ. This equates to capacitance values less than 1.5µF at 100Hz,

Capacitor test instruments

This short listing, using only examples from Hewlett Packard[6], illustrates typical measurement equipment commercially available. Other manufacturers also offer measuring systems.

Hewlett Packard makes a range of *LCR* meters to suit most requirements and budgets. The *HP4263B* is a well established meter able to measure from 100Hz to 100kHz in five frequency steps and from 1pF to 1F or 10nH to 100kH, with a 0.1% basic accuracy. Complete with a component test jig, this meter costs around £3000.

The *HP4278* meter has the speed and precision needed for production capacitor testing. Providing the two most common test frequencies, 1kHz and 1MHz, this meter can test capacitors up to 200µF. Its basic accuracy is 0.05% at 1MHz and its measurement time is 21ms maximum.

Should you need a wider frequency range, the *HP4284* meter has similar basic accuracy, a maximum measurement time of 830ms at 1kHz and a choice of 8600 test frequencies selectable from 20Hz to 1MHz. Capacitances from 0.01fF to 9.999F can be measured. This engineers tool, complete with a component test jig, costs around £8000.

Its companion meter, the *HP4285*, has a 0.1% basic accuracy and a wide test frequency range from 75kHz to 30MHz in 100Hz steps. It measures capacitors from 0.01fF to 999.99µF with a maximum measurement time of 200ms. Both meters also measure inductance.

The *HP4291* introduced the voltage/current impedance measurement method to frequencies from 1MHz to 1.8GHz. Having a basic accuracy of 0.8% it can measure a wide range of impedances.

The more recent *HP4286*, a dedicated *LCR* meter, offers similar performance measurements over a frequency range from 1MHz to 1GHz with a basic 1% accuracy.

150nF at 1kHz or 150pF at 1MHz. Larger capacitances or lesser impedances require use of four-terminal measurement leads or test jigs, as detailed in the panel entitled Four-terminal measurements.

The large magnitude differences between a capacitor's impedance or reactance and esr vectors means that accurate measurement of esr is much more difficult than is measurement of capacitance.

Since the capacitance value is much more easily measured than is loss factor, many low-cost instruments measure capacitance only. However while the capacitance value is important for circuit design calculations, it is esr which determines the power dissipated by the capacitor in use. The power dissipated results in heat, which ultimately determines the capacitors service life.

A quick measurement of capacitance can be helpful. But the esr figure is needed to allow the designer to discriminate between different capacitor makes and constructions. It allows you to ascertain a capacitor's suitability in power and pulse applications or even to confirm that an electrolytic capacitor has dried or worn out.

As you can see from the above numbers, a capacitor's esr is strongly frequency dependent. It may also be influenced by ambient temperature, ac test voltage and any dc bias voltage.

With most dielectric systems, the measured capacitance value is similarly affected by frequency, ambient temperature, ac test voltage and any applied dc bias voltage. Consequently, while these standardised test frequencies and voltages will be used in the maker's end-of-line production tests, measurements at other combinations are needed to quantify a capacitor's behaviour in the field.

Measuring esr

I said that esr is more difficult to measure than capacitance, but why? For an ideal capacitor, voltage and current have a phase difference of 90°. A practical capacitor exhibits resistive losses and a level of self inductance, resulting in a reduction of this phase angle.

A low-loss capacitor, such as the 0.1µF foil and polypropylene example above, would have a phase angle of 89.991° at 1kHz. The 100pF example's phase is 89.964° at 1MHz. Even the 10 000µF electrolytic example has a phase angle of 85.806° at 100Hz.

The small phase angle change between these first two examples – only 0.027° – quadruples the measured esr from 0.25 to 1.0Ω. This demonstrates how difficult it is to measure the esr of low-loss capacitors. It also emphasises the importance of minimising test lead or jig error contributions and optimising both accuracy and resolution of the phase angle measurement.

Measurement methods. Capacitance and esr can be measured by comparison with a known capacitor in a bridge circuit. Alternatively, capacitor current and phase angle can be measured while the device is stimulated by a known voltage.

One variation of this bridge circuit – the reflection bridge – measures the bridge's unbalance voltage and phase angle resulting from the test capacitor.[2]

The conventional ac Wheatstone capacitor bridge circuit has two precision variable resistance arms and a known standard capacitor. It suffers from a major disadvantage in that adjustment of one resistance arm affects the balancing conditions for the other arm. In practice, many interacting adjustments are required to attain the final loss factor balance, **Fig. 3**.

When measuring low-loss capacitors, this interaction is time consuming but acceptable. As capacitor loss increases – and especially with large value electrolytics – final balance may be impossible.[2]

The transformer ratio-arm bridge was developed many years ago to eliminate this problem. It results in almost complete independence when balancing capacitive and loss factor controls. It gave excellent results for capacitors to 10µF.

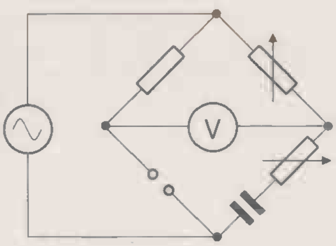


Fig. 3. The two balancing arms of this traditional ac Wheatstone capacitance bridge interact, needing repetitive adjustments. Measuring lossy capacitors, it is slow to balance.

A special low impedance adaptor was developed to measure impedances less than 10Ω. While this adaptor extended measurements to larger capacitance values, these cannot be read directly from the dials and accuracy is degraded.

Variations on Wheatstone

To overcome these balance interaction problems, many variations of the basic Wheatstone bridge were developed. One particularly useful exploration of balancing problems investigated ten different bridge configurations. Estimates of time to balance were derived for each configuration when measuring low or high loss components.[3]

Perhaps the most successful of these variants replaced one resistive balancing arm with a variable capacitance arm. When built many years ago to measure large value electrolytic capacitors, it proved to have almost complete independence between the capacitive and loss controls and provided a direct readout of esr. There's more on this in the panel entitled Capacitor bridge.

Recently, I needed to perform a series of difficult esr measurements at audio frequencies on capacitors having typically a 100V dc bias. No other suitable bridge being available, I built an up dated version. By including additional range switching this bridge could also measure smaller capacitance values and inductance, **Photo 1**.

I said earlier that these measurements could also be performed by measuring capacitor current and phase angle. For this measurement a resistor is used as a zero-phase reference standard. Accuracy of capacitance value measured depends on the sine of the measured phase angle, so may be little affected by measurement parasitics.

But esr depends on the cosine of the phase angle measured between the voltages on the capacitor and this standard resistor, so parasitics become important. Even at low frequencies, provision of a practical resistance standard free from capacitance and self inductance can prove difficult. **Fig. 4.**

Perhaps the best solution for practical experiments is to use a precision SMA 50Ω load or termination with a suitably accurate phase meter.[4] See also the panel entitled Impedance *V/I* measurements.

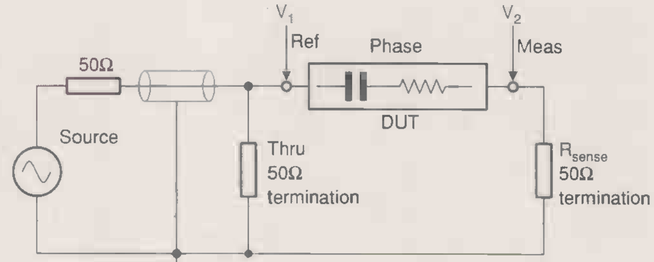


Fig. 4. Basic V/I impedance magnitude and phase angle measurement circuit, as used in LCR meters, is equally suited to measurements using lower cost discrete instruments.

Commercial *LCR* meters based on this approach and measuring to 1MHz have been available for more than a decade. One example can even measure at 30MHz, but commands a premium price. ■

What's next?
Having covered conventional capacitor measurement methods here, Cyril looks at reflection techniques in part 2. He also explores dielectric absorption, with results taken using a simple and easily repeated measurement method.

References

1. Bateman, C., 'Understanding capacitors', *Electronics World*, December 1997.
2. Bateman, C., 'Looking into impedance', *Electronics World*, August 1997.
3. 'Precise Balancing of Bridges', News from Rohde & Schwarz 23.
4. Bateman, C., 'Fazed by phase?', *Electronics World*, November 1997.
5. Bateman, C., 'Power Dissipation in Capacitors'. *Electronics World*, April 1995.
9. 'Test & Measurement Catalog - 1998', Hewlett Packard. Cain Road Bracknell, Berks RG12 111N.

Impedance V/I measurements

Impedance measurements can be performed using either a constant current or constant voltage source. Most engineers have a signal generator available so constant voltage tends to be the most popular.

Many writers advocate using a large value series resistor to approximate a constant current source. But when used to measure reactive loads – whether capacitors or inductors – this technique results in gross errors due to phase angle differences. This is easily confirmed in practice by measuring a known capacitor at low frequencies.

My preferred method, which I used to illustrate this series of articles, closely mimics the commercial *LCR* meter measurement methods, but uses available instruments. It was described in my article

Four-terminal measurements

A conventional two-terminal measurement of impedance uses the same test leads to pass the measurement current and measure the voltage drop at the device under test. This results in the measured voltage drop being overstated, according to the voltage drop along the test leads used and any contact resistances present.[2]

Using one pair of test leads to supply the test current and a second pair to measure the voltage drop at the device under test, while taking care to avoid mutually induced lead voltages, largely overcomes these errors, **Figs 5, 6**.

Using four coaxial test leads to replace the two pairs of leads, with Kelvin test contacts, eliminates almost all test lead errors.[2] The screens of the cables carry the return currents.

Occasionally a 'guard' or three-terminal technique is used to isolate the device under test from other circuit parasitics. Upgraded to the four terminal concept, this effectively becomes an accurate six terminal measurement.

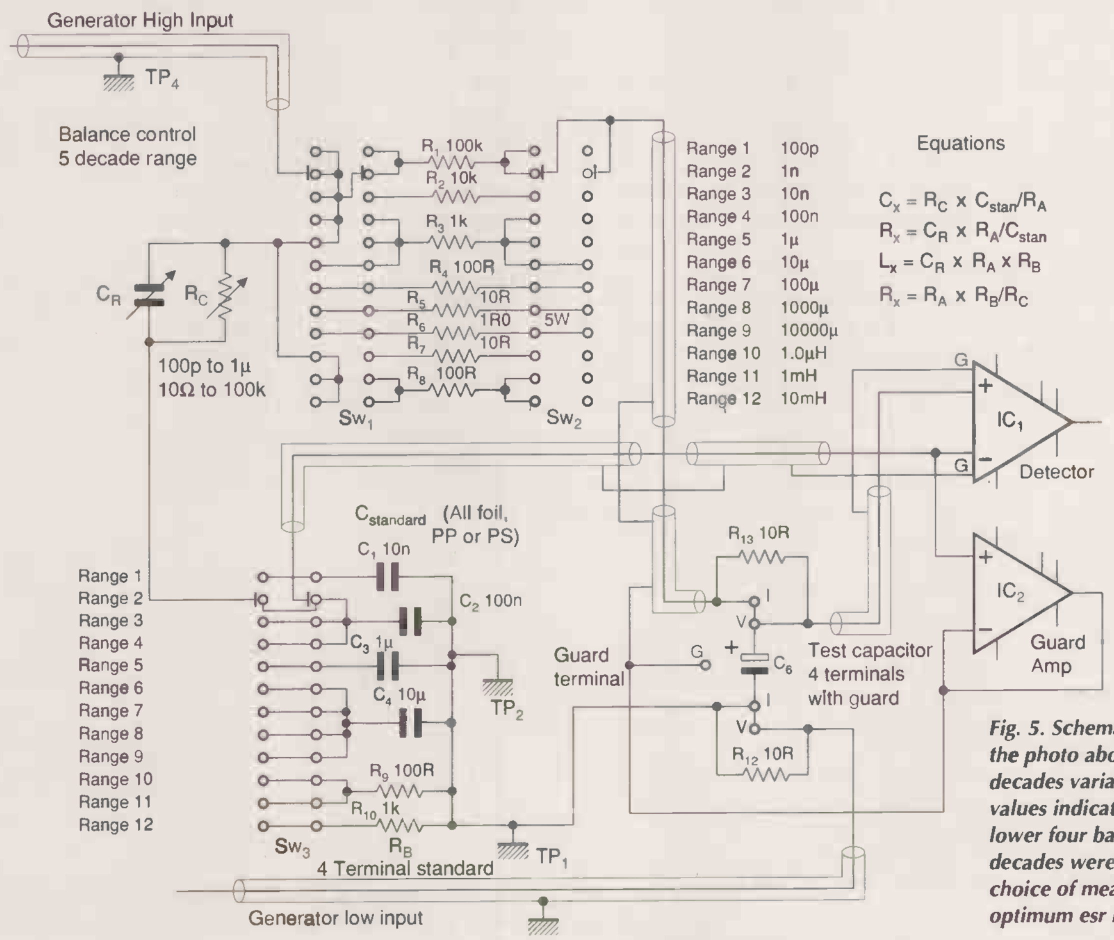


Fig. 5. Schematic of the bridge in the photo above. As built using five decades variable arms, the range values indicated need only use the lower four balancing decades. Five decades were built to provide a choice of measurement range for optimum esr balance sensitivity.

'Fazed by Phase' in the November 1997 issue.[4]

In essence this method uses a 50Ω laboratory signal generator, correctly terminated close to the device being measured with a 50Ω through termination, or preferably for better source isolation, a 10dB 50Ω attenuator pad.

The device being measured, in series with a known non-inductive, non-capacitive resistor, is connected between the inner and outer of this through-termination or attenuator pad. The test device is connected to the attenuator, one side of the known resistor being connected to earth.

Voltage from either side of the device under test to earth is measured and noted as V_1 and V_2. Voltage V_1 is the reference voltage at the inner of the attenuator pad while V_2 is the voltage across the known resistor.

The phase difference between V_1 and V_2 is also measured. Ideally the known resistor should have a value differing from the test device by no more than a factor of ten. Voltage and phase measurement probes should be of similar impedance and low capacitance. The normal divide ten oscilloscope probes are ideal.

$$|Z|_{DUT+R_{sense}} = \left(\frac{V_1 \times R_{sense}}{V_2}\right)$$

$$esr_{DUT} = \cos(\textit{phase angle}) * |Z| - R_{sense}$$

$$Reactance_{DUT} = \sin(\textit{phase angle}) \times |Z|$$

For negative reactance,

$$capacitance = \text{abs}\frac{-1}{2\pi f \times reactance}$$

Having obtained impedance and phase angle, capacitance and esr are easily calculated.

The four-terminal method described above, with Kelvin contacts to the device under test and with an intervening guard plate, describes the arrangement used for the *HP16047C* component test jig. This jig can be seen in place on my bridge in the photo.

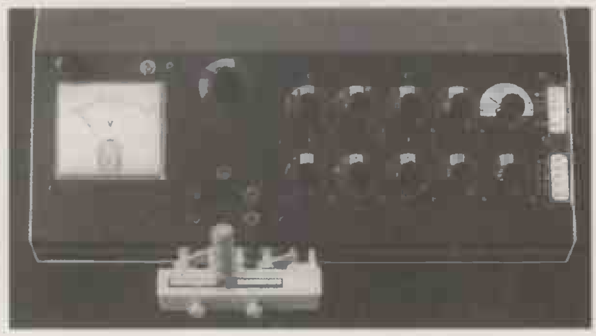


Photo 1. Based on the circuits in Figs 5 and 6, this bridge has independent balancing arms. Its variable capacitance arm measures esr, the variable resistance arm measures capacitance over nine ranges, to a maximum of 1F. Internal switching provides three inductance ranges to 100mH. Two capacitor connection methods, Hewlett Packard test jigs or four terminals with guard lead wires, can be seen.

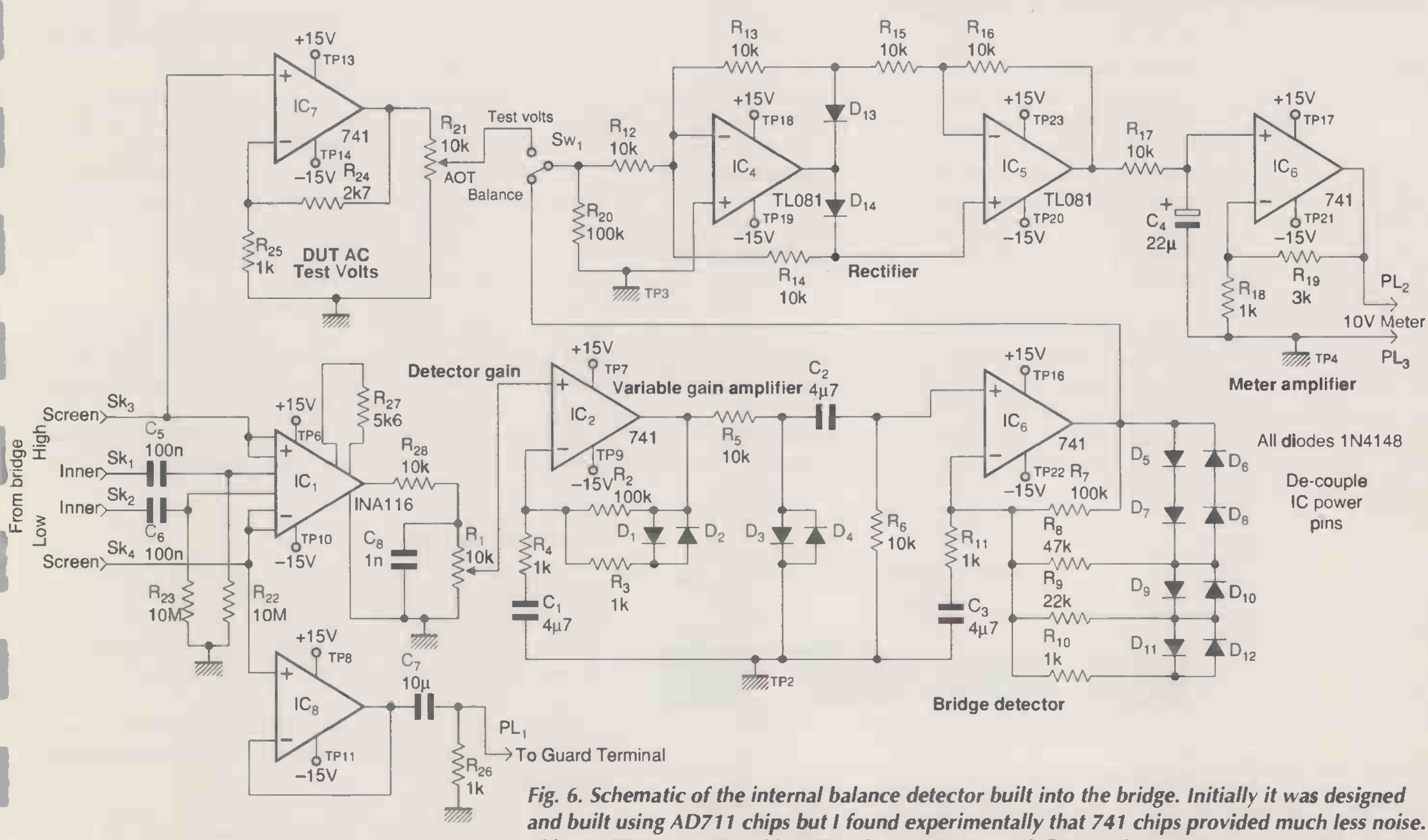


Fig. 6. Schematic of the internal balance detector built into the bridge. Initially it was designed and built using AD711 chips but I found experimentally that 741 chips provided much less noise. This sensitive detector, which provides a 30% meter deflection for a 10μV bridge unbalance voltage, needs 250 mV for full deflection. It is usable from 20Hz to 20kHz. My external high-Q, tuneable General Radio 1232A detector, which can be connected across R_1, extends measurements to 100kHz.

Wiring a prototype

A method for making densely packed prototype boards without special equipment, devised by Jouko Paloheimo and Rae Perälä.

Building a prototype circuit with many connections is not easy without a printed circuit board. On the other hand, making a complex printed circuit board for a one-off is expensive.

Here we show a way to make exacting circuit boards with ordinary tools. No chemical or photographic methods are needed.

The technique – in brief

A piece of double-sided pcb material is cut to the final size. The copper of the component side forms the earth plane, the other side becomes the supply plane.

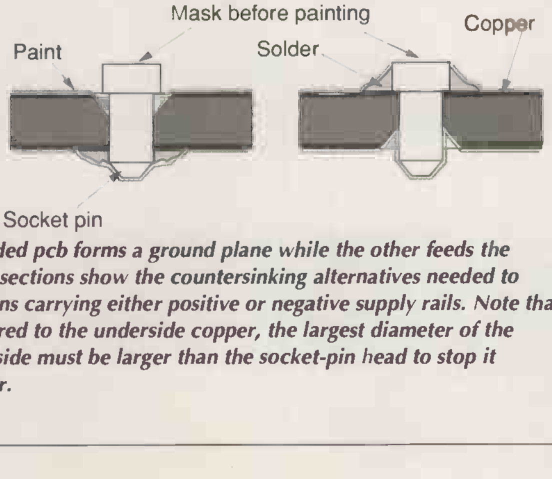
The hole pattern is drilled. Shallow craters are countersunk around the holes not intended for connection. Connection points are masked and the board is sprayed with a paint of suitable colour.

Integrated-circuit packages, or sockets for them, connect to the board only by their earth and supply pins. Additional wiring is performed in one of three ways: via wire wrapping, using a pressure sleeve or soldering. For connecting discrete components, DIL sockets are used.

Wire wrapping may not provide a long-term solution, but wrapped joints can be easily soldered once you are sure that the circuit works properly.

Board choice. Ordinary double-sided glass-fibre reinforced epoxy laminate is suitable. Board thickness of 1.6mm and copper thickness of 18μm are best. Thicker copper is usable, but it makes soldering more difficult.

A piece of final size is cut with a router, jigsaw, or even a hacksaw. Smooth the rough edges after sawing.



One side of a double-sided pcb forms a ground plane while the other feeds the supply rail. These cross sections show the countersinking alternatives needed to accommodate socket pins carrying either positive or negative supply rails. Note that for the socket-pin soldered to the underside copper, the largest diameter of the countersink on the top side must be larger than the socket-pin head to stop it touching the pcb copper.

Holes. For prototypes, it is feasible to drill the holes with a domestic drill provided that it is attached to a robust stand. High drilling speeds are not essential, 2500 to 3000rev/min will suffice – and less for larger holes and sinking. Drills can be ordinary high-speed steel types. Tungsten carbide types last longer but they are more brittle. Hole diameters associated with the technique described here are usually 1.3, 1.4 or 1.5 mm.

Accurate hole location is achieved by using pre-drilled Vero or stripboard as a drilling aid. A stack is formed by taping the stripboard and one or two of the required prototype circuit boards together.

The hole pattern is marked on the stripboard. When drilling, the stack is positioned under the drill by hand. Just when the drill meets the hole, the stack is released, letting the stack centre itself.

After drilling, the holes may have burrs, but this is not much of a problem because most of them will be enlarged afterwards and the remainder are easily smoothed.

All holes that do not connect to the copper layer should be countersunk to form a shallow crater on both sides to prevent unintentional connections between the layer and the components. Only the connection points to the copper layer should be left unsunk, but deburred.

A drill of up to 2.5mm diameter is suitable for the countersinks. A consistent sink depth is achieved by adjusting the drill stand stop so that the sink tool point lies exactly on the circuit board surface, then putting sheets of paper of suitable thickness under the board before sinking.

Avoid breaking the copper between adjacent holes. When sinking, do not hold the board tightly, but rather let it centre itself.

Here, we diverge

Two main variations are possible. In the first, any holes carrying power supply connections are furnished with separate individual socket pins. In the second, the IC packages or their sockets are soldered by their supply pins directly onto the board. We recommended the first method since it is more flexible.

Use of sockets is recommended. Any DIL sockets used must have turned pins. Do not use the cheaper stamped-pin varieties.

If you decide to use single-pin sockets for the supply connections, you should find them readily available. If not, press them out of a turned-pin IC socket. When using loose pins the hole size is 1.4mm. For foraged pins, the size should be 1.5mm.

The individual power pin sockets are soldered on the appropriate sides. A heavier tip is useful in the iron. Extra flux aids soldering too. Since only the body of the pin is needed, the thin wire tip should be cut off.

To make later modifications easier, do not tie connections such as unused inputs, straight to the board.

Side walls for carrying connector sockets, potentiometers and other mechanical parts can be made from strips of the same pcb material, **Photo 1**. Before soldering them into place, drill any necessary holes.

Any oxide on the copper surface should be cleaned off. Put the strip in place and fix it with a speck of solder, then straighten the board and finish the seam on both sides. It is advisable to use extra flux and a heavier iron for this task.

Insulating the pcb copper

Next the board is sprayed on both sides with paint for neat appearance and to prevent accidental shorts, **Photo 2**.

If any pins of the IC packages or sockets are to be soldered directly to the board, a small area around the holes concerned should be masked by a piece of tape during painting. Since even a small amount of adhesive impairs the solder joint, the choice of tape is important.

The preferred method – separate connector pins fixed on

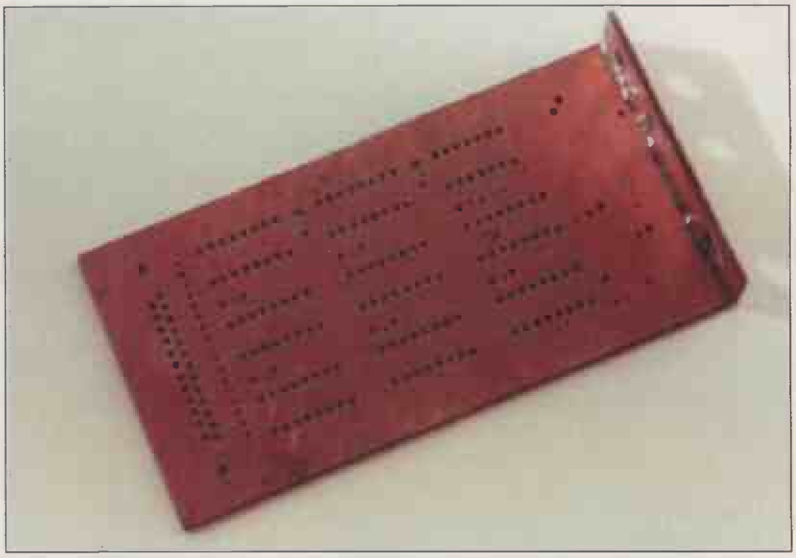
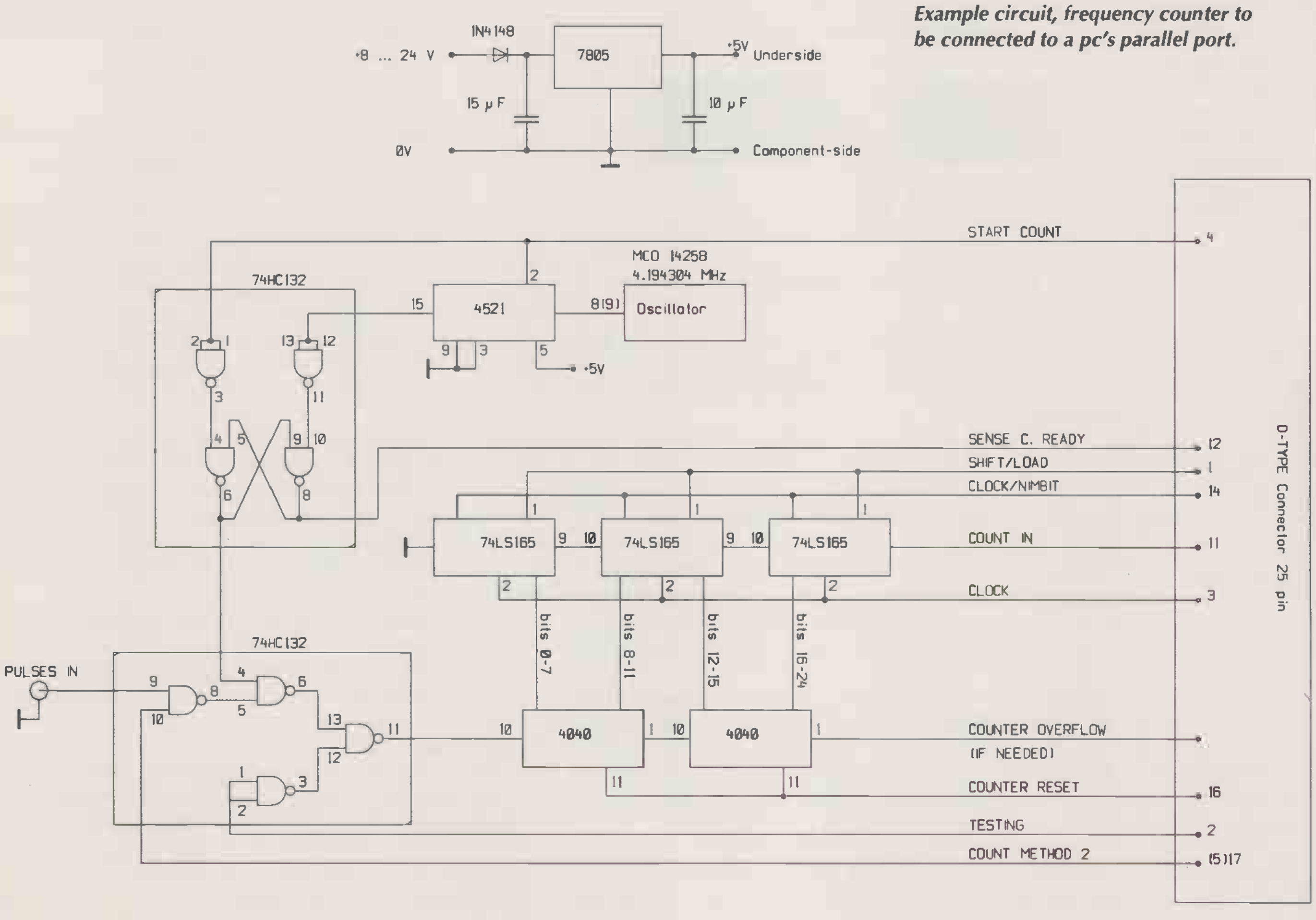


Photo 1. Drilled frequency counter board with a side-wall for connectors. Its measures 65 by 128 mm and accommodates a voltage regulator and nine DIL ICs.

Frequency counter – an example

A frequency counter circuit for connection to the printer port of a computer serves as an example. Its circuit is shown here. The only reason for showing this circuit is to illustrate the pcb prototyping technique so full details are not given.

Here is a short description though for interest. We wrote the control software in *Delphi 2*. Input signals are transformed to ttl/cmos level via a schmitt-trigger circuit. A one-second-long sample is fed into two 12-bit counter circuits. When the gate time is over, the counted bits are transferred to three parallel register circuits and serially counted by the software.



Example circuit, frequency counter to be connected to a pc's parallel port.

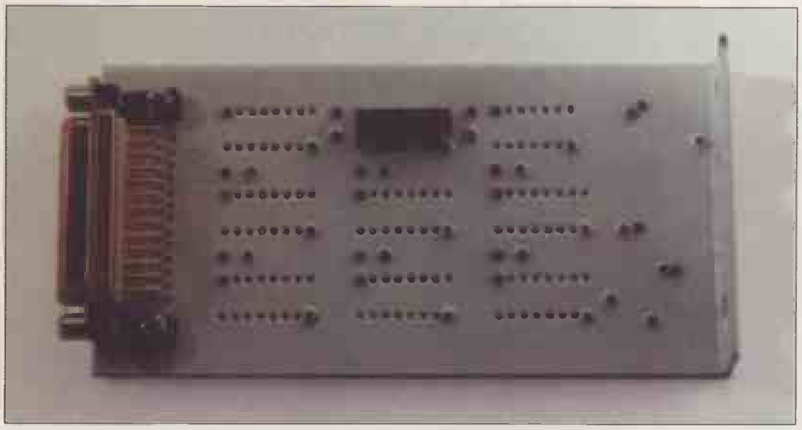
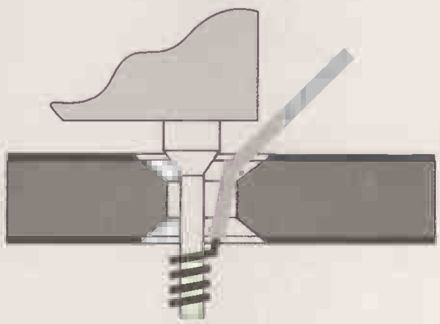
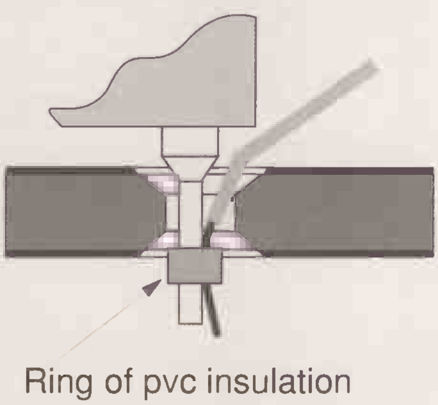


Photo 2. Painted circuit board having a 25-pin D-type connector and a DIL-package.



A turned-pin IC socket pin with its connection wrapped around. Once the board is successfully tested, the wrapped connection can be soldered to ensure long-term integrity.



Alternative method of connecting the wire to the IC pin using insulation stripped from a piece of wire to form a pressure connections.

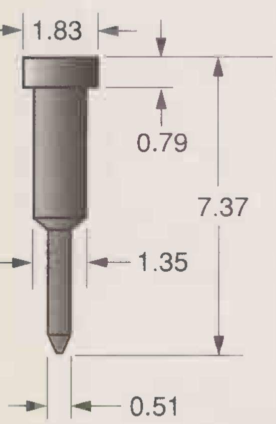


Fig. 4. Socket pin. If you cannot find a source for them, pull some out of a turned-pin IC socket.

the board – is in this respect easier. Push a pin into the connecting opening and slip plastic insulation stripped from a piece of wire, or heat-shrink tubing over the projecting pin and the gap.

Wiring

All wiring is done from the component side. The backside is left free for soldering and troubleshooting.

Only one type of wire is suitable – tinned 0.25mm diameter copper wire for wire wrapping, with a total thickness including insulation about 0.6mm. The choice of colour is yours. For most applications, this wire thickness is ample: it is equivalent to 1.4mm track width on an ordinary circuit board.

Connections can be made using three different methods. Wire wrapping can be carried out using an ordinary propelling pencil as a wrapping tool. Simply remove the pencil's lead and it is ready for use. The thin steel tube on the tip is from 0.3 to 0.7mm diameter, 0.5mm being perhaps the easiest.

The wrapping method is simple: when the socket is in place, strip 10 to 15mm of the insulation from the wire, push the bare wire into the hole, hold it fast with your fingers, and on the other side push the pencil's steel tube around the wire. Keeping the wire in the tube taut and at a suitable angle, start slowly wrapping it around the pin. Usually between three and six turns are possible, and adequate.

Wrapping is easy, as is unwrapping. Carefully done and in a suitable environment, a wrapped connection will remain reliable for a long time. Wrapping two wires on a pin can be done but no more. If you need more, use chaining or the following wiring method.

The pressure-sleeve connection method involves short plastic sleeves cut from wire insulation of suitable diameter. The insulation sleeve ring is pushed over the pin and the wire, pressing the two tightly against each other. With practice pressure sleeving can be as fast as wire wrapping.

Soldering is the third option. Here we break all the rules. Small pieces of about 1mm long are cut from thin resin-cored solder. Bare wire is pushed into the hole from the component side and on the other side is stretched against the pin with pliers. The junction is wetted with a droplet of flux. A bead of solder is then moved to the junction using a thin iron tip. Excess wire is cut off and a neat joint is ready.

At this stage, you can position the sockets in the connecting pins and start wrapping them one by one. Alternatively, you can cut and trim all the wires and insert the ends into relevant holes for joining, doing all wiring before putting the sockets in place. Wiring first gives the most compact installation. You need to have a list of connection points to hand of course.

Measure the shortest distance between holes. Add 15mm to both ends and cut the wire to length. Strip wire at both ends, bend the stripped part at right angles and put it into place. On the back side of the board, bend the protruding ends so that they stay put. After all wires are in place, position the sockets into connecting pins and start wrapping.

If a twinge of remorse hits you here, it is quite easy to pull all the sockets off the board, the wiring mat will follow and the board is ready for a second attempt.

Extending the concept

If interconnections are needed between IC pins, they can be made under the socket. Drill a row of 1.4mm holes on a 0.1 to 0.8mm thick single-sided laminate.

Cut a suitable strip with scissors. Place it over the pins of the socket and solder. If some pins do not need connecting, simply scratch away a little of the copper around the hole – or drill the hole larger – to bypass the pins. Do this before soldering or you may scratch breaks across the strip.

We used this method for the frequency counter shown in the panel. Some sockets have a protruding ridge underside preventing shallow assembly; the ridges can be easily torn off with pliers.

Resistors, capacitors and the like are not suitable for mounting directly on the board. Ordinary 0.25W resistors need more space than the three modules available in 14 and 16 pin sockets. One way of solving this problem is to cut two legs off an IC, place them opposite each other in a socket and bend them outwards. Put a resistor on the ends, solder and trim. Now you have a portable component.

Many transistors and diodes can be pushed into sockets. Another tip: the strips described above can be used as supports for installing surface-mount devices under the sockets.

All these techniques have been tried and found convenient.

Conclusion

The techniques outlined here are not ideal for the novice, but in the hands of an innovative prototype designer, they offer an excellent compromise relative to Veroboard and etching a pcb. They make it possible to produce high-performance prototype circuit boards that would otherwise be too expensive to produce with traditional methods. ■

TELFORD ELECTRONICS

Old Officers Mess, Hoo Farm, Humbers Lane,
Horton, Telford, Shropshire TF6 6DJ, UK
Phone: (00 44) 01952 605451 Fax: (00 44) 01952 677978
e-mail: telfordelectronics@telford2.demon.co.uk
Carriage: £10+VAT @17.5% to be added to all UK orders
Overseas orders welcome - Please call

**ALL OUR EQUIPMENT HAS A 30 DAY GUARANTEE.
(EXCEPT CLEARANCE ITEMS WHICH ARE SOLD AS-IS)**

LAB-VOLT EQUIPMENT

FM/PM Receiver	9415-10
Indirect FM/PM Generator	9414-00
True RMS Voltmeter/Power Meter	9404-00
SSB Receiver	9412-00
AM/DSB Receiver	9411-00
RF/Noise Generator	9406-00
AM/DSB/SSB Generator	9410-00
Direct FM Multiplex Generator	9413-00
Spectrum Analyzer	9405-00
Frequency Counter	9403-00
Indirect FM/PM Generator	9414-00

Please phone for price

NEW STOCK

Power Supplies

HP6264B	DC Power Supply 0-20V 0-20A	£250.00
Power Ten Systems Power Supply 0-30V 0-60A		£300.00
Sorensen Power Supply Type: DCR300-9B 0-400V 0-10A		£450.00
Powerline Power Supply Type: LAB510 0-30V 0-10A		£175.00
Powerline Power Supply Type: LAB532 5V-5A, +15V-0.5A, -15V-0.5A, 0-30V-2A		£200.00
Farnell 30/100 30V 100A		£700.00

MISCELLANEOUS

HP54503A	Digital Storage Oscilloscope 500MHz	£2,000.00
Tektronix TAS455	60MHz Dual Channel	£600.00
Blackstar	5Hz-100MHz Frequency Counter	£45.00
Keithley	TRMS Multimeter	£150.00
Fluke 5220A	Transconductance Amplifier	£3,000.00
Bruel & Kjaer 2636 Measuring Amplifier		£4,000.00
Bruel & Kjaer 5935 Dual Microphone Supply		£650.00

I.L.X. Lightwave Equipment
LDT5910B Temperature Controller
PDA6424 Photo Diode Amplifier
LDX3742 laser Diode Controller
LDX3207B Precision Current Source
Anritsu MW920A OTDR + MH951A 850nM Plug-In + MH952A 1300nM Plug-In
3M Fibre Splice Preperation Kit
Cossor Optical Cable Fault Locator Type: OFL108L
Laser Precision Type: DB2900 Single Mode Variable Attenuator
Schlumberger Type: S17780 DTDR + S177822 + S177823 Plug-Ins
Nakamichi Discrete Cassette Decks
Types: BX300E, ZX9, 680ZX

TEKTRONIX

5D10	Waveform Digitizer	£400.00
7403N	60MHz Mainframe	£175.00
7704A	200MHz Mainframe	£350.00
7A11	Internal Probe Amplifier 150MHz	£100.00
7A12	Dual Trace Amplifier 120MHz	£120.00
7A13	Differential Comparator	£200.00
7A15A	Single Channel Amplifier 80MHz	£80.00
7A15N	Single Channel Amplifier 75MHz	£60.00
7A16A	Single Channel Amplifier 225MHz	£110.00
7A18	Dual Trace Amplifier 75MHz	£75.00
7A18A	Dual Trace Amplifier 75MHz	£85.00
7A19	Single Channel Amplifier 600MHz	£200.00
7A26	Dual Channel Amplifier 200MHz	£125.00
7A42	Logic Triggered Vertical Amplifier 350MHz	£500.00
7B50	Time Base	£100.00
7B51	Delaying Time Base	£125.00
7B53A	Dual Time Base 100MHz	£100.00
7B70	Time Base 200MHz	£200.00
7B80	Time Base 400MHz Delayed	£125.00
7B85	Time Based 400MHz Delayed	£140.00
7B87	Digital Time Base 400MHz	£325.00
7D01	Logic Analyser	£100.00
7D02	Personality Module PM100 Series	£100.00
7D10	Digital Events Delay Unit	£300.00
7D11	Digital Delay Unit	£50.00
7D20	Programmable Digitizer	£400.00
7S11	Sampling Unit	£275.00
DF1	Display Formatter	£50.00
DF2	Display Formatter	£50.00
S1	Sampling Head 1000MHz	£150.00
7603	100MHz Mainframe	£275.00
7633	100MHz Mainframe (Fast Storage)	£400.00
7854	400MHz Mainframe (Digital Storage)	£800.00
7904	500MHz Mainframe	£450.00

**CONTINENTAL MICROWAVE
Down Converter
Type: DC421
Down Converter
Type: DC221
DC117A203**

OSCILLOSCOPES

Gould 4030	Digital Storage 20MHz 20MS/S	£350.00
Gould OS300	20MHz	£120.00
Hitachi	VC6015 D.S.O.	£300.00
Hitachi	V222 20MHz	£225.00
HP54111D	500MHz Digital	£1,950.00
HP54200A	50MHz Digital	£750.00
HP54501A	100MHz Digital	£1,600.00
Iso-Tech	ISR640 40MHz	£300.00
Iso-Tech	ISR640 40MHz	£225.00
Iwatsu DMS6430	Digital Memory	£475.00
Iwatsu SAS8130	Waveform Analyser DC-3.5GHz	£1,500.00
Leader	LBO-522 20MHz	£200.00
Philips	PM3217 50MHz	£350.00
Philips	PM3340 2GHz Digital	£3,000.00
Philips	PM3305 35MHz	£250.00
Philips	PM3325A 60MHz D.S.O. 100MS/s	£1,200.00
Philips	PM3262 DC-100MHz	£250.00
Philips	PM3352A 50MHz Digital Storage	£1,200.00
Tek 2215	60MHz	£350.00
Tek 2225	50MHz	£375.00
Tek 2235	100MHz	£600.00
Tek 2236	100MHz	£750.00
Tek 2245A	100MHz	£950.00
Tek 2336	100MHz	£750.00
Tek 465	100MHz	£350.00
Tek 466	100MHz	£300.00
Tek 475	200MHz	£425.00
Tek SC502	15MHz	£300.00

Tek TDS420	150MHz 4 Channel 100MS/S	£2,950.00
Telequip	D61A 10MHz	£75.00

**SPECIAL PURCHASE
Marconi 2955
Radio Communications Test Set
£1,850.00**

**Marconi TF2015 + TF2017
10MHz - 520MHz Signal Generator
With Synchronizer
£250.00**

MICROWAVE

Continental Mic	Transmitter Control VML TR-240-1/1	£750.00
Digital Microwave	12GHz TX/RX (new)	£1,200.00
HP H 752A	Directional Coupler 3dB	£150.00
HP X 382A	Variable Attenuator 0-50dB 8.2-12.4GHz	£120.00
HP11691D	Dual Directional Coupler	£600.00
HP11692D	Dual Directional Coupler	£700.00
HP11720A	Pulse Modulator 2-18GHz	£720.00
HP11722A	Sensor Module	£600.00
HP33304A	Programmable Attenuator 18GHz 0-11dB	£175.00
HP33305A	Programmable Attenuator 18GHz 0-110dB	£175.00
HP33320A	Attenuator 11dB	£250.00
HP33320B	Attenuator 21dB	£250.00
HP33322A	Attenuator 110dB	£250.00
HP335D	VHF Attenuator 120dB DC-1GHz	£300.00
HP532B	Frequency Meter	£200.00
HP5342A	18GHz Microwave Frequency Counter	£1,200.00
HP536A	Frequency Meter 3.7-12.4GHz	£200.00
HP54111A	2GHz-S/S Test Set	£560.00
HP8405A	Vector Volt Meter	£250.00
HP8410B		£200.00
HP8414A		£175.00
HP8502A	Transmission/Reflection Test Set 500KHz-1.3GHz	£750.00
HP8743B	Reflection-Transmission Test Set Unit 2-12.4GHz	£600.00
HP8745A	S-Parameter Test Set 0.1-2GHz	£560.00
Marconi 6019/2	Calibrated Variable Attenuator 12.4-18GHz	£200.00
Marconi 6030/10	Directional Coupler X Band	£200.00
Marconi 6052/3	Rotary Vane Attenuator 8.12-12.4GHz	£120.00
Marconi 6960+6910	Power Meter 10MHz-20GHz	£900.00
Maury Microwave	Sliding Termination 8035H up to 20GHz	£600.00
NEC	Pasolink 50 50GHz TX/RX	£500.00
Racal 9303	True RMS Level Meter	£800.00
TEK TR502	Tracking Generator	£750.00
Waveguide	X Band WG16 10ft Lengths	£30.00
Weinschel	Adaptor APC7-SMA (new)	£65.00
Wiltron	87A50 VSWR Bridge 2-18GHz	£600.00
Wiltron	64NF50 VSWR Bridge 3-8GHz	£400.00

**RACAL RA1784 + MA1072
HF Remote Controlled Receiver
£500.00**

**RADIALL POWER ATTENUATOR
3dB 30W 0-4GHz
Brand New & Boxed
£50.00**

SIGNAL GENERATORS

Adret 7100B	300KHz-650MHz	£700.00
Adret 740A	0.1-560MHz	£750.00
Cushman CE12	Two Tone Generator	£150.00
Farnell DSG2	Synthesized 0.1MHz-110KHz	£185.00
Farnell PSG1000	10KHz-1GHz	£1,200.00
Flann 4311A	12-18GHz	£50.00
Fluke 6010A	10Hz-11MHz Synthesised	£175.00
HP11710B	Down Convertor (HP8640B)	£275.00
HP214B	Pulse Generator 100V 2A	£1,200.00
HP3325A	Synthesizer Generator 1Hz-21MHz	£1,500.00
HP4204A	Oscillator 10Hz-1MHz	£125.00
HP654A	Test Oscillator 10MHz	£225.00
HP8005B	0.3Hz-10MHz	£300.00
HP8008A	10Hz-200MHz	£450.00
HP8015A	1Hz-50MHz Pulse	£450.00
HP8165A	Programmable Signal Source	£1,200.00
HP8620C +HP86222B	0.01-2.4 GHz Sweeper	£1,500.00
HP8642M	0.1-2100MHz	£7,000.00
HP8647A	250KHz-1000MHz	£2,300.00
HP8684B	5.4-12.5GHz	£1,950.00
Marconi 2019A	80KHz-1040MHz	£1,450.00
Marconi 2022	10KHz-1GHz	£1,250.00
Marconi 6057	Signal Source 5.5-8.5GHz	£200.00
Marconi 6059A	12-18GHz Signal Source	£200.00
Racal 9053	Two Tone	£120.00
Racal 9084+9934A	0.01-104MHz	£500.00
Racal 9087	10KHz-1.3GHz	£2,300.00
Systron Donner 1702	Audio-1GHz	£600.00
Tek 504	0.001-240MHz	£350.00
Tek FG501A	2MHz Function	£250.00
Wavetek 1080	1-1000MHz Sweeper	£800.00
Wavetek 157	Programmable Waveform	£150.00
Wavetek 159	Waveform Generator 1Hz-3MHz	£300.00
Wavetek 171	Synthesizer/Function	£400.00
Wavetek 185	Sweeper/Function 0-5MHz	£350.00
Wavetek 2001	1-1400MHz	£600.00
Wavetek 907A	7-12.4GHz	£900.00
Wiltron 6100+6223B	Sweeper 4 12.4GHz	£500.00

**HP3708A
Noise & Interferance Test Set
£11,500.00**

SIGNAL ANALYZERS

AD 352	FFT Analyzer	£300.00
Advantest	TR4132 Spectrum Analyzer 1-1GHz	£1,800.00
B&K 2033	Signal Analyzer	£2,000.00
HP182T+HP8557A	Spectrum Analyzer .01-350MHz	£800.00
HP182T+HP8558B	Spectrum Analyzer 100KHz-1.5GHz	£1,350.00

HP334A	Distortion Analyzer	£250.00
HP339A	Distortion Measuring Set	£1,200.00
HP3581C	Selective Volt Meter	£600.00
HP3582A	0.02Hz-25.999KHz Spectrum Analyzer	£1,500.00
HP8903B	Audio Analyzer	£3,200.00
Marconi 2305	Modulation Meter	£2,000.00
Marconi 2382+2380	400MHz Spectrum Analyzer	£3,500.00
Marconi 2601	True RMS Voltmeter	£500.00
Marconi 2955	Test Set+2960 TACS Unit	£2,400.00
Marconi TF2370	110MHz Spectrum Analyzer	£600.00
R&S	SMDU Z1	£400.00
R&S	Ure RMS Voltmeter	£800.00
R&S	ZPV + E3 P.I. Vector Analyzer 0.3-2GHz	£2,000.00
R&S CMS52	Comms Service Monitor	£6,500.00
Racal 9302	RF Millivolt Meter	£350.00
Racal Dana	9702 Spectrum Analyzer 1-1GHz	£1,300.00
Spectral DY. SD37	FFT Analyzer	£1,800.00
Tek 7L12	100KHz-1.8GHz	£800.00
Tek DA4084	Programmable Distortion Analyzer	£700.00

**HP8657A
Signal Generator
0.1-1040MHz
£3,500.00**

DATA/TELECOMS

Anritsu	MS334A PCM Error Detector	£120.00
BT (Fulcrum)	T1020 Network Transmission Performance Analyzer	£500.00
Cushman	CE24 FX Selective Level Meter	£400
Datalab DL1000	Programmable Transient Recorder	£250.00
GN Elmi EPR31	PCM Signalling Recorder	£5,000.00
HP1350A	Graphics Translator	£200.00
HP1631D	Logic Analyzer	£650.00
HP3336A	Synthesizer/Level Generator	£1,300.00
HP3497A	Data Acquisition/Control Unit	£400.00
HP3586B	Selective Meter	From £850.00
HP3717A	70MHz Modulator/Demodulator	£POA
HP37201A	HP-IB Extender	£300.00
HP37204	HP-IB Extender	£300.00
HP3762A	Data Generator	£350.00
HP3763A	Error Detector	£800.00
HP3764A	Digital Transmission Analyser	£3,200.00
HP3770B	Telephone Line Analyzer	£200.00
HP3780A	Pattern Generator/Error Detector	£1,100.00
HP3781A	Pattern Generator	£500.00
HP3782A	Error Detector	£500.00
HP4935A	Transmission Tester	£1,100.00
HP4984A	In-Service Transmission Impairment Measuring Set	£POA
HP5005B	Signature Tester	£950.00
HP5006A	Signature Analyzer	£50.00
HP6942A	Multiprogrammer	£200.00
HP8170A	Logic Pattern Generator	£600.00
HP8954A	Tranceiver Interface	£600.00
Iwatsu DM2350	Digital Memory 10 Bit/20ns	£400.00
Marconi 2828A	Digital Simulator	£200.00
Marconi 2829	Digital Analyzer	£200.00
Marconi 2831	Channel Access Switch	£200.00
Marconi OA2805	PCM Regenerator Test Set	£250.00
Marconi TF2019C	Noise Generator - Many Filters Available	£250.00
Marconi TF2092C	Noise Receiver	£250.00
Marconi TF2808/2	Pattern Generator and SLMS (Brand New/Boxed)	£120.00
Marconi TF2807A	P.C.M. Multiplex Tester	£200.00
Marconi TF2830	Multiplex Tester	£200.00
Meguro	MK612A VTR Jitter Meter	£75.00
Phoenix	5500A Telecommunications Analyzer	£1,500.00
Racal 202, 205	State Logic Analyzer	£150.00
Schlumberger	7700 140 m Bit/s Filtermeter/Generator	£125.00
Schlumberger	7710 Mainframe Set 34/140 M Bit/s	£125.00
Siemens	D2155 Level Meter/W3155 Tracking Oscillator	£150.00
Siemens P2032	Bit Error Measuring Set	£900.00
Tek 834	Programmable Date Comms Tester	£150.00
Thurlby	LA4800 Logic Analyzer	£500.00
W&G	SPM15 Level Meter	£800.00
W&G	PS12 Level Generator	£300.00
W&G	SPM12 Level Meter	£POA
W&G	PCM2-3 PCM Test Set	£300.00
W&G	SBG-1 SSB Level Generator	£150.00
W&G	DLM3 Data Line Test Set	£500.00
W&G	SPM19 Level Meter	£2,500.00
W&G	MU3 Test Point Selector	£POA
W&G	PJM-1 PCM Jitter Meter	£250.00

**ROHDE & SCHWARZ
CMT 54
0.1-1000MHz
Communications Test Set
£3,250.00**

PLOTTERS/RECORDERS

HP	Draft Master RX	£500.00
HP Colour Pro		£45.00
HP DraFt Pro-DXL	7575A	£250.00
HP7475A	Plotter RS232	£150.00
HP7550A	Plotter	£250.00
Racal Recorders	4DS & 7DS	from £200.00
HP2225A	Thinkjet Printer HPIB	£95.00
HP2225D	Thinkjet Printer RS323C	£POA

**SEMI-RIGID CO-AXIAL CABLE
TYPE: UT141/A
0-20GHz 3M Lengths
Brand new: £10.00 per length
Discount on Qty: (100pcs = £500.00)**

GOOD SELECTION OF 18-20 GHz COAXIAL SWITCHES IN STOCK: £65.00 EACH

FARNELL MP30-80 1KW 30V 80A AUTO RANGING POWER SUPPLY. PRICE: £500.00

PYE CHARGERS TYPE: BC21C NEW & BOXED. PRICE: £25.00

MOTOROLA BATTERY CHARGER; TYPE NTN4922A, GOOD CONDITION. PRICE: £85.00

MATCH BOX: MATCH EFFICIENCY METER MODEL: MB800. MADE BY HELPER INSTRUMENTS: PRICE: £150.00. FREQUENCY RANGE: 775-1025MHz SWR (VSWR) INDICATION RANGE: 1.0:1 TO 5.0:1

Adret	5104 Drving Synthesizer 90-120MHz	£125.00
Aeritalia	Type: TE307 Electric & Magnetic Field Sensor	£150.00
Bird	Coaxial Attenuator 30dB 50 2KW	£300.00
Boonton	82AD Modulation Meter	£200.00
Farnell	E350 Stabilised Voltage Supply	£120.00
Farnell	RB1030/35 Electronic Load 1kW 30A 35V	£300.00
Farnell	TSV70 Mk2 Stabilised Power Supply	£180.00
Ferrograph	RTS2 Recorder Test Set	£200.00
Fluke	8520A Digital Multi Meter	£250.00
Fluke	8860A Digital Multi Meter	£150.00
General Radio	1265A DC Power Supply 0-400V 0-5A	£475.00
General Radio	1308A Audio Oscillator + Power Amplifier	£1,500.00
General Radio	1633A Incremental Inductance Bridge	£375.00
Giga	GR1101A 12-18 GHz Microwave Signal Generator	£150.00
Giga	GU1328A 2-8GHz Microwave Signal Generator	£150.00
Harris	RF/2305 Receiver/Exciter	£200.00
HF Multicoupler	1 Input 8/16 Outputs 1-40MHz	£300.00
HP	11713A Attenuator Switch Driver	£300.00
HP	1741A 100MHz Oscilloscope	£300.00
HP	1742A 100MHz Oscilloscope	£275.00
HP	181A Main Frame c/w 1840A+1825A	£125.00
HP	3400A RMS Volt Meter	£120.00
HP	3570A Network Analyser 50Hz-13MHz	£150.00
HP	4333A Distribution Analyser	£300.00
HP	435A Power Meter	£175.00
HP	435B Power Meter	£250.00
HP	489A Microwave Amplifier 1-2GHz	£125.00
HP	5315A Universal Counter 100MHz	£200.00
HP	5328A Universal Counter 100MHz	£120.00
HP	5363A Time Interval Probes	£150.00
HP	8412B Phase Magnitude Display	£175.00
HP	8443B Tracking Generator/Counter	£250.00
HP	8445B Automatic Preselector	£300.00
HP	8552B IF Section	£250.00
HP	8553B RF Section 0-100MHz	£200.00
HP	8553L RF Spectrum Analyser 0-110MHz	£200.00
HP	8556A LF Spectrum Analyser	£200.00
HP	86601A RF Section 0.1-110MHz	£300.00
HP	8750A Storage Normalizer	£200.00
HP	491C Microwave Amplifier 2-4GHz	£125.00
HP	8413A Phase Gain Indicator Unit	£175.00
HP3488A	Switch Control Unit	£800.00
HP8508A	Vector Voltmeter	£2,500.00
Iwatsu	SC/7103 Frequency Counter	£160.00
Keithley	192 Programmable Digital Multimeter	£200.00
Marconi	6056B Signal Source 2-4GHz	£150.00
Marconi	TF2337A Auto Distortion Meter	£150.00
Megger Pat 2	Portable Appliance Tester c/w Calibration	£420.00
Polarad	1105E/FT 0.8-2.4GHz Signal Generator	£250.00
Racal	9104 RF Power Meter	£200.00
Racal	9300 RMS Volt Meter	£175.00
Racal	9301A RF Millivoltmeter True RMS	£180.00
Racal	9921 UHF Frequency Counter	£275.00
Racal	MA1720 Drive Unit	£300.00
Racal	9081 5-520MHz Synthesized Signal Generator	£375.00
Racal Dana	9478 Frequency Distribution Unit	£200.00
Schlumberger	7055 Micro Volt Meter	£150.00
Systron Donner	5000A Sweeper c/w Oscillator 5014/26 3.2-6.5GHz	£250.00
Tektronix	464 Oscilloscope	£300.00
Tinsley	5761 Resistance Bridge	£200.00
W&J	3737A/10 HF Receiver	£120.00
W&J	DMS107 Demodulator	£120.00
W&J	565 Receiver	£200.00
W&J	DM/112 Demodulator	£250.00
W&J	MTF/106A Microwave Tuning	£150.00
W&J	WJ9518AE/9 FDM Demodulator	£250.00

CIRCLE NO. 128 ON REPLY CARD

VHF millivoltmeter

Nick Wheeler's vhf millivoltmeter is useful to 150MHz, but more importantly, he achieves less than 2pF input capacitance through using surface-mount parts and a GaAs fet front end.

There's often a need to measure low-level rf signals. If these are in a low-impedance part of the system and at a level of tens of millivolts, you can do this with an oscilloscope and a divide-by-ten probe. But the sensitive ranges of most oscilloscopes usually have a limited bandwidth – typically a fifth of the nominal instrument rating.

High-impedance test points on a circuit will be seriously loaded or detuned by the 20pF or so of the oscilloscope probe in its ×10 mode, and may be disabled completely if you use the probe in the ×1 mode.

This article describes a vhf millivoltmeter whose response extends to over 150MHz. Its input is less than 2pF in parallel with 100kΩ and the first scale indication is 2mV rms. Radio frequency signals can be rich in harmonics and this is a peak-reading instrument. The sensitivity quoted assumes a sinusoidal signal.

Indication is via a 50μA moving-coil meter. You will find that an analogue indication is essential for most applications. The rf part is in a screened probe head and there is only a dc input in the connecting lead to the box housing the meter and mains psu.

Implementation

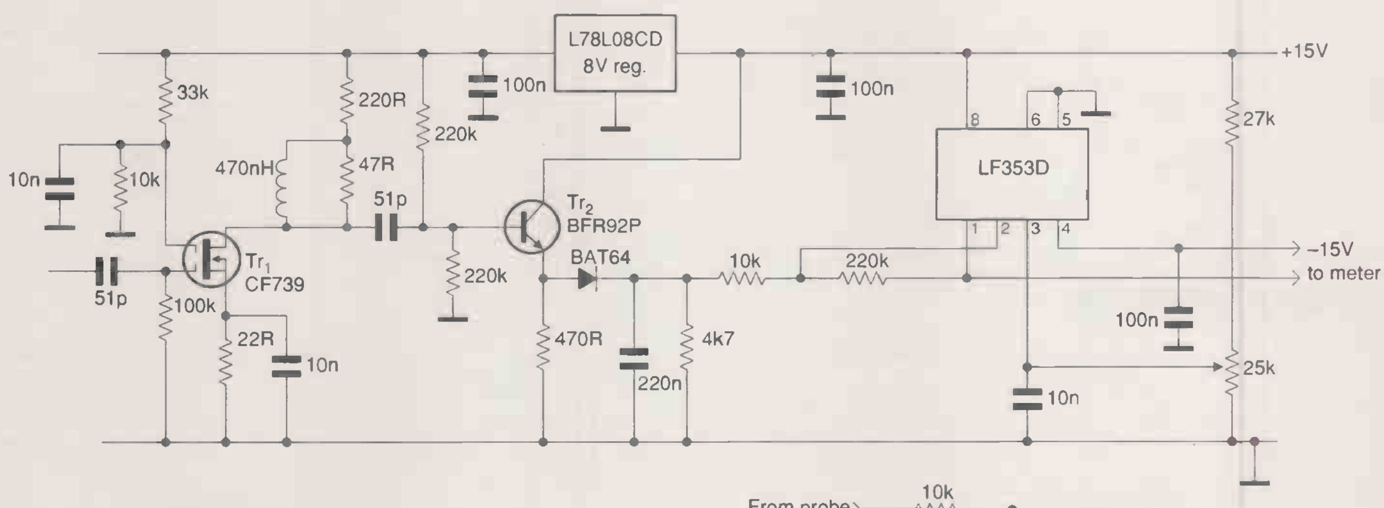
This instrument uses surface mount technology. I believe that it would be virtually impossible to realise it by any other means.

All the active parts are accommodated on a double sided pcb measuring 9 by 1.5cm. I think that I could have shrunk the design further, so that it would have fitted inside a piece of 15mm domestic copper water piping, but I decided to settle for 22mm.

I have laid out the circuit diagram, **Fig. 1**, so that the placement of the parts corresponds roughly with the layout of the top surface of the pcb, **Fig. 2**. Most of the other side of the pcb is a copper ground plane, removed only where it would increase stray capacitance.

Input device Tr_1 is the useful Siemens *CF 739* (RS 288-345). This is a dual-gate fet, characterised up to 2GHz. The circuit is a conventional shunt-peaked video amplifier. The 0.47μH peaking inductor is damped by 47Ω. This was determined experimentally as giving the best approximation to a flat response. This is followed by a *BFR 92P* emitter follower, Tr_2 (RS 287-910). The emitter is a low-impedance point which can be probed with an oscilloscope for the purpose of getting the peaking right.

You will notice that the coupling capacitors are 51pF. Although much



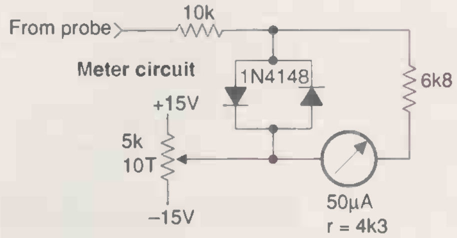


Fig. 1. Full circuit of the vhf millivoltmeter, demonstrating its simplicity. All earths are via pins to the backplane.

Fig. 2. Both sides of the circuit layout for the vhf millivoltmeter. Note that the component side is as it appears on the board. Flip it left to right before making a transparency.

greater values are available in the same package size, I have made them this value to roll off the response below 100kHz – particularly to avoid the effects of mains and other low-frequency pickup. Measurements can be made at 450kHz.

The diode is a *BAT 64*, a Schottky part (RS 287-229). Transistor Tr_2's emitter rests at about 3.5V in the absence of a signal and the forward voltage across the diode is just over 0.2V.

Successive positive-going half-cycles of any signal charge the 220nF capacitor to the positive peak excursion of the emitter of Tr_2, less the diode drop which remains essentially constant over the range of currents involved. The diode prevents this charge from draining away except though the 4.7kΩ resistor in parallel with the 10kΩ input resistor to the *353* op-amp.

In effect, the diode is automatically forward biassed exactly the right amount to negate its small forward voltage drop. Another advantage of this arrangement is that Tr_2, which has a reverse $V_{B\text{-}E}$ rating of only 2.5V, is not put at risk.

Only one of the two op-amps within the *353*'s SOIC package is used. I use a dual *353* as opposed to a single *351* as they are the same price.

Choosing the right amount of gain

The chosen gain, set by the 220kΩ feedback resistor, is a matter of compromise. Higher gain gives greater meter deflection for a given signal but makes zero-adjustment very tricky. The 25kΩ ten-turn trimmer potentiometer is used to give approximately zero volts out for no signal, but actual zeroing is by the ten-turn shaft-operated potentiometer in the meter/power-supply box.

The meter is protected from damage by the diode-resistor arrangement shown. The values are adjusted to give full-scale deflection for 50mV rms at 50MHz. The scale is compressed towards fsd, as the protective diodes are beginning to conduct.

A protective device which I have not included is the conventional arrangement of two diodes in inverse parallel shunting the input. Probably the best readily available part for this purpose is the double-diode *BAT 17-04* (RS 288-452). But even this excellent part has a shunt capacitance per diode of typically 0.75pF. The two would virtually double the input capacitance. The effect of this, taken together with the necessary current limiting resistor, would be severely to reduce the upper frequency limit. So I have left the *CF 739* at risk. They only cost £2 each anyhow.

You will notice that there is a regulator in the supply to Tr_1. This is the SOIC version of the *7808* part. Such regulators cost little more than the resistor/zener combination which would otherwise have been needed.

I will not detail the power supply, which is conventional, except to mention that the rails are stabilised using *7815* and *7915* parts.

Accuracy and application

One cannot hope for such an instrument to be accurate to better than 10%. Noise, stray fields and drift see to that. What it is useful for is determining whether circuits like IF amplifiers are operating in the right ball-park in regard to such matters as automatic-gain control action.

And, of course, the meter is useful for tuning because its small input capacitance does not detune circuits to which it is applied. In spite of the very small amounts of power involved and the tiny thermal capacity of the surface-mount parts, the instrument takes a few minutes to stabilise after being switched on.

Obviously, a sensitive instrument of this kind is prone to pickup. Operating with the input unconnected will result in full-scale swings of the meter pointer if you place your hand anywhere near the input. The lead to the point being tested must be as short as possible, and the earth used must be as near as possible to the test point.

In spite of the fact that this instrument will cope successfully with high-impedance signal sources, you should always go for the the lowest possible source impedance, the emitter of an emitter-follower rather than its base, for example.

Calibration

I calibrated my prototype at 50MHz in a properly terminated 50Ω coaxial system. Everything was placed on, and bonded to, a metal plate. A good 100MHz oscilloscope claiming ±3% accuracy was used. The 20dB pad enables small signals to be applied to the input while larger ones can be measured on the oscilloscope. The setup is shown in **Fig. 3**.

A 100MHz oscilloscope has some response up to about 150MHz. This means that the second and third harmonics of a 50MHz signal will, if they are significant, be perceptible. A signal that looks like a sinewave can therefore be assumed to have an rms value of about $1/2\sqrt{2}$ of its peak-to-peak value.

In summary

This circuit uses a combination of surface-mount technology and a uhf GaAs fet to provide a broadband amplifier with response extending well beyond 100MHz. Where this design differs from IC solutions like the *SL560* is in its high input impedance.

There are obviously many other applications for this approach. You will not get away with them, however, unless you use surface-mount devices to achieve the postage-stamp sized rf circuitry described here. ■

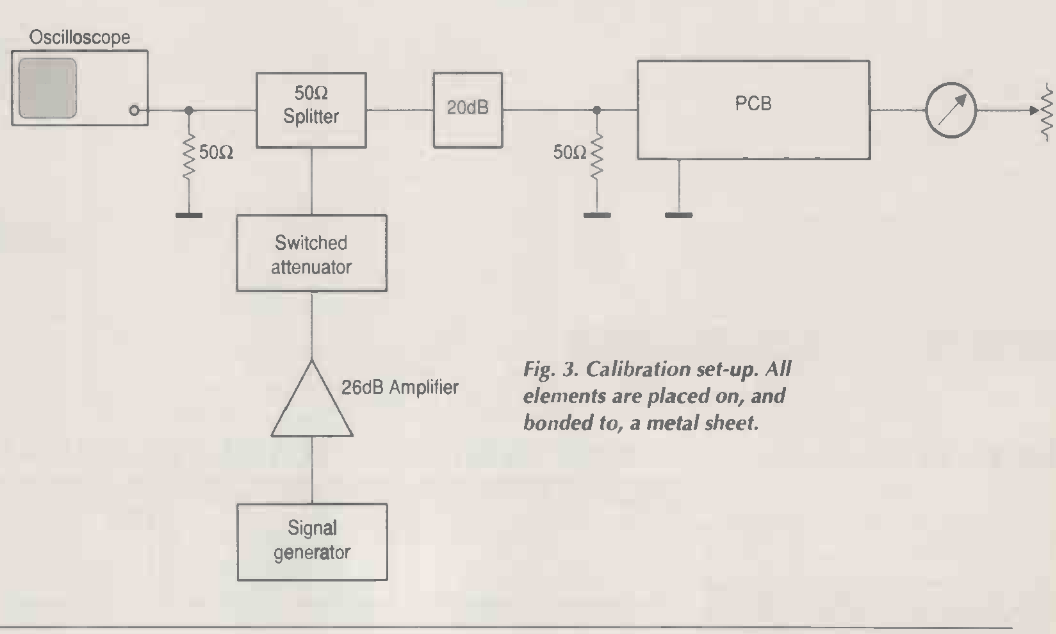


Fig. 3. Calibration set-up. All elements are placed on, and bonded to, a metal sheet.

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 5¼" 1.2 Mb floppy disk drive & **integral 40Mb hard disk drive** to the front. Real time clock with battery backup is provided as standard. Supplied in good used condition complete with **enhanced keyboard, 640k + 2Mb RAM, DOS 4.01 and 90 DAY Full Guarantee.** *Ready to Run!*
Order as **HIGRADE 286** ***ONLY £129.00*** (E)

Optional Fitted extras: VGA graphics card	£29.00
1.4Mb 3½" floppy disk drive (instead of 1.2 Mb)	£19.95
Wordperfect 6.0 for Dos - when 3½" 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, supurb small size desktop unit. Fully featured with standard simm corinectors 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*
Many other options avaiable - call for details. Only **£399.00** (E)

FLOPPY DISK DRIVES 3½" - 8"

5¼" or 3½" from only £18.95 !

Massive purchases of standard 5¼" and 3½" 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 3½" supported on your PC).

3½" **Panasonic** JU363/4 720K or equivalent RFE	£24.95(B)
3½" **Mitsubishi** MF355C-L. 1.4 Meg. Laptops only	£25.95(B)
3½" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" **Teac** FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" **Teac** FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" **BRAND NEW Mitsubishi** MF501B 360K	£22.95(B)
Table top case with integral PSU for HH 5¼" 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)

3½" **FUJI** FK-309-26 20mb MFM I/F RFE	£59.95(C)
3½" **CONNER** CP3024 20 mb IDE I/F (or equiv)RFE	£59.95(C)
3½" **CONNER** CP3044 40mb IDE I/F (or equiv,)RFE	£69.00(C)
3½" **RODIME** RO3057S 45mb SCSI I/F (Mac & Acorn)	£69.00(C)
3½" **WESTERN DIGITAL** 850mb IDE I/F *Brand New*	£185.00(C)
5¼" **MINISCRIBE** 3425 20mb MFM I/F (or equiv.) RFE	£49.95(C)
5¼" **SEAGATE** ST-238R 30 mb RLL I/F Refurb	£69.95(C)
5¼" **CDC** 94205-51 40mb HH MFM I/F RFE tested	£69.95(C)
5¼" **HP** 97548 850 Mb SCSI RFE tested	£89.00(C)
5¼" **HP C3010** 2 Gbyte SCSI *differential* RFE tested	£195.00(C)
8" **FUJITSU** M2322K 160Mb SMD I/F RFE tested	£195.00(E)

Hard disc controllers for MFM , IDE, SCSI, RLL etc. from £16.95

THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!

TV SOUND & VIDEO TUNER
CABLE COMPATIBLE

The **TELEBOX** is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by makers such as **MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD** etc. The composite video output will also plug directly into most video recorders, allowing reception of **TV channels not normally receivable on most television receivers*** (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. **TELEBOX MB** covers virtually all television frequencies VHF and UHF **including the HYPERBAND as used by most cable TV operators.** A composite video output is located on the rear panel for direct connection to most makes of monitor or **desktop computer** video systems. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

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

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

DC POWER SUPPLIES

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

IC's -TRANSISTORS - DIODES

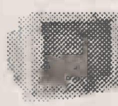
OBSOLETE - SHORT SUPPLY - BULK

6,000,000 items EX STOCK

For *MAJOR* SAVINGS - CALL FOR SEMICONDUCTOR HOTLIST

VIDEO MONITOR SPECIALS

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



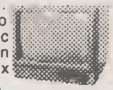
Mitsubishi FA3415ETKL 14" SVGA Multisync colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including **IBM PC's** in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** and **APPLE.** Many features: Etched faceplate, text switching and **LOW RADIATION MPR** specification. Fully guaranteed, supplied in EXCELLENT 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 flap controls, **VCR** correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" 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 burns). In attractive square black plastic case measuring W10" x H10" x 13½" D. 240 V AC mains powered. **Only £79.00** (D)



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

20" 22" and 26" AV SPECIALS

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

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

SPECIAL INTEREST ITEMS

MITS. FA3445ETKL 14" Industrial spec SVGA monitors	£245
2kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
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 330Khz, IEEE	£550
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & HP3782A Error Detector	£POA
HP APOLLO RX700 system units	£950
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP3081A Industrila workstation c\w Barcode swipe reader	£175
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£675
HP54121A DC to 22 GHz four channel test set	£POA
HP7580A A1 8 pen HPGL high speed drum plotter	£1850
EG+G Brookdeal 95035C Precision lock in amp	£650
View Eng. Mod 1200 computerised inspection system	£POA
Ling Dynamics 2kW programmable vibration test system	£POA
Computer controlled 1056 x 560 mm X Y table & controller	£1425
Keithley 590 CV capacitor / voltage analyser	£POA
Racal ICR40 dual 40 channel voice recorder system	£3750
Fiskers 45KVA 3 ph On Line UPS - New batts Dec.1995	£9500
ICI R5030UV34 Cleanline ultrasonic cleaning system	£POA
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£1200
Zeta 3220-05 A0 4 pen HPGL *fast* drum plotters	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 2998 Infrared spectrophotometer	£POA
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3750
Andrews LARGE 3.1 m Satellite Dish + mount (For Voyager!)	£950
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
TAYLOR HOBSON Tallysurf 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

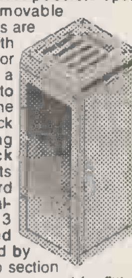
19" RACK CABINETS

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

Top quality 19" rack cabinets made in UK b **Optima Enclosures Ltd.** Units feature designer, smoked acrylic lockable front door full height lockable half louvered back doo and louvered removable side panels. Full 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 w have ever sold. Racks may be stacked side by side and therefore require only two side panels to stand singly or in multiple bays.
Overall dimensions are: 77½" H x 32½" D x 22" W. Order as:

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

32U - High Quality - All steel RakCab



Made by **Eurocraft Enclosures** Ltd to the **highest possible spec** rack features **all steel construction** with removable side, front and back doors. Front and back doors are **hinged for easy access** and all are lockable with **five secure 5 lever barrel locks.** The front door is constructed of double walled steel with a **'designer style'** smoked acrylic front panel to enable status indicators to be seen through the panel, yet remain unobtrusive. Internally the rack features fully slotted reinforced vertical fixing **members to take the heaviest of 19" rack equipment.** The two movable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A **mains distribution** panel internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin **switched utility socket.** Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvres. The top panel may be removed for fitting of integral fans to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower rear for cable / connector access etc. Supplied in **excellent,** slightly used condition with keys. Colour Royal blue. External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)

Sold at LESS than a third of makers price !!

A superb buy at only £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 etc. Imagine using your finger with 'Windows', instead of a mouse !! (a driver is indeed available !) ***The applications for this amazing product are only limited by your imagination!!*** Complete system including Controller, Power Supply and Data supplied at an incredible price of only: ***£145.00*** (B)
Full MICROTOUCH software support pack and manuals for IBM compatible PC's £29.95 RFE - Tested

LOW COST RAM & CPU'S

INTEL 'ABOVE' Memory Expansion Board. Full length PC-XT and PC-AT compatible card with **2 Mbytes** of memory on board. Card is fully selectable for Expanded or Extended (286 processor and above) memory. **Full data and driver disks supplied. RFE.** Fully tested and guaranteed. Windows compatible. **£59.95**(A1)
Half length 8 bit memory upgrade cards for PC AT XT expands memory either 256k or 512k in 64k steps. May also be used to fill in RAM above 640k DOS limit. Complete with data.
Order as: XT RAM UG. 256k. £34.95 *or* **512k £39.95** (A1)

SIMM SPECIALS

1 MB x 9 SIMM 9 chip 120ns	Only	£16.50 (A1)
1 MB x 9 SIMM 3 chip 80 ns **£19.50**	or 70ns	£22.95 (A1)
1 MB x 9 SIMM 9 chip 80 ns **£21.50**	or 70ns	£23.75 (A1)
4 MB 70 ns 72 pin SIMM *-with parity-*	Only	£95.00 (A1)

INTEL 486-DX33 CPU **£55.00** INTEL 486-DX66 CPU **£69.00** (A1)
FULL RANGE OF CO-PROCESSOR'S EX STOCK - CALL FOR £££

FANS & BLOWERS

EPSON DO412 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
PANCAKE 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. Bona Fide account orders accepted from Government, Schools, Universities and Local Authorities - minimum account order £50. Cheques over £100 are subject to 10 working days clearance. Carriage charges (A)=£3.00, (A1)=£4.00, (B)=£5.50, (C)=£8.50, (D)=£12.00, (E)=£15.00, (F)=£18.00, (G)=CALL. Allow approx 6 days for shipping - faster CALL. Scotland surcharge CALL. All goods supplied to our Standard Conditions of Sale and unless stated guaranteed for 90 days. All guarantees on a return to base basis. All rights reserved to change prices / specifications without prior notice. Orders subject to stock. Discounts for volume. Top CASH prices paid for surplus goods. All trademarks etc acknowledged. © Display Electronics 1996. E & O E. 06/6

SWITCH MasterCard VISA EST 25 YEARS

CIRCLE NO. 129 ON REPLY CARD

NEW PRODUCTS CLASSIFIED

Please quote *"Electronics World"* when seeking further information

ACTIVE

Discrete active devices

"Smallest" mosfet. Fairchild Semiconductor says its *FDR4420A* is the smallest 9mW mosfet to appear in the SuperSOT-8 package. Gate charge is 41nC for rapid response and the package is 38% smaller than a standard SO-8, the 1mm thick device handling roughly the same power as the SO-8 when on a board. Fairchild Semiconductor Corporation. http://www.fairchildsemi.com.
Enq no 501

Linear integrated circuits

Comparators with ott cm. If Motorola can hi-jack the English language by claiming "rail-to-rail" as a trademark, then so can Maxim, who claims "beyond-the-rails" as its own, the point here being that input common-mode range of the *MAX961/964/997/999* comparators extends 100mV outside the supply rails. These are single/dual/quad types having a propagation delay with 5mV overdrive of 4.5ns and 3.5mV of hysteresis. All the devices are for 3V and 5V operation and outputs source and sink 4mA to within 0.52V of ground and V_{cc}. Supply current is 5mA per comparator and variations between types include a shutdown to 270μA per comparator and complementary outputs with latch-enable. All handle the extended industrial temperature range. Maxim Integrated Products UK Ltd, Tel., 0118 930 3388; fax, 0118 930 5577.
Enq no 502

Memory chips

Multi-chip sram modules. IDT packs several sram chips into one module to save space – up to 54% is claimed; they go into a single ball-grid array package to give 16-bit and 24-bit data widths. Memories are available in 2Mb and 3Mb density, the *IDT7MMV4101* having three 128K by 8 asynchronous srams and is meant for use with the Motorola 5630x and Analog's *ADSP-21062L* signal processors, another one, the *IDT7MMV4103* being designed for the Texas TMS5320C5x and other 16-bit dsps. Integrated Device Technology. Tel., 01372 363339; fax, 01372 378851.
Enq no 503

12Mbit dsp memory. EDI has a 3.3V, 12Mbit sram that exhibits access times of 12, 15, 17 and 20ns for use in no-wait, fixed-point dsp memory; in particular as a single-chip, 512K by 24 external memory for the Motorola *DSP5630x*, which will address three such devices. EDI (UK). Tel., 01276 472637; fax, 01276 473748.
Enq no 504

Microprocessors and controllers

8-bit controller for battery power. A new member of Hitachi's H8/300L family is the *H8/3644F*, which has 32Kbyte of flash memory and 1Kbyte of sram. At 10MHz, a 16-bit add operation takes only 400ns and 5mA while, for battery power, a second 3kHz oscillator enables the unit to run on 10μA. There is a complete evaluation kit with hardware – including five free samples – and software for development and debugging. Processor speed is controllable by software to balance performance and power consumption. Hitachi Europe Ltd, Tel., 01628 585163; fax, 01628 585160.
Enq no 505

USB controller. In one 18-pin ic, the Cypress *CY7C63000* universal serial bus controller contains all the necessary features for the connection of low-speed – i.e. up to 1.5Mb/s – peripherals to the serial port of a pc. This is one of a series of one-time-programmable controllers, its risc core having a 72-instruction-set arrangement optimised for USB use. Memory is 126byte of ram and 2K or 4K of eprom for program storage. There are 12 general-purpose i/o lines, each of which being able to generate an interrupt. Pronto Electronic Systems Ltd. Tel., 0181 554 5700; fax, 0181 554 6222.
Enq no 506

Mixed-signal ics

115.2kb/s ir receiver/transceiver. Unitrode's *UCC5341/5342* infrared receiver and transceiver conform to the analogue section of the Infrared Data Association 1.0 standard and are meant for use in wireless communications in portable equipment, both having very low current consumption (250μA active and 0.5μA asleep). Receivers in both have a limiting transresistance amplifier detecting current pulses from a pin diode and driving RXX pulses to a uart. Receiver output is at cmos/ttl level and internal resistors reduce the amount of external decoupling needed. The 5342 transmitter section has a low-impedance open-drain mosfet at the output that will sink 300mA from an output led at 3V or 500mA at 5V. Unitrode (UK) Ltd. Tel., 0181 318 1431; fax, 0181 318 2549.
Enq no 507

Motors and drivers

Servoamplifier. Copley's *Model 7425AC* servoamplifier drives ac brushless motors up to 2.5hp in torque mode and is usable with a wide range of controllers and chipsets. Input from the controller is two ±10V sinusoidal signals to the amplifier, U and V, the third, W, for the three-phase drive, being synthesised by the amplifier. Use of sinusoidal drive eliminates cogging, since there is a constant torque throughout the entire 360° rotation. Outputs of 5V/200mA and ±10V/5mA are provided by the amplifier to excite encoders. The amplifier accepts 32-264Vac at 50/60Hz and develops ±20A peak or ±10A continuously. Pulse-width modulation is at 25kHz and there is minimum ripple at zero output, thereby avoiding hysteresis heating of a stationary motor. Copley Controls. Tel., 001 617 329 8200; fax, 001 617 329 4055.
Enq no 508

Microwave components

1.9GHz Rx/Tx front end. Mitsubishi announces the *MGF7136P* receive/transmit front end gallium arsenide ic for the 1.9GHz band, complete with power amplifier. Power gain is 38dB for the transmission amplifier with adjacent channel power over 55dBc at ±600kHz. The receive amplifier has a gain of 14dB and noise figure of 1.8dB and has internal output matching. The receiver mixer has a gain of 9db and noise figure of 7dB. Receive/transmit switching, timing and transmit amplifier bias control is controlled by internal logic. Mitsubishi Electric UK Ltd. Tel., 0990 134275; fax, 0171 351 7633
Enq no 509

Optical devices

Electroluminescent keyboards. Using new techniques, Concept Keyboards can provide panels or keyboards which may have any combination of selected areas illuminated, instead of the more usual arrangement where only fixed areas may be lit. Electroluminescent material is embedded by screen printing to give lighting that replaces bulbs or leds, together with the associated pcbs. Areas to be lit are programmable and brightness is variable. Power comes from surface-mounted inverters, which do not generate the rfi often found in the larger types previously needed. Concept Keyboards Ltd. Tel., 01705 372233; fax, 01705 372237.
Enq no 510

Oscillators

GPS oscillator control. Datum's *GPS-LC* is a GPS receiver, crystal oscillator and alarm system, providing an output frequency with a variation of 1 in 10^{-11} averaged over 24h. GPS signals control the crystal oscillator, which may be either temperature-compensated or oven-controlled, the oscillator running without control to supply the output in the event of signal loss, provided that its stability is within preset limits. If these are exceeded, an alarm signal mutes the output, which is restored when the GPS is acquired again. Control of the GPS-LC is by a pc or modem by way of an RS-232 interface, which also carries data and alarm signals. Outputs provided are 5, 10 or 13MHz sine, DECT 100Hz sync. and telecomms outputs of 2048kHz and 2048kb/s. Sematron UK Ltd. Tel., 01256 812222; fax, 01256 812666.
Enq no 511

High-spec crystal oscillators. Temperature-compensated crystal oscillators in the *CMH2000/3000* ranges from C-MAC are designed to meet the requirements of the European Space Agency in both frequency stability and the ability to cope with the physical aspects of operating in space. Oscillators in the *2000* series use a conventional thermistor network for temperature compensation, while the 3000 units have an analogue asic for compensation, handling up to fourth-order *f/t* functions; this type has a somewhat reduced radiation resistance. Frequencies offered by the 3000 series are in the 2-155MHz range and, between –20°C and 70°C, a stability of ±0.3ppm. Outputs may be sinusoidal, a clipped sine or logic levels and frequency adjustment is by pot. or voltage. C-MAC Quartz Crystals Ltd. Tel., 01279 626626; fax, 01279 454825.
Enq no 512

Please quote *"Electronics World"* when seeking further information

Power semiconductors

Dtv power transistor. Designed for the 470-860MHz band, Ericsson's *PTF10037* laterally diffused mosfet is aimed squarely at the digital terrestrial television transmitter field. It will put out 100W of output power from a 28V supply, with a minimum gain of 12dB, but can also handle up to 32V to give a 120W output; drain/source breakdown is 65V. At 60W, two-tone third intermod. distortion figure is –40dBc and the device will cope with a load mismatch of 10:1 at 100W at all phase angles. It is internally matched, thereby saving on external components. Ericsson Components AB. Tel., 01793 488300; fax, 01793 488301.
Enq no 513

PASSIVE

Dual-channel pot. From CTS, the *CTS 250* 9mm dual-channel potentiometer, which is meant for use in multimedia stereo applications. Values are in the 5kΩ-250kΩ range, non-standard values being available. Mismatch between tracks is within 3dB and slider noise under 100mV. Terminals may be either straight or right-angled. Quiller Switches Ltd. Tel., 01202 436777; fax, 01202 421255.
Enq no 514

Surface-mount inductors. Dubilier's first ever inductors in the *DCH* range have either ceramic or ferrite cores and are rated at 800mA for the ceramic type and 380mA for the ferrite; resonant frequencies are 160MHz-2.5GHz for the ceramic and 7-320MHz for ferrite. Values lie in the range 0.0082µH-100µH ±10%. Case size is 1210, flame-retardant. Dubilier Ltd. Tel., 01371 875758; fax, 01371 875075.am
Enq no 515

Electrolytics for cars. Panasonic has a new range of aluminium electrolytics for use in vehicles, which are not famous for being kind to electronic components. These are claimed to have an operating life at 125°C of 500h for surface-mounted types and 1000h for the leaded variety. They use a newly developed electrolyte that does not evaporate at high temperatures, a new sealing compound and better impregnation. Ratings are in the range 10µF/50V to 330µF/10V and case diameters 8-10mm. Panasonic Industrial (Europe) Ltd. Tel., 01344 853862; fax, 01344 853310.
Enq no 517

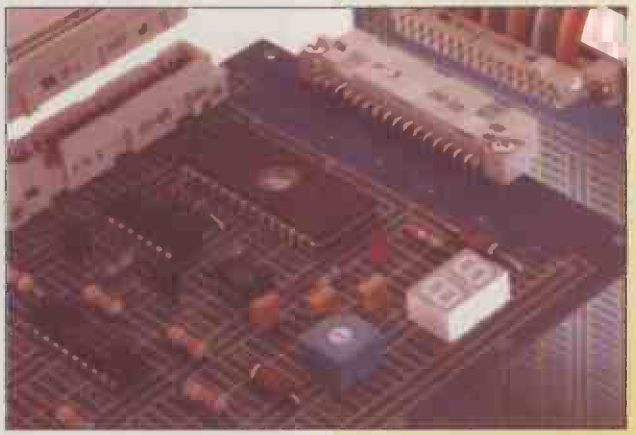
Connectors and cabling

Coaxial eht connectors. *Series 200* connectors are larger versions of the Deutsch Series 100 type and are rated at up to 30kV at sea level. Coaxial, two- and three-pole versions are available in corrosion-resistant aluminium alloy, with protective caps and adaptors as standard. There are cable entries for any cable to 12.25mm diameter, for standard coax. cables to BS2316 and to accept semi air-spaced, non-microphonic and other types. The connectors match into a 50Ω system. the vswr at 1.5GHz not exceeding 1.3. Insulation resistance is better than 10GΩ at 5kV and the capacitance of a mated pair is 4.6pF. Deutsch Ltd. Tel., 01342 410033; fax, 01342 410005.
Enq no 518

New IDC options. Pancon's *Hi-Con Half-B* (series 120) female connectors have been added to the company's list of 28AWG flat-cable insulation-displacement options.

These female connectors have 32 contacts and their measurements and technical data are all according to DIN 41612. Three performance levels are available: level 1 for 500 mating cycles, level 2 for 400 mating cycles and level 3 for 50 mating cycles.

Manufactured with or without mounting flange these connectors are applicable for backplane mountings. Locking between cover and connector housing is done with metal clamps. Polarisation of the connectors is possible without loss of contacts. Pancon GmbH. Tel., 00 49 6172 175 251 fax 00 49 6172 175160.
Enq no 516



Displays

Super-TFT lcds. Two new Super-TFT liquid-crystal displays by Hitachi are both of XGA resolution, 14in diagonal and giving a 285.7 by 214.3mm viewing area. The economically named *TX36D01VC0CAA* panel has a cmos interface and the equally terse *TX36D11VC0CAA* an LVDS interface. Viewing angle of this type of display is 160° in all directions with no decrease in contrast (200:1) or image quality. Brightness is 200cd/m^2 and backlights are replaceable. The displays provide 8-bit colour when the company's interface board is used. Hitachi Europe Ltd. Tel., 01628 585163; fax, 01628 585160.
Enq no 519

Small lcd. Meant for use in hand-held devices, the *0802* alphanumeric liquid-crystal display module is available from DM Electronics. Overall size is 58 by 32mm and the 2 by 8 character size 5.56mm. Characters are black on a yellow/green background and the unit is available in a reflective form or with a backlight. The interface is 8-bit parallel. D M Electronics. Tel., 01235 811880; fax, 01235 811889.
Enq no 520

Hardware

Screened plug-in modules. Vero has a range of 3U, two and four-rail plug-ins with front panels to meet IEEE1101.10 requirements. They will go into a complete EMC sub-rack, the metal front panel inserts affording earth continuity or may be used as single units in a standard sub-rack when emc is not needed for the entire equipment. Front panels may be fitted with printable polyester overlays. Vero Electronics Ltd. Tel., 01703 266300; fax, 01703 265126.
Enq no 521

Test and measurement

Resistance measurement. The first measurement in the Tegam *Model 1750* resistance measuring instrument makes its appearance in 12ms in fast mode, to within 0.05%, other readings coming every 10ms, but if you need accuracy at the expense of speed the readings happen 18 times per second to within 0.01%. Some new circuitry eliminates thermal and electromagnetic errors caused by contact between the device being tested and whatever is handling it and programming by front-panel buttons and a lcd is said to be simple. There are eleven ranges from 2mΩ to 20MΩ and delay times, settling times and noise rejection are operator selected. RS-232, RS-422 and IEEE-488 interfaces are present and calibration is a shop-floor procedure. Wren Technologies Ltd. Tel., 0118 941 4123; fax, 0118 845 2002.
Enq no 523

H-v oscilloscope measurement. Yokogawa offers the *Model 701852* signal-conditioner for the company's *DL708 ScopeCorder* oscilloscope. This is a high-resolution, high-voltage isolation module with a special connector to allow voltages up to 850V in differential mode to be measured. It also has a 16-bit a-to-d converter to give a signal resolution of more than 250 times that of conventional types with 8-bit converters. The *ScopeCorder* mainframe has a 10.4in colour tft display and takes up to eight conditioning modules, 16 digital inputs being recorded in addition to the eight analogue channels. There is a hard-disk drive and printer. Martron Instruments Ltd. Tel., 01494 459200; fax, 01494 535002.
Enq no 522

Pcb signature analyser. When a populated pcb develops the type of fault in which the application of normal power might cause further trouble, the Tektronix *TR 210 Huntron Tracker* provides the answer. Signature analysis is the method used, a current-limited, variable frequency, variable-amplitude ac signal being applied to two test points to make a unique current/voltage analogue signature which varies with the fault. It may be used on digital, analogue and mixed-signal boards. The instrument was developed from the Huntron Tracker 2000, the built-in monitor of the Huntron device now

Please quote *"Electronics World"* when seeking further information

being replaced by an oscilloscope in the XY mode. Tektronix UK Ltd. Tel., 01628 403300; fax, 01628 403301.
Enq no 524

Calibrator. Wavetek's *Model 9100*, which can calibrate virtually any type of instrument known to man, with the exception of power meters, can now do that as well. An additional option, the *PWR*, fits inside the calibrator and generates up to 1kV and 20A to calibrate power meters to 20kW or 20kVAR, extended to 1mW/MVAR by using optional current coils or up to 150MW/MVAR by directly driving the instrument's current transformers. A ±180° phase control is provided for power factors from zero to ±1. Various waveforms are available, including square, impulse, triangular and trapezoidal *V* and *I* and sine. Harmonics up to 3kHz may be generated at up to 7V rms and there is control of power level by independent adjustment of *V*, *I* or phase, with simultaneous display of output current, voltage, power and phase. Option PWR can be fitted to existing Model 9100 calibrators. Wavetek Ltd. Tel., 01603 256684; fax, 01603 483670.
Enq no 526

Production equipment

UV curing lamp. *UV-H 253* by UV Light Technology is a hand-held, high-intensity UV-A lamp for the rapid curing of ultra-violet materials such as adhesives and polyester resin/glass-fibre composites without the emission of solvents. Light output is uniformly spread over a large area, the bulb being a 250W metal halide type and reflector has been computer-optimised. A black filter glass is transparent to light between 320nm and 400nm. A cooling system is used and bulb life is about 500h, an hour counter indicating life remaining. UV Light Technology Ltd. Tel., 0121 454 6053; fax, 0121 454 6188.
Enq no 525

Click analyser. According to EMC Partner, all automatic, program-controlled machines and electrically operated or thermal appliances generate discontinuous disturbance – or clicks. The definition of a click is an event lasting under 200ms with a period of over 200ms, analysis of which is the reason for the *CL55C* click analyser made by AFJ International. Some European emission standards require click measurement and this instrument reduces the time needed. It counts long and short clicks and continuous interference for each channel and, if there are more than two clicks in two seconds or more than five in a minute, they are recorded. Receivers are built-in and external receivers may be used. The instrument is driven by a pc and runs under Windows. EMC Partner UK Ltd. Tel., 01494 444255; fax, 01494 444277.
Enq no 527

Hand-held oscilloscope. A 20MHz, hand-held digital storage oscilloscope, the Escort *Palmscope*, has a smaller front-panel area than a sheet of A4 paper and offers dual channels, a sample rate of 20Msample/s, a twenty-screen memory, auto setup and a 20MHz, seven-digit counter. The instrument has a daylight-reading screen and an RS232 interface makes for simple transfer of data to a pc for analysis; a printer port is also provided. Power is from internal battery, external dc or ac. Feedback Test and Measurement. Tel., 01892 653322; fax, 01892 663719.
Enq no 528

Literature

Anglia. Celebrating 25 years of passive and discrete component distribution, Anglia has added over 80 new ranges, expanded existing lines and has a 340-page catalogue to prove it. New this time are board-mounting hardware, cable management and crimp terminals. Several product selectors and details of a technical enquiry fax service are provided. Anglia Microwaves Ltd. Tel., 01277 630000; fax, 01277 631111.
Enq no 529

Optical products. Kingsbright's new catalogue of optoelectronic components is available on paper and CD-Rom, containing details of leds, displays, semiconductors and passive components from Rubycon, Nichicon, Jamicon, Taiyo Yuden and others. Components Bureau Ltd. 01480 496565; fax, 01480 496480.
Enq no 530

CompactPCI. Vero has a short catalogue of its components for the up-and-coming CompactPCI standard. There are 14 V2.1 compliant backplanes in 3U and 6U form for 32-bit and 64-bit working, and 3U and 6U units wired, screened and thermally managed development systems in Verotec or Modular Microrack enclosures, ready to take the relevant boards and run. The publication also describes a number of pluggable and open-frame power converters for the systems. Vero Electronics Ltd. Tel., 01489 780078; fax, 01489 780978.
Enq no 531

Dc-dc converters. *Datel* offers a new brochure that details the company's range of 225 plug-in converters in the 3W-60W region. Products are categorised in output configuration, output voltage, output current and input range, enough detail being provided to allow a choice of converter. Data sheets for all the units described are available on the Datel web site at *http://www.datel.com* or direct from the company by fax or post. Datel (UK) Ltd. Tel., 01256 880444; fax, 01256 880706.
Enq no 532

Power supplies

30W switchers. 30W, non-isolated switching regulator ics in the *PT3300* family by Power Trends have an input voltage range of 20-60V. Three fixed output voltages are available at 3.3V/8A, 5V/6A and 12V/2.5A, all adjustable by ±10% by an external resistor. Features include output inhibit, remote sensing, current limiting, short-circuit protection and over-temperature shut-down. The non-isolation design reduces the cost of such units. Acal Electronics Ltd. Tel., 01344 727272; fax, 01344 424263.
Enq no 533

Web shopping. Vicor's web site now contains programs to indicate the relevant power converter or power supply module when the user enters input and output from pull-down menus, showing powers available for these requirements, module size or the number of modules needed. However dubious the etymology, these "configurators" do seem to be an easy way of finding the modules needed, assuming that you have Netscape Navigator 3 or higher. Vicor UK. Tel., 01276 678222; fax, 01276 681269.
Enq no 534

Radio communications

Keyfob transmitter. Two low-cost am keyfob transmitters by RF Solutions employ Microchip's 64-bit Keeloq code-hopping protocol. The two versions are a single-switch, single-channel type and a two-switch, three-channel model, both having the Keeloq encoder and a transmitter with aerial to allow operation at distances over 30m. The transmitters automatically send a unique signature key, programmed in manufacture, after which the data stream is scrambled using a 32-bit

Materials

Decorative coatings. Integrated Vacuum Coatings has a new range of coatings for plastics enclosures to confer better feel and style. *Valudec* finishes can be metallic paint, soft-feel paint and lacquer, electroplated or evaporated mirror finish and a material called *Valudec 3D*, with which an object such as a mobile 'phone or pocket organiser is painted with a pattern in three dimensions; a company logo, for example, will go round corners. You can even have a leopard-skin computer, should you so wish. IVC Ltd. Tel., 0121 511 1115; fax, 0121 544 5253..
Enq no 535

code-hopping system, which is not amenable to code grabbing by furtive individuals lurking about with a scanner. A receiver/decoder may be made to ignore the code changes in cases where utmost security is not needed. If the transmit key be accidentally left on for more than 25s, a shut-off prevents battery drain; a low battery state is indicated by a led and is also transmitted to the receiver. RF Solutions Ltd. Tel., 01273 488880; fax, 01273 480661.
Enq no 536

433MHz transceiver. RF Micro Devices' *RF2906* is a low-cost rf transceiver ic containing a superhet receiver, a binary phase-shift keying transmitter, a vco and a dual-modulus prescaler. Receiver functions include a 20dB, rf low-noise amplifier/mixer, a limiting if amplifier, received signal-strength indicator, balanced if

Please quote *"Electronics World"* when seeking further information

multiplier demodulator and a data amplifier; while for transmission, there is a bpsk modulator and level-controlled amplifier, a saw resonator providing an input to a vco for carrier generation or local oscillator for the receiver. On a 3V supply, receiver cascaded noise figure is 10dB, the transmitter producing 8.5dBm into 50W. A transmit/receive switch allows Rx and Tx to work through a common pin to allow a 50Ω impedance for both. Current drawn is 29mA for transmit, 4.6mA receive and under 1μA when asleep. As a stand-alone transmitter or transceiver, modulation may be bpsk, fsk or on-off keyed am. Anglia Microwaves Ltd. Tel., 01277 630000; fax, 01277 631111.
Enq no 537

Switches and relays

100A inrush relay. With the ability to withstand an inrush current of 100A, Matsushita's *LK* relay is for use in audio/visual equipment and switches 5A at 30V dc or 277V ac; with the single Form A contact open, the relay withstands 1kV rms and has a contact/coil isolation of 400V rms. It is available as a monostable type and uses 530mW. Environmental rating is to IP40. Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231599.
Enq no 538

Power relay. *Siemens/ Schrack PE Series* relays are 5A, 240V ac, single changeover types switching up to 5A, having only a 10mm profile on a 20 by 10mm base. These relays, which are suitable for reflow soldering, come in coil voltages of 5-48V dc and activate with a coil power of 200mW. Insulation meets VDE 0110. Easby Electronics Ltd. Tel., 01748 850555; fax, 01748 850556.
Enq no 539

Transducers and sensors

Digital compass. Honeywell offers the *HMR3000* digital compass module, which uses the company's own magnetoresistive sensor with tilt correction. Response time is 50ms and a heading resolution of 0.1° at tilt angles of up to 45°. It is not much more than matchbox-sized and draws less than 25mA. Inertial Aerosystems Ltd. Tel., 01252 782442; fax, 01252 783749.
Enq no 540

Shock sensors. *PKGS* shock sensors by Murata are to detect vibration and protect CD-rom and hard-disk drives against damage; the high speed of a CD drive can cause vibration in the whole computer and be transmitted to the vulnerable hard-disk drive. These sensors, which have a sensitivity of 2mV/g, drive an amplifier and speed-control unit to reduce the speed of the CD drive until any detected vibration is reduced until it is lower than the prescribed limit. Toshiba's *TA8563FN* and the Rohm *BU3893FV* ics are suitable for the purpose and Murata has a board containing a Toshiba device and the sensor for loan to demonstrate the output of the sensor. Murata Electronics (UK) Ltd. Tel., 01252 811666; fax, 01252 811777.
Enq no 541

Ir-sensitive ics. Rohm has a range of infrared receiver ics that now includes a number of high-sensitivity devices in the *RPM6900* series for longer-range working. These devices have horizontal and vertical sensitivities of 30° and 35° respectively and operate at distances of more than 16m. Centre frequencies of 33, 36, 36.7, 37.9, 40 and 56.9kHz are available and typical on and off pulse widths are 600μs. Outputs are at logic level and all devices work on 5V at 1.5mA. Rohm Electronics UK Ltd. Tel., 01908 282666; fax, 01908 282528.
Enq no 542

Photo sensors. Matsushita's *J range* of photoelectric sensors come with a number of different mountings for side or end-looking operation and with cable or a connector. Light or dark "on" are available and the sensors operate quickly; light "on" in 20μs and dark "on" in 200μs. Minimum object for reliable sensing is a 0.8 by 1.8mm translucent target. Power is 5-24V dc at 30mA maximum. Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231599.
Enq no 544

COMPUTER

Small pc. *MBPC-200 Series* computers by Advantech are small and contained in industrial cases with a view to operation in vehicles and machine control – the legendary "harsh environments". The whole thing is about the size of a thickish paperback and runs a 386 or 486 single-board computer in Advantech's PCM range. PC/104 modules allow expansion to provide audio, video and communications and the computer is compatible with most commercial software. Semicom UK Ltd. Tel., 01279 422224; fax, 01279 433339.
Enq no 543

Data communications

Ethernet transceiver. Claimed to be the first 10/100Mb/s Fast Ethernet transceiver to work at 3V, TDK's *78Q2120* BicMOS device also works from 5V and needs only a 1:1 isolation transformer, a 25MHz crystal and a standard media access controller chip to form a complete Ethernet adaptor. There is on-chip auto-negotiation to accommodate 10BASE-T/100BASE-TX data streams over Category 5 unshielded twisted pairs, interfacing being direct to any controller via the standard media-independent interface. Separate high-impedance control ports allow parallel connection to other transceivers and there is a host loop-back mode for test and diagnosis. TDK Semiconductor Corporation. Tel., 0181 443 7061; fax, 0181 443 7022.
Enq no 545

Development and evaluation

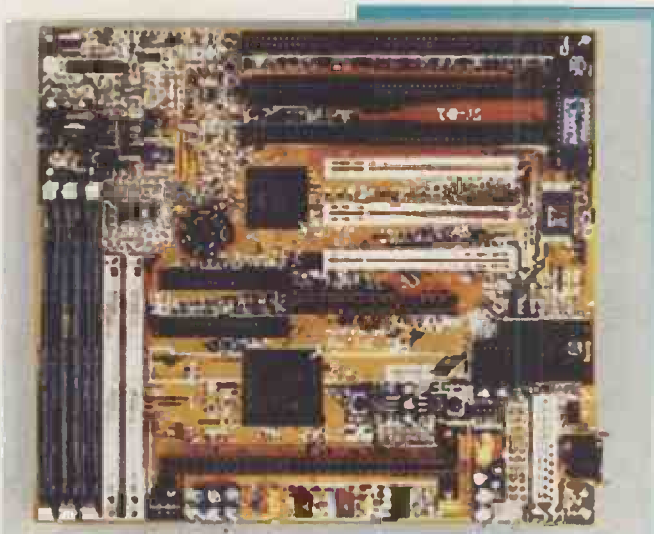
ST6 starter kit. SGS-Thomson's ST6 is an 8-bit microcontroller and the *ST6 in a Box*, produced for Farnell, is a kit containing the necessary information and hardware to bring students and engineers up to speed with programming the device. It contains an ST6 prototype board, a book on making a start, two ST6 samples, a programmer, development software and the ST6 CD-rom. Farnell Components Ltd. Tel., 0113 263 6311; fax, 0113 263 3411.
Enq no 546

Computer peripherals

17in crt monitor. Panasonic's *PanaSync S70* 17in monitor uses only 4W in energy-saving mode and a scan rate of up to 70kHz to cope with pc graphics up to 1280 by 1024, refreshed at 65Hz, or 1024 by 768 at 86Hz. The display supports Vesa DDC1 and 2b and is automatically given the correct configuration when connected to a plug-and-play computer, a screen display, in five languages, providing information on adjustments including degaussing and rotation. The flat, square tube has an anti-reflection coating and the monitor conforms to MPRIL, TCO'92, TUV and Energy Star. Price is £300 plus vat. Web site *http://www.panasonic.co.uk.* Panasonic UK Ltd. Tel., 0500 404041.
Enq no 547

Software

Virtual analogue switch. An addition to TTi's VIPS range of virtual instrument pods is the *VIPS 60* analogue switch, which provides eight separately controlled, single-pole/single-throw switches for digital or analogue signals; inputs and outputs may be commoned to make multiplexers. The VIPS modular system connects to the parallel port of a pc and provides a graphic interface running under Windows 3.1 or 95. The pods derive power from the pc and up to four pods may be connected at a time using an expansion unit. Software supports DDE for real-time exchange of data with other Windows applications and DDL drivers allow VIPS functions to be called from users' own programs. Thurlby Thandar Instruments Ltd. Tel.,01480 412451; fax, 01480 450409.
Enq no 549



Computer board-level products

AGP mainboard. Soyo's *SY-6KL* motherboard for a 233-333MHz Pentium II is made in the standard Baby AT form and uses the newest high-speed graphics interface, the Accelerated Graphics Port, rather than using the PCI bus; AGP uses a dedicated channel to address the main memory for greater throughput. The board uses the Intel 440LX AGP chipset and also has the PCI and ISA expansion buses and other advanced system and BIOS features. There are three 168-pin dimm sockets and two 72-pin simms, with a floppy drive port for two drives, an IrDa infrared port and the usual two serial and one parallel port and a PS/2 mouse connector. Soyo UK Ltd.Tel.,0181 481 9720; fax, 0181 481 9725.
Enq no 548

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

Hart Audio Kits and factory assembled units use the unique combination of circuit designs by the renowned John Linsley Hood, the very best audiophile components, and our own engineering expertise, to give you unbeatable performance and unbelievable value for money.
We have always led the field for easy home construction to professional standards, even in the sixties we were using easily assembled printed circuits when Heathkit in America were still using tagboards!. Many years of experience and innovation, going back to the early Dinsdale and Bailey classics gives us incomparable design background in the needs of the home constructor. This simply means that building a Hart kit is a real pleasure, resulting in a piece of equipment that not only saves you money but you will be proud to own.
Why not buy the reprints and construction manual for the kit you are interested in to see how easy it is to build your own equipment the HART way. The FULL cost can be credited against your subsequent kit purchase.

'AUDIO DESIGN' 80 WATT POWER AMPLIFIER.

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

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

ALPS "Blue Velvet" PRECISION AUDIO CONTROLS.

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

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

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

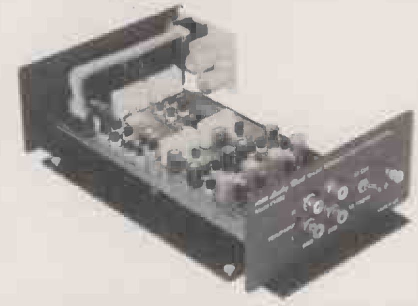
TOROIDAL MAINS & OUTPUT TRANSFORMERS for EL34, 32W VALVE AMPLIFIER

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

PRECISION Triple Purpose TEST CASSETTE TC1D.

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

SHUNT FEEDBACK PICKUP PREAMPLIFIER



If you want the very best sound out of vinyl discs then you need our high quality preamplifier with Shunt Feedback equalisation. The K1450 also has an advanced front end, specially optimised for low impedance moving coil cartridges as well as moving magnet types. Selected discrete components are used throughout for ultimate sound quality. The combination of John Linsley Hood design, high quality components and an advanced double sided printed circuit board layout make this a product at the leading edge of technology that you will be proud to own. A recent review in "Gramophone" magazine endorsing this view. Bought in kit form our step by step instructions it is very easy and satisfying to assemble, or you can buy a factory assembled version if you wish.
This magnificent kit, comes complete with all parts ready to assemble inside the fully finished 228 x 134 x 63mm case. Comes with full, easy to follow, instructions as well as the Hart Guide to PCB Construction, we even throw in enough Hart Audiograde Silver Solder to construct your kit!

K1450 Complete Kit £116.58
K1450SA Audiophile Kit £138.94
A1450SA Factory assembled Audiophile unit £188.94

"CHIARA" HEADPHONE AMPLIFIER.

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

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

"Andante" Linear Technology AUDIOPHILE POWER SUPPLIES

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

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

SPEAKER DESIGN SOFTWARE.

VISATON "Speaker Pro 6" is a complete speaker design program for use on IBM machines. Covers cabinet and crossover design and contains a full expandable database of drive units. Earning a "most reccommendable" accolade it tests this program is ideal for the professional speaker builder or serious audiophile.
0303 Speaker Pro 6. 3.5"Disk £45.51

SPEAKER DAMPING MATERIALS

Polyester Wool and Pure Lambs Wool both have optimal damping properties and are pleasant to handle. Standard 125g bag is sufficient for 20 litres enclosure volume.
5070 Polyester Wool. 125g £3.20
5069 Pure Lambs Wool. 125g £6.73

SPECIAL OFFER!. SOLENOID CONTROLLED FRONT LOAD CASSETTE DECK SFL800

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

HART TECHNICAL BOOKSHELF

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

New Titles.
"A BEGINNER'S GUIDE TO TUBE AUDIO DESIGN" Bruce Rozenblit. A practical book that does exactly what its title says and takes a modern look at valve amplifier construction. 132pp. ISBN 1-88280-13-3 . . . . £18.20
"HIGH PERFORMANCE LOUDSPEAKERS" Edn.5. Martin Colloms. Latest edition, just out. A really in-depth coverage of the whole World of speakers and high quality sound reproduction, but entirely readable in style. Just reviewed in "HiFi World". 478pp. ISBN 0-4719-7089-1 . . . . £24.95*

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

LOUDSPEAKERS; THE WHY AND HOW OF GOOD REPRODUCTION. G.Briggs. 1949. £8.95
"THE LOUDSPEAKER DESIGN COOKBOOK" Vance Dickason. (5th Edn.) £23.95*
ELECTROSTATIC LOUDSPEAKER DESIGN AND CONSTRUCTION Ronald Wagner BKT6 . . . . £15.95
"THE ELECTROSTATIC LOUDSPEAKER DESIGN COOKBOOK" Roger P.Sanders. 1995 . . . . £24.95
"BULLOCK ON BOXES" Bullock & White £10.95
"AN INTRODUCTION TO LOUDSPEAKERS & ENCLOSURE DESIGN" V. Capel. BP256 . . . . £3.95
"LOUDSPEAKERS FOR MUSICIANS" BP297 . . . . £3.95
"THEORY & DESIGN OF LOUDSPEAKER ENCLOSURES" J.E.Benson £21.95
"QUICK & EASY TRANSMISSION LINE SPEAKER DESIGN" Larry D.Sharp £8.95
"THE COUPLED CAVITY HANBOOK" David Purton £4.90
"VISATON. HOME HI FI CATALOGUE." Full Specifications and Thiele Small Data on all Drive Units £4.50
"VISATON. CAR HI FI CATALOGUE." In car guide £3.50
"VISATON. CABINET PROPOSALS" Book 1. In GERMAN £6.50
"VISATON. CABINET PROPOSALS" Book 2. In GERMAN £6.50
"SPEAKER PRO 6." VISATON Cabinet Design Software. . £45.51
"SPEAKER PRO 6." Demo Version with drive unit database £9.28

"VALVE AMPLIFIERS" Morgan Jones. 1995/6 . . . . £24.50
THE VTL BOOK David Manley 1994. BKVT1 . . . . £17.95
MULLARD TUBE CIRCUITS FOR AUDIO AMPLIFIERS BKAA27 . . . . £11.95
"THE WILLIAMSON AMPLIFIER." 0-9624-1918-4 . . . . £6.95
AN APPROACH TO AUDIO FREQUENCY AMPLIFIER DESIGN. GEC 1957 . . . . £17.95
AUDIO ANTHOLOGIES, articles from Audio Engineering. Six volumes covering the days when audio was young and valves were king!. BKAA3/1 to 6. . . . . All £12.95 each
"THE RADIOTRON DESIGNERS HANDBOOK" (CD) £49.00
"PRINCIPLES OF ELECTRON TUBES" H.D.Reich PH.D. £25.95
"POWER AMP PROJECTS" Anthology. 1970-1989. . . . . . £15.50
"WORLD TUBE DIRECTORY" 1996-7 Sourcebook of valve related products £5.95
Fuller descriptions of the contents of all our books is given in our full catalogue, price £4.50

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

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

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

Send for Your FREE copy of our LISTS

WILMSLOW AUDIO Tel. 01455 286603 Fax. 01455 286605

All Prices include UK/EC VAT.

HART. At WILMSLOW AUDIO 50 Main St., Broughton Astley Leicester LE9 6RD

LETTERS

Letters to "Electronics World" Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Pot problems

Can anyone put me in contact with the ultimate purchaser of H J Leak's stock of spare parts for his *Delta 70* series of power amplifiers?

I bought mine about 30 years ago and the stereo volume control is becoming defective. The value, namely 20Ω, means that it is not obtainable from normal electronic components stockists and I am reluctant to substitute, say, 4700Ω, which seems to be the nearest standard logarithmic version about.

In, those days, total harmonic distortion was almost invariably quoted by manufacturers of power amplifiers, but very little seems to be offered these days. Have designs so changed that all mainline makers nowadays are below the one-time magic of 'below 0.1% thd at all output levels within the specification'?

My *Delta 70* still seems OK – apart from the volume control – and I'm reluctant to dump it.

A M Pollock
Amersham
Buckinghamshire

(20Ω isn't a misprint by the way, but it does seem a little low – Ed)

Crystal amplifier?

I read with interest 'Radio reflections from Russia' in the December '97 issue. In my father's 1931 copy of 'The Outline of Wireless' by Ralph Stranger is the following paragraph;

"O. Lossev, a Russian scientist of Ninji Novgorord, discovered that a crystal detector can also be used for generating and amplifying purposes' (are we not coming fast to an all-crystal multi-stage receiver?)...

Was such a receiver ever built and does one still exist? Ralph Stranger records Lossev writing in *Wireless World* No 27, 1924.

Charles Tomkins
Orlingbury
Northants

Tap it and see

I found Hannes Coetzee's article, February '98 issue, most interesting. I am curious to know how susceptible the receiver is to microphony, which only got a passing mention.

Direct conversion receivers can suffer badly in this respect, and this gets worse with increasing frequency. A 28MHz receiver built years ago was pretty much unusable because of this.

Another bane is mains hum which appears to have been avoided by battery operation.

Ian Braithwaite
St Albans
Hertfordshire

Etching capacity

After reading Cyril Bateman's interesting articles on capacitors, and noting in his reply that he was a designer of electrolytic capacitors for Erie at one stage, I was hoping he would comment on the following.

I have a report that I wrote in 1960 concerning the etching of capacitor foils. I would point out that the aluminum company for whose research laboratories I was working had no connection with capacitor manufacture, although after this report we attempted to interest one manufacturer in the technique. Although that company eventually claimed to be able to reproduce our results, we received no further information.

The etching technique produced a surface on super-purity aluminum (99.9999%) which on looking at stereo electron micrographs looked as if it had been drilled all over with a 1 micron drill to a depth of 11 microns. This surface on formation at 500 volts has a surface gain of a little over 10, and the actual metal loss was around 10%. The power factor at 50Hz was noticeably better than commercial capacitors at this time, and if the formation voltage was dropped to 100, surface gain increased to 15.

Since it was 1960, we did not appreciate that it may have been interesting to try much lower formation voltages, although graphs of surface gain were showing a distinct upward curvature for lower voltages.

I left the aluminium industry in 1970 and have had no further contact with it. I have been retired for some time, but owing to the rather unique nature of this etching, produced by a pulse method which could now be accomplished so much easier with solid state devices, I would be interested to know if Mr Bateman has any knowledge of anything similar in use today.

RS Young
Uxbridge
Middlesex

Cyril replies:
Thank you for you most interesting letter. I am not familiar with the pulse current method you mention. Various etching methods have used 'ac' techniques, so your pulse technique might well be used, but just not recognised as such. Due to the cost of the large quantity of electricity used to etch foils, etching plant is usually located close to low cost hydro-electric plants, so most capacitor foil is 'bought in' ready etched and formed.

As you probably know, during the sixties, considerable and rapid improvements in etching methods resulted in extremely large increases in foil surface 'gains', particularly at the lower forming voltages. My involvement with electrolytics commenced when Erie bought A.H. Hunt Capacitors in 1968, so your work pre-dates mine.

I suspect the pulse method of etching would have been particularly beneficial, used in the range of bi-polar electrolytics, then developed using un-etched or smooth foil, for use in loudspeaker crossover networks.

Today, I'm afraid, the availability of suitable metallised film capacitor values inhibits use of electrolytics in crossovers, except when material cost control outweighs quality.

One perennial problem with increased foil surface gains, is the corresponding increase in capacitor esr. This was especially true in 1969 when I designed the first ever published range of capacitors following the then new IEC voltage and capacitance value progressions.

While the size reduction was easily attained, an acceptable esr or power factor required use of lower density tissues together with a new much more conductive electrolyte at low voltages.

I'm sure this power factor problem has not reduced over the years, so any etching method which reduces power factor is especially interesting to the foil suppliers.

Scooter mod

Can anyone help with an alternative circuit for a 6 volt battery charger for my elderly Lambretta scooter? One that doesn't burn out new batteries that is.

Adrian Appley
Bromley
Kent

Corner response

Speakers' Corner in the April issue has errors and misrepresentations.

An ideal acoustic transmission line would dissipate all the energy radiated from the rear of the diaphragm, making it irrelevant whether its end were open or closed. Such perfection is not practicably achievable, so transmission lines are usually dimensioned such that, as Mr Watkinson describes, the path length from the rear of the diaphragm to the open end of the line is equal to a half-wavelength at frequencies around the lower limit of the loudspeaker's passband. This provides a measure of constructive interference which helps

Room for resonance

In his letter 'Room for resonance' in the February issue, Mr Frobisher describes a highly unpleasant but very frequent effect with home hi-fi. Most people try to cure this with more expensive electronics – with the only effect of a big hole in the wallet. But practically every audio system can sound much better if room acoustic is improved.

The lack of effort on this theme is, in my opinion, due to the fact that there exists no correct solution with electronics. So you have to improve the room itself, which normally leads to more conflicts about priority between aesthetic and acoustic requirements. Few people would like to have an acoustic studio in the living room – surely least of all the non-technical wives.

Information for a practical acoustic room is rare. I would be glad if *Electronics World* would give more attention to this neglected theme.

The best information that I have found on the Internet is at http://www.sysdevgrp.com for information and materials. http://www.sysdevgrp.calc.htm for calculator http://www.rpginc.com for information and materials.

J Ingold
Rüti
Switzerland

bolster low bass output.

If the acoustic transmission line were merely a delay line then it would introduce comb filtering effects at higher frequencies as the forward and delayed rear radiation combined constructively or destructively according to frequency. This alone would make it useless for high fidelity loudspeakers. But a transmission line is distinguished by its carefully graded absorbent filling, which while not effective at the lowest frequencies is increasing effective at attenuating port output as frequency rises. The step response of a well designed transmission line loudspeaker is therefore not the double step illustrated on page 341 because the high frequencies necessary to sustain the leading edge of the second step are dissipated within the line.

In any case, if we assume a line delay of 17ms (to reinforce output around 30Hz) the listener in a normal domestic environment will by then already have had numerous opportunities to reprise the diaphragm's forward output as a result of early reflections from nearby room boundaries. Such reflections have been shown actually to assist certain aspects of auditory perception.

The same cannot be said of the short-period reflections that occur as a result of secondary radiation from loudspeaker cabinet edges or internal reflections within the enclosure, both of which are amenable to suppression but neither of which apparently merits a mention.

Later on the same page we read that, "The only low-frequency transducer of practical size which can be made phase linear is the sealed box... with suitable damping factor there is no resonant behaviour and the speaker behaves like a high-pass filter." This is mostly nonsense.

As has been demonstrated many times, loudspeaker drive units exhibit substantially minimum phase behaviour. In other words, contrary to Mr Watkinson's assertion on the previous page, it is entirely possible to calculate their phase response from their amplitude response using the Hilbert Transform. (This only falls down when all-pass elements are introduced into the electroacoustic circuit, which practically means when most forms of crossover network are included.)

In a minimum phase system, non-flat amplitude response is always accompanied by non-linear phase response, so the second-order bass roll-off of a closed box loudspeaker must introduce phase distortion. Exactly the same is true of the high-pass filter to which he likens it.

Even if a closed box loudspeaker is damped to the maximally flat (Q_{TS}=0.7) alignment or higher, so that it exhibits no peak in the amplitude response, it remains both phase-distorting and a resonant system. If by non-resonant Mr Watkinson actually means non-oscillatory, that description applies when the total system damping (electrical plus mechanical) is 0.5 or less. But such critically damped, non-oscillatory alignments are feasible with reflex loading, although their phase distortion is inherently greater because of their fourth-order (24dB per octave) ultimate roll-off.

Either form of loudspeaker can have its phase distortion compensated by dsp filtering, but this is no trivial matter in respect of processing power.

Digital signal processing – or analogue networks – can also be used to extend the loudspeaker's amplitude response to lower frequencies, but this is not the simple method of achieving low bass capability from a small enclosure that Mr Watkinson appears to believe.

To maintain constant sound pressure with falling frequency requires the drive unit's volume displacement to increase at 12dB per octave, i.e. diaphragm must quadruple with each halving of frequency. This requirement rapidly forces modestly proportioned bass drivers into significant distortion at anything other than moderate output levels.

Calculating the volume displacement required to produce a sound-pressure of, say, 90dB at 30Hz at a typical listening distance of 2.5m is a sobering exercise. At large diaphragm displacements a small sealed box contributes further distortion due to the nonlinearity of its air spring.

One of the principal attractions of reflex loading is that port output supplants driver output at low frequencies, considerably reducing the diaphragm excursion demand. If you like, a reflex loudspeaker trades increased phase distortion for reduced nonlinear distortion at low frequencies. Using either type of loading, a larger cabinet will always be desirable because it beneficially affects the inter-related factors of bass extension and sensitivity.

Although active loudspeaker techniques do "allow for wide, flat frequency response without impaired time response" the reality is that most active loudspeakers introduce just as much waveform distortion due to inherent driver roll-offs and the use of crossover networks with all-pass characteristics as passive designs do. In the real world the decision whether to go active – with or without phase compensation – inevitably reduces to a cost-benefit analysis.

Evidence of the outcome of such analysis is all around us: whatever the inherent benefits of active operation, its added expense has persuaded the large majority of commercial loudspeaker designers – many of them bright, capable people who actually create loudspeakers for a critical audience rather than pontificate about it – that the complex design problems inherent in their task are, for the time being anyway, more effectively addressed otherwise, at least in the lower echelons of the price spectrum.

They will not read anything in Mr Watkinson's flawed article to persuade them differently.

Keith Howard
Twickenham

If only...

As a pensioner I do not have enough spare cash to devote to learning to conduct an orchestra. So I wait impatiently for the virtual orchestra, a baton that I could brandish at empty space that will deliver sound through a suitable system.

A baton with accelerometers attached would send signals to a computer knowledgeable of the score. This computer would keep a phase-locked loop running at the right tempo. An orchestral performance under speed with instruments on separate tracks would allow the notes, all too long, to be curtailed individually using digital reservoirs as found in cd players. So a series of quavers would emerge as a faster series of quavers still joined together while special arrangements would shorten staccato notes accordingly

Clearly different instruments often play notes beginning at different times and this makes multi-track recording necessary. The setup would need to carry details of the orchestral score so as to line up the start of each note in the right place.

Bernard Jones
London

A plea for SC84 software

I built John Adams's intelligent eprom programmer from an article in the November 1994 issue of *Electronics World*. It has since worked faultlessly in stand-alone mode, copying from master to slave. But I now need to control the programmer via an external computer using the RS232 interface.

I understand that someone produced some dos-based controlling software for the programmer. Can anyone help me get hold of a copy?

Richard Sierakowski
Marlborough
Wiltshire

Phantastic references

In the May issue, Ian Hickman asks for references to phantastron and sanatron. 'Radiation Laboratory' series published by McGraw Hill just post-war contained 'Waveforms' and 'Radar System Engineering'. If I remember correctly, the first work covers both and the latter just the phantastron.

O.S. Puckle's book 'Timebases,' published by Chapman and Hall, 1951, describes both circuits. Millman & Taub 'Pulse and Digital Circuits,' published by McGraw-Hill, 1956 does both too.

F.C. Williams and N.F.Moody article "Ranging circuits, linear time-base generators and associated circuits" *JIEE* Vol.93, pt IIIA, 1946 should also be of interest.

R. Chive
Kent

Versatile radiation meter

Darren Heywood's radiation meter described in the May issue is unnecessarily complicated. I say this with a background of many years experience in building and using high resolution portable and fixed ionising radiation sensors for detecting variations in solar emission and cosmic ray flux.

Although the GM tube needs a high and stable operating voltage, the output pulse per event is correspondingly large. For environmental monitoring, pulse rates are relatively low so eht power is very modest. I have had many years of stable and accurate operation using eht supplies with 100μA capability and GM tube series resistors up to 20MΩ without loss of and the benefit of greatly enhanced tube life.

Here's how

A stabilised eht supply can be built using 12V eht modules from Brandenberg or Farnell. These packaged units are tiny and can be driven direct off an internal 12V battery or via a series power fet and voltage divider to give automatic stabilisation.

I prefer to use a series chain of 200V and 100V zeners on a rotary switch so different eht voltages can be selected. A 100µA meter at the earthy end of the chain provides battery charge level indication by showing current flowing in the stabilisers.

A typical unit using a 30 inch by 1 inch cosmic ray sensing GM tube operating at a background rate of 500c/min on 1300V stabilised takes a total battery load of 30mA for the tube supply and another 15mA for the pulse amplifier and counter. This gives several days continuous field use from a 2AH sealed lead acid battery inside the unit. Smaller tubes like that used by Mr Heywood use less power but also detect less.

The GM tube gives an output pulse of several volts whose shape and duration is fixed by the power supply and cable and tube impedances.

Anthony Hopwood
Holdfast
Worcester

Darren replies

Thank you for showing interest in my article. Bearing in mind that *EW* has worldwide readership, it is not always possible for those people living abroad to obtain electronic parts that we find easy to obtain here in the UK and hence the parts used in my eht circuit are very affordable and not difficult to obtain and was designed to give the end user as much flexibility as possible. Moreover, my ht supply is a tight control loop which allows the user to set the eht anywhere within the 0 to 1100V range with less than 0,1% deviation over long term.

I believe this to be more professional than to switch the supply by means of zener diodes.

The vast majority of GM tubes available usually have a working voltage of between 300 and 1100V, thus my design can accommodate a wide variety of different tubes, however, some specialised types might fall outside this band.

As stated in my article, the cost of ultra sensitive tubes is quite staggering, for a doubling in sensitivity, the cost goes up ten fold. I had to compromise here and chose a tube with the best sensitivity for my pennies.

In your letter, I get the impression that my tube is overdriven thus shortening its life? The *MX120/01* is fed from the supply from a 2.2MΩ through a 1MΩ to ground, thus the tube can be thought of as a simple switch. When it ionises, the pulses dropped across the 1MΩ resistor are around 12V in height which means the tube is sinking around 12µA of current. On page 405 of *EW*, bottom right hand corner, is the recommended input conditioning circuit for the *MX120/01* from its manufacturer, Mullard. They recommend sinking around 8µA – 4µA less than mine.

This means that the tube sinking 12µA will last around 25 years while the one sinking 8µA will last 30 years of continuous use.

In regards to my eht supply being able to sustain 1000V at 1mA, might be of interest to other readers requiring a good quality general purpose eht supply for purposes other than to excite GM tubes.

It seems that with the circuitry you describe, you are simply recording the counts/min. This value on its own is not a standard unit, and does not mean a great deal.

For example, the *MX172* and MX178 output 5400 and 8800 counts a minute respectively. But that is while both are subject to exactly the same radiated dose of 1mRad/h.Thus each tube has a specified gain associated with it. This is clearly stated and outlined in my article.

Due to the hazardous nature of radiation, I included a world wide standard 4-20mA output with the idea that the user could place the detector in the hazardous area, then run a cable back to the safety of a laboratory and connect the current loop direct to a chart recorder. In this way, radiation monitoring is done safely. The strip chart would then be an accurate recording of 0-1000µRad/h over time (µRad/h meaning a specified dose quantity). Although, I do not have access to the *MC71* data sheet, the question now arises, can my detector accommodate this tube? I think the answer to this question is yes, making the detector versatile and flexible which is exactly what my article is all about.

If any reader would like to see my detector working and/or you require full 100% proven pcb design layout then I would only be happy to accommodate.*

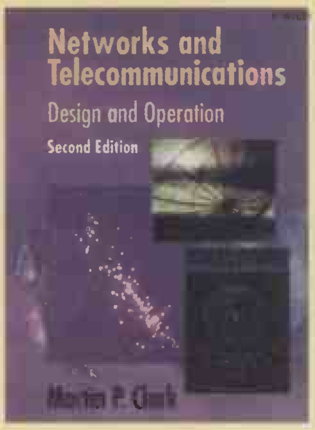
Incidentally, does anybody know what the safe permitted dose is in mRad/h please?

*Please send your request to *Electronics World* Editorial at the Quadrant House address on the leader page.

CD access from an Acorn

Acorn computer users can view the Zilog CD – given free with UK issues of *Electronics World* April 1998 – by using a public domain PDF file viewer. This can be downloaded from the Acorn Cybervillage site http://www.cybervillage.co.uk/acorn/

Steve Jagger
Machynlleth
Powys



Networks and Telecommunications Design and Operation

Second Edition
Martin P. Clark, Telecommunications Consultant, Frankfurt, Germany

Telecommunications network design and operation is now widely regarded as an issue of business management as well as electrical engineering. In this updated edition, Martin Clark, a pioneer of this perspective, applies it to the increasing complex and diverse realm of voice, and data and multimedia networks.
Written in an accessible style and clearly illustrated throughout, this is a basic, practical and intuitive insight into modern network engineering and sections including:

- Technical accounts of modern voice, data and multimedia networks
- Coverage of ATM, B-ISDN, SDH, mobile radio and satellite networks, Internet and TCP/IP
- Practical aspects of running and setting-up networks
- Running a business based on telecommunications

A text specifically for readers new to the whole subject of telecommunications, and professional telecommunications managers who need an introduction and reference work on all aspects of technology, operational techniques and regulation.

ISBN 0 471 973 46 7

UK £80.50 Europe £86 ROW £105

Introduction to Digital Mobile Communication

Yoshihiko Akaiwa

A comprehensive treatment of the digital technologies that make personal mobile communication a reality
Although today's mobile communication engineers and designers can build upon the advances in digital telecommunications, specific technical requirements - robustness against fast fading,

spectrum and power efficiency, and the demand for low-priced equipment- post new technological challenges that demand creative solutions.
Introduction to Digital Mobile Communications is a comprehensive treatment of the digital technologies that are rapidly spawning new advances and applications. Written by a pioneer in the field, this book covers all the important concepts, from the fundamentals of signal analyses and digital communication to descriptions of the latest transmission systems. Rich in detail and broad in its coverage, this remarkable book:

- Describes equipment and circuit implementation methods and their performance characteristics
- Discusses elements of and methods for digital modulation and demodulation schemes
- Provides practical designs and circuits for spectrum-efficient modulations
- Covers mobile radio channels and digital mobile radio systems
- Includes extensive mathematical treatments and mathematical models
- Presents the latest research results with detailed references

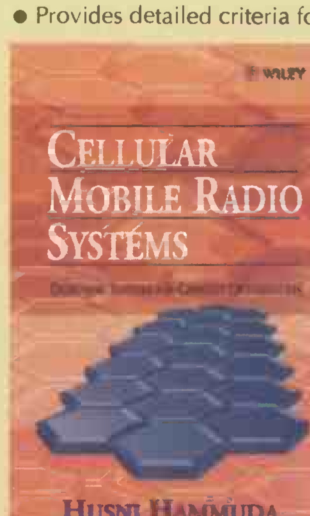
This valuable resource provides a solid introduction to mobile radio communication for the students or professional in related fields. Most important, for design engineers and equipment manufacturers, its up-to-date findings will stimulate new research and creative design and system development efforts.
Yoshihiko Akaiwa is a leading researcher in the digital mobile communication field. Currently a professor at Kyushu University, he worked as a researcher for over twenty years at the NEC Corporation
ISBN 0 471 17545 5
UK £57.50 Europe £60.50 ROW £73

Cellular Mobile Radio Systems

Designing Systems for Capacity Optimization
Husni Hammuda, Ericsson (UK) Ltd

Rapidly increasing demand for mobile radio frequency subscription is already pushing cellular networks to the point of overload. Of the various methods which are being explored to tackle this problem one of the most notable is the integration of advance modulation and multiple access techniques. In this book, Husni Hammuda, a pioneer of this hybrid, shows how it can be applied in practice to optimise the efficiency of mobile radio cells.

- Provides detailed criteria for



the evaluation of combinations of modulation and multiple access techniques
- Includes primary performance data as well as predictive models
- Theoretical material is explained using examples from first and second generation transmission systems
- Covers recent innovations in personal communications

For the practising cellular communications engineer this is a systematic set of solutions for improving traffic flow in cellular networks. It also includes complete theoretical and case material ideal for post-graduate network engineering researchers.

ISBN 0 471 95641 4
UK £37.50 Europe £39.95 ROW £46.95

Network-Based Images

A Practical Guide to Acquisition, Storage, Conversion, Compression and Transmission
Gilbert Held, 4-Degree Consulting, Macon, Georgia, USA

Network-Based Images offers a fresh approach to the acquisition and manipulation of visual images on computer by focusing on the network application side.
This practical Guide explains the methods used to store images electronically and discusses the popular image-based applications, such as storage, conversion and compression. Gilbert Held reviews the procedures used to minimize the effects of other image-based applications to increase efficiency.
This network oriented book provides detailed information on the transmission of images to other systems and includes an overview of the associated problems.
Features include:

- Use of images on LANs includes LAN-based World Wide Web Servers
- Use of HTML image related statements
- Techniques to avoid costly network upgrades
- How to segment LANs
- Network modifications to

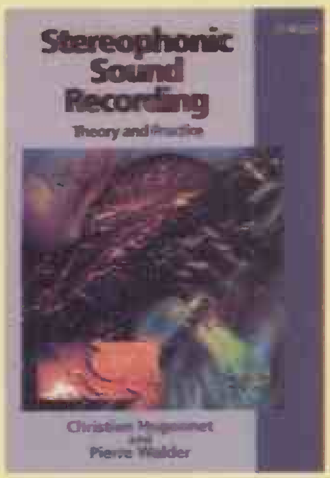
counter the bandwidth effect of images upon LAN transmission

Essential reading for network managers and administrators as well as Web server administrators and personal computer users. This book will provide unique coverage of images oriented to efficient use on networks: storage, acquisition, and use in applications
ISBN 0 471 97357 2
UK £37.50 Europe £39.95 ROW £46.95

Stereophonic Sound Recording

Theory and Practice
Christian Hugonnet and Pierre Walder

Recent advances in digital audio have heralded substantial innovations in sound recording techniques and increased the importance of applying the latest microphone techniques. The authors of this book focus on these innovations, giving numerous examples of their use within the framework of an analysis-based recording



engineering theory.
The book provides a complete overview of well-known sound recording procedures practised world-wide, whilst also presenting a methodology that will provide the reader with an efficient approach to sound recording of classical music, rock and pop music, drama and speech. The widely illustrated theoretical knowledge is presented in clear and simple language.
Building on their considerable experience of creating innovative recording techniques, the authors provide an authoritative analysis of the subject that offers valuable, practical guidance that will aid the development of new recording methods. Their inside knowledge of the requirements of the phonographic, broadcasting, film and other media industries ensures expert coverage of new products and approaches including:

- recording techniques for all types o microphones
- in-depth analysis of the principles and use of stereophonics
- influence and role of the venue acoustics on the sound recording
- guidelines for mastering and mixing different levels of sound from different sources

For professional audio engineers, this manual provides systematic advice for getting optimal performance from studio equipment. For students of audio engineering it will form a comprehensive introduction to the area of stereophonic recording, backed up by real-world case studies and a wealth of practical experience.
ISBN 0 471 97487 0
UK £32.45 Europe £34.95 ROW £41.95

Protect Your Privacy on the Internet

Privacy defense tools and techniques you can use right now
Bryan Pfaffenberger

CD-ROM includes a complete collection of Windows privacy software.
Is your complete life story available to anyone with Internet access? It's really not all that hard to snoop in

Continued over page

All prices are fully inclusive of packaging 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

Total__________

Name____________________

Address____________________

Postcode__________

Telephone____________________

Method of payment (please circle)

Access/Mastercard/Visa/Cheque/PO

Cheques should be made payable to Reed Business Information

Credit card no____________________

Card expirey

Signed

Please allow up to 28 days for delivery

cyberspace. As more and more business is conducted over the Internet, it has become increasingly difficult for both businesses and individual users to protect private information. Your reputation, Your finances, and your basic right to privacy are on the line every day. What can you do about it?

You can fight back. Protect Your Privacy on the Internet tells you everything you need to know to ensure your privacy and use the same technology that's being used against you to protect yourself. You'll get industrial-strength encryption tools to keep your affairs secret, the way they ought to be.

Bryan Pfaffenberger arms you with privacy defense strategies such as:

- Creating a bullet-proof password
- Getting your name out of the databases
- Cleaning up your browser's trails

Protect Your Privacy on the Internet gives you proven privacy defense strategies and techniques to help you make the Net a safer place to work and play. You'll get the names of Internet privacy organizations that are working to protect your privacy rights and find out what you can do to help. On the accompanying CD-ROM you'll find a collection of Windows Privacy freeware and shareware, including:

Pronto96 - an e-mail program that works in conjunction with encryption software to protect your e-mail

Mutilate - software that thoroughly erases files beyond recovery, even by expert snoopers

Win-Secure-It® - a utility preventing unauthorised access to files on your computer

AMSD Ariadna™ - a full-featured browser that reads tables and Java but ignores "cookies", text files that transparently save where you've been

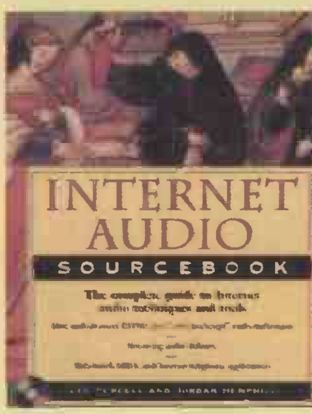
Random Password Generator - a program enabling you to generate up to 1,000,000 passwords to protect you against unauthorized access to your Internet account

Cyber Patrol™ - parental control software that prevents kids from uploading personal and demographic information to commercial sites

ISBN 0 471 18143 9

UK £27.45 Europe £29.95 ROW £36.95

Internet Audio Sourcebook



The complete guide to Internet audio techniques and tools
Lee Purcell and Jordan Hemphill

"The World Wide Web has spouted vocal cords, gained a voice, and begun to sing." – Lee Purcell and Jordan Hemphill

Internet Audio Sourcebook offers you a quick, easy way to acquire the knowledge, skills, and some of the tools you need to build cutting-edge audio capabilities into your Web pages, including:

- Music, narration, and sound effects
- Streaming audio for real-time broadcasts
- Automated, spoken-voice instruction
- Audio conferencing and Internet telephony
- MIDI techniques for musical training and analysis

Taking a step-by-step approach, the authors get you up to speed on the latest audio tools and techniques. First they school you in the basics of creating, processing, and storing audio data.

You learn the various methods of working with digital sound and how to use available tools to shape audio content for the Internet. Then they show you how to deliver your digital sound over the Web. They explain the HTML coding used to access audio files and teach you techniques for integrating Java applets, JavaScript code, and VBScript code into your HTML documents.

Finally, the authors show you how to get the most out of new audio technologies, including streaming audio, MIDI applications, voice synthesis and recognition, and Internet telephony, as well as covering hot new products like the Headspace Beatnik audio engine and Liquid Audio.

The CD-ROM
You get fully functional demos of top-of-the-line sound processing applications, including Sonic Foundry's Sound Forge and Hohner Midia's Samplitude Studio. Authoring tools such as Symantec's Visual Café, Aimtech's Jamba, and Acadia Software's Infuse JavaScript editor are also included.

ISBN 0 471 19150 7

UK £28.45 Europe £31.95 ROW £39.95

Web Security Sourcebook

A Complete Guide to Web Security Threats and Solutions
Aviel D. Rubin, Daniel Geer, and Marcus J. Ranum

The front door is unlocked and wide open. The alarm's not working and no one's home. All of your valuable, money, and intimate details of your life are just sitting inside, waiting to be taken. No, it's not your house, it's your computer.

The Web now penetrates every aspect of our lives, from the home PC to the Business office. But with each advance in convenience comes a geometric increase in vulnerability to the integrity of data and software as well as to the confidentiality of information. Although the flaws inherent in the Web are real, solutions are available. Let Aviel Rubin, Daniel Geer, and Marcus Ranum give you the answers.

Here's a book that's valuable today and indispensable for the future. It includes basic and advanced techniques for client-side and server-side security, browser security, writing secure CGI scripts, firewalls, and secure e-commerce. There's a special appendix that demystifies the complex world of cryptography. And the book comes with access to a dedicated Web site containing up-to-the minute information on the latest security threats and solutions.

So whether you're a Webmaster trying to close the door on sites and applications, or an everyday user hoping to keep your desktop safe, this is your essential source of:

- Protecting and securing Web pages, search engines, servers, and browsers
- Writing impregnable applets and scripts, and avoiding the dangers inherent in every language
- Using (and abusing) firewalls and cryptographic controls
- Securing commerce and payment transactions

ISBN 0 471 18148 X

UK £27.45 Europe £29.95 ROW £36.95

Encyclopaedia of Acoustics

Edited by Dr Malcolm J Crocker, Auburn University

Sound Information in 167 detailed Chapters. Now there's a new four-volume reference that covers every imaginable area of acoustics, sound and vibration - from the design of a concert hall to the intricacies of the human ear. It's the Encyclopaedia of Acoustics.

In this on-of-a-kind set, edited by well-known acoustical expert Dr Malcolm J. Crocker, you'll get:

- Extensive cross-referencing and indexing
- 2000- plus pages of insights from more than 200 international expert contributors
- An exhaustive examination of the fundamentals of acoustics and vibration in the first two volumes
- A revealing exploration of acoustic applications in Volumes Three and Four
- General Introductions at the start of every section

This up-to-date work is the definitive acoustics resource for students, engineers, scientists, and researchers in the field.

Casebound © 1997, four-volume set
approx. 2,000pp.
(750pps./volume)
ISBN 0471 80465 7

UK £372.45 Europe £384.97 ROW £390

ADVERTISERS' INDEX

CLASSIFIED

Tel: 0181 652 3620 Fax 0181 652 8938

The Papua New Guinea University of Technology

Lae

ACU

Associate Professor Telikom/ Ericsson Foundation Chair in Communication Engineering

Department of Electrical & Communication Engineering

papua new guinea

The Department of Electrical and Communication Engineering is one of four engineering departments in the Papua New Guinea University of Technology. The Department is the only Electrical Engineering School in the whole country. It offers degree programmes leading to BEng (Power) and BEng (Communication). It also offers a Diploma programme, which is a three year course leading to Diploma in Electrical Engineering (Communication) & Diploma in Electrical Engineering (Electronics). Plans are already in place to offer MEng programmes by course work in Power and Communication Engineering. The Department has three major disciplines, ie. Power and Control, Communication & Electronics and Computer Systems Engineering. It has established brand new state of the art Data Communication and Multi Media laboratories in addition to the current communication research laboratory and has been active in research mainly on three projects. One is with the International Telecommunication Satellite Organisation (INTELSAT) - Analyses of concurrent point rainfall. The other two are on NETCOM and Satellite Communication.

The Foundation Chair in Communication Engineering is the result of collaboration between Telikom, Ericsson and the University to provide leadership in teaching and research in the area of Communication Engineering. The funding is initially available for three years, hence the contract extension beyond three years will depend on industry funding. The successful candidate will be expected to have extensive teaching and research experience in Communication Engineering with PhD degree, and with strong track record in research and teaching. For academic enquiries only, please contact Professor Majid Al-Dabbagh, Head, Department of Electrical & Communication Engineering (tel: [675] 473 4701; fax: [675] 475 7209; email: mdabbagh@ee.unitech.ac.pg).

Salary per annum: Associate Professor: K51,890 - K57,163 (Level of appointment depends upon qualifications and experience.) Initial contract period is normally for three years but shorter periods can be negotiated. Other benefits include a gratuity of 30% in the first year, 35% in the second year and 40% in the third year taxed at 35%; support for approved research; appointment and repatriation fares for yourself and family; settling-in and settling-out allowances; six weeks' paid leave per year; recreation leave fares for yourself, spouse and two authorised dependants after 18 months of service; education fares and assistance towards school fees for two authorised dependants; salary protection plan and medical benefit schemes are available. Staff members are also permitted to earn from consultancy up to 50% of earnings annually.

Detailed applications (two copies) with curriculum vitae, including certified copies of qualifications obtained and names, addresses and fax/phone numbers of three referees and an indication of the earliest availability to take up the appointment should be received by: **The Chairman of the Interim Council, PNG University of Technology, Private Mail Bag, LAE, Papua New Guinea (fax: [675] 475 7200)** by **19 June 1998**. Further general information may be obtained from the **Association of Commonwealth Universities (46617), 36 Gordon Square, London WC1H 0PF (tel: 0171 387 8572 ext. 206; fax: 0171 383 0368; email: appts@acu.ac.uk)**.

A member of the Association of Commonwealth Universities

ARTICLES FOR SALE

PCB CAMERAS

B/W 32mm lens or pinhole **£39**+VAT (5+ £35 each)

B/W 42mm with audio lens or pinhole **£45**+VAT (5+ £39 each)

Colour 42mm twin board with audio and lens **£99** +VAT

Also Domes, bodies, lenses, switchers, quads, coverts, autorecording, PIRs, pencil and waterproof cameras, monitors, housings, RF mods (up to CH 69) etc. Export trans/RX cameras.

HENRY'S

404 Edgware Rd, London, W2 1ED
Tel: 0171 724 0323 Fax: 0171 724 0322
Orders hotline: 0800 7316979
email: sales@henrys.demon.co.uk
Web: "http://www.henrys.co.uk"
Official orders (subject to status) & most credit cards accepted

TELEPHONE, FAX, EMAIL OR CALL IN. Open 6 days a week.

AUDIO & RF DESIGN - DC to 3GHz

- Stereo Coders & processors
- RF Amplifiers & Transmitters
- Wireless Control Systems
- 2.4 GHz Audio & VideoLinks
- Aerial combining Systems

So whatever your need call us!

LIBRA SOLUTIONS
Tel. 0181-428 2776
mnoar@globalnet.co.uk

RF DESIGN SERVICES

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

WATERBEACH ELECTRONICS

TEL: 01223 862550
FAX: 01223 440853

POWER SUPPLY DESIGN

Switched Mode PSU
Power Factor Correction
Linear PSU

Lomond Electronic Services

Tel/Fax: 01243 842520
eugen_kus@cix.co.uk

19" **Rack Enclosures**

New and Used most sizes
16U to 50U side and rear panels
mains distribution 19" Panel mounts
optima eurocraft. Prices from £45 +vat

M&B Radio
86 Bishopsgate Street Leeds LS1 4BB
Tel. 0113 2702114 Fax. 0113 2426881

NEWNES "RADIO AND TELEVISION SERVICING" 1945-1969 (1 MISSING). OFFERS. TEL: 01865 251041 (STEVE).

COUNTER PHILIPS PM6668 (1GHz) £150. SIGNAL GENERATOR PHILIPS PM5326 0.1Hz/125MHz £160. 'SCOPE PHILIPS PM3214 £200. MANY OTHER ITEMS. TEL: 01590 673162/676708.

ELECTRONIC DESIGN – ANALOGUE AND DIGITAL. P & P ELECTRONICS. TEL: 01924 402931.

LEADER LDM171 DISTORTION ANALYSER £350 ONO. ADVANCE J3 VERY LOW DISTORTION SINE/SQ SIGGEN £175 ONO. TEL: MATTHEW 01923 236968 EVES.

ARTICLES WANTED

VALVES, etc, WANTED

Most types considered but especially KT88, PX4/PX25, KT66, KT77, EL34, EL37, ECC83. Valves must be UK manufacture to achieve top prices. £200 paid for working quad stereo system (II + II + 22).

COURTEOUS, PROFESSIONAL SERVICE
Ask for a free copy of our wanted List.

BILLINGTON EXPORT LTD., Billingshurst, Sussex RH14 9EZ
Tel: 01403 784961 Fax: 01403 783519
Email: billingtonexportltd@btinternet.com
VISITORS PLEASE PHONE FOR APPOINTMENT.

WANTED: PRE-WAR TV. Offered: Network Analyser HP8505A. Jac Janssen, Hogeham 117D, NL-5104JD Dongen Netherlands. Fax: +3113 4624684. Thanks

WANTED: W.W.2. Military Radios. Old Crypto gear. Suitcase sets. OZ8RO. Rag Otterstad, Hosterkobvej 10, DK-3460 Birkerod, Denmark. EMail: ooterstad@inet.uni2.dk.

TOP PRICES PAID

For all your valves, tubes, semi conductors and IC's.

Langrex Supplies Limited
1 Mayo Road, Croydon
Surrey CR0 2QP
TEL: 0181-684 1166
FAX: 0181-684 3056

★★WANTED★★

Test equipment, Electronic Scrap, Valves, Transmitters/Receivers, Factory & Warehouse Clearance. Confidentiality Assured.

TELFORD ELECTRONICS
Phone: 01952 605451
Fax: 01952 677978

Contact Joannah Cox on
0181 652 3620

ELECTRONIC**UPDATE**

A regular advertising feature enabling readers to obtain more information on companies' products or services.

T & M EQUIPMENT

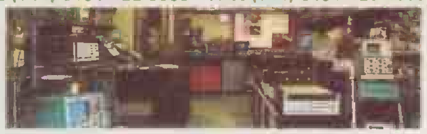
ANRITSU ML93A optical power meter (MA96A 0.75-1.8uM)	£1000
ANRITSU ME518A pcm error - rate test set 150Mbit/sec	£500
ADVANTEST TR9407 fft spectrum analyser to 1MHz	£3500
BRADLEY 192 oscilloscope calibrator	£500
HP182T/8559A 21GHz spectrum analyser	£3500
HP8590A 1.8 GHz portable spectrum analyser	£2950
HP85032B N type calibration kit	£750
HP83475A lightwave communications analyser	£2500
HP83572A sweeper plug-in (for 8350B) covering 26.5-40GHz	£7500
HP8557A/182T 350MHz	£1000
IFR A-7550 1GHz portable spectrum analyser	£2750
IFR A-8000 2.6GHz portable spectrum analyser	£4000
MARCONI 2019 synthesized signal generator 80kHz-1040MHz	£1500
MARCONI 2380/2382 high specification, 400MHz spectrum analyser	£3500
MARCONI 2610 true rms voltmeter	£750
MARCONI 2955A test set with 2960 ETACS cellular	£3000
PHILIPS PM5193 synthesized function generator	£1750
PHILIPS PM8272 2-pen recorder	£650
SCHLUMBERGER 7081 8.5 digit precision voltmeter	£1500
SCHLUMBERGER 1254 frequency responce analyser	£3500
TEKTRONIX 'scope calibrator TM504/SG503/PG506/TG501	£1000
TEKTRONIX 492 21GHz spectrum analyser	£5000
WILTRON 560A scalar analyser	£1000

• ralfe electronics •

exclusively professional T&CM ©

• 36 Eastcote Lane • South Harrow • Middx HA2 8DB • England •
TEL (+44) 0181-422 3593 • FAX (+44) 0181-423 4009

EST 45 YRS



DISTRIBUZIONE E ASSISTENZA, ITALY: TLC RADIO, ROMA (06) 871 90254

TEST EQUIPMENT

★ HP 'HIGH-END' ★

3577B/001/002 network analyser	£7500
8642B/001 signal generator	£16000
8663A/03 signal generator	£24000
8665A/003/004 signal generator	£23000
8720D/1D5 network analyser	£44000
8722C/001 network analyser	£43000
8753C/006 6GHz netwok analyser	£12500
8753D/006/010 network analyser	£23000
8970B/020 noise figure meter (with 346A £6500)	

HEWLETT PACKARD

1640B serial data generator	£500
11581A attenuator set	£350
10715A digital interferometer	£1000
3336A synthesizer/level generator	£2000
3235A switch/test unit	£1000
11857D 7mm test port cables	£500
33320G/33322G programmable attenuators 4GHz, with driver 11713A	£750
As above but 18GHz set	£1250
3552A transmission test set	£500
35650A mainframe	£2000
3586A selective level meter	£1250
E3615A bench power supply	£175
37900D signalling test set with 2 x 37915A interface cards	£5500
4948A (/04) in-service TIM set	£500
4093B protocol tester base (PT300)	£3500
435B/8481A microwave power meter	£500
85032B N-type calibration kit	£750
8018A serial data generator	£1000
5334B frequency counter /060	£1000
8111A pulse generator 20MHz	£1250
83411C lightwave receiver 1300/1550nm	£1750
83440C lightwave detector 20GHz 1300/1550nm	£2000
86222A/8620C 10MHz-2.4GHz sweep generator	£1500
8684B signal generator 5.4 - 12.5 GHz	£2000
8753C/006GHz vector network analyser	£12500
8903B audio analyser £3000 - (specify your own filter requirements add £200 for each filter)	
J2215A FDDI portable multimode test set	£1500
J2304 internet advisor with ethernet interface	£2500

All equipment sold calibration-checked by independent labs and carries un-conditional refund and 90-day guarantees

FOR EXCLUSIVE ACCESS TO OUR COMPLETE STOCK INVENTORY AND SPECIAL BARGAIN DISPOSAL DEALS PLEASE CHECK OUR WEBSITE

www.ralfe-electronics.co.uk

CERT 95/013

ISO9002 ACCREDITED STOCKIST MEASUREMENT & TEST EQUIPMENT

CIRCLE NO. 140 ON REPLY CARD

New for '98 FREE Data Acquisition Software Tool

DAQ Designer '98 from National Instruments, is a free system configuration tool that reduces the complexity and time it takes to configure a PC-based data acquisition system and assures that system developers have the right plug in boards, signal conditioning products, cable assemblies, and software packages for their application.

Call **National Instruments** *now for your FREE copy on* 01635 523545

CIRCLE NO. 141 ON REPLY CARD

CABLING SOLUTIONS FROM THE LCD EXPERTS

Trident Microsystems' new LVDS system, provides the cabling solution to overcome all the problems associated with driving Digital TFT over long distances.

Trident's new LVDS system now allows for digital drive of **up to 20 metres in length**.

For further details call Trident today
Tel: 01737 780790
Fax: 01737 771908

CIRCLE NO. 142 ON REPLY CARD

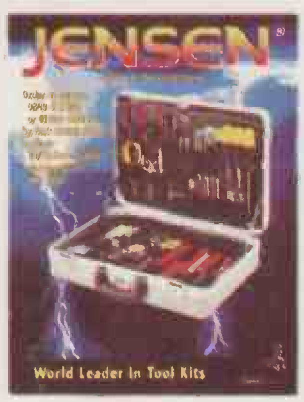
LCR & IMPEDANCE METERS

The 3522 LCR HiTESTER and 3531 Z HiTESTER together provide a wide range of test frequencies. The 3522 offers DC and a range from 1mHz to 100kHz and the 3531 covers the range from 42Hz to 5MHz. Test conditions can now come closer to a component's operating conditions. The high basic accuracy of ±0.08%, combined with ease of use and low price give these impedance meters characteristics.

TELONIC INSTRUMENTS LTD

Tel: 0118 9786911
Fax: 0118 9792338

CIRCLE NO. 143 ON REPLY CARD



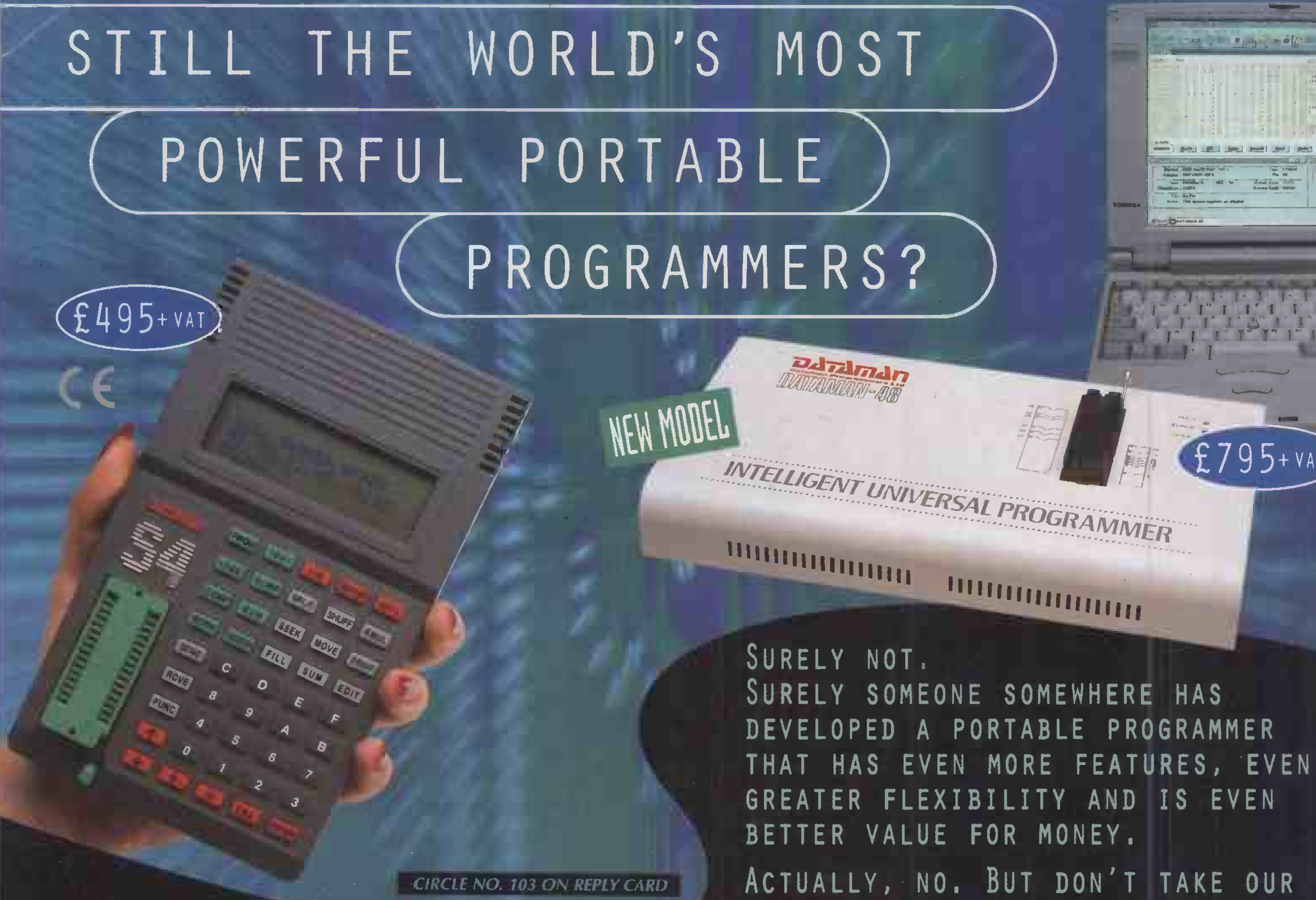
NEW JENSEN TOOLS CATALOGUE

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 acccessories, 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. 144 ON REPLY CARD



SURELY NOT.
SURELY SOMEONE SOMEWHERE HAS DEVELOPED A PORTABLE PROGRAMMER THAT HAS EVEN MORE FEATURES, EVEN GREATER FLEXIBILITY AND IS EVEN BETTER VALUE FOR MONEY.

ACTUALLY, NO. BUT DON'T TAKE OUR WORD FOR IT. USE THE FEATURE SUMMARY BELOW TO SEE HOW OTHER MANUFACTURERS' PRODUCTS COMPARE.

DATAMAN-48LV

- Plugs straight into parallel port of PC or laptop
- Programs and verifies at 2, 2.7, 3.3 & 5V
- True no-adaptor programming up to 48 pin DIL devices
- Free universal 44 pin PLCC adaptor
- Built-in world standard PSU - for go-anywhere programming
- Package adaptors available for TSOP, PSOP, QFP, SOIC and PLCC
- Optional EPROM emulator

DATAMAN S4

- Programs 8 and 16 bit EPROMs, EEPROMs, PEROMs, 5 and 12V FLASH, Boot-Block FLASH, PICs, 8751 microcontrollers and more
- EPROM emulation as standard
- Rechargeable battery power for total portability
- All-in-one price includes emulation leads, AC charger, PC software, spare library ROM, user-friendly manual
- Supplied fully charged and ready to use

S4 GAL MODULE

- Programs wide range of 20 and 24 pin logic devices from the major GAL vendors
- Supports JEDEC files from all popular compilers

SUPPORT

- 3 year parts and labour guarantee
- Windows/DOS software included
- Free technical support for life
- Next day delivery - always in stock
- Dedicated UK supplier, established 1978

Still as unbeatable as ever. Beware of cheap imitations. Beware of false promises. Beware of hidden extras.
If you want the best, there's still only one choice - Dataman.

Order via credit card hotline - phone today, use tomorrow.

Alternatively, request more detailed information on these and other market-leading programming solutions.

MONEY-BACK 30 DAY TRIAL

If you do not agree that these truly are the most powerful portable programmers you can buy, simply return your Dataman product within 30 days for a full refund

hotline
01300 320719

VISA

Orders received by 4pm will normally be despatched same day.
Order today, get it tomorrow!

DATAMAN

Dataman Programmers Ltd, Station Rd,
Maiden Newton, Dorchester,
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

C4