GET WIRED

Two new tests for speaker cables

Ultrasound defect detector

Magnetic sensor circuits

Using the PC's timer

Easy rectifier design steps

RF oscillators from AC gates

Thoughts on demodulation

Dual PCB CAD reviews: Quickroute and Propak
BASIC STAMPS®

PIC based BASIC Stamps are perfect for one-off and low volume applications.

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

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

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

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

PIC16Cxx DEVELOPMENT TOOLS

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

PIC16Cxx Programmer
- True hardware emulation of program memory, registers and I/O
- Unlimited breakpoints.
- Single stepping
- Software-programmable oscillator
- Windows Environment
- Runs from 32Khz to 10Mhz ('xx) and 20Mhz ('5x)
- Source level debugging for PASM(X), MPASM and MPC
- Optional trace facility

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

Please call or fax to receive our catalogue and price list. All prices exclude VAT and £3 shipping.

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

BASIC Stamp & the Parallax logo are registered trademarks of Parallax, Inc.
THE ROUTE TO PCB CAD
Rod Cooper investigates Quickroute and Propak in this fourth article examining low-cost pcb cad packages.

925 SPEAKER CABLES
Cyril Bateman has found a new loudspeaker cable measurement technique that could be just what the subjectivists are looking for.

930 SPEAKER CABLES
PULSE TESTED
Eric Foster’s measurement technique shows clear cable performance differences, but at frequencies too high to hear.

937 CABLE SCIENCE?
Signals passing through a conductor are affected by a complex combination of field and semiconductor effects, says Geoff Williams.

941 HANDS -ON INTERNET
This month, net explorer Cyril Bateman has found an electronics manufacturers directory and yet more useful design software.

947 EVENT TIMING
VIA THE PC
Alan Bradley explains how to program the timer chip in the pc for precise event timing.

952 FINDING FAULTS WITH SOUND
Component damage caused by the thermal stresses occurring during pcb assembly are notoriously difficult to detect. Steve Martell describes a new detection method.

956 WHEN IS A GATE NOT A GATE?
74AC gates make handy and low cost rf oscillators – Ian Forster shows a variety.

959 NEW THOUGHTS ON DEMODULATION
Edward Forster examines the amplitude-locked loop and its use as a demodulator.

969 APPLYING MAGNETO RESISTANCE
Applications for magneto-resistive sensors range from detecting Earth’s magnetic field to protecting igt's.

980 DESIGNING RELIABLE RECTIFIERS
Half-wave rectifiers are simple, but they still need to be designed properly.

REGULARS

907 COMMENT
Market forces rule?

908 NEWS
Video camera chip under $20, Mixed-signal fpga, More efficient igt's.

912 RESEARCH NOTES
Computers detect facial expressions, Higher chip performance from flat silicon, Glass curtains, Water hammer.

962 CIRCUIT IDEAS
200MHz spectrum analyser, Video switch for 1km links, Linear ser trigger, PC-based battery meter.

975 NEW PRODUCTS
Pick of the month - classified for convenience.

986 LETTERS
Motional feedback headphones, anti-gravity, Marconi, Power amp design.
Quickroute 3.5 is a powerful, affordable and easy to use integrated schematic & PCB design system for Windows. With its multiple button bars, 'tool tips', and 'parts bin' Quickroute helps you to get working quickly and efficiently.

Quickroute is available in 4 different versions (see Table) all of which offer great value for money. Quickroute is available with multi-sheet schematic capture, 1-8 layer auto-routing, copper fill, engineering change, and a range of popular file import/export features allowing connection to simulators and other software packages (details on request). Prices are Personal (£68), Designer (£149), PRO (£249) and PRO+ (£399). Please add P&P and V.A.T to total (see below*).

Quickroute 3.5 is a powerful, affordable and easy to use integrated schematic & PCB design system for Windows. With its multiple button bars, 'tool tips', and 'parts bin' Quickroute helps you to get working quickly and efficiently.

Quickroute is available in 4 different versions (see Table) all of which offer great value for money. Quickroute is available with multi-sheet schematic capture, 1-8 layer auto-routing, copper fill, engineering change, and a range of popular file import/export features allowing connection to simulators and other software packages (details on request). Prices are Personal (£68), Designer (£149), PRO (£249) and PRO+ (£399). Please add P&P and V.A.T to total (see below*).
Market forces rule?

Market forces are supreme. They always ensure the best price and the widest choice of goods and services. Or do they?

Look at the state of the consumer electronics industry. Desperately low margins and retail bankruptcies. High customer expectations of the products themselves, but an equal expectancy of low prices. Unfortunately, you get what you pay for, so generally the quality is questionable and customer satisfaction is low. Given this climate, what encourages manufacturers to invest in new ideas? Isn’t it all too risky?

No, there are still great prizes to be won. Many homes do not have computers, mobile phones or satellite television. There is no need for any ‘quantum-leap’ products, like the change from mono to stereo radio or the move from black and white to colour television. Just bigger, faster and more features will do. The direction the market is taking seems to be quite predictable.

For example, the market driver in personal computers is speed and size of storage, but it is almost self sustaining in that software developers gazzle up extra features without much return in performance. Why does Windows 95 need over 50 megabytes of hard disk space? So pcs have to get bigger.

There are some interesting developments and huge investment in mobile communication with the advent of GSM and, shortly, hand portable satellite telephones linked to Iridium, Inmarsat or a Bill Gates variant. Maybe wrist-watch telephones are just around the corner, the pagers are already here. But no videophone yet. With its slow changing images, the worthy Amstrad attempt a couple of years ago wasn’t quite what the market wanted.

The world of radio and television is less fast moving. Digital broadcasting is almost here together with wide screen tv and surround sound. The technology may be brilliant but will there be anything worth watching with the mushrooming number of mediocre tv channels?

Occasionally life is not always so predictable. Look at the Internet. No one designed it, and yet it is here. What use is it if I hear you say? A massive library, a low cost communication medium, a place for pastimes. Its applications will trouble the mind - did the first phone develop from amateur radio?

Generally speaking market forces have delivered progress, using an incremental approach with minimal risk. However, the stage is set for another quantum leap, but one which market forces cannot deliver. It’s not new but it needs saying again.

It’s the provision of a terrestrial high bandwidth communications infrastructure – a proper fibre connection to businesses and homes – provided that they want it. It has been talked about for a long time but the time is right to do it.

BT has offered install the infrastructure but is prevented by its licence. Cost-conscious cable-tv companies are installing coaxial cable with separate lines for telephones, but no fibre optics. Surely, if you are going to dig up the road and disrupt the traffic why not do the job properly?

The trouble is that the provision of this infrastructure benefits lots of different applications, but one application on its own cannot afford to do it. Hence there is a vacuum.

What can this connection give us? A real videophone service - hopefully compatible with the rest of the world - and fully developed on-line services including banking and reference services. Or interactive learning which could boost further education perhaps, and video-on-demand, which could turn broadcasting upside down. It could also offer telecommuting, giving a flexibility to working that companies will not countenance at the moment. And interactive television.

I think the latter is the most revolutionary application of all. It goes further than tv talent shows or phone-ins. Imagine watching a parliamentary debate on tv – presented with proper visual aids - and then having a chance to vote. To have your say on devolution, European integration, a single currency - or even the proposed local bypass scheme.

Of course there would be the same arguments against it as referendums; these are that the questions can be loaded, computer security, people voting against an unpopular government rather than addressing the question, people unqualified to vote, or just plain old apathy. But isn’t it worth trying?

We have to cable up. The benefits are enormous and the opportunities for industry are massive. But then the investment will be massive and it won’t happen unless the Government takes the lead and defines the playing field to enable and encourage things to happen, and perhaps throw in a little vision. We must think of it in terms of supplying water, electricity and gas to people’s houses - is there any argument against this?

The moral of the tale is that we cannot rely on market forces to completely shape the future that we want. We could easily get stuck in a rut. The Government must take an active role. It should facilitate change, cajole and encourage, and above all think long term. But first, let’s all get connected.

Peter Marlow
New mixed signal FPGA technology developed in UK

Mixed signal ASIC design house, WML, is developing a field programmable system-on-a-chip (Fipsoc) that mixes analogue and digital blocks on the same device.

The analogue sections can be configured to implement filters, amplifiers, drivers and d-to-a/a-to-d converters. The logic section comprises some 10,000 gates configured with look-up tables and registers.

Device programming is controlled by an on-chip 8051 microprocessor. Two different configurations can be stored and swapped with a command to the processor.

The actual programs themselves are held within a separate eeprom—much like a ram-based FPGA.

A CAD system has been developed by WML to design circuits and program the devices. The design flow includes mixed signal design specification, simulation, placement and route, programming and emulation.

The company claims the Fipsoc can be used for analogue systems in the same way that GPUs can be used in the digital world. Designs could be prototyped on a Fipsoc and migrated to a mixed-signal ASIC for volume production.

First silicon of the Fipsoc is expected next month.

Imaging sensor for under $20

A CMOS imaging sensor, priced at under $20 in large quantities, has been introduced by US company Marshall Electronics.

Specifications of the monochrome camera-on-a-chip are near-identical to that of Vision’s CMOS sensor. However, Roy Warrender, commercial director of the Edinburgh-based company, said: “This equates to an early generation of our product.”

Leonard Rogers, vice-president of Marshall, responded: “Unlike Vision, we have something working, in production and being sold into products.”

Marshall’s camera, developed by Omnivision Technologies, features a 300 x 240 pixel array and EIA composite video output. The chip runs from a 9V battery, consuming less than 100mW.

A special feature allows for an unlimited number of cameras to be connected in series or parallel on a single coax cable. The multiple cameras can be mounted on buildings, for example, removing the need for expensive motors and lenses.

Design awareness initiative is extended

DTI gives Microelectronics in Business design centres 18 months to become self-financing operations. The government has extended its FPGA and ASIC awareness campaign in the hope that its university design centres can become self-financing within the next year and a half.

The original three-year MIB programme—which remains the government’s most direct support for the microelectronics design sector—was due to end this month when funding would have run out for the project’s nine design and support centres.

The DTI will now spend £800,000 to keep the design centres running for a further 18 months, after which the DTI expects many of them to be self-financing design and technology transfer centres.

Last year, existing commercial ASIC design houses criticised the MIB programme for using DTI money to set up university design houses rather than supporting the existing industry. At the time the DTI denied this.

Now it seems the intention is to enable the university-based support centres to become self-financing businesses. Professor Sa’ad Medhat, head of the school of electronics at Bournemouth University, where he runs an MIB support centre, believes it is likely that some MIB centres will be self-financing technology transfer and design businesses. “Eighteen months was the period we chose and I think it is possible, if we ramp up our technology transfer node activities,” he said.

Richard Wilson, Electronics weekly
LOW COST DEVELOPMENT SYSTEM

ECAL comprises a versatile relocatable assembler with integral editor which runs about ten times faster than typical assemblers. Support includes 4, 8, 16 & 32 bit processor families including 75X, 6502, 6809, 68HC05/11, 8031/51, H8-300, 78K, PICs, ST6 & Z80/180, 68000, 80C196, H8-500 & Z280.

ECAL is either available for a single processor family or all families.

Single processor version £295
Multiprocessor version £395

Overseas distributors required

OEMA Ltd.,
7 & 7A Brook Lane,
Warsash,
Southampton S031 9F
Tel: 01489 571300
Fax: 01489 885883

The PC based ECAL hardware emulator is fully integrated with the assembler. Connection is made to the target through the eprom socket so a single pod can support all processors. Facilities include windows for the inspection or change of registers or memory. You can even watch your program executing at source level!

Download time is about two seconds!
Pods can be daisy-chained for 16/32 bit systems.

Applications include software development, hardware debug, test and, finally, teaching about micro-controllers in education.

ECAL emulator £475

Quantity discounts of up to 50% make ECAL software ideal for education.

CIRCLE NO. 107 ON REPLY CARD

1.06 0.40 -0.26 0.93 -1.60 -2.26 -2.93 -3.60 -4.26

OSCILLOSCOPE LIVE CHOP

MEASURE MODE
CH
MEM
CHOP
ADD
COMPARE
X -Y PLOT
30 (sec)
FFLEZ TIME PRINT
ONE SHOT MODE
CH1 SET
TIME-MAG.
!;TIME-OUT HYSTERESIS
ENT C142 SET

Spectrum Analyser CH 1
MEASURE FREQUENCY PRINT

You get a free µScope when you buy a TP508 or a HS508 until September 1st 1996

resolution 6 bits
sampling speed 100 kSamples/sec
input range 2.5V, 5V, 10V and 20V
connects to PC parallel printer port

Easy installation: just plug in and measure

CIRCLE NO. 108 ON REPLY CARD
Video codec based on fractals

Iterated Systems, the Atlanta-based image compression company, has released a video codec based on fractal technology.

Called ClearVideo, the video decoder is available as shareware whereas the encoder is licensable and has already been taken up by Electric Switch, which offers a video compression service, and ProSieben, for use on its Web site.

ClearVideo is claimed to be capable of compressing all classes of content, from talking heads to full action video. Resulting data rates are dependent on the image resolution and the amount of image movement, but rates as low as 28.8kbit/s are reported and QCIF 15 frame/s full action video can be squeezed into 120kbit/s.

"Compression is non-real time, whereas decompression can be performed in real time on a 486 PC running Windows 95, WindowsNT and Macintosh versions are also available," said an Iterated spokeswoman.

New Asics carry 12 million gates

First samples of the new 0.18um geometry Asic technology from Texas Instruments (TI) will be out in the middle of next year. "We have test chips now, and we have designs being put through which are of about five million gates complexity," Mohan Maheswaran, TI's Asic manager in Dallas, told EW.

Currently the largest gate count arrays on offer in the market are the 3.5 million gate Asics offered by IBM Microelectronics. "Our technology (called Timeline) gives us 12 million gate count gate arrays with 70 per cent utilisation and 30m gate count standard cells also with 70 per cent utilisation", said Maheswaran. Metal layers are currently up to five, with the capability to go to six.

"It allows people to start thinking in totally new ways", said Maheswaran, "you can actually implement a number of PC boards on one chip." Current applications are in high end telecommunications uses and in high end computing, says TI.

Gate delays on the Timeline technology are 19ps ("the time it takes light to travel 6mm") and power dissipation is 0.008mW/MHz/gate.

In smaller densities some very high speed/power circuits can be fabricated. "At 100,000 gates and 200MHz frequency, circuits can be implemented which use 0.01mW/MHz/gate," said Maheswaran.

Cores include DSPs, ARM, ATM and MPEG. Memory cells are SRAM, ROM, flash and DRAM (up to 10Mbit).

Pace looks at cable tv

Pace Micro Technology, the Yorkshire-based volume set-top box manufacturer, is currently in discussions with four UK cable operators for a deal over digital set-top boxes. In its plans to capture the digital cable market, Pace has been in discussion with a number of cable operators worldwide.

"The opportunity for us in cable in the next few years is probably larger when we started in Direct-to-Home," said Steve Barnes, sales and marketing director at Pace.

"Today Pace is talking to over 160 different broadcasters and operators. But not all of these will come out in a service and not every one will grant Pace their contract." Meanwhile, BSkyB is still evaluating the bids for the next generation of digital set-top boxes for a digital satellite service expected to be launched in the autumn of 1997. One of the interested parties is Pace.

Faster fast Fouriers

Fast Fourier transforms, FFTs, can now be implemented on programmable logic from Altera as part of the company's Megafunctions library of cores.

It is claimed that the execution speed can be increased by a factor of ten to 15 over conventional dsp-based solutions.

The company quotes a 1024 point FFT running in 0.2ms when programmed into an EPF10K100 – the company's flagship device.

The length and data width of the transform can be set by the designer. Suggested applications include rf communications systems in cable and wireless and spread spectrum modems.

Book-to-bill looks up

Chip demand jumped in September with a book-to-bill ratio of 0.99, its largest jump this year, according to the Semiconductor Industry Association. "From any perspective, these are the most positive numbers we've seen all year," said Douglas Andrey, analyst at the SIA. "The modest increases in orders for August and September suggest that the 1996 slowdown in growth has bottomed out."

The book-to-bill ratio is still far below its most recent peak of 1.16 in September of 1995 but it is a welcome sign of better times ahead for numerous chip companies suffering from a downturn in the market largely because of over production.

IR advances ight efficiency

International Rectifier has introduced a new range of igbts, called Gen 4, that are 20 to 40 per cent more efficient than their predecessors.

Tim Munday, a field application engineer for IR, said: "The gains in efficiency come from a combination of lower saturation voltage and reduced switching losses. Much of the advance has come because we are using our new fab which has reduced the manufacturing tolerances."

Insulated-gate bipolar transistors are power devices that are used predominantly in motor drives. Current Gen 4 devices are rated at 600V with 1200V devices to follow soon.
Transform your PC into a digital oscilloscope, spectrum analyser, frequency meter, voltmeter, data logger... for as little as £49.00

Pico Technology specialises only in the development of PC based data acquisition instrumentation. **Call for your guide on 'Virtual Instrumentation'**.

### Virtual Instrumentation

Pico's PC based oscilloscopes simply plug into the parallel port turning your PC into a fully featured oscilloscope, spectrum analyser and meter. Windows and DOS software supplied.

**ADC-100 Dual Channel 12 bit resolution**
The ADC-100 offers both a high sampling rate 100kHz and a high resolution. Flexible input ranges (±50mV to ±20V) make the unit ideal for audio, automotive and education use.

- **ADC-100** £199
- **ADC-100** with PicoLog £219

**ADC-200 Digital Storage Oscilloscope**
- 50 MSPS Dual Channel Digital Storage Scope
- 25 MHz Spectrum Analyser
- Windows or DOS environment
- ±50mV to ±20V
- Multimeter
- 20 MSPS also available

- **ADC-200-20** £359.00
- **ADC-200-50** £499.00

Both units are supplied with cables, power supply & manuals.

Pico Technology Ltd. Broadway House, 149-151 St Neots Rd, Hardwick, Cambridge. CB3 7QJ UK

Tel: + 44 (0)1954 211716  Fax: + 44 (0)1954 211880  E-mail: post@picotech.co.uk  Web: http://www.picotech.co.uk/

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

---

### Data Logging

Pico's range of PC based data logging products enable you to easily measure, display and record temperature, pressure and voltage signals.

**TC-08 Thermocouple to PC Converter**
- Supplied with PicoLog software for advanced temperature processing, min/max detection and alarm.
- 8 Thermocouple inputs
- No power supply required.

**TC-08** £199

**TC-08** £224 with cal. Cert.

**Call for free demo disk and product range catalogue**

Post & Packing UK £3.50, Export customers add £9 for carriage & insurance.

---

---

### SEETRAX CAE RANGER PCB DESIGN

WITH COOPER & CHYAN AUTOROUTER

---

**RANGER2** £150

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

**RANGER2 UTILITIES £250**

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

**UPGRADE YOUR PCB PACKAGE TO RANGER2 £60**

---

TRADE IN YOUR EXISTING PACKAGE TODAY

Seetrax CAE, Hinton Daubney House, Broadway Lane, Lovedean, Hants, PO8 OSG
Call 01705 591037 or Fax 01705 599036  + VAT & PP

All Trademarks Acknowledged
ECT used to nail hammer

Most of us know what water hammer sounds like and are aware that it can cause stress in a system: but what does it look like? Researchers at Mist in Manchester think they have the answer, by developing an electrical capacitance tomography (ECT) technique that promises the first accurate method of characterising this common yet complex phenomenon.

Typically, water hammer can occur when a valve is suddenly closed at the end of a long pipe. The water flow is abruptly stopped resulting in a pressure wave that travels back up the pipe. In turn this causes an expansion at the supply end which reverses the wave making it travel back to the valve, where the processes is repeated until it runs out of energy.

The problem has been that, up to now, recording techniques have not been fast enough to capture the very rapid transients that characterise hammer, while complexity of the effect has made modelling difficult and inaccurate.

But the Mist researchers have based their technique ("Monitoring water hammer by capacitance tomography", WQ Yang et al, Electronics Letters, Vol 32, No 19, pp. 1778-1779) on the fact that the expansion cause cavitation - pockets of air - within the pipe.

To make the measurements, a set of capacitance electrodes are mounted around the pipe, so that the inter-electrode capacitance-changes caused by variations of permittivity within the pipe can be used recorded. Cross sectional images can then be constructed from the data. The Mist system uses 12 measurement electrodes, 10cm long, mounted onto the outside of 41mm uPVC pipe, just upstream of the valve. When the valve is closed, a vapour bubble is formed then collapses, its life captured by the electrodes.

Though the transient process in the Mist experiment lasts only 0.27s, the system can collect measurements at 100frame/s allowing detailed behaviour of the water hammer to be observed.

Next step for the team is correlate data between an upstream and downstream sensor to find the transport speed of the water hammer waves and to find the velocity profile of the flow.

More information contact: WQ Yang, Process Tomography Group, Department of Electrical Engineering and Electronics, Mist, PO Box 88, Manchester M60 1QD.

Silicon fab goes flat out

A new technique that enables fabrication of atomically-flat silicon surfaces as opposed to the 'terraced' surfaces that exist in current devices could bring big improvements to performance and yield of silicon microelectronic and optical devices.

The technique, developed by materials scientists at Cornell University, uses high pressure and temperature to force atomic steps on the silicon surface to migrate to specially created boundaries. Though the slight irregularities, on the nanometre scale in current silicon layers, do not have much effect on the operation of the present generation of devices, future miniaturisation is going to make smoothness a critical factor.

Normal surfaces of silicon, though looking flat, consist of short, smooth terraces each ending in a step of atomic dimensions at about 1.5nm. But using their new manufacturing procedure, the Cornell team has been able to create extensive regions on a silicon wafer that have no atomic steps at all. They have achieved this by creating a grid of ridges, 0.5μm high and 1μm wide on the surface of the wafer and clearing the intervening squares of their atomic steps by forcing them into the ridges.

The grid is created using electron beam lithography, and each square, about 10μm wide, has about a billion atoms on it, with several thousand atomic steps all across the square. The sample is then subjected to ultra-high vacuum and then high temperatures of 1020-1150°C.

At these temperatures, silicon atoms are detached from the atomic steps so that in effect the steps migrate to the ridges at the boundary of the square, leaving the surface of the square atomically flat.

"The benefit is that it should now be feasible to make smaller devices with better control of the dimensions, at the atomic level, and it should eliminate the harmful features of the surface that could get through the manufacturing process," says Jack Blakely, Cornell professor of materials science and engineering who has led the work.

"Circuits built on step-free surfaces can be designed with smaller dimensions and utilise thinner semiconductor channels and insulating layers to increase performance and decrease power consumption. By having it flat, this could be an ideal surface on which to build an integrated circuit."

More information from Jack Blakely, Materials Science and Engineering, Cornell University Ithaca, NY, USA.
PCB Designer
For Windows 3.1, '95 or NT

Looking for the price?
It's just £49.00 all inclusive!
...no VAT...no postage...
...no additional charges for overseas orders.

Dealers and distributors wanted. Phone (01432) 355 414 to order

Internet
See our Web site at www.niche.co.uk for
information and a working demo. e-mail
pcb@niche.demon.co.uk.

 Produce Single or Double sided PCBs.
 Print out to any Windows supported printer.
 Toolbar for rapid access to commonly used components.
 Helpful prompts on screen as you work.
 Pad, track & IC sizes fully customisable.
 No charges for technical support.
 Snap-to-grid sizes 0.1", 0.05" 0.025" and unrestricted.
 SMT pads and other pad shapes.

Also available from,
South Africa: JANCA Enterprises, PO Box 32131, 9317
Fichardtpark at R299,00. Phone/FAX: (051) 223744
France, Telindel, Quartier Les Pradets, Chemin des Veys,
83390 Cuers. Phone: 94 28 66 67

Leak
Alkdoi*11:
VISA
Amex/Access/Delta/Visa

Electronics Workbench
New 4.1 32 Bit Version
Electronics Workbench saves you time. It's highly productive
simulated workbench let's you design and verify circuits faster
than it would take on a real bench. Mix analogue and digital components and ICs in any combination

Electronics Workbench:
• Click & drag schematic capture
• Mixed analogue/digital SPICE simulator
• Instant Bode plots and scrollable waveforms
• 50 analogue components with 350 models
• 140 digital components and ICs in TTL and CMOS
• Windows 95/NT/3.1, DOS and Macintosh versions
• FREE unlimited technical support
• 30-day money-back guarantee

Robinson Marshall (Europe) Plc
Fax: 44-(O)-1203-233210
Nadella Building, Progress Close,
Leofric Business Park, Coventry CV3 2TF
E-mail: sales@rme.co.uk.
Shipping charges UK £6.99 All prices are plus VAT.
Electronics Workbench is a trademark of
Interactive Image Technologies Ltd., Toronto, Canada
All other trademarks are the property of their respective owners.

Niche Software (UK)
12 Short Hedges Close, Northleigh, Cheltenham GL54 3PD

RADIO DATA MODULES
MODEM TRANSCEIVERS
UK, E.E.C, Scandinavia, Eastern Europe, North & South America,
Middle East, South Africa, New Zealand, Far East or Australia.
Wherever you are, we have a module on the right frequency for you!

* 400 to 500MHz Versions *
  " Range up to 5Km *
  " Compact Size ideal for Hand Helds *
  " UK, North American, Australian *
  " MPT, ETS & FCC Approval *
  " Up to 64 selectable channels *
  " Starter Kit only £299.95 *

Low Cost High Speed Data Transmitters: UK, EEC and Beyond

* Available UK Approved MPT1340 418MHz *
  " Export 1-ETS-300-220, 433.92MHz *
  " Reduce Component Count, Cost, Size & Power Drain *
  " Operate to 20,000 bps *
  " Transceiver also available with up to 40K data rate *

With up to 1MB data rate, RS485 interface and 100mW of
output power these units are ideal for many high speed
industrial or office data transfer applications. Even com-
pressed colour video may be transferred. Price £480.00
each or starter kit for only £799.95.

VHF Modules for UK, Australia and Beyond

* " UK, 173MHz to MPT1344 & MPT1328 Licence Exempt *
  " Miniature Low Cost of canned 1 & 10mW Transmitters *
  " 173.500MHz Transmitters & Transceivers for Australia & RSA *
  " PCB mount or canned, Superhet Receivers *
  " Low Cost Meter Reading Transceivers on 183.8875MHz *
  " Prices from £19.00 to £200.00 per unit *

Radio - Tech Limited, Overbridge House, Weald Hall Lane
Thornwood Common, Epping, Essex CM16 6NB.
Sales +44 (0) 1992 57 6107 Fax +44 (0) 1992 56 1994
Internet: http://www.radio-tech.co.uk

INTERNET...
Put a smile on your interface

Sometimes your computer does something so stupid—like trashing a vital file it really should have known you wanted—that words just stick in the throat. But work being carried out at the University of Maryland could mean that your computer will one day be able to recognise those looks of open-mouthed disbelief and face-twisting fury, and react accordingly. (In the Research Notes office that would involve quietly sliding its keyboard out of the reach of a fast moving fist).

Aim of the research being undertaken by Yaser Yacoob and Larry S Davis at the Computer Vision Laboratory is to recognise facial expressions from image sequences. The work has been prompted by the fact that visual communication plays such a central role in human communication and interaction. If successful, the research will allow computers to sense our moods, concentration and understanding, while also opening up possibilities for better video transmission of facial expressions across low-bandwidth systems.

According to the authors (“Recognising human facial expressions from long image sequences using optical flow”, *IEEE Transactions on pattern analysis and machine intelligence*, Vol 18, No 6, pp. 636-642), low bandwidth transmission of facial data can be made more efficient by using mid- and high-level visual representation of the facial actions. Or as the researchers put it: “Send a smile and a few parameters that determine the mouth actions involved”.

Previous researchers have analysed the six principal expressions of happiness, sadness, surprise, fear, anger and disgust, but have tended to concentrate on static “mug-shot” representations. However Yacoob and Davis have developed algorithms that use optical flow computation to identify the direction of rigid and non-rigid motions caused by human facial expressions, and have so far demonstrated recognition of the six expressions on a large set of image sequences.

Analysis involves tracking rectangles that enclose the facial features. Every rectangle encloses one feature of interest. Each of the 32 subjects so far tested was asked to display the expressions of emotion in front of a video camera, while minimising head movement—though subjects inevitably did move their heads during the experiment.

The experiments showed, through analysis of the optical flow field in the rectangles, that cues to detect the beginning of “fear” include the inward raising of the eyebrows and opening of the mouth.

Some confusion still exists between fear and surprise, anger and disgust and sadness and surprise. There is also some difficulty where one expression begins then transforms into another.

Despite that, in the more than 30 subjects that were studied in the laboratory environment, the researchers were able to report a “good” classification of facial expressions in a very large database.

For more information contact Yaser Yacoob at the Computer Vision Laboratory, Center for Automation Research, University of Maryland, College Park, MD 20742-3275, USA. email yaser@cs.umd.edu

Millimetre antenna has no moving parts

A prototype antenna that operates at millimetre wave frequencies and has no moving parts, no phase shifters and can be implemented in plastic has been built by researchers at Georgia Institute of Technology. The electronically-scanned device, which is believed to be the first Rotman lens to operate at a frequency as high as 37GHz, could offer an inexpensive, rugged, reliable and compact alternative to current millimetre wave antenna technologies.

Most antennas operating at millimetre wave frequencies use mechanical scanning or phase shifters, both of which have disadvantages. Mechanically steered antennas are slow in response and suffer reliability problems due to shock and vibration. Phase shifters are costly to fabricate and introduce considerable rf losses.

But in a Rotman lens, such as the Georgia Tech device, millimetre wave energy coming from a particular direction is focused by passing the electromagnetic energy through a pair of parallel plates shaped like a lens. Beam-forming or focal ports are located on one side of the plates, fed by a switch array. The array ports are on the opposite side, each connected to an antenna element. Energy fed into a specific focal port will emerge from the antenna elements and produce a beam along a particular direction.

Switching the input from focal port to focal port steers the

Switching the input from focal port to focal port steers the

continued on page 916...
THE Autorouter for EASY-PC Pro’ XM!

MultiRouter is "the best Autorouter that I have seen costing less than £10,000!" R.H. - (Willingham, UK)

- MultiRouter uses the latest 32 bit, Shape based, Multi-pass, Shove-aside, Rip-up and Re-try Technology
- 100% routed 140 Components on a 210mm x 150mm board in less than 10 minutes! (75MHz Pentium)
- 100% Completion where other autorouters fail
- Only £295! Could Easily Pay For Itself On The First Project!

Number One Systems
UK/EEC: Ref: WW, Harding Way, St.Ives, Cambridgeshire, ENGLAND, PE17 4WR.
Telephone UK: 01480 461778 (7 lines) Fax: 01480 494042
USA: Ref: WW, 126 Smith Creek Drive, Los Gatos, CA 95030
Telephone/Fax: (408) 395-0249

Electronics Workbench
New 4.1 32 Bit Version
Electronics Workbench uses a powerful SPICE simulator to ensure that circuits work like the real thing. And since you have complete control over the value and behaviour of all components, you control the design process.

Electronics Workbench:
- Click & drag schematic capture
- Mixed analogue/digital SPICE simulator
- Instant Bode plots and scrollable waveforms
- 50 analogue components with 350 models
- 140 digital components and ICs in TTL and CMOS
- Windows 95/NT/3.1, DOS and Macintosh versions
- FREE unlimited technical support
- 30-day money-back guarantee

ONLY £199

Robinson Marshall (Europe) Plc
44-(0)-1203-233216
Fax: 44-(0)-1203-233210
Nadella Building, Progress Close,
Leofric Business Park, Coventry CV3 2TF
E-mail: sales@rme.co.uk.
Shipping charges UK £6.99 All prices are plus VAT.
Electronics Workbench is a trademark of Interactive Image Technologies Ltd., Toronto, Canada.
All other trademarks are the property of their respective owners.
Architects get wise to electrochromic windows

One of the 'simplest' concepts for reducing air conditioning bills while keeping office buildings cool in summer is to install window glass that can be darkened or lightened automatically, or at the touch of a button. Unfortunately, how to produce practical systems with acceptable life and cost has proved anything but simple. However, work being carried out at the National Renewable Energy Laboratories in Colorado could help overcome many of the present technical barriers to electrochromic (EC) windows.

The breakthrough made at NREL ('Low-voltage electrochromic device for photovoltaic-powered smart windows', C Bechinger et al, J. Appl. Phys, Vol 80, No 2, pp.1226-1232) is in developing an all-solid state electrochromic device that can be switched over a range of optical transmissions by voltages of less than 1V. This voltage is smaller than any other device tested so far, and at these levels, the researchers say, it should be possible to power the devices by an integrated semi-transparent photo-voltaic (pv) cell, so removing the associated wiring costs that substantially push up investment in ec windows.

In the NREL system, indium-tin-oxide (ito)-coated glass forms the electrically conductive transparent substrate for the device, onto which thin films of WO3, MgF2 and V2O5 are deposited, topped by a semi-transparent gold electrode.

Colouration occurs by a complex reaction between the clear WO3 and a light-absorbing compound of lithium and WO3. The reaction involves injection and extraction of electrons and metal ions. But, according to the team, the key to the low voltage switching is inclusion of the MgF2 layer which acts as the lithium ion conducting layer.

When electrical connection is made, the device transmission drops to about 40% of its bleached-state level in around 60s. To return to the original transparent state, the device simply needs to be short circuited to cause spontaneous bleaching within minutes.

In the tests, voltage was supplied by a semi-transparent photo-voltaic powered cell connected to the ec device. But the researchers say they expect a monolithic pv-ec device to function in a similar manner.

Degradation seems much improved over other types and the NREL devices are reported to have been cycled in air at ±1V with almost no change in optical behaviour after 5000cycles. Eventual degradation was thought to be due to corrosion caused by reaction of lithium with water that has penetrated the device. The researchers say that in practical devices the gold electrode would be replaced with a much thicker transparent electrode that would also control the water content of the device.

Current cost of ec windows is estimated to be somewhere between $100 and $1000/m2. However the integration of the power source into a self contained window could make the NREL devices much more attractive than other designs and also allow smart windows to be retrofitted to existing buildings.

With the cost of energy becoming much more of an issue in building-economics, electrochromic smart windows could one day become a familiar part of architectural design.

More information contact: Clemens Bechinger now at the Universitaet Konstanz, D-78434 Konstanz, Germany email clemens.bechinger@uni-konstanz.de
Electronics Workbench

New 4.1 32 Bit Version

Electronics Workbench is the first affordable integrated tool to offer true mixed-mode simulation. It delivers the power you need to design and verify analogue, digital and true mixed-mode circuits fast.

**Spectrum Analysers**

<table>
<thead>
<tr>
<th>Name</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tektronix 2445A</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445A, 1740A, 1741A, 1744A</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445, 2445A</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445A, 2445</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445A</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445A, 2445A</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445A, 1740A, 1741A, 1744A</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445A, 2445</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445A, 2445A</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445A</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445A, 2445A</td>
<td>£1500</td>
</tr>
<tr>
<td>Tektronix 2445A, 2445A</td>
<td>£1500</td>
</tr>
</tbody>
</table>

**TDLS**

- 100MHz U.O.E.
- £2500
- 150MHz D.S.O.
- £3500
- 200MHz D.S.O.
- £4500
- 300MHz D.S.O.
- £6000
- 500MHz D.S.O.
- £8000
- 1GHz D.S.O.
- £12000
- 2GHz D.S.O.
- £20000
- 3GHz D.S.O.
- £30000
- 4GHz D.S.O.
- £40000
- 5GHz D.S.O.
- £50000
- 6GHz D.S.O.
- £60000
- 7GHz D.S.O.
- £70000
- 8GHz D.S.O.
- £80000
- 9GHz D.S.O.
- £90000
- 10GHz D.S.O.
- £100000

**Discrete Components**

- 3.3V Logic ICs
- 5V Logic ICs
- 7.5V Logic ICs
- 9V Logic ICs
- 12V Logic ICs
- 15V Logic ICs
- 24V Logic ICs
- 36V Logic ICs
- 48V Logic ICs
- 60V Logic ICs
- 72V Logic ICs
- 84V Logic ICs
- 96V Logic ICs
- 108V Logic ICs
- 120V Logic ICs

**ICs in TTL and CMOS**

- 30A ICs
- 50A ICs
- 100A ICs
- 200A ICs
- 300A ICs
- 400A ICs
- 500A ICs
- 600A ICs
- 700A ICs
- 800A ICs
- 900A ICs
- 1000A ICs

**Optical Sensors**

- 0.1Hz to 20MHz
- £450
- 100kHz to 2GHz
- £650
- 1MHz to 5GHz
- £850
- 10MHz to 10GHz
- £1500
- 20MHz to 20GHz
- £2500
- 50MHz to 50GHz
- £5000

**Power Supplies**

- 10V, 10A
- £150
- 20V, 10A
- £250
- 24V, 10A
- £350
- 40V, 5A
- £500
- 50V, 5A
- £650
- 60V, 5A
- £700
- 70V, 5A
- £850
- 80V, 5A
- £1000
- 90V, 5A
- £1150
- 100V, 5A
- £1300

**Limited Offer**

- Limited Offer
- £999

**Order Form**

- **UK Postage and Packing**
- £4.99
- **Overseas Postage and Packing**
- £9.99

**Contact Information**

- **E-mail**
  - sales@rcrus.co.uk
  - sales@rcrus.com

- **Fax**
  - 01234 567890

- **Telephone**
  - 01234 567890

- **Address**
  - RCUS Ltd
  - 123 Main Street
  - City, Country
  - Postcode

**Additional Information**

- **Credit Card Payments**
  - Accepted

- **Delivery Information**
  - Usually dispatched within 2-3 working days

- **Returns Policy**
  - Returns accepted within 14 days of purchase

- **Customer Service**
  - Tel: 01234 567890
  - Fax: 01234 567890
  - Email: sales@rcrus.com

**Contact Us**

- **Phone**
  - 01234 567890

- **Fax**
  - 01234 567890

- **Address**
  - RCUS Ltd
  - 123 Main Street
  - City, Country
  - Postcode

- **Website**
  - www.rcrus.com

**Free Library**

- Over 70,000 Books
- Over 800,000 Technical Papers

**Loop Testers**

- 50MHz
- £250
- 100MHz
- £450
- 200MHz
- £650
- 300MHz
- £850
- 400MHz
- £1000
- 500MHz
- £1500
- 600MHz
- £2000
- 700MHz
- £2500
- 800MHz
- £3000
- 900MHz
- £3500
- 1GHz
- £4000

**Miscellaneous**

- **Free Library**
  - Over 800,000 Technical Papers

- **Loop Testers**
  - 50MHz
  - £250
  - 100MHz
  - £450
  - 200MHz
  - £650
  - 300MHz
  - £850
  - 400MHz
  - £1000
  - 500MHz
  - £1500
  - 600MHz
  - £2000
  - 700MHz
  - £2500
  - 800MHz
  - £3000
  - 900MHz
  - £3500
  - 1GHz
  - £4000

**Over 30 Years Experience**

- **Electronics Workbench**
  - Over 70,000 Users
  - Over 800,000 Technical Papers

**Over 70,000 Users**
In the penultimate article in this comprehensive series of PCB CAD reviews and discussions, Rod Cooper investigates Quickroute and the Propak suite.

**Review 1 – Quickroute 3.5**

Quickroute3.5 – QR35 for short – is a development of the popular Quickroute3 that was reviewed in Electronics World, January 1995. Most of what that review said still applies, but there have been some major changes. For example, the manual that was criticised for being written in the wrong order now starts with schematic design, and works through PCB design to the autorouter – making it one of the most logically compiled manuals available!

I remember seeing Quickroute some time ago as a dos-based shareware program. The version was 1.5 and I believe it was written for the American market as the pricing was in dollars. It was then a tiny 256Kbyte in size and would run on virtually any PC. For historical interest a screen from this program is shown in Fig. 1 and the similarities with the latest version will be apparent.

I used the top two versions, Quickroute 3.5 Pro and Pro+, for this review, priced at £249 and £399 respectively. Both Pro and Pro+ are integrated schematic capture/autorouter packages, combined with manual PCB design, but Pro+ has some extra features such as Spice and Spiceage netlist export, DFX export to mechanical CAD programs, Tango and Gerber net-list import, and copper fill.

Quickroute programs are intuitive and easy to use, and perhaps because of that are easy to review, and are thus firm favourites with reviewers. The ease of use comes not just from being in Windows but also from their relative simplicity. There is for example, no autosave or autopan, no autonecking of tracks, no snap-to function for drawing, and there is not much configuration to do on the autorouters. Simplifying the structure while retaining the essentials gives a program which will have considerable appeal to those starting out in cad.

To run QR35 you need Windows 3.1, or better and a fairly powerful PC. Although the package will run on a 386SX with 4MB of RAM, it will be noticeably tardy. It would not run at all on a 286. The recommended machine is a 486 running at 60MHz or higher with at least 5MB of RAM. Like most of the Windows-based programs, if you use less than
the recommended hardware, you may find parts of the program such as screen redraws and autorouting irritatingly slow.

The drawing area on a 14in monitor is about 7.5in by 5in with the parts bin on screen, and 9in by 5in without it. The parts bin takes up a lot of room, and it is difficult to understand why it is quite so big. It can of course be turned off, but if I were running QR35 with the parts bin, I would be inclined to use a larger monitor with higher definition in order to see more of the circuit. The button bar has been increased to a double bar and this also diminishes the size of the drawing area. Some of these buttons you use only once per design - such as the 'New Schematic' and 'New PCB' buttons and could be easily dispensed with. I think a return to the original single button bar and a smaller parts bin would help those people with 14in and 15in screens.

Interesting features
QR35 has some interesting features. Starting with the schematic drawing section, it made a refreshing change to see a lattice grid used for layout instead of the usual dot matrix. The default colour for line drawing is a yellow initial line on a white background - very difficult to see, as any graphics technician will tell you. But mercifully the colours can be changed. I chose a grey background with blue lines.

The schematic drawing program is not orthogonal, permitting lines in any direction. I found it required sustained attention to maintain a neat orthogonal layout during long drawing sessions. After a while, it is tempting to take few short cuts and put in a diagonal line or two, but this instantly gives any schematic an untidy look.

There is no positive confirmation that a drawn line is connected - at least not at the time of drawing. To check connectivity, you press the redraw button after drawing and visually check each connection. Properly connected lines are given a circle symbol. Although this was acceptable on small designs, on large boards this became a very tedious process. It was easy to miss some connections. I fell into the trap of just scanning the schematic, which led to error messages at later stages, which in turn meant retracing my steps back to the schematic to correct them.

The schematic sections of Ranger2, Propak, CircuitMaker and Electronic WorkBench have means of confirming a connection at the time it is made combined with a strong snap-to-function. I think this is the way it should be done.

Zoom in and out is controlled either from the button bar or by the function keys F1-7. Key F8 is a custom zoom option. These keys can also be used for panning by pointing the mouse to where you wish to pan and pressing the function key at whatever zoom level you are in.

Function keys are more helpful if you want to zoom or pan while you are already using the mouse to draw a line. You can also pan using the scroll bars. To centre the drawing and show it fully there is another function, 'Page View', which adjusts the zoom to fill the screen.

Many cad programs use the left mouse button to select or start something and the right button to stop it, but QR35 uses the right button for various other actions. It can activate the library volumes from the button bar or pan the drawing area for example. This takes some getting used to if you have experience in other areas of cad.

The nominal drawing area is 32in by 32in. Multi-sheet schematics are supported, as are global nets. There is no map diagram showing where you are, but Page View can be used to find lost drawings.

Graphical library presentation
One of the best features of Quickroute is the graphical presentation of the library volumes. Clicking on the icon on the button bar gives a large screen of one page of a library volume, and you can see exactly what you are selecting from the high-quality symbols. This is a big improvement on text-only libraries.

If the library volume consists of more than one page, it is easy to flip though the pages.

Fig. 2. Same schematic with parts bin on, after processing, so many of the circles are now junction dots, indicating net formation. Note area taken up by parts bin.

Fig. 3. The initial rat's nest formed from the above screen with components on a linear grid.

Fig. 4. Rat's nest after interactive editing. Note outline of board now inserted.
You might think this leads to some odd-looking schematics, and perhaps it does, but it has great practicality. However, there is a limitation on this method at present because the standard autorouter puts a ceiling on the maximum size of the track. If the track width exceeds 60% of the grid, a smaller track is substituted. In effect, this limits track size to less than 0.03in with the standard autorouter, but with Quickroute's new AR3 autorouter, I am told this limit should disappear. It should be possible to route tracks of any size.

Code named AR3, the new autorouter may well appear with a different name. It is in the pre-launch stage at the time of writing, but I was able to test a beta version of it with good results.

Getting from the schematic to a rat's nest was very easy, the rat's nest being generated in linear fashion, as shown in Fig. 3. This is step in the right direction, away from rat's nest 'heaps' that have to be separated manually, but not as quick or easy to re-arrange as the systems used in Range-2, Propak or Trasmaker.

I discovered that it was possible to 'lose' small components behind large-width rat lines. Sorting out the rat's nest required some care as it is possible to disturb the ratlines when picking components.

The standard autorouter is very easy to operate, has only a few pre-run configuration controls, and was unable to route the test circuit completely, see Fig. 5. This puts it in category C. The new AR3 autorouter was able to route the test circuit, putting it in category A, as shown in Fig. 6.

Note that the version of AR3 that I tested could not route all sizes of track, so those shown in Fig. 6 are thin. It is a gridded autorouter with rip-up-and-retry added to its strategy bank. It also has increased configurability; each net can, if required, be configured individually. This autorouter has considerable potential.

Summary

Quickroute 35 is probably the most intuitive of the integrated schematic-drawing and autorouter products. However, do not think you can get away with not reading the manual from cover to cover - you can't.

Being comparatively easy to learn, QR35 will be attractive to those seeking a less fraught introduction to pcb cad, to educationalists, or to those who design pcbs only occasionally.

The relative simplicity of QR35 has its drawbacks. Professional designers - those designing pcbs for a living - may quickly reach the limits of Quickroute 3.5 and may be frustrated by its lack of certain features. For example it would benefit from the addition of orthogonal drawing and inhibition of incorrect lines in the schematic program, and autosave. The standard autorouter is limited in power and ability.

The relative simplicity of QR35 has its drawbacks. Professional designers - those designing pcbs for a living - may quickly reach the limits of Quickroute 3.5 and may be frustrated by its lack of certain features. For example it would benefit from the addition of orthogonal drawing and inhibition of incorrect lines in the schematic program, and autosave. The standard autorouter is limited in power and ability.

However, Quickroute is being developed further, with a policy of responding to users' comments, so this observation may not apply for very long. For example, from what I have seen of the new AR3 autorouter, this will be both powerful and versatile.

The most attractive feature of QR35 is the excellent library presentation - quite the best of this set of reviews - while the extended library pack included with both PRO+ and PRO versions gives better than average coverage of most of the commonly used components.

Fig. 8. For comparison, one page from the latest version of Quickroute.
There are two parts to Propak, which are integrated and both run under Windows. Isis Illustrator+ is the schematic drawing and capture part of this program. It runs on a 386 pc running Windows 3.1 with 2Mbyte of ram, but more memory than this is recommended in the manual. It was not satisfactory on a 286 with 2Mbyte of ram.

Ares - the pcb routing part - is a full 32-bit application, so will work best on Windows 95 or Windows NT. However, it will also work with Windows 3.1 and the WIN32S extension that most readers will be familiar with.

Propak is supplied with WIN32S. I installed the whole package on a 386SX running at 20MHz, at first with 4Mbyte of ram. I thought this would be a reasonable minimum set-up for this type of Windows program as the handbook is not clear about the hardware requirements for Ares. Although it ran, I soon increased the ram to 8Mbyte to get it to run to my satisfaction. Needless to say, on the 486, it ran very quickly.

The manual for Propak is contained in a single volume with individual sections for Isis and Ares, emphasising the two-part nature of the product. For such a multi-feature program the manual is relatively short and to the point. It assumes a slightly higher level of knowledge of cad and computer literacy than the other programs and does not go into basics much, but this should not trouble most of the designers that Propak is aimed at.

Isis has a non-standard Windows format which gives a drawing area of 7.5in by 6in on a 14in moni, which is not very large. There is a menu bar at the top, but an icon area in a box to the right of the screen, see Fig. 9, replaces the customary Windows button bar.

Some of the icons are mode select buttons, which lead to groups of other buttons controlling graphics, symbols, pins etc. All these buttons are in a similar style and I found it very difficult to remember which were which. I only solved this by pinning an icon explanation chart next to the monitor, reminiscent of a practice common in dos.

Although there is a small icon text reference, Isis is a sophisticated program with automatic junction dots, adjustable autosave, auto name generation and a component finder - handy for very large schematics. It also has a type of autopan, and many other worthwhile features, some of which distance it considerably from other drawing programs.

Most noteworthy of these is the 'wire autorouter', or WAR, which enables drawing to be speeded up by putting in the drawn connections between symbols automatically. You just click on the pins you want to connect and the autorouter inserts an orthogonally drawn line, putting in corners as required.

I timed myself on transferring a drawing from a rough sketch on paper and found it cut down the transfer time by about 30%. As the drawing fills up, and lines get more difficult to place, WAR gets slower just like a human operator, but it's still quicker than hand drawing. The results with WAR depend very much on the component layout, so if you need to present a good looking schematic you may need to do some editing. Its chief advantage lies in speed.

Also of note is support for radiused corners, and this can give the drawing a smooth professional appearance if this is what you require. The ability to move component text - i.e. text such as R2, 100k, C5 etc - independently of the component also assists in making the schematic look neat and compact. Text stays upright during component editing.

The schematic drawing section is not orthogonal, but maintaining a neat diagram seemed easy due to the good snap-to system. Drawn lines can only be placed between pins; incorrectly drawn lines are inhibited just like Ranger2 so you cannot accidentally hang lines in space etc. In this way, positive connectivity of pins is assured.

The small 's' that appears when you are in within drawing range of a pin is of great assistance, and is comparable to Circuitmaker's SmartWire method. Snap-to distance can be set to suit yourself and I suggest it is one of first parameters to set before starting drawing in Isis. It is tempting with the 's' system to set the snap distance too small, as I did, to get more circuitry into a small screen, but then you will need to maintain a constant high level of concentration to draw. It then too easy to miss a connection and engage some other function with the mouse button. Increasing the snap distance solves this.

Another good feature is the electrical rules check - an automatic check for simple errors in design. I suppose everyone has made an embarrassing error like leaving an output pin disconnected at some time or other, only to discover it after making the pcb. If you are prone to such errors, this feature will definitely be of interest.

The sheet size can be varied from A4 to A1, and Isis supports multi-sheet designs in an interesting hierarchy of root sheets, which should contain the core of the design, and sub-sheets, containing peripheral designs. This could be useful for large schematics such as an active filter stereo audio amplifier. The left and right preamplifiers could be drawn on two root sheets, and three or more identical power amps per channel handling the high, medium and low frequencies, drawn on sub-sheets. Any circuit changes to one sub-sheet could then be automatically replicated in the others, a big saving in effort.

Visiting the library
Access to libraries was easy, and parts are transferred in the logical way, to the parts bin first, not to screen. Note that in Isis, the parts bin is called the object selector.

Isis gives you a good graphical representation of the component before it goes to the parts bin. In most other programs, the libraries contain long lists of components. All the electrical and package information is included with each one and when you select a specific
component, say a BC108 transistor all this information is transferred with it to the netlist when the schematic is captured.

In Isis, the libraries are much shorter. There are indeed library volumes for analogue and digital ICs with transferable package information, but only generic library volumes for discrete components such as transistors, thyristors etc. When you select such a generic component, the package outline has to be selected manually from a drop-down menu at the ratsnest stage. So a transistor like the BC108 is represented by the generic n-p-n transistor symbol in Isis. It could in theory exist in any package from TO3 to TO92 at this point. The package information is entered later manually from the package selector as TO18.

The benefit of this arrangement appears to be much shorter and more accessible libraries. They will not be full of devices you never use, but it does mean an extra step to be done later. However, if you are moderately computer literate there is a system in Isis which can be set up to do this automatically. This is called ‘Ascii Data Import’, or ADI, and it means getting out the data books and entering in your most-used devices in a simple table in text in a file called Package.ADI. You can use Window’s Notebook accessory to do this.

If you set up such a library, my strong advice is to copy it immediately so that your painstaking work will not be lost if your hard disk takes a holiday. When this file is activated on any specific schematic you have drawn, the outline for each device in Isis is then automatically provided for Ares to use.

I suggest that you try the two systems from the evaluation programs and compare both methods. It would be a good idea for Labcenter to provide as an optional extra some ready-made general library packs like others, for busy engineers who do not have the time to sort out their own libraries.

The zoom control in Isis is easy to use, with seven levels, so is the autopan. Like other programs the zoom is a coarse control, but there is a custom zoom feature, and I found it very useful for making a schematic fill the screen. A map at the top right of the screen – called the ‘overview window’ by Labcenter – shows you where you are on the drawing area and assists in panning and finding lost drawings.

Generating a net list is also straightforward and can be in several formats besides Labcenter’s own SDF format – including Tango, Spice and Futurenet. I tried connecting to a third party simulator with the Spice net list and it was both easy and successful.

Although Isis and Ares are separate entities, the transfer of the schematic net list to Ares is painless; one click generates the netlist and triggers Ares, so the connection between the two for all practical purposes is seamless.

Ares is a pcb layout format that is very similar to the Isis schematic format and if you master one then the other will come easily. There are of course a few alterations as you would expect, but these are minor.

Ares consists of two parts – a manual drawing program and an autorouter. The manual drawing part can be used on a ratsnest generated from Isis, or you can, if you wish, start from scratch in Ares and put the package outlines on the board manually, and then connect the traces. However, the latter would be a waste of Ares’ resources.

If you start with a net list from Isis, the first thing to do is to position the parts on the board. This is done in a way similar to Ranger2, and is a good system. The parts are selected and placed one at a time from a parts bin, or ‘Object Selector’, in the desired position. The rat’s nest can then be automatically generated with a couple of clicks in the ‘Tools’ menu.

Manual routing from the rat's nest is accomplished by selecting a track size, and clicking on a component pad to start the track and tracing the track as you would in any manual system. When the far component is reached, clicking on a pad will complete the track.

There is no rubber-banding. You draw the track as you would normally in any manual pcb program. For some, this will be a most welcome feature. The rat line stays in place until the track is fully drawn, showing you the target pad for your track. Only when you complete the track does the rat line disappear.

If you make an error, on erasing the track the rat line re-appears, and you can re-draw the track. This is an excellent system, and for manual drawing from schematic capture it is the program I would recommend from those reviewed.

There is support for curved tracks, autonecking, and auto via placement. Also of interest is the plotter driver, which avoids complete reliance on the Windows plotter driver. The Windows driver is only used to draw straight lines, and Ares own plotter driver does the rest. This speaks volumes about the plotter driver provided in Windows 3.1.

The autorouter is moderately configurable, easy to set up and was comparatively quick. It is not a rip-up-and-retry or push-and-shove autorouter, so it would be unreasonable to expect too much of it. It worked best, as you would expect, on double-sided boards, but as the autorouter test shows, it could do a reasonable job on single-sided boards as well, falling into category B.

Summary
I spent more than the allotted time on assessing Propak and even then was still discovering interesting features tucked away in the program.

Isis would suit the professional designer who regularly uses it, particularly if large multi-sheet or multi-layer boards are involved. The user is unlikely to become frustrated by quickly reaching the limits of the system as it is a fully featured, sophisticated program. By the same token, anyone not using the package regularly will find the steep re-learning curve an obstacle after an absence from use.

On small boards, Propak would be a sledgehammer to crack a nut. For presentation of a schematic drawing, where appearance was important, Isis would be my choice from the programs reviewed.

The Ares part of the product is of particular interest to those who wish to avoid rubber-banding when manual routing from a rat's nest. It is the only schematic-capture type of manual drawing program I recommend.

The benefit of using schematic capture and then manual drawing is that you can use the built-in connectivity check to verify that your handiwork corresponds to the netlist and as a result, the schematic you have drawn. With this system it is difficult to make an unusable pcb.

For double-sided boards that are not too dense or complex, the autorouter will usually be satisfactory provided you are prepared to put some time and effort into sorting the ratsnest. For single-sided boards some manual editing or reducing of the design rules may be needed.
The MICRO MODULE
A NEW LOW COST controller that gives you customisation for as little as £95 one off + VAT

For users of PCs, 8051 & 68000

and that's just the half of it...

P.C. 'C' STARTER PACK AT ONLY £295 + VAT

The MICRO MODULE will reduce development time for quick turnaround product/projects and with the P.C. 'C' Starter pack allow you to start coding your application immediately, all drivers and libraries are supplied as standard along with MINOS the real time operating system. All ready to run from power on.

The 'C' Starter pack includes: A MICRO Module with 128 Kbyte SRAM, P5U, Cables, Manuals, C compiler, Debug monitor ROM, Terminal program, Downloader, a single copy of MINOS. Extensive example software, and free unlimited technical support all for £295 + VAT.

Cambridge Microprocessor Systems Limited
Unit 15-18, Chelmsford Road Ind. Est,
Great Dunmow, Essex, U.K. CM6 1KG
Phone 01371 875644 Fax 01371 876077

CIRCLE NO. 119 ON REPLY CARD

Finally an upgradeable PCB CAD system to suit any budget...

BoardMaker

BoardCapture - Schematic Capture
- Direct netlist link to BoardMaker2
- Forward annotation with part values
- Full und obedient facility (50 operations)
- Single sheet, multi-paged and hierarchical designs
- Smooth scrolling
- Intelligent wires (automatic junctions)
- Dynamic connectivity information
- Automatic on-line annotation
- Integrated on-the-fly library editor
- Context sensitive editing
- Extensive component based power control
- Back annotation from BoardMaker2

BoardRouter - Gridless autorouter
- Simultaneous multi-layer routing
- SMD and analogue support
- Full interrupt, resume, pan and zoom while routing
- Output drivers - Included as standard
  - Printers - 9 & 24 pin Dot matrix, HP Laserjet and PostScript
  - Penplotters - HP, Graphtec, Roland & Houston
  - Photoplotters - All Gerber 3X00 and 4X00
  - Excellon NC Drill / Annotated drill drawings (BM2)

Contact Tsien for further information
Tel 01354 695959 Fax 01354 695957

CIRCLE NO. 120 ON REPLY CARD

December 1996 ELECTRONICS WORLD
New Special Offers

- Use 8758 heterodyne $15.50
- LM1455 timer: quadruple: LC 16 surface mount $2.50
- LM324 quad op amp $4.95
- LM358 dual op amp $2.50
- 74HC00 IC $2.20
- 74HC14B IC $1.95
- 74HC153 IC $3.95
- VHF-FM receiver: 100kHz to 1000MHz $10.95
- Quad band radio $49.95
- Double antenna $19.95

Handy kit 49.95.

Crossware Products
St John's Innovation Centre, Cowley Road, Cambridge, CB4 4WS, UK
Tel: +44 (0) 1223 421263, Fax: +44 (0) 1223 421006
E-mail: sales@crossware.com

Wanted Distributors Worldwide!

Get out of a pickle - get into SpiceAge!

Hands up all who have been there? A great idea turns into sleepless nights: getting one thing right breaks something else...

Some circuits require the refining of many interdependent variables. SpiceAge provides a virtually limitless inventory of components, signal functions and instruments with facilities for sweeping values, with am and fm through arbitrary functions. It can guide you to a solution that could take much longer to find using hardware.

SpiceAge up your design without burning a hole in your pocket. Prices from just £85 + VAT to £695 + VAT. Friendly technical help comes free (dreadful puns optional). For a demonstration kit and details of our other and third party support programs (includes schematics, PCB layout, filter synthesis and model synthesis), please contact:

Charles Clarke at Those Engineers Ltd, 31 Birkbeck Road, LONDON NW7 4BP.
Tel: 0181 906 0155 Fax: 0181 906 0969 Email 100550.2456@compuserve.com

New from Crossware

ANSI C for Embedded Development

Our new range of Professional Standard C compilers protect your investment by conforming to the ANSI specification. In addition our target specific extensions will help you get the best from your embedded system.

To find out more about this new range of products, call us today or visit our Website.

http://www.crossware.com

68000
68020/CPU32
8051
Subjectivists claim to hear considerable differences in loudspeaker cable performance, but traditional distortion measurement methods do not bear this out. Cyril Bateman argues that traditional measurement methods are inappropriate.

The claim that loudspeaker cables can and do cause distortions in hi-fi sound reproduction systems has resulted in two schools of thought. One school maintains that this is impossible since these distortions cannot be measured, the other disregards the measurement problem but maintains their ability to hear a different sound with change of cables. Consequently discussions on these cable distortions have aroused more controversy than almost any other electronics design debate. Mystical diodes, over emphasised skin effect and magical properties of differing materials have all been proffered as reasons to explain these audible distortion effects.

Much of my working life has been spent measuring the s-parameters of anomalous components at all frequencies from dc to 3GHz. As a result, I fully appreciate how important load matching and characteristic impedance of cable or test jigging are - even for extremely short electrical lengths.

I had long assumed that cable characteristic impedance remained important, even at the lengths used for audio. This was confirmed on examining the measured results in Duncan's recent articles and my own 42-strand cable test result.

This article, and a follow up, presents evidence that loudspeaker cables do behave as transmission lines and that the cable's characteristic impedance, propagation delay and mismatch behaviour is maintained down to audio frequencies.

Hi-fi components interact
Since the combination of amplifier, cable, crossover networks and speakers all interact, speaker cables cannot be properly measured or evaluated in isolation.

Amplifiers have forward propagation delay around 1µs and considerable closed-loop feedback. Cables have characteristic impedance and one way transit delays around 6ns/m, while loudspeakers have extremely wide impedance/phase changes with frequency. Additionally - and perhaps most importantly - a moving-coil loudspeaker generates substantial voltage and current long after its drive signal has ceased, easily observed by physically disturbing a speaker cone.

Conventional distortion measurements are based on a continuous sine wave. Many musical sounds however, those from pianos and cymbals for example, start as a fast transient and decay slowly. This envelope is similar to that of the exponentially-damped waveform included in the PSpice simulator. No doubt with electronic synthisers the converse waveshape having instantaneous turn off, as used by Duncan, is also possible. Both transient signals should be evaluated.

Turn-off transient effects
Since badly matched or undamped loudspeakers generate a back emf into the amplifier, my first test, which approximates to Duncan's, involved two amplifiers. These were configured back-to-back, but separated by the test cable and a load-sensitive voltage drive circuit.

One amplifier was driven at 10kHz by a signal generator. The test amplifier input was earthed via a 4.7kΩ resistor and both amplifiers were powered. The drive circuit was resonant at 10kHz, and current energised by the driven amplifier. The cable and test amplifier impedance damped the resonating voltage, which undamped attained more than 100V.

I made measurements of various test cables and observed the voltages at both cable ends. Care was taken to space both amplifiers as far apart as permitted by the leads of the two 250MHz scope probes used. The ADC100 virtual oscilloscope was placed well away from the set-up for comparing loudspeaker cables. Channel A of the oscilloscope was connected to terminal A at one end of the cable under test and channel B was connected at the other end, on terminal B.
the computer to minimise stray pickup and the test cables were dressed in air in a wide U shape, similar to that used by Duncan. To avoid earth loops when using the ADC100, the scope probes were earthed to a single point at the test amplifier end of the test cable.

In each case, the driving amplifier was a low-cost mosfet design from Maplin (part No LP56L). I also carried out tests using Douglas Self’s ‘Blameless’ class B4 as the driven amplifier. It was built with better than 1% metal film resistors and matched semiconductor pairs. This was unhappy with less than 4.7kΩ input shorting impedance. Also, at 10kHz it had a somewhat higher output impedance than the mosfet design.

Since much debate has centred on the effects of the cable’s resistance, inductance and capacitance, I bought a variety of readily available cables, all cut to 4.9m long. These represented a mix of known and unknown combinations, I, bought a variety of readily available cables, all cut to 4.9m long. These represented a mix of known and unknown impedance and resistance, in both coaxial and line pairs. This mix of cable structures was deliberate; simple examination of their impedance equations confirms that low impedance cabling with both minimal inductance and minimal resistance was used to feed the inductor’s voltage into the test cable and thus into the test amplifier.

Due to the very high unloaded 10kHz voltage and current which the capacitor must sustain, I used two in series 100nF, 400V Siemens polypropylene B3225L (Electrovalue part 50.1400). The inductor used was a 5.4mH super power low-loss 1mm wire having a Q of 15 at 10kHz, from Falcon Acoustics, Tabor House, Mulbarton, Norwich, contact Malcolm Jones. The two resistors were HSA25 wire wound. The resonant drive circuit comprised a 5.4mH inductor and 50nF capacitor. The inductor was in shunt to ground thus replacing the speaker voice coil, the capacitor was used to feed current from the driven amplifier via an 8.2Ω short circuit protection resistor. A second resistor of 3.9Ω used to simulate the voice coil resistance, was used to feed the inductor’s voltage into the test cable and thus into the test amplifier.

Transmission lines

Transmission lines cables are made in two main formats each comprising two separated conductors. These formats are coaxial and line pairs.

In both cases, reduced conductor separation reduces series inductance, increases shunt capacitance and reduces the cable’s characteristic impedance, Z0.

\[ Z_0 = \sqrt{\frac{R + j\alpha L}{G + j\omega C}} \]

where \( e \) is the dielectric constant of the insulator. Capacitance, also from ref. 7, is.

\[ C = \frac{24.16 e}{D} \frac{pF/m}{log \frac{d}{D}} \]

This characteristic impedance assumes an infinitely long length or a shorter length terminated by this impedance and produces no reflected wave. All other termination impedances (mismatch) produce a reflection which is returned to the source. If both ends are mismatched and the cable has no loss, these reflections continue indefinitely dependent on the degree of mismatch.

At low frequencies, since the inductive reactance is small and capacitive reactance is large, the characteristic impedance can increase. If \( R/L = G/C \), the special case of a ‘distortionless’ line, then \( Z_0 \) is frequency independent.

Certain constructs can be designed for characteristic impedance by their physical dimensions. For coaxial cable,

\[ Z_0 = \frac{138}{\sqrt{e}} \frac{D}{d} \]

where \( e \) is the dielectric constant of the insulator. Capacitance, see ref. 8, is.

\[ C = \frac{12.07 e}{2D} \frac{pF/m}{log \frac{d}{D}} \]

Transmission lines have a propagation delay that depends on length and dielectric materials used. In practice this approximates to 6ns/m for commonly used plastics.

Resonant drive circuit

The resonant drive circuit comprised a 5.4mH inductor and 50nF capacitor. The inductor was in shunt to ground thus replacing the speaker voice coil, the capacitor was used to feed current from the driven amplifier via an 8.2Ω short circuit protection resistor. A second resistor of 3.9Ω used to simulate the voice coil resistance, was used to feed the inductor’s voltage into the test cable and thus into the test amplifier.

Due to the very high unloaded 10kHz voltage and current which the capacitor must sustain, I used two in series 100nF, 400V Siemens polypropylene B3225L (Electrovalue part 50.1400).

The inductor used was a 5.4mH super power low-loss 1mm wire having a Q of 15 at 10kHz, from Falcon Acoustics, Tabor House, Mulbarton, Norwich, contact Malcolm Jones. The two resistors were HSA25 wire wound.

Transmission lines cables are made in two main formats each comprising two separated conductors. These formats are coaxial and line pairs. In both cases, reduced conductor separation reduces series inductance, increases shunt capacitance and reduces the cable’s characteristic impedance, Z0.

\[ Z_0 = \sqrt{\frac{R + j\alpha L}{G + j\omega C}} \]

which, from ref. 7, at high frequencies approximates to,

\[ Z_0 = \frac{L}{C} \]

This characteristic impedance assumes an infinitely long length or a shorter length terminated by this impedance and produces no reflected wave. All other termination impedances (mismatch) produce a reflection which is returned to the source. If both ends are mismatched and the cable has no loss, these reflections continue indefinitely dependent on the degree of mismatch.

At low frequencies, since the inductive reactance is small and capacitive reactance is large, the characteristic impedance can increase.

\[ R/L = G/C, \] the special case of a ‘distortionless’ line, then \( Z_0 \) is frequency independent.

Certain constructs can be designed for characteristic impedance by their physical dimensions. For coaxial cable,

\[ Z_0 = \frac{138}{\sqrt{e}} \frac{D}{d} \]

where \( e \) is the dielectric constant of the insulator. Capacitance, see ref. 7, is.

\[ C = \frac{24.16 e}{D} \frac{pF/m}{log \frac{d}{D}} \]

For the line pair,

\[ Z_0 = \frac{276}{e} \frac{2D}{d} \left( \frac{D}{2H} \right) \]

where \( H \) is height above ground. Capacitance, see ref. 8, is.

\[ C = \frac{12.07 e}{2D} \frac{pF/m}{log \frac{d}{D}} \]

Transmission lines have a propagation delay that depends on length and dielectric materials used. In practice this approximates to 6ns/m for commonly used plastics.
No cable, 240 1.5µF load, 10 kHz transient
1.5 µH with 10 ohm shunt, output inductor
V(t) is stimulus, V(t0) is output.

No cable, 240 1.5µF load, 10 kHz transient
1.5 µH with 10 ohm shunt, output inductor
V(t) is stimulus, V(t0) is output at cable (speaker) end.

Fig. 3. Simulated behaviour of typical amplifier output configuration when driving into a capacitive and shunt resistor load. Voltage V(1) is taken as the location of the feedback connection.

Fig. 5. Basic PSpice Net-List as used for Figs 3 to 7. This can be simulated using the evaluation version of PSpice.

Fig. 4. Simulation of configuration identical to Fig. 3, except for the addition of 5m of high impedance Figure 8 style cable. This distortion should be clearly audible on transients. Voltage V(3) is waveform at amplifier output terminals for all simulations.

Fig. 6 Simulation of Identical configuration as Fig. 3, except for increased value of amplifier output inductor to 5µH. This distortion should be clearly audible on transients.

Audio power amplifiers are often tested with a load of 8Ω with 1.5 or 2µF in parallel. Continuous sine-wave simulations with and without 5m of a typical figure-of-eight cable show negligible distortion when 'Fourier' transformed. Since distortion of the first cycle was clearly visible however I changed the stimulus to simulate a transient using the exponentially damped sine wave in PSpice. This clearly shows the transient distortion noted, which would be audible within a music program, Fig. 3.

Further simulations to explore this show that distortion increases with increase of load resistance or output inductor value. Regardless of load resistance however, an inductive load caused smaller distortions, Figs 4, 5, 6.

Predictably these distortions reduced as cable impedance was lowered, even though the shunt resistor remained high. This is because the input impedance of the cable/amplifier combination, now provided the necessary damping, Fig. 7.

Applying the proof These results prove that cable characteristic impedance is important in audio systems. With this in mind I will now examine Duncan's plots.

In two articles Duncan concentrated on two cables. These were an undefined mains cable and Jenving Supra Ply 2.0. Both were tested at 1kHz using an unspecified Tannoy...
15in dual-concentric loudspeaker.

In a *Studio Sound* article, he also used an unspecified 15in dual-concentric Tannoy loudspeaker with tests performed at 125Hz, 1kHz, and 15kHz on eight additional cables. Examination of the published test report of Tannoy’s *D700* speaker system indicates that if similar to Duncan’s speaker, you could expect impedance of 3.1Ω resistive, 6.5Ω inductive and 5Ω resistive respectively. You could also expect resonant impedance peaks at around 45Hz/2Ω and 270Hz/2Ω.

From his measurements, these cables have an estimated high frequency impedance of 79.6 and 37.5Ω respectively. At 1kHz, the inductive reactance is reduced and capacitive reactance is increased. Because of this, both impedances will be higher, but making some allowance for this also the missed peak in Fig. 3 for reference 2, cable C, you can see that Duncan’s voltage ratios closely follow the mismatch ratios at the speaker end of the line.

These results clearly demonstrate how transients can be distorted in speaker/cable systems while continuous sine waves are not. They could bridge the chasm presently existing between the two opposing schools of thought.

In my next article on this topic, I explore other published test methods. I also look at how all these results pertain to a complete amplifier, cable and speaker system and provide all measured results by plots and tables. I would however ask that anyone wishing to shoot these findings down in flames - first repeat the experiments.

**References**

Universal programmer only £525

The Speedmaster 1000+ and Micromaster 1000+ offer new levels of affordability in device programming. At only £295, the Speedmaster 1000+ supports all types of memory devices, plus 8748/51, BPRoms, GALs and erasable PALS. The Micromaster 1000+ at just £255 extends this support to include PALS, EPLDs, MACH, MAX, PSDs and over 180 microcontrollers including PIC, ST6, MC68HC705, MC68HC711, TMS370, TMS320, 87Cxxx, 89Cxxx, COPs etc. The Micromaster 1000+ can support all device types, even Motorola micros, with NO ADAPTERS or MODULES for any dual in line devices up to and including 40 pins. As with all our programmers free software updates are included via BBS or our ftp site.

LV40 Portable
Reaching the parts other programmers can’t reach

The NEW LV40 Portable stands head and shoulders above other portable programmers with it’s comprehensive device support which includes EPROMs, EEPROMs, Serial PROMs, BPRoms, Flash, NVRAMs, PSDs, PALS, GALs, PEELs, EPLDs, MACH, MAX and over 180 microcontrollers. Unlike other portables, no adapters or modules are needed for any of these devices up to 40 pins dual in line. With socket adapters the LV40 is capable of supporting devices of over 40 pins and other package types. At £995 for the complete package you’ll soon see why the LV40 Portable is the best value, most powerful portable programmer in the world.

High Speed Gang Programming

The Speedmaster GLV-32 Gang/Set programmer offers simultaneous high speed programming for up to 8 EPROMs and Flash (up to 8MHz) at 3.3V and 5V. The 3.3V facility ensures that programmed devices will work correctly at their nominal operating voltage. Functions include: gang programming, set programming and full editing. The Speedmaster GLV32 works in PC or stand alone mode.

New programmers start at only £295

With prices starting as low as £295, ICE Technology’s new range of parallel port programmers offers something for every budget. All programmers support dual in line device directly in the socket - no adapters or modules are needed for any families of devices, providing extensive device coverage at very affordable prices. The full range of programmers is shown in the panel on the right. Our new easy to use device support checklist will help you to choose the programmer that is right for you, just call or use our faxback for a copy. All programmers come with free software updates on our BBS or our ftp site, full technical support direct from the manufacturer and one year’s guarantee. All models can run from batteries or mains - ideal for use with laptops.

Low cost EPROM programmer

At only £295, the EPMaster LV is a powerful EPROM programmer which offers so much more than other EPROM programmers. With it’s 40 pin socket it can support all types of EPROMs including 16 bit wide with no need for additional modules. Serial PROMs, Serial EEPROMs, Flash and EEPROMs are all included in the device support at no extra cost. In addition, low voltage parts are fully supported with the programmer’s separate 1.8V, 3.3V and 5V logic circuits. EPMaster LV connects to the parallel port of any PC compatible and can be operated from batteries or mains electricity. You can also add a built in ROM/RAM emulator with a capability of up to 512k by 16, turning the EPMaster LV into a powerful development tool.

Programmer models and prices

<table>
<thead>
<tr>
<th>Programmer</th>
<th>Speedmaster 1000+</th>
<th>Micromaster 1000+</th>
<th>£</th>
</tr>
</thead>
</table>
| EPMaster LV | EPROM, EEPROM, Flash, Serial PALS, Serial EPROMs 8 to 40 pin at without adapters, built in emulator modules: 12k by 8, 256k by 16 | EPROM, EEPROM, Flash, Serial, BPRoms, PALS, GALs, PALS, EPLDs, MACH, MAX, 8748/51 | £295
| Micromaster 1000+ | EPROM, EEPROM, Flash, Serial, BPRoms, PALS, GALs, PALS, EPLDs, MACH, MAX, 8748/51 | EPROM, EEPROM, Flash, Serial, BPRoms, PALS, GALs, PALS, EPLDs, MACH, MAX, 8748/51 | £65
| SPEEDMASTER LV | EPROM, EEPROM, Flash, NVRAMs, Serial PROM, Serial EEPROMS, BPRoms, GALs, PALS, EPLDs, MACH, MAX, 8748/51 | EPROM, EEPROM, Flash, Serial, BPRoms, PALS, GALs, PEELs, MACH, MAX, PSD, over 180 microcontrollers without adapters. | £495
| SPEEDMASTER GLV32 | High speed EPROM/Flash 8 way Gang/Set Programmer. Supports 3.3V and 5V | High speed EPROM/Flash 8 way Gang/Set Programmer. Supports 3.3V and 5V | £645
| MICROMASTER LV | EPROM, EEPROM, Flash, Serial, BPRoms, PALS, GALs, PALS, EPLDs, MACH, MAX, PSD, over 180 microcontrollers without adapters. | COP Gang Programmer | £625
| LV40 Portable | All devices supported by Micromaster LV 1000+ compatible portable with built in keypad and LCD display | 8 way gang programmer for National Semiconductor COP family of micros | £1500
| | | from £65 | |
Speaker cables
pulse tested

By feeding cables with fast pulses and looking at the resulting waveforms, Eric Foster has been able to illustrate clear capacitive, inductive and eddy differences between cables suitable for speaker driving. Sadly for the cable marketers though, these differences are too high in frequency to be audible.

Pulse induction is normally associated with metal detectors. However it can also be used as a unique method of testing loudspeaker cables to determine differences that may relate to audible effects. The measurement waveform takes place after the primary pulse has ceased and is dependent on the cable inductance, capacitance and cross sectional eddy currents. In the system outlined, cable resistance is not of major significance as the pulse generator impedance is deliberately made high. This is done to limit the power supply current and to keep the test pulse amplitude constant over widely varying cable types and lengths.

Injecting a pulse
The essence of the method is to inject a current pulse into a known length of cable with the far end shorted.

Test receiver and transmitter for examining inductive, capacitive and eddy characteristics of cable. Pules produced by the 555 and c-mos logic IC are buffered by the bipolar transistor and fed to the mos driver to produce fast, low-impedance pulses. Dated, but nevertheless suited to this application, the 709 amplifies the reflection from the cable for displaying on an oscilloscope.
At the termination of the current pulse a wide band op.amp. amplifies any low level decay effects due to induced eddy currents in the wire cross section or to polarisation signals in the insulating material — if they occur.

One metre lengths were chosen as these were easier to obtain, and the measured effect can easily be extrapolated to longer lengths. For the more readily available, and inexpensive, cables such as mains lead and coaxial, 5m lengths were measured in addition to the shorter ones.

This method is unique because the resultant waveform is solely due to the cable under test and is not complicated by speaker impedances, reflections or power amplifier characteristics.

**Implementing the test system**

Transistor Tr1 provides the current pulse to the cable via R2 and D1. Resistor R3 limits the amplitude of the pulse to about 0.36A. This corresponds to the current that would flow for 1W peak in an Ω load.

Duration of the pulse can be varied between 50 and 150µs by means of VR1 and the pulse frequency varies correspondingly between 5kHz and 1.5kHz. In practice, for the cables tested, the pulse duration and frequency had no effect on the recovery waveform as the cable time constants measured were very much faster. Diode D1 isolates the cable under test from the drain capacitance of Tr1 after switch off which would otherwise lower the cable’s resonant frequency.

Resistor R4, across the driven end of the cable, damps out any ringing which is due to the cable-under-test’s inductance and self capacitance. Without the damping resistor the ringing frequencies measured in the range 10-20MHz for the 1m lengths. This is well outside the audible band.

Wide band amplifier IC5 exhibits a gain of 400. Although the 709 is an early IC, dating back to the late 1960s, it has excellent gain, bandwidth and recovery characteristics. These characteristics are difficult to find in more modern ICs. This is no doubt due to its straightforward bipolar architecture.

The cable-under-test’s recovery waveform is viewed on an oscilloscope connected to IC5 output. As IC5 is wired as an inverting amplifier the cable-under-test waveforms are inverted, but this is of no consequence in demonstrating cable recovery. If you want to pursue this further, you could re-connect IC5 as a non-inverting amplifier or follow the existing circuit with a fast inverting buffer.

Figure 1 shows the output waveform of the test circuit with a 1m length of mains cable. There is an initial positive excursion, followed by a short negative saturation period caused by the cable's reverse emf. This negative transition is the area of interest.

**Reference waveform criteria**

To generate a reference waveform, the terminals of the test unit are shorted by soldering them together. The initial negative excursion in this case is the amplified result of the buck emf generated in the stray inductance of the pcb tracks associated with Tr1 and its immediate components.

It is vital to keep this inductance to a minimum, so that the amplifier has returned to a flat baseline in 3-4µs. This constitutes the reference waveform, Fig. 2, with which to compare cable-under-test waveforms.

Cables with low inductance, low capacitance and low cross-sectional eddy currents will depart little from the reference waveform. The negative spike adjacent to the right cursor is a clock generator spike while the ripples and bumps are largely op-amp noise.

The cursor is set at 1/ΔT of 21kHz, which corresponds to the highest frequency that can be obtained from a standard cd. Any transient or absorbed energy decay should have vanished well before this so as not to affect the audio band.

Measurement terminals of the test unit consisted of two 25mm lengths of 7/0.2, twisted as far as possible to minimise their inductance.

---

**Fig. 1. Output from the 709 op-amp resulting from a test on a 1m length of mains cable.**

There is an initial positive excursion, followed by a short negative saturation period caused by the cable's reverse emf. This negative transition is the area of interest.

**Fig. 2. Reference waveform.** The nearer the cable test comes to this shape, the lower the inductance, capacitance and cross-sectional eddy currents.

**Fig. 3. Shark Wire is inexpensive speaker cable comprising 129 strands of 0.1mm oxygen-free copper.**

**Fig. 4. Van den Hul CS122 speaker cable has seven bunches comprising 21 strands of 0.15mm silver-plated copper.**

**Fig. 5. Jennis Supra Ply 2.0 normally shows a small eddy current decaying within 10μs, but when twisted, the eddy current and time constant increase.**

**Fig. 6. When twisted, Jennis Supra Ply 2.0 performs less well under this test.**
The cable-under-test was then soldered in turn to these to ensure good electrical contact. Proprietary speaker terminals or connectors were not used because they could contribute their own eddy current effects.

**Figure 3** shows response from a 1m length of inexpensive speaker cable from Shark Wire Co. This is a parallel wire consisting of 129/0.1mm strands of oxygen-free copper and a conductor separation of 5mm. The negative excursion and overshoot due to the series inductance settles down in under 5µs and there is no evidence of cross sectional eddy currents. Having experience in pulse-induction metal detection, this came as no surprise to me. It is usual to use fine stranded wire in the search coil winding to minimise cross section effects.

By comparison, **Fig. 4** shows the response from 1m of Van den Hul CS/122. The conductors in this cable consist of seven bunches of 21 strands of 0.15mm silver-plated copper encased in an inner conductive plastic material with a conductor separation of 11mm.

The exponentially decaying waveform is due to eddy currents in the overall wire cross section aided by the higher conductivity of the silver coating. Even so they have decayed away within 20µs, or 1/ΔT of 50kHz. Jenving's Supra Ply 2.0 was an interesting cable to try, endorsed as it was by Ben Duncan in his tests. **Figure 5** shows a small eddy current signal decaying within 10µs. If the cable is twisted or bent however, the braided 0.14mm strands make better contact with one another and the eddy current amplitude and time constant increases, as in **Fig. 6**.

**Heywire** from Heybrook Audio uses single solid copper cores of 0.6mm diameter. This is small enough not to exhibit eddy currents, but combined with the 8mm conductor spacing gave the highest series inductance. However, the resulting overshoot decayed in 4µs, **Fig. 7**, and is similar to Shark Wire cable.

Of the cables measured, **Cable Talk 4** had the largest eddy current loss – the signal taking a full 25µs to decay into the noise level, **Fig. 8**. The conductor bunches consist of 42 strands of 0.3mm copper separated by a 6mm spacing.

**Non audio cables**

Mains lead is often derided for audio use and I have never seen rf cable advocated for this application. So I tested 10A lawnmower flex and RG58C/U coaxial cable to see how they would fare.

The lawnmower cable, **Fig. 9**, with 32/0.2mm conductors spaced at 2mm, came out surprisingly well; the eddy currents dying away in 10µs. Type RG58 coaxial cable, **Fig. 10**, was the cleanest of all, showing no overshoot and eddy currents in the braid decayed within 7µs.

**Comparison of the parallel conductor cables** with the coaxial cable shows the coaxial type to have the lowest series inductance. Compare **Figs 11 and 12**.

If the damping resistor is removed, the ringing frequency of the cable can be measured. Both the inductive spike and ringing are displayed on a time base ten times faster than the previous cable responses so you can see that the signal is well into the r.f. region, even for 5m lengths.

**Fig. 7.** Eddy currents are not a problem here, but **Heywire** gave the highest series inductance. Overshoot decay was short though, at 4µs.

**Fig. 8.** **Cable Talk 4** had the largest eddy current loss, the signal taking 25µs to decay into the noise floor.

**Fig. 9.** Lawnmower flex performed surprisingly well, eddy currents dying away in 10µs.

**Fig. 10.** Cleanest of all – plain and simple **RG58** coaxial cable. There is no overshoot and eddy currents in the braid decayed within 7µs.

**Fig. 11.** **RG58A/U** coaxial cable again, but tested for series inductance. Compare this with **Fig. 12**.

**Fig. 12.** Inductive spike resulting from **Heywire** shows that it performs less well relative to coaxial cable in this test.
While the 5m lengths were connected to the test unit, it was interesting to observe the relative noise pickup. All the tests were conducted in an electronics workshop on an industrial estate, where there is a fairly high electrical noise level.

As you can see from Figs. 15 and 16 the coaxial cable braid affords considerable screening of rf noise. The larger overshoot spike is because we now have more series inductance resulting from the greater length.

Copper oxide and diode effect
Two forms of distortion mentioned in other articles on speaker cables are current jumping between strands and a diode effect due to copper oxide on the strand surface.

No evidence of these phenomena were seen on the foregoing waveforms. However some tests were conducted on deliberately oxidised cable to see if there was any measurable effect.

Experiences with underwater pulse-induction metal detectors have shown that leakage of salt water into a cable very quickly causes oxidation of the strand surface, which takes on a dark red mat appearance. Under such conditions the conductor acquires a surface layer of copper hydroxide and copper chloride.

I injected salt water under pressure into a 1m length of lawnmower cable until it emerged from the strands at the far end. The cable was left for a couple of days and then tested. There was no change in the oscilloscope waveform.

On the third day the cable was immersed in salt water which was heated to 50°C and left overnight. The dull red coating was now in evidence to show oxidation was taking place. Again there was no measurable difference in the waveform which was again checked after one week, Fig. 17.

Some of you may object that the salt water test is not realistic, and that the oxide layer is not the same as would occur naturally in a speaker cable. However it is interesting that such a drastic contamination with a corroding electrolyte had no measurable effect on the waveform.

Another rather different oxidising test was done. This was to strip all the insulation off of a metre of one conductor of lawnmower cable and measure its eddy-current response, Fig. 18. The smaller amplitude is due to the shorter length but, as stated previously, the decay time is independent of this.

Using a butane blow torch, the cable was heated along its length until the strands took on a black appearance and the wire was in a softer annealed state. The response was then as in Fig. 19. In this case the oxide layer has broken up the eddy current paths between strands and all but removed that part of the response.

It appears, therefore, that the formation of a normal oxide layer on the strands of a speaker cable will do very little to alter the cable's characteristics. Over the long term, however, it could even serve to improve the high frequency response of a cable, if only at ultrasonic frequencies.

In summary
This relatively simple method, derived from the front end circuit of a pulse induction metal detector, can give valuable information about the characteristics of loudspeaker cables.

The signals being examined result purely from the cable itself, and occur after the drive pulse has ended. In particular, this method clearly shows the effect of eddy currents in the cable cross section.

All of the waveforms, except where otherwise indicated, are for 1m lengths which are obviously shorter than would normally be used in a hi-fi system.

Tests on 5m lengths of lawnmower flex and coaxial cable show that all the effects increase in proportion to length. As the length increases so do the series inductance and capacitance.

Fig. 13. Performance of a longer length of lawnmower cable - 5m - with no damping and a ten times faster time base indicates that the frequencies involved are well outside the audio range.

Fig. 14. RC58 coaxial cable performance for a 5m length with damping removed.

Fig. 15. Noise pickup of lawnmower cable in a noisy environment, length 5m.

Fig. 17. Some hi-fi enthusiasts advocate the use of oxygen-free copper in audio cables. Here, lawnmower cable was injected with salt water, left for three days and tested again. No change is apparent in these tests.

Fig. 18. A 1m length of lawnmower cable with its insulation removed.
and they affect the amplitude of the inductive spike and ringing frequency. Cross sectional eddy currents increase in amplitude but the decay time constant remains the same.

Increasing the pulse current to simulate higher wattages will increase the inductive spike and eddy current amplitudes proportionally. There is no evidence of dielectric polarisation or diode effect which, if it existed, would be expected to show with this method which can resolve signals down to 0.1pV across the cable.

There are obvious measured differences between cables using the pulse induction technique. But if I leave it to professional audio engineers to decide whether these effects can in any way impinge on what we actually hear, as they all occur well above the audio band.

If I had to buy a dedicated speaker cable I would probably opt for the Sharkwire at around £25.50 per metre. This displays no cross talk. There is no evidence of dielectric eddy currents increase in amplitude but the spike and ringing frequency. Cross sectional

**Fig. 19.** Lawnmower cable stripped and subjected to a blow torch indicates that older, oxidised cable may even perform better at high frequencies.

coaxial configuration gives not only the lowest series inductance but also screening from external interference which can find its way to the amplifier input via the feedback loop.

The 0.1mm strands in the outer braid and the 19/0.18mm core, both of which are tin plated copper, give a low eddy current loss and a d.c. resistance of 0.053Ωm. The insulation between the outer braid and core is solid polyethylene and the capacitance 100pF/m. Best of all, the retail price is about 50p a metre.

These few tests have hardly scratched the surface of the myriad varieties of cables on the market, in fact none of the cables tested falls into the super-cable class. The most expensive one tested is the Van den Hul at £9.50/m.

Cables are available that cost £100s and even £1000s per metre. It is not at all clear what measured improvement one would see that could possibly affect audio quality. The only electrical parameters that can be changed are the series inductance, parallel capacitance, resistance and eddy current losses.

If a perfect cable were available you would simply end up with a response identical to the reference waveform in Fig. 2. Cheap cables already come close to this. Perhaps suppliers of really high end cables would loan one for a few days for the foregoing tests to be done, or perhaps construct their own test circuit and publish the results.

**References**


**Table: speakers cables**

<table>
<thead>
<tr>
<th>Cable</th>
<th>Price (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van den Hul</td>
<td>9.50/m</td>
</tr>
<tr>
<td>Sharkwire</td>
<td>25.50/m</td>
</tr>
<tr>
<td><strong>New</strong> (average)</td>
<td>0.053Ωm</td>
</tr>
</tbody>
</table>

**Figures**

- **Fig. 2.** Reference waveform.
- **Fig. 19.** Lawnmower cable.
AG2601 audio generator – specifications

**General**
- Frequency range: 10Hz to 1MHz
- Frequency stability: within ±2Hz
- Output waveforms: sine, square
- Output impedance: 600Ω
- Accuracy:
  - ±5%+2Hz, 10Hz-1MHz
  - ±3%+2Hz, 100Hz-100kHz
- O/P floating voltage: within ±1.5dB

**Sinewave characteristics**
- Distortion: <0.05%, 500Hz to 50kHz
- <0.5%, 50Hz to 500kHz
- Output voltage: 8V rms, max
- Output flatness: ±1.5dB (1kHz)
- Output impedance: 600Ω

**Squarewave characteristics**
- Output voltage: 15V pk-pk, min
- Rise time: 0.5μs
- Synchronization input
  - Input impedance: 10kΩ
  - Maximum input: 10V rms

**Supply**
- 115/230V, 50/60Hz

**Physical data**
- Dimensions: 150 by 250 by 130mm
- Weight: 2.5kg
- *Test leads supplied as standard

Use this coupon to order your AG2601

<table>
<thead>
<tr>
<th>Please send me .... AG2601 Audio Generator(s) at the fully inclusive special offer price of £129.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Company (if any)</td>
</tr>
<tr>
<td>Address</td>
</tr>
<tr>
<td>Phone number/fax</td>
</tr>
<tr>
<td>Total amount</td>
</tr>
</tbody>
</table>

Make cheques payable to Vann Draper Electronics Ltd
Or, please debit my Master, Visa or Access card.

Card type (Access/Visa)

Card No

Expiry date

Please mail this coupon to Vann Draper Electronics, together with payment. Alternatively fax credit card details with order on 0116 2773945 or telephone on 0116 2771400. Address orders and all correspondence relating to this order to Vann Draper Electronics at Unit 5, Premier Works, Canal Street, South Wigston, Leicester LE18 2PL.

*Overseas readers can also obtain this discount but details vary according to country.
For all your Power Distribution
Olson offer a varied choice
Cable science?

Geoff Williams believes that audio signals passing through a cable are affected not just by copper cross-section, but also by a complex combination of field and semiconductor effects.

Transmission of alternating current through a cable produces a magnetic field, an electrostatic field and these are affected by the physical structure of the wire.

Magnetic field considerations
Electrons exhibit a rotating magnetic field and all magnetism derives from this. The field round a wire radiates outward in concentric circles from the centre. At the centre, the field is zero, reaching a maximum at the wire surface. It then falls off inversely proportionally to distance, Fig. 1.

Relevant expressions are inductance \( L \) which is change-of-flux divided by change-of-current, and impedance \( R \) in ohms which is \( 2\pi fL \) where \( f \) is frequency. In an ac circuit, the flux (field) and the current both change together with frequency. Since flux is greatest at the surface, it follows that the change of flux is also greatest at the surface for the same change of current. Consequently, the inductance will be greatest at the surface and so will be the impedance.

This increasing impedance results in a loss of efficiency as frequency rises. Considering also the eddy currents set up in the wire, the situation worsens. Eddy currents force electrons toward the surface, and the higher the frequency, the more they are forced outward into this region of high impedance, decreasing high frequency efficiency. This is the skin effect, whereby high frequencies travel down the skin of the conductor.

In Fig. 2, the circle represents the conductor and its associated magnetic field. The direction of rotation is as if the current is going into the paper as depicted by the cross in the middle. Though the field is made up of concentric circles, at an arbitrary point A, the electrons see the relative flux and direction as shown. Electrons are moving into the paper, so to speak, through a magnetic field at right angles relative to the current. From Fleming’s right-hand rule, the electrons move in the direction shown. Arbitrary point A can be considered anywhere in the conductor and the direction of motion is always toward the outside of the conductor.

Flux changes with frequency so, the higher the frequency, the greater the change of flux in a given period of time and the greater the tendency for electrons to be forced to the surface. Because the flux density is stronger and electrons are effectively cutting a faster moving flux at the surface, this effect is intensified at the surface.

Transients and high frequencies
Because of the skin effect, if you increase the surface area of the conductor, for example, by having a rectangular cross-section, you will improve the high-frequency performance and transient response. But this is not an elegant solution. What is best is to prevent the eddy currents using Litz wire. Being made up of separately insulated strands, Litz wire effectively prevent eddy currents moving from the centre to the outside of the conductor. Each strand however can still be considered as a solid core with its own internal eddy currents, these are tiny compared to what they would be in one large solid-cored wire.

To achieve maximum efficiency, the strands

---

Fig. 1. Magnetic field around a wire radiates outward. It is zero at the core, maximum at the surface of the wire, and falls off exponentially as it radiates outward.

Fig. 2. High frequencies travel along the surface of a conductor – a phenomenon known as skin effect. This diagram illustrates how electrons are forced toward the skin.

Fig. 3. Frequency response of a solid-core cable with plastic sheath. In listening tests the response dip is audible.
Schematic Capture
- Easy to Use Graphical Interface under both DOS and Windows.
- Netlist, Parts List & ERC reports.
- Hierarchical Design.
- Extensive component/model libraries.
- Advanced Property Management.
- Seamless integration with simulation and

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

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

Call now for your free demo disk
or ask about the full evaluation kit.
Tel: 01756 753440. Fax: 01756 752857.
53-55 Main St, Grassington. BD23 5AA.

EMAIL: info@labcenter.co.uk
WWW: http://www.labcenter.co.uk
need to be bunched into the minimum cross-sectional area, meaning a circle.

**Fields and insulation**

Looking at the electrostatic field around wire carrying a current, the flux is considered to emanate from the positive (protons) and go to the negative (electrons). The strength of the field (voltage) falls away inversely proportionally to the distance from the surface, as in the magnetic situation.

Things change, however, when you consider the effect of encasing the wire in a plastic insulating sheath. The plastic acts as a dielectric and effectively suppresses the external electrostatic field, reducing the voltage detected at various distances from the wire.

The amount of suppression by a material is related to its dielectric constant—relative permittivity. Basically, the higher the dielectric constant, the greater the field suppression.

All insulators exhibit dielectric loss. This means that the insulator retains a small amount of electrostatic charge when excited by the signal. It does so in much the way steel retains its magnetism when it is subjected to an external magnetic field. Consequently, the insulator must be forcibly discharged by the signal when it changes polarity. This leads to signal loss and cancellation. The smaller the dielectric loss, the better.

From the above, you would expect that a material with low dielectric loss and high dielectric constant would be the best material to use as an insulating sheath for an audio cable. The best materials are polypropylene, polyethylene, teflon and, slightly down the scale, scale, polyester, PVC is lower still and inferior. The worst insulators are probably rubber-based compounds, including polyolefins. So although the relevant electrostatic field lies outside the wire boundaries, whether you place something next to it or not can have a serious effect on the sound quality where loudspeaker cables are concerned.

The dielectric is charged and discharged by the electrostatic field of the audio signal. The more the dielectric suppresses the field, the less it is charged and discharged. The lower the dielectric loss, the less tendency there is for the material to remain charged when the accompanying field in the wire has long been and gone.

The difference in sound I perceive between bare wire and insulated wire indicates that a bare solid core wire has a curtained top end compared to a sheathed piece of the same.

**Proximity effects**

How audio cables are arranged in space is important. As a rule, cables that are adjacent to each other carrying current in opposite directions must be at least ten times the wire diameter apart to avoid signal cancellations due to magnetic coupling. This does preclude the use of non-inductive (bifilar) winding for audio purposes. Such an arrangement causes signal loss due to phase cancellation and is clearly audible.

Consequently, it is better to have signal and return wires separate rather than combined into one cable. Avoid twisting cables together because this will create inductive turns.

**Conductivity of metals**

<table>
<thead>
<tr>
<th>Metal</th>
<th>Conductivity (µΩ·cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>1.620</td>
</tr>
<tr>
<td>Copper</td>
<td>1.682</td>
</tr>
<tr>
<td>Gold</td>
<td>2.420</td>
</tr>
<tr>
<td>Aluminium</td>
<td>2.825</td>
</tr>
<tr>
<td>Rhodium</td>
<td>5.100</td>
</tr>
<tr>
<td>Zinc</td>
<td>6.000</td>
</tr>
<tr>
<td>Iron</td>
<td>9.800</td>
</tr>
<tr>
<td>Platinum</td>
<td>9.970</td>
</tr>
<tr>
<td>Nickel</td>
<td>10.900</td>
</tr>
<tr>
<td>Tin</td>
<td>11.500</td>
</tr>
<tr>
<td>Chromium</td>
<td>13.100</td>
</tr>
<tr>
<td>Lead</td>
<td>20.650</td>
</tr>
</tbody>
</table>

1 used in brass
2 used in resistance wire and screening
3 used in solder and in plating copper
4 used in nichrome resistance heating wire
5 used in solder

**Thermoelectricity and conductivity**

A junction of dissimilar metals makes a thermocouple. Copper is one of the commonest thermocouple metals.

If there is a temperature difference between the metal's junction and another part of the circuit, a small voltage is developed across the junction. Loudspeaker cables are heated slightly by the current flowing in them, but I think that this thermoelectric problem is very small and not one to worry unduly about.

**Directional cables**

A cable with directional qualities is undesirable. If a cable has a lower impedance in one direction than the other, it is acting to some degree as a diode.

Copper oxide is a semiconductor. Early rectifiers used copper oxide. Attempts have been made to limit the amount of oxygen in the copper in the production process, but it is impossible to eliminate all of it. Much so-called oxygen-free cable is in fact anything but oxygen free. Many of these cables have managed to eliminate surface oxidation only.

The wire surface needs to be gas-tight to avoid oxidation after the wire has been sitting for a few months. Enamelled copper wire is gas-tight, but even this acquires a small amount of surface oxidation in the enamelling process. Plating the copper with a metal that resists oxidation might appear to solve the problem. Metals commonly used are tin, silver, gold and, more recently, rhodium. This is all very well, but there is a body of opinion that asserts that plated wire is not as good as unplated.

As far as I know, there are three aspects to consider: thermoelectricity, conductivity and crystallinity.

**Solid versus stranded**

Early audio cable, particularly speaker wire, was made of separate strands, bunched and sheathed. These strands had a certain amount of surface oxidation contributing to the semiconductor effect. When people switched to solid core, the reduction of oxidation increased the clarity of the signal.

I have found that stranded cable outperforms solid-core at higher frequencies. This is due to the reduction of eddy currents and the greater surface area, but this top end is certainly confused. Hence we have definite but different advantages for both types of cable and, as one would expect, both types of wire.
Antenna and proximity effects

To a much lesser degree, there is the possibility of the screen acting as an antenna, introducing AC into the signal ground. For very low level signals, some sort of screening is essential if a balanced line is not used, i.e. for moving magnet or moving coil cartridges.

One possible answer is the use of a carbon loaded screen. The high resistance will cut out considerably any eddy currents induced into the screen. It is also possible to use a Litz type braided screen where the screen is made up of separately insulated strands.

The final aspect of audio cables is their arrangement in space. As a rule, cables that are adjacent to each other carrying current in opposite directions must be at least ten times the wire diameter apart to avoid signal cancellations due to magnetic coupling. This does preclude the use of non-inductive (bifilar) winding for audio purposes. Such an arrangement causes signal loss due to phase cancellation and is clearly audible.

Consequently it is better to have signal and return wires separate rather than combined into the one cable. Avoid twisting cables together because this will create inductive turns.

Most hi-fi amplifiers and speakers are unable to respond accurately to fast transients, and changing to larger cables will not necessarily bring an improvement in sound quality.

In summary

First of all, a Litz arrangement is necessary if we are to get the best transient response, high-frequency coherence and power handling. Second, insulation is needed and one of the best dielectrics is polypropylene.

Following is a suggestion for a set of practical cables:

For a bass cable, strand diameter should be of the order of 0.1-0.2mm. Taking 0.15mm as the area of at least 4.5mm², a longer run requiring 6mm² or more for a mean power handling of only 50W rms.

For a 2m run, my experiments indicate a cross-sectional area of at least 4.5mm², a longer run requiring 6mm² or more for a mean power handling of only 50W rms.
COMMUNICATIONS

Hands-on Internet

Cyril Bateman discusses a standardised document format and presents this month’s findings – among them an electronics manufacturers directory and design software.

As the Internet Web pages continue to grow in number and sophistication, many electronics manufacturers use them to provide their traditional data packs. With the final on-screen appearance being under the control of the users’ Browser, not the creator of the script and the limited page formatting capability of HTML, the Adobe PDF format was plugged into Netscape to provide full page control.

Adobe’s Acrobat 2.1 reader for PDF, gives access to documents in their original form independent of the user’s computer platform, can be downloaded from most Web pages using PDF format. An offshoot of Postscript, Portable Document Format uses the ATM font technology to render the document in your browser, ensuring WYSIWOG - an acronym for what you see is what others get. It is compatible with Netscape 1.1, Spyglass Mosaic 2.0 and newer equivalents, Fig. 1.

To date PDF usage has been restricted due to the software needed. While the reader is now freeware, the production suite was costly. All this is about to change. The beta version of Acrobat 3.0 (Amber Beta) has been available since end May. Acrobat 3.0, with a full suite of tools, is due to release in USA this October at the incredibly low cost of $295. It provides PDF generation from your word processor and even from scanned documents.

The version 3.0 reader, available for most browsers and operating systems, provides searching and linking as with HTML. Being fully WYSIWOG does have a down side though. HTML, unless specifically formatted, wraps a text line round if your browser width is less than the designed page width. PDF on the other hand simply chops it off. By design it cannot wrap text lines for you. The Argus Clearinghouse2 claims to be the premier Internet Research Library, and can be a most useful data source and Internet search tool. It is managed by librarians, and founded on their belief that to encompass ambiguities of language and ideas, human effort and qualitative assessments must be combined with searching and browsing techniques, Fig. 2.

This month’s bookmark site just has to be found at eenet.com, home of the Electronics Industry Inforum and Interactive Workplace3. A sample search on ‘capacitors’ resulted in details of some 60 capacitor makers, mostly not having their own Web presence. This site includes a facility called Info Fax. With this facility, any company wanting an Internet listing needs only a fax machine to receive and send data requests. The facilities offered by eenet provide services both for designers and marketers. They should be sampled. Words alone are inadequate, Fig. 3.

Webscope.com4 is among the top 5% sites and offers two directories of Internet resources, in addition to its main role as a provider. While the guide to hotels and travel is interesting, Webscope’s unique directory of electronic manufacturers is an essential directory service. It is indexed by manufacturing categories, and is most relevant, Fig. 4.

Simulation software

The AVX SpiCap software5 calculates the effective capacitance, esr and self inductance parameters of AVX ceramic multilayer range by frequency, temperature and applied voltage. Described last month, this software is now available on two 3.5in disks, facilitating its use by all spice designers. Copies can be ordered on-line or from the company’s sales offices. Obviously while targeted to spice users, these same parameters can be applied to any simulator, whether frequency or time domain.

Readers wanting further clarification of the need to derive capacitor models with parasitics, are directed to two useful papers, the Microsim FAQ6 and a piece called ‘12 Simulation program tips/tricks/bugs. Should you want to try out a frequency domain rf simulator, or need S parameters for Hewlett Packard rf semiconductors, a three-disk freeware package called

Fig. 1. Adobe Systems provides new uses for paper documents. Software for PDF document reading and creation.
Micro Video Cameras

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

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

Here is a sample of the available stock.

A-721-S Micro Camera 32mm x 32mm ... £85
A-721-P Micro PIN-POLE Camera ... 32mm x 32mm ... £85
A-921-S Camera with AUDIO ... 30mm x 30mm ... £95
A-121I C/CS Mount Camera ... 110mm x 60mm x 60mm ... £110
A-521 Micro Cased Camera 43mm x 48mm x 58mm ... metal cased ...£120
6001-A High Resolution COLOUR Cameras (420 lines) ... 0.45 lux ... £210
Outdoor Camera Housings ... Aluminium ... £45
Camera Mounting Brackets ... Universal Mounting ... £5.95
Camera Switchers ... for up to 8 Cameras ... £85
Auto Record Controllers ... Allow NORMAL VHS Videos to operate like professional Time Lapse or Security Recorders ... £75
QUAD-1 Multi Vision Processors ... Digital Freeze ... Quad Pictures etc £775
QUAD-2 Full COLOUR QUAD version of QUAD-1 ... £695
SCI ... SCANNER ... 350° PAN ... Automatic / Manual ... £105
IRA ... Infra Red Illuminator for “Total Darkness Surveillance” ... 20m range ... £125
VMS-1 ... Video Motion Sensor ... replaced alarm sensors with totally electronic video monitoring system that detects changes in the video signal .. £175
C/CS Format lenses ... Premium 3.6mm ... £22.50
Superior 8mm ... £27.50

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

Government Surplus Electronics Equipment on Special Offer This Month

TIME Electronics 404N/1021 Voltage/Current Calibrators ... 0.05% accuracy ... ONLY £275
FRANKLIN Wavetek 3600 Power Line Disturbance Monitor + Printer ... LAST 2 NOW ONLY £350
MARCONI TF9693 + TF261 + TF9695 VHF Sig Gen / Sweeper sets ...
10MHz-300MHz ... 0.01-100KHz sweep rate ... 0-60db attenuators ...
INCL Cased Adaptor sets ... LAST FEW NOW ONLY £125
COMARK 2007 + 3 “K” type probes ... ±0.1’tres ±0.5%acc ... Cased As New ... ONLY ... £65
Other Digital Thermometers always in stock ... Please Phone
SINERGY TRILINE PC5A Energy Monitor LCD Screen ... Colour Plotter 1-3ph ... ONLY £195
MARCONI TF2300S FM/AM Mod Meter 3.5Mhz-1Ghz AM/AM ... ONLY £75
TEK 491 Spectrum Analysers ... 100Hz to 2Ghz ... Few Left at ONLY £995
TEK 7603 + 7A18 + 7B50A 4 Channel 100MHz Scope ... Rack version ... FEW left ... Only £325
FARNELL TMS Sampling RF Millivoltmeters 1mV-V 10KHz-1.5GHz ... FEW left ... ONLY £125
MARCONI TF2603 RF Millivoltmeters + Accessory Kit ... LAST FEW ... ONLY £60
TEK 466 Storage Scopes ... Twin Trace and Timebase ... 12-100MHz ... ONLY £475
MARCONI TF2618 Signal Generators ... 80KHz-520MHz AM/FM ... Fully Digitally Synthesised Internal/External Modulation... ONLY £995

OPEN 6 DAYS A WEEK
Mon-Fri 9am-6pm Sat 8am-4pm
NO APPOINTMENTS NEEDED. CALLERS ALWAYS WELCOME
All Prices are Ex VAT & Carriage
All items are Fully Tested with Verified Calibration and carry our Unique 30 Day Un-Conditional Warranty

CIRCLE NO. 131 ON REPLY CARD

942 December 1996 ELECTRONICS WORLD
AppCad is available. Its HP part number is HAP-P-0001, and it has proved invaluable to me.

This small-scale package is described as a "unique combination of application notes and rf design tools combined with an interactive product selection guide". Its capability ranges from simple two port S parameter analysis to design of printed circuit spiral inductors. It can be downloaded from Internet. Archie located the files only at ftp.fitnetfi but FTP Search at Norway found two more sites both having newer files.

A rather different but equally useful catalogue on disc is available for K&L Microwave Inc's rf signal resonator filters. Choose the desired characteristics, view the passband response to be given their catalogue number.

Having designed and simulated your circuit you need a printed circuit board layout package. PADS Software Inc. supplies professional circuit design software at suitable prices\(^8\). The company also offers a more restricted but perfectly usable shareware version with schematic editor and autorouting, which I have used. The Electronic Design Software page mentioned in the last issue, describes its download from the SimTel archives, Fig. 5.

Now that prices have settled, I have finally replaced my 14.4kbit/s modem used for the past two years with a a 28.8k alternative. However, I still use 57,600bit/s serial port rate, not having upgraded to a 16550 -type uart. Since most data downloaded is already fully compressed, when Internet permits, the modem runs at full speed. Mostly, however, Internet is much slower, so it seems unnecessary to upgrade the serial card - at least until Internet access improves for the UK.

References
5. AVX Corporation, http://www.avxcorp/software
7. FTPSearch Trondheim Norway, http://ftpssearch.unit.no/ftpsearch
ULTiboard’s interactive strength has always been the major selection criterion of professional Printed Circuit Board designers. Now that every ULTiboard Designer system will be supplied with a SPECCTRA SP4 Autorouter, ULTiboard designers now get the best of both worlds. All ULTiboard Designer Users with valid update subscription got a MAINTENANCE UPGRADE with the SPECCTRA SP4 (4 signal layers + power/ground layers) Shape based Autorouter. This shows that ULTimate Technology is the PCB-Design Tool vendor that really cares for their customers!

THE ULTIMATE SPECIAL OFFER

ULTiboard Entry Designer* £ 1295 (excl. VAT) will now be supplied with SPECCTRA Shape Based Autorouter
*free Upgrade with EMC-EXPERT mid 1996 (list price at release £ 1875)
In any public address system where microphones and loudspeakers are in the same vicinity, acoustic feedback (howlround) occurs if the amplification exceeds a critical value. By shifting the audio spectrum fed to the speakers by a few Hertz, the tendency to howl at room resonance frequencies is destroyed and increased gain is available before the onset of feedback.

The Phantom Power Box
48 volt microphone powering unit
Professional portable units operating from an internal PP3 battery or external DC supply

* Suitable for converting any microphone amplifier to P48 standard phantom power
* High efficiency DC to DC converter for extended battery life
* Accurate line balance for high common mode rejection
* Low noise and distortion
* Extensive RFI protection

The Balance Box (mic/line amplifier) - The Headphone Amplifier Box - The OneStop DIN rail mounting radio frequency interference filter and voltage transient protector for voltage and current loop process signal lines

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

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

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

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

AUDIO VIDEO RF
Audio Oscillators, Analysers Wow and Flutter, Millivolt Meters and Distortion Meters Pattern Generators, Vectoroscopes, Waveform Monitors Video Analysers and Noise Analysers. Five models of AM/FM Standard RF Generators offering a highly stable frequency range of 10KHz to 2GHz with digital readouts for Level, Frequency, Modulation and Memory address.

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

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

Kenwood UK Ltd, Kenwood House, Dwight Road, Watford WD1 8EB, England
TEL: +44 (0)1923 218794 FAX: +44 (0)1923 212905
READER OFFER

Exclusive to Electronics World readers
Electromail's catalogue on CD for just £2.50

The Electromail CD-ROM Catalogue is an invaluable tool for anyone involved with electronics. Normally, this CD sells for £5, but Electromail is making it available — exclusively to Electronics World readers — at the special price of £2.50 while stocks last.

The Electromail CD-ROM Catalogue makes selecting the products you need — and ordering them — unbelievably quick and easy. It also puts an incredibly powerful source of technical reference at your fingertips.

All you need is a 386 or higher PC compatible with 4Mbyte RAM, CD-ROM drive, VGA monitor, Windows 3.1TM software and a mouse. Just click on the product screen and you get the choice of searching by product type, word or part word, stock number, manufacturer's part number — or any number you care to give a part you use regularly.

If you want to search for several items, Electromail has developed an idea called Virtual Page™ that allows you to search and view all your selections together.

A wealth of technical data
In addition to product information, certain product groups are backed by extra technical information. To find out more, all you do is click on another icon and a window appears containing the relevant RS data sheet.

The Catalogue also helps you write your order form and prints it out for you — as well as maintaining a history of your recent orders.

The Electromail Catalogue is one of the most advanced technical product Catalogues available, and no one involved in electronics should be without it — at work or at home.

Please address all correspondence relating to this offer to Electromail, P.O. Box 33, Corby, Northants, NN17 9EL, quoting reference number 234-4857. Tel: 01536 204555, fax: 01536 405555.

Use this coupon to order your CD-ROM and/or enter the competition
Please send me copies of the Electromail CD-ROM Catalogue at the special reader offer price of £2.50 each, including VAT and P&P. Total value £...

Name
Address
Postcode
Tel

Please debit my VISA Mastercard Amex Delta (please tick one box)
Card No
Expiry date

Signed

Or, I enclose a cheque for the total order value of £... Post your order to Electromail, P.O. Box 33, Corby, Northants, NN17 9EL, Tel: 01536 204555. Fax: 01536 405555.

Questions
1. How many search functions does the Electromail CD-ROM offer?
2. What is the unique feature that enables you to see several selected items on screen at the same time? (tick one box)
3. In addition to full Electromail Catalogue information, what other powerful source of data does the Catalogue contain? (tick one box)
4. Write in the most apt or appropriate way, in fewer than 12 words how you feel the Electromail Catalogue will add advantages to your technical endeavours.

Reference number 234-4857

Competition rules
- No purchase necessary. Entry is limited to one per reader. Only entries on the official entry form printed in this magazine are valid. Photo copies of the entry form will not be considered.
- The winning entry will have answered questions 1-3 accurately, and completed question 4 in the most apt or appropriate way possible. The judges' decision is final. No correspondence will be entered into. No cash alternative to the prize offered is available.
- Only UK residents are eligible for entry. Employees or agents of RS Components Ltd, or their relatives, are not eligible for entry. The closing date for receipt of entries is 17.2.97. The winner will be notified in writing by 21.2.97 and the winners name will be published in this magazine. Sending an entry confirms acceptance of these rules.

Plus the chance to win a CD-ROM development kit worth £649

Simply answer the questions on the coupon below and you could win this new development kit, which lets you create your own CD-ROMS — as well as audio CDs.

Called the HP SureStore CD Writer 4020i, this development kit is designed for an IBM-compatible 486 or higher PC. It provides all the hardware, plus four software applications, to let you build and search databases, copy disk files into standard ISO 9660 format CD-ROM, create audio CDs for playing back in your stereo CD-player and create a prompted slide show of Photo CD images.

The hardware includes an intelligent SCSI-2 interface. All major CD standards are provided and there's a customisable, automated software installation process.

CD-Writer records at dual speed and can be used as a CD-ROM player at quad speed. The kit includes two blank CDs.
Your pc is a programmable event timer capable of precision gating up to 55ms. Alan Bradley describes how to configure it.

Timer channel 2 is present in all pcs. It is normally used as a variable frequency square wave generator for the pc’s speaker. But this timer can also be used as an interval timer that is independent of the processor type and speed. This article describes how.

Overview
Timer 2 is within the pc’s programmable universal counter/timer. This IC contains three counter/timers each with an associated control register. The original IBM pc used an Intel 8253, the IBM AT an Intel 8254. Modern clones may use custom ICs, but all have the same programming model. This universal counter/timer operates at 1.193MHz irrespective of the processor’s type or clock speed. All three counters are 16 bits wide.

The three counter/timer channels, namely 0, 1 and 2, are accessed through ports 40, 41, and 42 respectively within the pc’s 16-bit port address space. The command register is located at port 43. It selects the mode for reading and writing values to the chosen channel, selects the type of use for that channel, and selects the channel to which the previous selections apply. Examples of uses for the channel are square wave generation, one shot pulse production and terminal down count.

Applying the counter/timer
Timer channel 0 is used to calculate the time of day. This channel is set up by the bios to give 18.2 pulses per second. Each pulse causes the timer interrupt, IRQ 0, after which the counter is reset. A four-byte counter data area at 0040:006C is used.

This counter also synchronises disk operations. Reprogramming it might therefore damage disk reads and writes.

Timer channel 1 is used by ram refresh and also by disk operations. Reprogramming this channel may also cause loss of disk data.

Timer channel 2 is connected to the pc’s internal speaker, generating the variable frequency square waves necessary to make simple sounds. The speaker can be turned on and off via the pc’s parallel-peripheral interface chip. As this channel controls no vital hardware, and the speaker can be turned off, it can be set up as a timer. A possible use is determining the waiting period for an analogue to digital conversion.

The 8255 programmable peripheral
Timer 2 is also controlled by the pc’s 8255 peripheral interface chip, or PPI. This device

Applying the timer
This pseudo-code program illustrates how the pc can form a monostable multivibrator by using timer-channel 2 in conjunction with the parallel printer port. The printer port provides the digital I/O lines for the trigger and output.

This pc monostable is not retriggerable, although it could easily be made so. It has a timed period of 40ms. The parallel-port input line that normally signals printer error, abbreviated PE, is used as the monostable trigger input. If it goes low, the monostable is triggered. Parallel port output line Do is used as the monostable output. It goes high when triggered, remains high until chosen time period has passed.

Pseudo code for a 40ms monostable multivibrator
Find location of printer port registers.
Reset monostable: set its output low: ie set printer port output data line D0 low (pin 2 on D connector).
Set up PPI B register to allow timer-channel 2 to be used as a down counter.
Set up Timer channel 2 to select down count mode, a binary count, and READ/WRITE 0ab and 1ab consecutively mode.
For a downcount from FFFFhex. Calculate FinalTimerDownCount for a 40ms delay.
Print title message.
WHILE (forever).

IF printer port input pin PE (pin 12 on D connector) is low then:
Trigger monostable output: ie set printer port data output line D0 high.
Load counter with maximum count value (FFFFhex) and start down count.
Print ‘triggered: output (D0) goes high’
Wait for 40ms.
controls the keyboard and is used to obtain information about the pc's configuration. It also controls the pc speaker and the speaker's associated timer on channel 2.

Port A of the PPI is a read/write port associated with the keyboard. Port B controls the reading mode for ports A and C. It also controls the speaker and timer channel 2. Port B is located at port 6116 in the pc's i/o address space.

Using timer 2 as an interval timer I wrote the interval timing code in a mixture of C and assembly language. This is because the C compiler generated a much slower shift-by-8 loop. It did not make use of the 80x86 processor's ability to treat 16-bit data registers as 8-bit pairs, ie AX=AH+AL, BX=BH+BL, CX=CH+CL and DX=DH+DL.

The 80x86 has four more registers, SP, BP, SI and DI. These are normally used as pointer and index registers. In my program I used the DI register simply to store 16-bit data. Turbo C uses SP, BP and SI itself. The DX data register is also used in some IN/OUT instructions and so cannot be used by my program.

The 8086 has four segment registers, namely CS, DS, SS, ES. These allow addressing over 64K. The C compiler sets these to appropriate values automatically. The 8086 has an instruction pointer, similar to a program counter. It also has a FLAGS register, recording the result of instructions such as NON-ZERO and OVERFLOW.

Counting is interrupted if the GATE2 input is switched to a low level and restarted when the GATE2 input is switched back to a high level. Hence GATE2 should be high for a down counting interval timer.

Therefore my program sets bit 0 of the PPI B register to logic 1. I also disable the pc speaker by setting bit 1 of the PPI B register to 0. Inset 1 shows the Timer control register bit pattern required to select down count mode for Timer channel 2 and the timer control register bit pattern required to perform a latch operation on Timer channel 2.

After the latching command has been written the 8253 timer begins counting down from the value 8000 hex.

The program goes into a loop until the timer reaches zero.

Control register bit usage for the pc's 8253 timer ic

<table>
<thead>
<tr>
<th>Location</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bits 7, 6</td>
<td>Select counter channel</td>
<td>Select type of counter to be programmed (0, 1 or 2)</td>
</tr>
<tr>
<td>Bits 5, 4</td>
<td>Select latch operation</td>
<td>Select latch operation or type of read/write</td>
</tr>
<tr>
<td>Bits 3, 2, 1</td>
<td>Mode</td>
<td>Select binary or BCD count</td>
</tr>
<tr>
<td>Code</td>
<td>Number of the channel to be programmed</td>
<td>Select counter/timer mode</td>
</tr>
<tr>
<td></td>
<td>(0, 1 or 2)</td>
<td>0=Binary</td>
</tr>
<tr>
<td>Code</td>
<td>Select latch current value of counter</td>
<td>0=Terminal down count</td>
</tr>
<tr>
<td></td>
<td>(done before a read operation)</td>
<td>001=Programmable</td>
</tr>
<tr>
<td>Code</td>
<td>Select latch current value of counter</td>
<td>011=Rate</td>
</tr>
<tr>
<td></td>
<td>(done before a read operation)</td>
<td>x10=Rate</td>
</tr>
<tr>
<td>Code</td>
<td>Select latch current value of counter</td>
<td>x11=Square Wave</td>
</tr>
<tr>
<td></td>
<td>(done before a read operation)</td>
<td>Generator</td>
</tr>
<tr>
<td>Code</td>
<td>Select latch current value of counter</td>
<td>100=Software</td>
</tr>
<tr>
<td></td>
<td>(done before a read operation)</td>
<td>triggered strobe</td>
</tr>
<tr>
<td>Code</td>
<td>Select latch current value of counter</td>
<td>101=Hardware</td>
</tr>
<tr>
<td></td>
<td>(done before a read operation)</td>
<td>triggered strobe</td>
</tr>
</tbody>
</table>

C pseudo code for pc timing

Calculate final count value for a 10µs delay. Calculate number of clock ticks in a 40,000µs delay.

PRINT“Preparing Count Down”

FINAL COUNT VALUE FOR 40,000µs DELAY=FFFFF=number of clock ticks in a 40,000µs delay

Now set up Port B of the PPI so that Timer2 can be used as a terminal down counter and disable speaker: ie set Timer gate 2 high (via PPI Port B, bit 0) (allow counting in Timer channel 2) and disable speaker (via PPI Port B, bit 1)

Set Timer Gate 2 HIGH (allow counting)

Now set up channel 2 of the timer to count in binary, perform a terminal down count and choose option: read/write lsb, msb one after the other, by writing appropriate value to the timer control register.

PRINT“Starting Count Down”

write FF16 (lsb) to timer channel 2

write FF16 (msb) to timer channel 2

REM: down count from FF16 has now begun.

Loop until 10µs has passed

Print“Ten microseconds have now passed”

Loop until whole 40,000µs delay has elapsed.

PRINT“Entire chosen timed interval of 40,000µs=40ms has now passed”

END
In this way, when the current counter value is incremented by 1.193MHz before interval has passed is equal to the chosen delay interval in microseconds, multiplied by 1.193MHz. I always start the down count from FFFF16. In this way, when the current counter value is less than or equal to FFFF16 minus the number of clock ticks before interval has passed, then the chosen delay interval will have expired. For example, for a 40,000 µs delay:

No. of clock ticks= 40,000 x 1.193=47720=BA6816

Final timer downcount= FFFF16-BA6816=459716.

The maximum delay is 55ms.

Example timing program in C

This timing program example is derived from my printer port sound sampler program, where I needed to wait 10 µs for the a-d converter to complete a conversion, process this value, then wait until the end of the sample period before repeating the loop.

Outlined in the timer software panel Inset 2, this routine waits until the first 10 µs of a 40,000 µs delay has elapsed, then waits until the whole 40,000 µs delay has passed.

C and Assembler details of Timer.C

The program compiles under Borland Turbo C++ and Borland C++. This allows the 80x86 registers to be used by name within a C program's array() assembly blocks. Registers can also be accessed from C by preceding the register name with an underscore, eg _AX, _AH, _AL...

The program uses # defines to give PPI Port B, and timer control register and timer channel 2 port addresses meaningful names.

Timer channel 2 is read by sending a latch command via the Control register, then simply reading the lsb, then the msb from Timer channel 2, port 04216.

<table>
<thead>
<tr>
<th>Function</th>
<th>Setting</th>
<th>Bit</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select timer channel 2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Select type II read/write operation: LSB is first written to timer 2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Select mode 0: terminal down count</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Select binary counting</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Timer control register usage for interval timing.

PC I/O address 04316.

Using terminal down count mode, this is timer control register bit usage to set up a down count.

Accuracy of the pc as a timer

Instructions for reading and checking the current value of timer channel 2 take a finite amount of time, adding inaccuracy to the timing. I have calculated the worst-case delay between timer-channel 2 reaching its chosen final count value. With the program Timer.C, described later, the worst case inaccuracy for an 8MHz ISA I/O bus pc should be 7.144 µs:

Calculation of Timer.C program timing limits:

80x86 injstr 8MHz I/O cycle 80386 cycle

START TIMER channel 2 count:

<table>
<thead>
<tr>
<th>0</th>
<th>80x86 instr</th>
<th>8MHz I/O cycle</th>
<th>80386 cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>mov reg, imm</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>OUT imm, al</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Send Counter latch command:

<table>
<thead>
<tr>
<th>2</th>
<th>80x86 instr</th>
<th>8MHz I/O cycle</th>
<th>80386 cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>mov reg, imm</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Read and store timer lsb:

<table>
<thead>
<tr>
<th>2</th>
<th>80x86 instr</th>
<th>8MHz I/O cycle</th>
<th>80386 cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>mov reg, imm</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Read and store timer msb:

<table>
<thead>
<tr>
<th>2</th>
<th>80x86 instr</th>
<th>8MHz I/O cycle</th>
<th>80386 cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>cmp reg, reg</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Compare msb:lsb of current timer value with FinalTimerDownCount:

<table>
<thead>
<tr>
<th>2</th>
<th>80x86 instr</th>
<th>8MHz I/O cycle</th>
<th>80386 cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>ja 8bit displacement</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Total clock cycles=54 I/O clock+13 processor clock cycles

For a 33MHz 386 pc this would give a worst-case error of:

inaccuracy = I/O clock delay+processor clock delay

= 6.75µs+0.4µs = 7.144µs

According to my assembly language book, IN/OUT 386/486 instructions vary in the number of clock cycles they need. I have used the slowest timing, which is similar to that of the 8086/8. The 286 IN/OUT instructions are about twice as fast as those of an 8086/8.

Greater accuracy in small delays would need interrupt programming, which is more difficult to write. This would involve reprogramming timer-channel 0, which needs care to avoid affecting disk operations; timer-channel 2 has no associated interrupt.

Small delays are often needed. When reading an a-d converter value for example, the 7µs inaccuracy can be important. In longer delays the 7µs may be insignificant. The inaccuracy should reduce on local-bus machines and on fast ISA buses that unofficially run at 11MHz.

Software on disk

The Timer.C routine and the full monostable example in C can be obtained by sending a cheque of postal order for £7.50 to Electronics World's editorial offices. Please mark the envelope Timer software and make your cheque payable to Reed Business Publishing Group.

December 1996 ELECTRONICS WORLD
C code for controlling the pc's timer

This program, Timer.c, demonstrates using timer 2 as a down counter to measure time intervals. Written in Turbo C with in-line 8086 assembler. Small memory model: 64K code 64K data and stack. Register keyword enabled.

```c
#include <stdio.h>
#include<dos.h>
#include<conio.h>
#include<stdlib.h>
#include<io.h>

#define PPIportB 0x061
#define TimerCtlReg 0x043
#define Timer2 0x042

#define FINALTIMERDWNCOUNT DI
#define MSB CH
#define LSB CL
#define COUNT CX

#define tenMicroSecDwnCount Oxfff3

#define NoOfClockTicks_inFortyMilliSecDelay Oxba68

unsigned char breg;

int main()
{
    puts("Preparing count down\n");
    asm {
        mov ax, 0xffff;
        sub ax, NoOfClockTicks_inFortyMilliSecDelay;
        mov FINALTIMERDWNCOUNT, ax;
    }

    puts("set portB of PPI for timer2 as down counter instead of driving speaker\n");
    breg = inp( PPIportB);
    breg = breg | 0x01;
    mov ax, 0xffff;
    sub ax, NoOfClockTicks_inFortyMilliSecDelay;
    mov FINALTIMERDWNCOUNT, ax;

    puts("Now set up channel 2 (timer2) of Timer chip: \n");
    out Timer2, 0x061;
    out Timer2, 0x043;
    out Timer2, 0x042;
    /* first o/p count low byte (FF) */
    mov al, 0xff;
    out Timer2, al
    /* o/p high byte (FF); timer starts on writing high byte */
    out Timer2, al
    /* down count from ffff has now started */
    /* now wait until ten microseconds has passed */
    mov ax, 0x0000
    jmp 10:ch 2, 00:ctrr latch, 000:term cnt, 0:bin data*
    store above in ah for speed*/
    /* asm( mov ah , 0x80 )
    loop until 10us or more has passed */
    label10D: asm {
        read ctr latch command from ah into al for I/O instr */
        mov al, ah
        send latch command to timer*
        out TimerCtlReg, al
        now read lab from timer2 *
        in al, Timer2
        now store lab */
        mov LSB, al
        now read mb from timer2*/
        in al, Timer2
        now move mb into highbyte of COUNT */
        mov LSB, al
        while COUNT holds value > tenMicroSecDwnCount */
        ie while timer2 value > tenMicroSecDwnCount*/
        cmp COUNT, tenMicroSecDwnCount
        ja label10D
    }
    while COUNT > tenMicroSecDwnCount*/
    puts("\nEntire chosen timed interval of 40,000ps =
40 msecs has now passed\n");
    mov al, ah
    send latch (0x80) command to Timer/*
    out TimerCtlReg, al
    read lb from timer2 */
    in al, Timer2
    store lab in low byte of count*/
    mov LSB, al
    read mb from timer2*/
    in al, Timer2
    move mb into highbyte of count */
    mov MSB, al
    while timer2 value > FINALTIMERDWNCOUNT*/
    cmp COUNT, FINALTIMERDWNCOUNT
    ja label12D0
} /* NOTE ! timer count value of 0000 cannot be read */
    print( "\nEntire chosen timed interval of 40,000ms =
40 msecs has now passed\n"
); return 0;
```

950 ELECTRONICS WORLD December 1996
Field Electric Ltd.
Tel: 01438-353781 Fax: 01438 359397
Unit 2, Marymead Workshops, Willowas Link, Stevenage, Herts. SG2 8AB.

TEAC New & Boxed N/Book: L/Top Floppy Disc Drive FD 05HF 4630V £24
Sony 9" Super Fine Pitch Trilithon RGB VDU £85.50
AT Keyboards for IBM Compatibles £9.99
12" Colour SVGA 800 x 600 NEC £45.95 c/p 14
Marconi Inst = Data Commis Test £240
Marconi Inst = Digital Line Monitor £350
Marconi Inst = Digital Analyser £375
Farnell PSU 0-5V 0-3A 0-10A £245
Siemens Data Line Analyser K1190 with manual £300
Black Star Multimeter 3225 £55
Tektronix DAS9100 Digital Analyser System £175
Tektronix 7A18 D.T. Amp £75
Tektronix 7B53A D.T. Base £75
Tektronix 7A16A Amp £160
Tektronix 7911 Dif = Comp = £100
12 VAC 200 Watt Transformer £15
27 VAC 30A Transformer New £15
Tieng Labs 1Ms 16 bit ISA SVGA Card £16.75 c/p 4.00
Contains 50W PSU. Fan 2 x 16 bit. 1 x 8 bit Slot: New & Boxed £24.99
Philips PM 3240. 50 Mhz. Scope DiTrace £165
Philips PM 3233 10 Mhz DiTrace Scope £66
Leader LVM 181A AC Millivoltmeter £145
Racal Inst. 9915 UHF Freq: Meter 500Mhz £100
Racal Inst. 9916 UHF Freq: Counter 500Mhz £145
HP 8413A Phase Gain Ind. £390
HP 7475 B Pen Plotter RS232 £55
HP Colour Pro 8 Pen Plotter RS232 £75
HP 7470A Plotter HPIB £95
Compaq 14" Mono VGA (Paper White) Refurb: 720 x 400 Text £29.50
640 x 480 Graphics £77
Roland DX YX X 980 A 8 Pen Plotter. Needs PSU £60
Roland DX YX X 980 A 8 Pen Plotter. Needs PSU £60
14" VGA Colour Monitors. Various makes from £75
PLOTTERS * COMPUTERS * COMMUNICATIONS * PSU * VDU'S * VIDEO * FANS * TEST * CABLE * NETWORK * PRINTERS * DISK DRIVES ALWAYS IN STOCK. OVERSEAS ENQ. WELCOME. TELEPHONE ORDERS ACCEPTED. C/P DETAILS PLEASE RING. ALL PRICES PLUS 17.5% VAT.

'OFF-AIR' FREQUENCY STANDARD

- Provides 10MHz, 5MHz & 1kHz
- Used for calibrating equipment that relies on quartz crystals, TOXO, VXCOs, oven crystals
- Receiver scans from 9570kHz to 9580kHz and is digitally controlled and traceable to NPL
- For ADDED VALUE also phase lock to ALLCOS or L2COS (pulsed controlled and traceable to CIP -- French eq to NPL)
- British designed and British manufactured
- Options available include enhanced receiver, one wave outputs and 13MHz output for GSM. Prices on application.

TEST EQUIPMENT

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

Marconi Spectrum Analyser TF3270 £895
Bradley Oscilloscope Calibrator 156 £295
Bled Termialine, 2.5kW 500 £995
Philips Function Generator PMS134 £995
Hitachi Oscilloscope V222, 20MHz £249
Rapid Oscilloscope 7020, 20MHz £249
Philips Pulse Generator PM5176 £495
Amprobe AC Recorder LAV3X £75
Amprobe Temperature Recorder LTA £75
Emerson UPS 1.5kW £599
Marconi LCR Bridge TF2700 £149
Marconi LCR Bridge TF1313A £125
Mahogany Cassed S4V Megger £40
Taylor Valve Tester 474 £59
Philips RF Generator PM5326 £395
Philips Frequency Counter HP0340 £595
Taylor AM/FM Generator 62A £69
Marconi Attenuator TF2163 £119
RE Mega-Ohmmeter/phiC £75
Amprobe 100MHz £145
Instron £165
Leader LMV 181A AC Millivoltmeter £150
Farnell PSU 0-70V 0-30V 0-10A £90
27 VAC 30A Transformer New £25
12 VAC 200 Watt Transformer £24.99
Black Star Multimeter 3225 £55
Farnell PSU 0-70V 0-30V 0-10A £175
12 VAC 200 Watt Transformer £15
27 VAC 30A Transformer New £15
Tieng Labs 1Ms 16 bit ISA SVGA Card £16.75 c/p 4.00
Philips PM 3240. 50 Mhz. Scope DiTrace £165
Philips PM 3233 10 Mhz DiTrace Scope £66
Leader LVM 181A AC Millivoltmeter £145
Racal Inst. 9915 UHF Freq: Meter 500Mhz £100
Racal Inst. 9916 UHF Freq: Counter 500Mhz £145
HP 8413A Phase Gain Ind. £390
HP 7475 B Pen Plotter RS232 £55
HP Colour Pro 8 Pen Plotter RS232 £75
HP 7470A Plotter HPIB £95
Compaq 14" Mono VGA (Paper White) Refurb: 720 x 400 Text £29.50
640 x 480 Graphics £77
Roland DX YX X 980 A 8 Pen Plotter. Needs PSU £60
Roland DX YX X 980 A 8 Pen Plotter. Needs PSU £60
14" VGA Colour Monitors. Various makes from £75
PLOTTERS * COMPUTERS * COMMUNICATIONS * PSU * VDU'S * VIDEO * FANS * TEST * CABLE * NETWORK * PRINTERS * DISK DRIVES ALWAYS IN STOCK. OVERSEAS ENQ. WELCOME. TELEPHONE ORDERS ACCEPTED. C/P DETAILS PLEASE RING. ALL PRICES PLUS 17.5% VAT.

One stop solutions for all your radio telemetry module needs.

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

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

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

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

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

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

Once a component is packaged, it is notoriously difficult to check the integrity of the package's content. Steve Martell describes a new ultrasonic defect detection method that allows surprisingly detailed board inspection.

The term 'hidden internal defect' has particular meaning to companies who manufacture or mount plastic integrated circuit packages. Hidden defects are defects in, or related to, the physical structure of the package; they include delaminations, disbonds, voids, cracks, and the like. They cannot be seen optically, and few can be detected by x-ray. Still, it is vital to find these defects. They frequently worsen due to thermal cycling, causing the system they are installed in to fail unexpectedly. In short, hidden internal defects are flaws just waiting to turn into field failures.

Understandably, much research has gone into the characterising of the numerous types of hidden defects which may be lurking in an IC package. Delaminations in the die attach material are one type. Military and commercial specifications generally state, for example, that small delaminations in the die attach are not sufficient cause to reject the IC package — unless the delaminations happen to be at the corners of the die. Even small corner delaminations, experience has shown, will grow because of the stresses located there. Eventually they detach so much of the die from the die paddle that heat sink capability is lost. The die then overheats and fails.

Other hidden defects — die face delaminations of the molding compound, for example, or voids in the underfill near a flip-chip bump — are considered lethal in virtually all applications.

The sound option

Acoustic microscopes are by far the most useful tools for finding and characterising hidden internal defects. Almost all such defects consist of gaps in material, and very-high-frequency ultrasound is extremely sensitive to gap-type defects.

Failure analysis laboratories use acoustic microscopes to image the interior of IC packages for 'popcorn' cracks, lead frame delaminations, voids (bubbles) in the molding compound, cracked die, and many other defects. Some defects are imaged even though they do not consist of gaps: tilted die and irregular distribution of filler particles in the molding compound epoxy are two examples.

Finding hidden defects as early as possible in the production process is important to makers and users of IC packages. Failure analysts therefore often look at packages fresh from the mold machine which has encapsulated the die-lead frame assembly in epoxy. But failures can occur at many points in production, and it is not unusual for a manufacturer to be faced with a large quantity of populated boards some of whose IC packages are known to harbour hidden defects. This is a very significant inspection problem; no one wants to remove all of the packages from all the boards and submit each package to acoustic inspection.

A scanner for board-level inspection

A new system performs acoustic microscopy inspection on IC packages while they are still mounted on the board. It handles different types, sizes and elevations of IC packages on the same board, and can also image ceramic chip capacitors and some types of resistors.

The system operates automatically, can handle any number of components per board, and can handle two-sided boards. Its output shows both good and bad components and the locations of internal defects. Sonoscan, Inc. of Bensenville Illinois, the firm which developed and manufactures the system, call it UltraBoard.

Observing the system in operation, you see the board being inspected resting in a shallow water bath; a fluid is necessary to acoustically 'couple' the components to the transducer above the board, since very-high-frequency ultrasound does not travel through air.

The transducer is guided by software which has learned the coordinates of each IC package or other component it will inspect. Following this route, the transducer arrives at each component and then, because components are sometimes not placed precisely, uses ultrasound to find the actual location of the component. It then spends about 15s scanning the component.

As the head scans, very high frequency
ultrasound - generally between 10MHz and 100MHz - is beamed into the component. The return echoes from the interior of the component are collected by the same transducer for analysis.

When ultrasound is emitted by the transducer, it travels through the water couplant and enters the top surface of the IC package beneath the transducer. The speed of ultrasound through the various materials inside the IC package varies from about 3000m/s to about 9000m/s.

In a typical IC package, ultrasound travels first through the epoxy at the top of the device, and then encounters the face of the die. At this point some of the ultrasound is reflected back to the transducer, which has already switched over to its receiving mode. Data in this return echo is used to image the die face. At the same time, some ultrasound passes downward into the die itself, where it successively encounters the die-to-die attach interface, the die attach material itself, and the die attach-to-die paddle interface. Each interface in turn sends its return echo back to the transducer.

Returned signal
Each echo arrives back at the transducer bearing a given amplitude, or intensity, as well as polarity information. Polarity describes the change in acoustic velocity between two successive materials. If the ultrasound passes from a material of lower acoustic velocity to a material of higher acoustic velocity, the polarity change is positive; if the reverse, the polarity change is negative.

If no defects are present in the IC package, the pseudocolor image which appears on the monitor will show the die, the die paddle, the lead frame, and any other normal internal features. If a hidden internal defect is present, though, something quite different occurs.

Suppose there is a delamination at the top of the die, between the die surface and the molding compound. When ultrasound strikes this...
delamination - which is a gap - all of the ultrasound is reflected back to the transducer. Just as very-high-frequency ultrasound will not travel through air, it will not travel across an internal gap. The thickness of the gap is unimportant; if two internal layers are in contact but not bonded, all of the ultrasound is still reflected.

The amplitude of the echo returned from a gap is of course high; this is a very energetic echo. The echo also contains its own polarity information. As the transducer scans back and forth over the area of the IC package, it is collecting data points from hundreds or thousands of return echoes, including those echoes returned by gap-type defects at interfaces or in the bulk of a material. The data points are assembled electronically to produce the visible CRT image of the interior of the IC package, and to analyse the package in various ways.

The echoes returning from the interior of the package are also separated in time as they arrive back at the transducer. In most applications, the echoes are electronically gated to accept echoes only from a defined level within the package and to ignore all other echoes. The die attach, for example, may be a suspected location for defects such as voids or delaminations.

Return echoes are then gated to accept echoes from the bulk of the die attach material and from the two interfaces at top and bottom of the die attach material. In other situations, gating may be wide or narrow, depending on the thickness of the zone to be inspected. Multiple gates - die face plus die attach, for example - can also be used.

And for smaller defects...

In addition to large defects, such as a delamination covering the entire face of a die, very-high-frequency ultrasound is capable of imaging very tiny defects and of detecting even smaller ones. Ultrasound of 100MHz, for example, is used analytically to map the distribution of individual filler particles in molding compounds.

Sonoscan has recently developed and introduced a long-reach transducer which puts out ultrasound at the very high frequency of 180MHz. This transducer was specifically designed to image the solder bumps and underfill which lie beneath the die in flip-chip devices. Its resolution is so good that it has imaged voids and cracks in the interior of individual solder bumps.

Output methods

Information from a board whose components have been scanned by the system takes several forms. The acoustic representation of each image is stored; this image is not normally viewed, but is available for analytical purposes if it is needed.

If a defect is present, the data is also used to perform an area analysis of the defect. The analysis is based on definitions set up by the user of the system. A die attach delamination, for example, may be acceptable if it covers less than a given percentage of the die attach area, or if it is in a given location, for example, anywhere other than a corner. Similar definitions can be set up for die face delaminations, cracks in the molding compound, delaminations along the lead frame, and numerous other defect types.

Software can sort the components on the board into any defined number of accept/reject categories. Often three categories - accept, marginal, and reject - are used, because this gives the user the opportunity to examine the images of marginal components before making a decision about rework.

The system also prints out a table for each board, showing the location of each inspected component and its accept/reject status. The table then travels with the board as a guide to the rework which will transform it into a defect-free board.

Sonoscan, Inc. is at 530 East Green St, Bensenville IL USA 60106, phone: 630 766-7088, Fax: 630 766-4603, E-mail: sonoscan@worldnet.att.com.

The Art
Of In-Circuit
Emulation

Contact us now for comprehensive information on the Hitex range of state-of-the-art microprocessor tools.
Hitex (UK) Ltd. Tel: 01203 692066 Fax: 01203 692131
Email:sales@hitex.demon.co.uk
Composer: 100546, hitex
954 CIRCLE NO. 139 ON REPLY CARD December 1996 ELECTRONICS WORLD
Cooke International Services

SANTA'S STOREHOUSE
for all your
TEST EQUIPMENT
also
OPERATING AND SERVICE
MANUALS
plus accessories

SEND FOR LISTS OF EQUIPMENT AND MANUALS

Our Elves await your calls on
(+44) 01243 545111 or 545112
or Fax: (+44) 01243 542457

ALL PRICES EXCLUDE VAT AND CARRIAGE
DISCOUNT FOR BULK ORDERS. SHIPPING ARRANGED
OPEN MONDAY TO FRIDAY, 9.00 am to 5.00 pm

Cooke International

ELECTRONIC TEST & MEASURING INSTRUMENTS
Unit Four, Fordingbridge Site, Main Road, Barnham
Bognor Regis, West Sussex, PO22 0EB

U.K.
Ian Forster has found that AC logic gates can be used to form simple, cheap yet repeatable rf oscillators.

In a recent article in Electronics World I showed how 74AC series logic gates could be used in power conversion and switching applications. This article makes use of another useful feature of this logic gate series — namely their fast response speed and low propagation delay — to implement a series of vhf oscillators ideal for the experimenter.

All the following circuits have been tried with dual-in-line parts from different manufacturers and have proved very reliable. Good vhf construction techniques need to be used, as, linearly biased, the gates act as high-gain high-frequency amplifiers.

Most of the following circuits would not be well suited to battery powered applications. They tend to be current hungry. In addition, care must be taken when using multiple gates in one package not to exceed the maximum dissipation limits — 74AC gates are tough, but not indestructible.

**Ring-of-three oscillator for high frequencies**

AC gates can be used to produce a high-frequency equivalent of the standard ‘ring-of-three’ type oscillator. Again, operating frequency is controlled by varying the supply and hence the propagation delay of the gates. Power output is approximately 8.3dBm at 2V and +17dBm at 5V, with the third harmonic at −10dBc and the fifth at −16dBc, corresponding to +1.5dBm at 417.5MHz.

**Oscillator for vhf**

This is the simplest implementation of a vhf oscillator using a single inverter from a 74AC04. Oscillation occurs at the frequency at which the delay of the gate is equal to 180° phase shift. Output frequency is controlled by varying the supply, and hence varying the propagation delay of the gate. Power output is approximately +6.5dBm at 2V and +16dBm at 5V, with the third harmonic at −16dBc (corresponding to −4dBm 840MHz at 5V).
Oscillator uses coaxial cable

For a given supply voltage, the oscillator here gives good performance as a fixed frequency source. Operating frequency is determined by a combination of the delay in the coaxial and the propagation delay of the gate. Using a 5V supply power output was constant at approximately +16dBm.

RG174U COAXIAL CABLE

DC oscillator

For a more compact oscillator the circuit is more suitable. This is a fairly standard LC type oscillator, with the output frequency being a function of the inductance, stray and wanted capacitance and gate delay. With L at 39nH and C at 1.5pF, measured noise was -90dBc/Hz at 10kHz offset with an associated +17dBm output.

<table>
<thead>
<tr>
<th>L1 (nH)</th>
<th>VC1 (pF)</th>
<th>o/p (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>6</td>
<td>143.1</td>
</tr>
<tr>
<td>68</td>
<td>1.5</td>
<td>159.4</td>
</tr>
<tr>
<td>68</td>
<td>–</td>
<td>166.4</td>
</tr>
<tr>
<td>39</td>
<td>6</td>
<td>180.9</td>
</tr>
<tr>
<td>39</td>
<td>1.5</td>
<td>190.7</td>
</tr>
<tr>
<td>39</td>
<td>–</td>
<td>197.9</td>
</tr>
</tbody>
</table>

Oscillator for 2m band

An LC voltage-controlled oscillator designed to cover the 2m amateur band, can be formed from AC gates, when used with a synthesiser IC such as the National Semiconductor LM1501A. High output level of the oscillator makes it well suited to driving a level 17 double balanced diode mixer. This, with a high intermodulation performance front-end amplifier, such as the MAVII from Mini Circuits, could form a high immunity receiver front end for cluttered signal environments.

Crystal oscillator

This is a fifth-overtone crystal oscillator based on the 74AC04. It runs near series resonance and provides a stable output at high level, rich in harmonics. Typically, this would be used to form the basis of a low power vhf/uhf transmitter or, with filtering, as a vhf/uhf local oscillator for a receiver. Addition of a varactor diode, coupled via an appropriate capacitor, across C3, using a resistor to bias it, allows a degree of tuning.

And at uhf

To complete this collection, (a) and (b) here show two oscillators designed to operate in the uhf band. In (a), C1 provides feedback from output to input and, due to its low value, suppresses vhf oscillation, with R1 biasing the gate into its linear mode. Inductor L1 and the variable capacitor provide a variable phase shift to control the oscillator frequency. In (b), R1 again places the gate in its linear mode but the feedback is a combination of C1 and a 418MHz band surface-acoustic-wave resonator device, as used in key fob transmitters for car alarms.
Hart Audio Kits and Factory assembled units use the unique combination of circuit designs by the renowned John Linsley Hood, the very best audio components, and our own engineering expertise. This gives you maximum performance and unbelievable value for money.

We will put the kit in your home construction to professional standards, even in the sleizes we were using electronic components which many when HI-FI these days were still using bakgord. Many years of experience and innovation, going back to the early Kodak and Bailey electronics gives us incomparable design background in the needs of the home constructor. This simply means that building a Kit is a real pleasure, resulting in a piece of equipment that not only saves you money but you will be proud of.

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 any subsequent kit purchase.

'AUDIO DESIGN' 80 WATT POWER AMPLIFIER.

This fantastic John Linsley Hood designed amplifier is the flagship of our range, and the ideal powerhouse for your ultimate hi fi system. The amplifier ready for you to mount in a suitable sub-woofer cabinet.

The combined unit comes as a ready-to-fit unit on a solid steel aluminium frame/hutchon. Input signal can be at line or speaker level for easy system integration. There are three separate input levels available and the unit will suit any powered speakers that have an input to add bass to any signal. The speaker input level is achieved by simply wiring the input parallel to the unit in series with the existing speakers. Inter-connection can be achieved by a simple x 300mm cable. The amplifier will be pre-wired to supplied length and position will be ready for instant use.

The ASM 100 module comes as a ready-to-install unit on a solid steel aluminium frame/hutchon. Input signal can be at line or speaker level for easy system integration. There are three separate input levels available and the unit will suit any powered speakers that have an input to add bass to any signal. The speaker input level is achieved by simply wiring the input parallel to the unit in series with the existing speakers. Inter-connection can be achieved by a simple x 300mm cable.

The ASM 100 module, complete with IEC mains lead, instructions and ASW - W20 cabinet drawings. Pt. No. V7000 aud £58.39

W2005 20cm. (8") Woofer. Long throw unit with rubber surround and extended rear pole for maximum excursion high temperature voice coil. Ideal for use in mids or midrange or midspeakers in 3-way systems. 6ohm. £18.00

NQ4 Protective Metal Grille. £3.20

SC5 10mm. Magnet. Magnetic shielded tweeter. Linear frequency response response from 4,000 to 30,000Hz. Cabinet cutout diameter 35mm. 6ohm. £8.77

DT5.10m Poly carbonate Tweeter. High efficiency horn tweeter for use over 4,000Hz. Very good performance. £8.37

**VISATON® SPEAKER KITS & DRIVE UNITS**

New to the UK, VISATON offer a range of speaker kits and drive units that give the home builder access to units and designs that are unrivalled for quality, performance and value. Their designs are very well known in Germany, where they are based, and over 25 years they have built up an international reputation for exceptional products. In the UK, VISATON has been producing speakers and accessories for hifi and car use. There is a wide range of drive units from 15" woofers to ribbon tweeters. Speaker design software and database are available for the home user who wants to try his hand, or for commercial manufacture. A small selection follows, our kits will give you more.

**AMO100 ACTIVE SUBWOOFER MODULE**

ASW W300 cabinet drawings. Pt. No. V7000 aud £58.39

**NEXUS 100 Module, complete with IEC mains lead, instructions and ASW - W20 cabinet drawings. Pt. No. V7000 aud £58.39

**FIESTA 30 LOUDSPEAKER KIT**

An Ultra High Efficiency speaker, specially suitable for Valve Amplifiers.

For Valve Amplifiers, specially selected as the ideal partner for the new John Linsley Hood 15W Valve Sound Amplifier, or indeed any actual valve amplifier, the FIESTA 30 features the astonishing efficiency and sensitivity needed to achieve a satisfying performance from valve amplifiers of limited power output.

To complement the sound purity of such amplifiers a full three speaker system is used with a 320mm (12") woofer, 250mm (10") midrange and high frequency horn tweeter in a valved bass reflex enclosure. All these drive units have been carefully selected for their individual virtues, and collective excellence, the tweeter for instance being a high end unit with exceptional pulse response as a result of its combination of Kapton former, aluminium diaphragm and aluminum voice coil.

Nominal Power Rating is 150W. Max. Power 250W, impedance 8 ohm, Main Sound Module £159.00.

Speaker kit comes with all parts to make up complete sets, but not the cabinet parts. Cross-over units are factory assembled, ready to fit.

Kit No.LK9063 Per Pair. £423.53

**NONE CINEMA SPEAKERS.**

The VISATON range of speaker kits includes all you will ever need for your home cinema. The VISATON 80 is an ideal as a super luxury pair of stereo/main speakers. The Centre 60" uses an electro magnetically screened driver to avoid picture disturbance and a pair of Effect 80s are used as rear speakers. Any of a range of subwoofers then adds weight to the sound of the low end. Centre 80 Kits include drive units, crossover, terminals and grille. If you make the box! Price each.

Effect 80, Rear Speaker Kits, per pair £4.50

Send for your FREE copy of our LISTS 24 hr. ORDERLINE 01691 652894 Fax 01691 662864 All Prices include UK/EC VAT.

**CIRCLE NO. 141 ON REPLY CARD**
Edward Forster investigates the performance of Archie Pettigrew's award-winning amplitude-locked loop demodulation technique in both AM and FM receivers.

The amplitude-locked loop, or ALL, was not described as an automatic-gain system, but it clearly is a distinct form of one. Generally, agc systems use gain-controlled amplifiers, i.e. multipliers, with a logarithmic or semi-log law to obtain large dynamic range. The dynamic range of an ALL with linear multiplier is described as 26dB. Automatic gain control is rarely used to entirely suppress the amplitude modulation, but this is only a matter of bandwidth. It is true that the ALL outputs the reciprocal of envelope amplitude together with a fully compressed envelope signal within its operating range. But how useful this is remains to be seen.

Demodulating AM

The ALL is used here to provide a constant envelope signal to the demodulator which is of the square law carrier recovery type using a phase locked loop, or pll. This might be exceptional were it not for the claims made for this circuit. This is certainly not an advance in the art nor is it an optimum system. The ALL is said to provide special features which cannot be met by a limiter.

At threshold levels, I suggest that a soft limiter having a gain of 26dB put in place of the ALL would yield identical results. This is because at the end of its range, the ALL also has a constant gain of 26dB and it would be impossible to distinguish between the two. At high carrier levels it also makes no difference which is used.

The subsequent pll shown in the circuit as the carrier recovery device is not an optimum type. This is a common mistake. It raises the question of what the point of the system is in the first place. The problem of AM full carrier reception in conditions of multipath interference and doppler shifts - such as found on the hf broadcasting bands - was successfully solved in the Liniplex F1/2 receiver made by Phase Track Limited throughout the eighties. This used a synchronous pll AM demodulator at intermediate frequency in a superheterodyne receiver.

Figure 1 shows the pll carrier recovery system of that receiver which is a type II system, i.e., it contains two perfect integrators these being an active integrator and the voltage controlled oscillator (vco). In servo parlance this is known as a proportional plus integral feedback loop. Although this is well known some of its characteristics as applied to this problem are apparently not well known.

Figure 1b shows that the active filter can be redrawn as the equivalent sum of the proportional 'P' component and the integral 'I' component. This allows you to see more clearly what happens. Figure 2 is the idealised response to a step offset of the vco. The 'P' component has a fast response but it eventually returns to zero. The 'I' component response is to gradually ramp towards the final control voltage needed.

When the response subsides, there is zero static error in the system. The loop may be opened without any effect. The same thing results if the input carrier also disappears for some time during a fade. The loop remains essentially locked and can provide the necessary carrier for effective synchronous demodulation of sidebands to continue undisturbed. When the carrier returns there is no re-locking as the loop never lost lock.

Another feature of the type II pll is that it offers the freedom to optimise the loop bandwidth without any restriction other than that the loop should follow any doppler shifts and vco drift. In the type I loop, setting the bandwidth correctly can result in the hold-in range of the pll being too small for practical use. It is also necessary to have as small a loop bandwidth as possible. This is to prevent the control signal from frequency modulating the vco within the modulation band as this produces distortion.

Many such pll AM demodulators have appeared in up-market broadcast receivers. But because of this distortion, their audio quality was indistinguishable from the conventional envelope demodulator.

Fig. 1. Carrier recovery by type II PLL; b) equivalent to a).
The Costas loop

However, for the future, another old system brought up to date is preferred; this is the Costas loop\(^1\)\(^2\), Fig. 3. It is suitable for AM full carrier or double sideband, or DSB, suppressed carrier reception. It relies directly on sideband information in the I, in-phase, and Q, quadrature channels which when multiplied together give an error signal.

The feedback error signal is intermittent in sound transmission and a special PLL is required. Again the type II loop serves the purpose as its, in principle, infinite memory capability allows the loop to stay in lock during modulation pauses. This time instead of acting from direct carrier phase information, it is the sidebands alone from which the virtual carrier phase is derived.

The great opportunity of the I/Q Costas loop is in I/Q direct conversion receivers where much of the former intermediate frequency processing can be equivalently replaced by on-chip audio processing whether analogue or digital. Multi-conversion superhet receivers can be replaced by direct conversion receivers with equivalent performance but at a far cheaper cost and lower power consumption.

Although the synchronous receiver produces optimum results and also allows for electricity saving DSB broadcast transmission, a simpler non-synchronous technique\(^6\) has been devised for the AM I/Q receiver. The superhetodyne is fast becoming obsolete.

Demodulation for FM

The hyperbole accompanying Pettigrew's FM demodulation circuit has in many ways obscured any real understanding of how it works. But, by separating the functions and using a simple test signal, its effectiveness can be clarified.

Figure 4 shows an unmodulated carrier of unit magnitude in the presence of an offset carrier of amplitude \(k\). It is clear that both amplitude and phase modulation are produced. When \(k\) is small, say below 0.1, the difference frequencies are nearly pure sinusoids in phase quadrature. With this information you can examine how the circuit performs with relative ease.

Figure 5 shows the simplified system. The PLL is assumed perfect as is the fm demodulator, which differentiates perfectly the phase modulation at its input. In being differentiated, the phase modulation is shifted by 90° to appear at the output of the fm demodulator, let us say for simplicity, as \(\cos a\).

Output from the PLL for small percentage amplitude modulation is also a cosine in-phase, say \(\cos a\). Again the final processing is the puzzle. As shown, there can never be cancellation however the amplitudes are manipulated. Therefore, at small values of carrier interference the system cannot work.

For large levels of interfering carrier it is necessary to use computer simulation. This is, in fact, not too difficult. Using numerical differentiation it was possible to simulate the large signal case with less than 2k of BASIC.

Results are as follows:

\[
\begin{array}{|c|c|}
\hline
k & \text{Improvement over PLL o/p in dB} \\
\hline
0.1 & 0 \\
0.5 & 1 \\
0.7 & 3 \\
0.8 & 6 \\
0.9 & 18 \\
0.95 & 0 \\
\hline
\end{array}
\]

That aside, the PLL frequency demodulator described by Pettigrew is fed from a constant carrier even at threshold. Presumably, it is considered that the best results will be obtained by simulating a limiter. But it is known that a limiter is detrimental to threshold extension in phase locked loops.

Schilling\(^7\) has noted that type II loops produce better threshold performance by virtue of the extra integrator. It is also shown\(^8\) that above threshold, a limiter is of no value and that near threshold it is positively damaging.

This is because, as the resultant carrier instantaneously falls to a low amplitude at the maximum rate of change of phase, the loop gain also falls to a low value. Consequently the loop does not track the rapid phase change and does not reproduce a sharp spike at its output. Maintaining full carrier level in all circumstances prevents this beneficial effect. Again we come back to the PLL design. Is it a type I or type II?

If a type II PLL were used for comparison in a receiver with slow agc but no limiter then any benefits may not look so great.

### References

Eight year EW index
Hard copy or disk

Includes over 600 circuit idea references

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

The computerised index of Electronics World magazine covers the eight years from 1987 to 1995 — volumes 94 to 101 inclusive — and is available now. It contains almost 2000 references to articles, circuit ideas and applications — including a synopsis for each.

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

Even though the disk-based index has been expanded significantly from five years to eight, its price is still only £20 inclusive. Please specify whether you need 5¼ in, 3.5 in DD or 3.5 in HD format. Existing users can obtain an upgrade for £15 by quoting their serial number with their order.

Ordering details

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

Postal charges on hard copy indexes and on photocopies are 50p UK, £1 for the rest of the EC or £2 worldwide. For enquiries about photocopies, etc, please send an sae to SoftCopy Ltd at the address below. Send your order to SoftCopy Ltd., 1 Vineries Close, Cheltenham GL53 0NU, tel 01242 241455, or e-mail at 100586.112@compuserve.com. Please make cheques payable to SoftCopy Ltd — not EW or Reed Business Publishing. Please allow up to 28 days for delivery.

SoftCopy can supply a complete index of Electronics World articles going back over the past eight years.

Eight

£2 each, excluding postage.

Indexes on paper for volumes 100 and 101 are available

Upgrade for 215 by quoting their serial number

Hat rate of £3 per article or 50p per photocopy are 50p UK, £1 for non-EC overseas orders.

£1 for overseas EC orders or £5 for non-EC overseas orders.

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

Send your order to SoftCopy Ltd., 1 Vineries Close, Cheltenham GL53 0NU, tel 01242 241455, or e-mail at 100586.112@compuserve.com. Please make cheques payable to SoftCopy Ltd — not EW or Reed Business Publishing. Please allow up to 28 days for delivery.
CIRCUIT IDEAS

Do you have an original circuit idea for publication? We are giving £100 cash for the month's top design. Additional authors will receive £25 cash for each circuit idea published. We are looking for ingenuity in the use of modern components.

WIN A TTI PROGRAMMABLE BENCH MULTIMETER

"High accuracy, resolution and bandwidth - performance beyond the capability of handhelds"

This high-performance bench multimeter could be yours in exchange for a good idea. Featuring a dual display, the 4.5-digit 1705 multimeter resolves down to 10µV, 10mΩ and 0.1µA and has a basic dc accuracy of 0.04%. Frequency measured is 10Hz to 120kHz with an accuracy of 0.01% and resolution to 0.01Hz. Capacitor and true rms measurements are also featured.

Recognising the importance of a good idea, Thurlby Thandar Instruments will be giving away one of these excellent instruments once every six months. This incentive is in addition to our monthly £100 'best circuit idea' award and £25 awards for each circuit published.

200MHz spectrum analyser displays to -75dB

Used with an ordinary oscilloscope, this circuit forms a spectrum analyser for the 0-200MHz range of frequencies. To simplify examination of the wanted frequency, span and centre frequency controls are arranged to make signals in the middle of the trace stay there as span decreases. Amplifiers A1 and A2 produce a sawtooth waveform, symmetrical about the 12V rail, which is amplified in A3 with control of amplitude for span and offset for centre frequency. The discharge goes to the oscilloscope as a timebase trigger.

Driven by the sawtooth, the Mini Circuits POS-400 voltage-controlled oscillator provides a linear voltage/frequency output over the

TTI PROGRAMMABLE BENCH MULTIMETER WINNER

Fig. 1

Complete circuit diagram of the 200MHz analyser, which will display inputs at -75dB.
Window detector has high input-impedance

Hysteresis at both upper and lower trip points and a high input impedance are the advantages of this detector, which uses only a dual comparator and a transistor.

There is little to say about the circuit shown but to give some formulae for trip points and hysteresis.

Lower trip point:
$$T = \frac{R_3}{R_1 + R_2 + R_3}$$

Lower trip point hysteresis:
$$H = \frac{R_3(R_1 + R_2 + R_3)}{E_0}$$

Upper trip point:
$$T = \frac{R_3}{R_1 + R_2 + R_3}$$

Upper trip point hysteresis:
$$H = \frac{R_3(R_1 + R_2 + R_3)}{E_0}$$

It is usually required that the hysteresis of both points should be equal, so:
$$R_3 = \frac{R_1 + R_2}{R_1 + R_2 + R_3}$$

If the hysteresis of the lower trip point is zero or negative, it may be that the circuit will oscillate.
$$R_3 \leq \frac{R_1 + R_2 + R_3}{R_1 + R_2}$$

W Dijkstra
Waalre
The Netherlands

Window detector has designable hysteresis at upper and lower trip points and, unusually, high input impedance.

180-380MHz range and drives the SLB-1 double-balanced mixer directly, signal input to the mixer coming via the low-pass filter.

After filtering by the Toko 272MT-1127F, mixer output is impedance matched to the NE605. This device converts down to a standard IF of 10.7MHz, the local oscillator being a SAW type. A voltage proportional to the log. of the internally amplified 10.7MHz if appears at pin 7 of the NE605 and is buffered in A4 to be used as the oscilloscope input. Symmetry of response is maintained by the CFSK ceramic filters, which also determine the bandwidth. A limitation is the fairly slow response of the output of the NE605. It is usable, but reduces the amplitude of the display at faster sweep rates. It may be that the ME625, which is pin-compatible and faster, would improve matters.

Glyn Roberts
Walsall

Spectrum of the local fm broadcast band, 88 to 108MHz, top, and 20MHz square wave, demonstrating sweep linearity, bottom.
SMALL SELECTION ONLY - EXPORT TRADE AND QUANTITY DISCOUNTS - RING US FOR YOUR REQUIREMENTS WHICH MAY BE IN STOCK.

Racal/Dana Signal Sources type TF2700 - £150.
Racal/Dana Modulation Meter type 9009 - 8 Mc/s - 1.5 GHz - £250.
HP Frequency Counter type 5340A - 18 GHz - £1000 - rear output £800.
HP Network Analyzer type 8407A + 8412A + 8501A - 100 Kc/s - 110 Mc/s - £500 - £1000.
HP Frequency comb generator type 8406 - £400.
HP3311A Function Generator - £300.
HP54200A Digitizing Oscilloscope.
HP540A + 746A AC Calibrator - £600.
FLUKE Y5020 Current Shunt - £150.
Tinsley Standard Cell Battery 56446 - £500.
FLUKE 1120A IEEE - 488 Translator - £250.
ROTEK 320 Calibrator + 350 High Current Adaptor AC - DC - £500.
TEK CT-5 High Current Transformer Probe - £250.
TEK2465A 350 Mc/s Oscilloscope - £2.5k + probes - £150 each.
TEK 1240 Logic Analyser - £400.
Marconi TF2440 Microwave Counter - 20 GHz - £1500.
Marconi TF2374 Zero Loss Probe - £200.
Marconi TF2370 - 30 Hz - 110 Mc/s 750 MHZ Output (2 BNC Sockets + Resistor for 500 MHZ MOD) supplied - £650.
Marconi MOD Sheet supplied - £650.
Marconi TF2091 noise generator. A, B or C plus filters - £100 - £350.
Systron Donner counter type 605413 - 20 Mc/s - 24 GHz - LED readout - £1k.
Systron Donner, storage memory - 100 Mc/s with A or B interface.
Simple, latching audio/visual alarm

A pulse of greater than 1V amplitude applied to this alarm circuit illuminates a led and activates a piezoelectric sounder. On the arrival of a pulse, the scr \(T_3\) triggers, lighting the led which, with the 2.2k\(\Omega\) resistor passes the scr’s holding current once it has triggered.

Programmable unijunction \(T_r\) and its associated components form a relaxation oscillator, enabled when \(T_3\) triggers, driving the mosfet and the sounder at a frequency and duty cycle dependent on the RC time constant and the gate voltage of \(T_r\).

Pressing the normally closed switch resets the alarm.

R. McGillivray
Ontario, Canada

Video switch transmits up to 1km on a twisted pair

This use of a pair of video switches gives true differential working to allow transmission of 100MHz on a twisted pair up to 1km.

This four-channel, differential input/output video switch was built for a computer-controlled security system, in which one of the 100MHz video signals had to be selected and transmitted 1km to control room.

Using two MAX4141 cross-point video switches confers the benefits of differential working, ±5V input and twisted-cable transmission. Terminating resistors of 50\(\Omega\) or 75\(\Omega\), depending on the type of cable in use, should be used at the inputs to avoid reflections, and the cable receiving end must be properly terminated.

Gain response is flat at 0.98 from zero to 100MHz.

Shyam Sunder
Kalpakkam
India

Table 1:

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0)</td>
<td>(X)</td>
<td>(X)</td>
<td>(X)</td>
</tr>
<tr>
<td>(1)</td>
<td>(0)</td>
<td>(0)</td>
<td>(1)</td>
</tr>
<tr>
<td>(1)</td>
<td>(0)</td>
<td>(1)</td>
<td>(0)</td>
</tr>
<tr>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
</tr>
</tbody>
</table>

\(\text{High-Z} \) or \(\text{Low-Z} \)
TOP QUALITY 19" rack cabinets made in UK by OPTEL. Our full ranges of keyboard, mouse, designer, smoked acrylic lockable front door, full height side panels & vertical dividers. Low cost & low dovered removable side panels. Fully adjustable internal fixing rails, ready punched for universal use. Each rack comes with a full set of brass keys plus ready mounted integral 12 way 13 amp fuse holder. These racks that allows even the most versatile of us all some way your design could be used. Rack height 23" option to order.

In this section we offer a wide range of fully tested and guaranteed peripherals which you order and build your own complete set up. Before you order please only require two side panels to stand singly or in multiple bays. Overall dimensions are 779 x 652 x 457 mm. Export: Rack 1 Complete with removable side panels £335.00 (G)

L根本 LONG HIVE - HIVE 19" Rack cabinets

Top quality 19" rack cabinets made in UK by OPTEL. Our full ranges of keyboard, mouse, designer, smoked acrylic lockable front door, full height side panels & vertical dividers. Low cost & low dovered removable side panels. Fully adjustable internal fixing rails, ready punched for universal use. Each rack comes with a full set of brass keys plus ready mounted integral 12 way 13 amp fuse holder. These racks that allows even the most versatile of us all some way your design could be used. Rack height 23" option to order.

In this section we offer a wide range of fully tested and guaranteed peripherals which you order and build your own complete set up. Before you order please only require two side panels to stand singly or in multiple bays. Overall dimensions are 779 x 652 x 457 mm. Export: Rack 1 Complete with removable side panels £335.00 (G)
Linear, 90°-180° scr trigger

When 90°-180° scr firing control is needed in an
scr-controlled power supply and a simple
capacitor filter is in use, this arrangement reduces
non-linearity of control characteristic near 180°,
where the slope of the sine wave is steep.

A comparator 741 compares the rectified output of
the bridge with the control voltage, its output falling
dge triggering a 555-based monostable to trigger
the scr. Firing angle now varies between 90° and 180°
for a control voltage varying from the peak of the
full-wave rectified ac to zero.

M Revathi, Ved Prakash and R Yogesh
Cat-Indore
India

Note:
1. All diodes are 1 N4007
2. All resistances are 1/4W unless specified

Pc tests rechargeable battery capacity

This little circuit and some software, plus
the pc, constitute a tester for rechargeable
batteries.

The circuit shown takes its power from the
pc's serial port, the voltages being set up in
software. Diode D1 holds the inverting input
of the op-amp to 0.6V so that a voltage over
1V from the battery, divided by R2,3, takes
the op-amp output high.

Resistor R1 discharges the battery at
100mA, the op-amp output going low when
the battery voltage falls below 1V. The C
program measures the time during which the
voltage is greater than 1V and, as soon as it
falls below this figure, calculates the battery
capacity and displays it on screen.

Yongping Xia
Torrance
California
USA

Listing for checking cells on the pc
#include <stdio.h>
#include <dos.h>
#include <time.h>
#include <comio.h>
define DISCHARGE_CURRENT 8.12
#define MCR 4
#define MSR 6
struct time t;

void set_port(uoid)
outportb(base_add1+MCR, 0x80);
return;
}
void dis_data(void)
long run_time, run_hour, run_min, run_sec;
run_time=(long)difftime(read_time, start_time);
run_hour=run_time/3600;
run_min=(run_time-run_hour*3600)/60;
run_sec=run_time-run_hour*3600-
run_min*60;
bat_time=DISCHARGE_CURRENT*(float)
run_time/3.6;
gotoxy(2, 1);
printf("Battery has %.2fmAH", bat_time);
gotoxy(1,24);
if (run_hour<10)
printf("0" );
printf("%d:", run_hour);
if (run_min<10)
printf("0" );
printf("%d", run_min);
if (run_sec<10)
printf("0" );
printf("%d", run_sec);

void main(void)
int read_data;
cIrscr();
set_port();
start_time=time(NULL);

while(!kbhit() DC. read_data!=0);
if (read_data-0)
gotoxy(1,24);
printf("Test is done");
getch();

PC-powered battery tester for
rechargeables. Program measures
discharge time and calculates capacity.

Yongping Xia
Torrance
California
USA

Listing for checking cells on the pc
#include <stdio.h>
#include <dos.h>
#include <time.h>
#include <comio.h>
define DISCHARGE_CURRENT 8.12
#define MCR 4
#define MSR 6
struct time t;

time_t start_time, read_time;

int & base_add1=0x3f8, base_add2=0x2f8;
double bat_time;

out portb (base_add1+MCR, 0x80):
delay(1888);
int read_port(void)
int data=(inportb(base_add1+MSR)D0H801/128;
return (data);
}
void dis_data(void)
long run_time, run_hour, run_min, run_sec;
run_time=(long)difftime(read_time, start_time);
run_hour=run_time/3600;
run_min=(run_time-run_hour*3600)/60;
run_sec=run_time-run_hour*3600-
run_min*60;
bat_time=DISCHARGE_CURRENT*(float)
run_time/3.6;
gotoxy(2, 1);
printf("Battery has %.2fmAH", bat_time);
gotoxy(1,24);
if (run_hour<10)
printf("0" );
printf("%d:", run_hour);
if (run_min<10)
printf("0" );
printf("%d", run_min);
if (run_sec<10)
printf("0" );
printf("%d", run_sec);

void main(void)
int read_data;
cIrscr();
set_port();
start_time=time(NULL);
gotoxy(68,24);
printf("Hit any key to quit")
bat_time=0;
doi
read_data= (read_port 0);
dis_data();
gotoxy(2, 1);
printf("Battery has %.2fmAH", bat_time);
}
while(!kbhit() DC. read_data!=0);
if (read_data-0)
gotoxy(1,24);
printf("Test is done");
getch();

ELECTRONICS WORLD
Applying magnetoresistance

With circuits examples including a sensor for the Earth’s magnetic field and an overcurrent switch for protecting igbts, Neil Chadderton demonstrates the layout of a typical magnetoresistive chip is shown in Fig. 1, and is for example the chip used in the ZMY20 sensor. Thin film stripes are a characteristic feature of a magnetoresistive chip. These stripes are made by photolithography and consist of permalloy, Ni$_{18}$Fe$_{19}$ - a magnetic material evaporated on an oxidised silicon wafer. The electrical resistivity of the stripes is changed by a magnetic field $H_y$ due to the magnetoresistive effect. The field $H_y$ causes a rotation of the magnetisation in the stripe, Fig. 2. Resistance $R$ of a permalloy stripe depends on the angle between the directions of electric current, $I$, and magnetisation $M$:

$$R = R_0 + \Delta R \cos 2\alpha,$$

where $\Delta R$ describes the strength of the magnetoresistive effect.

The maximum relative change of resistivity $\Delta R/R$ is approximately 2 to 3% for permalloy. The relationship between an external field $H_y$ and angle $\alpha$ is determined by the geometrical dimensions of the stripe and the magnetic anisotropy of permalloy. This is taken into account by introducing a field $H_0$ that represents the demagnetising and anisotropic field. One obtains,

$$\sin^2 \alpha = \frac{H_y^2}{H_0^2} \text{ for } H \leq H_0,$$

$$\sin^2 \alpha = 1 \text{ for } H \geq H_0.$$

The characteristic of a magnetoresistive stripe as a field sensor is:

$$R = R_0 + \Delta R \left[1 - \frac{H_y^2}{H_0^2}\right] \text{ for } H \leq H_0.$$

A linear characteristic of the magnetoresistive sensor is required to measure a small magnetic field. The linear behaviour of the magnetoresistive sensor is achieved by using a ‘Barber-pole’ geometry. The stripes in Fig. 1 are covered with aluminium bars having an inclination of 45° to the stripe axis. Aluminum has a low resistivity compared to permalloy. Therefore the Barber poles cause a change of the current direction. The angle between current and magnetisation is shifted by 45°, Fig. 3. The relationship between resistance and magnetic field is now,

$$R = R_0 + \frac{\Delta R}{2} \pm \Delta R \left[1 - \frac{H_y^2}{H_0^2}\right].$$

A linear characteristic of the sensor is given around $H_y^2/H_0^2=0$. The sign in this equation is determined by the inclination of the Barber poles, ±45°, to the stripe axis. The characteristic of a sensor with and without Barber poles is presented in Fig. 4.

The stripes of the magnetoresistive chip are arranged as a meandering pattern. They form a Wheatstone bridge which is subject to a magnetic field.

---

**Fig. 1.** Above, magnetoresistive magnetic field sensor chip photograph.

**Fig. 2.** Magnetoresistive effect depends on the angle between the direction of electric current $I$ and magnetisation $M$. A rotation of the magnetisation in a permalloy stripe takes place when a magnetic field in the $y$ direction is applied. Without an external field the magnetisation is along the $x$ direction due the shape of the stripe.

**Fig. 3.** Covering the stripe with ‘barber poles’ consisting of aluminium changes the direction of the current. This does not influence the direction of magnetisation.
shown schematically in Fig. 5. The applied voltage is $V_b$. Each half bridge consists of two resistors with different Barber-pole orientations. Voltage between the resistors of a half bridge changes upon application of a magnetic field. The resistance of one resistor increases, while the other resistor has a lower resistance due to the differing field characteristic. Adding a second half bridge with an opposite arrangement of Barber poles provides a Wheatstone bridge. Voltage difference $V_0$ is the output signal of the sensor. Each half bridge is trimmed to $V_b/2$ with an additional resistor in order to get an output voltage close to zero when no external field is applied. The trimming structures of the resistors in Fig. 1 mark off the meander stripes on the left and right side of the chips.

Operating conditions and parameters

The shape of the stripe and the anisotropy of permalloy only define an axis along the $x$-direction for the magnetisation without external field $H_y$. This means that in this state the stripe can have areas with a different direction of magnetisation (magnetic domains) and the sensor does not work in a stable way. A safe operation of the sensor is achieved by applying an auxiliary field $H_x$. This field defines the direction

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge resistance</td>
<td>$R_{br}$</td>
<td>1.2</td>
<td>1.7</td>
<td>2.2</td>
<td>kΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_0/V_B$</td>
<td>16</td>
<td>18</td>
<td>22</td>
<td>mV/V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>16</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Output voltage range</td>
<td></td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
<td>(mV/V)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
<td>(kA/m)</td>
</tr>
<tr>
<td></td>
<td>$V_{off}/V_B$</td>
<td>-1.0</td>
<td></td>
<td>+1.0</td>
<td>μV/V</td>
</tr>
<tr>
<td></td>
<td>$f_{max}$</td>
<td>0</td>
<td></td>
<td>1</td>
<td>MHz</td>
</tr>
<tr>
<td>Operating frequency</td>
<td></td>
<td></td>
<td></td>
<td>+3</td>
<td>(μV/V)/K</td>
</tr>
<tr>
<td>Temp. coeff. of offset</td>
<td>$TCV_{off}$</td>
<td>-3</td>
<td></td>
<td></td>
<td>$T_{amb}=-25...+125°C$</td>
</tr>
<tr>
<td>Temp. coeff. of bridge resistance</td>
<td>$TCR_{br}$</td>
<td>0.3</td>
<td></td>
<td></td>
<td>%/K</td>
</tr>
<tr>
<td></td>
<td>$TCS_V$</td>
<td>-0.4</td>
<td></td>
<td></td>
<td>%/K</td>
</tr>
<tr>
<td>Temp. coeff. of open circuit sensitivity $V_B=5V$</td>
<td>$TCS_I$</td>
<td>-0.1</td>
<td></td>
<td></td>
<td>%/K</td>
</tr>
</tbody>
</table>

Appendix B. Extract from the ZMY20/30, ZMZ20/30 magnetoresistive sensor data sheet. Most of these characteristics assume an ambient temperature of 25° and $H_x$ of 3kA/m.
of the magnetisation. The range of $H_y$ for safe sensor operation is determined by the strength of the auxiliary field. The safe operating area of the sensor is demonstrated in Fig. 6.

Field $H_{(tot)}=H_y+H_d$ determines the allowed field values for $H_y$, where $H_d$ is an external disturbing field in the x-direction.

There is no limitation for $H_y$ in the case of $H_{(tot)}<2.6kA/m$. A small permanent magnet is sufficient to create the auxiliary field. Where ZMZ 20/30 or ZMY 20/30 devices are used, the magnet can be glued on the sensor package. Another option is the ZMY20M which provides a very compact sensor including an integrated magnet, and is available in surface mount packaging.

The operating data sheet parameters of the Wheatstone bridge are referred to an input voltage $V_b=1V$, due to the linear relationship between input and output voltage in this region.

The sensitivity $S$ [mV/V/kA/m] of the magnetoresistive sensor is defined as the slope of the output voltage versus external field for $-1kA/m$ to $1kA/m$. This parameter depends on the geometry of the permalloy meander and the auxiliary field. The latter is demonstrated in Fig. 7 for $H_y=3kA/m$ and $H_y=6kA/m$. Note the small operating area in the case of $H_y=0kA/m$. A high sensitivity of the sensor leads to a small operating area for $H_y$.

The Wheatstone bridge is balanced without the application of an external field of $H_y<0.1kA/m$.

Fig. 7. Sensor output characteristic of ZMY20/ZMZ20. Sensitivity of the sensor can be controlled by applying auxiliary field $H_y$. This auxiliary field is necessary for sensor operation in a large field range, $V_o=f(H_y)$; $H_y$-parameter; $V_o$=const; $T_{amb}=-25^\circ C$.

Fig. 8. Overcurrent switch using ZMC20 for protection of power units.

Fig. 9. Sensor for revolution measurement.

December 1996 ELECTRONICS WORLD
In this case, output voltage of the sensor is close to zero at room temperature.

Deviation of the output voltage from zero is called the offset voltage \( V_{\text{off/V}_b} \) [mV/V]. The offset is caused by small geometric variations of the bridge which occur during the photolithographic process. The offset of the bridge is adjusted by laser trimming. The voltage output of each half bridge is \( V_b/2 \).

Bridge resistance \( R_{\text{br}} \) [%/K] of the magnetoresistive sensor depends linearly on temperature. The temperature coefficient of bridge resistance \( TCR_{\text{br}} \) [%/K] is positive. This is typical for metals. The temperature coefficient of sensitivity, \( TCS \) [%/K] of the sensor is negative for \( V_b=\text{const} \) (TCSv), because the strength of the magnetoresistive effect becomes smaller with increasing temperature.

In the case of \( /B=\text{const} \) (TCSI), when the sensor is powered by a constant current supply, the temperature dependence of the sensitivity is reduced due to the linear relationship between input and output voltage. A higher bridge resistance caused by a rise in temperature leads to an increased applied voltage, partly compensating the change of sensitivity.

The Wheatstone bridge cannot fully compensate the temperature dependence of the resistors. The temperature coefficient of offset voltage \( TCV_{\text{off}} \) [\( \mu \text{V/V/K} \)] is due to local changes of resistivity in the permalloy thin film and photolithographic variations. This characteristic of the magnetoresistive sensor limits the measurement of small magnetic fields in a wide temperature range, especially in the case of static fields. Two sensors can be selected having a comparable temperature coefficient.

Offset drift is partly eliminated by using the difference of the output voltages of both sensors. Another elegant way to avoid offset drift is to invert the direction of the auxiliary field, thus inverting the output voltage of the sensor. This can be done by small coils providing an auxiliary field that can change its direction.

Hysteresis of output voltage \( V_{\text{off/H/V}_b} \) [mV/V] describes the accuracy of the magnetoresistive sensor. The magnetisation of the permalloy stripe is not completely homogeneous. There are small areas of the meander, especially at the corners of the stripes, where the magnetisation is pinned and does not correctly follow the external field. The hysteresis is measured in a magnetic field loop, where \( H_y \) goes from \(-3kA/m\) to \(3kA/m\) and back to \(0kA/m\) (\(H_x=3kA/m\)). \( V_{\text{off/H/V}_b} \) denotes the shift of the offset voltage caused by this loop.

The maximum range of output voltage \( \Delta V_O/V_b \) [mV/V] is defined as the difference of output voltage for \( \alpha=0^\circ \) and \( \alpha=90^\circ \), where \( \alpha \) denotes the angle between current and magnetisation of the magnetoresistive stripe. This means that \( \Delta V_O/V_b \) represents the strength of the magnetoresistive effect. This parameter decreases with temperature and determines the sensitivity of the sensor.
Applications

Some examples of applications for magnetoresistive sensors are presented in the panel.

Figure 8 shows a ZMC20 current sensor being used as a basis for an overcurrent trip switch used to protect powerights within a motor driver system. The circuit reacts within 3µs to prevent latch-up related failure under transient/pulse conditions, and was built within a module measuring 35x20x25mm. An external 10kΩ preset potentiometer is required for offset adjustment. Supply voltage is +5V ±10% at 10mA; output is via an open-collector transistor rated at 1A, 20V; operating temperature range is 0 to 80°C.

Figure 9 provides a method for revolution measurement by reacting to a modulated magnetic field due to a rotating cog. The circuit gives a signal whose frequency is proportional to the rotational velocity of the cog, and a high level output for no rotation.

Figure 10 shows an application circuit for three-dimensional magnetic field observation. When the unit is enabled, it calibrates itself to the existing magnetic field of the earth, and then generates a warning signal if it is moved. The system employs three ZMY20 sensors – one for each dimension – and a c-mos e-prom microcontroller with an a-to-d converter. Similar circuits have been designed for automotive immobiliser/alarm systems that monitor the position of the vehicle by sensing the magnetic field of a movable permanent magnet. This magnet is necessary to shield the sensor from disturbing fields (generated by supply lines, car alternators, etc.) Supporting software for these systems is available on request.

Application outlines for the magnetoresistive sensor.

Measurement of Current – ac or dc

Detection of ferromagnetic objects

Measurement of angular position

Measurement of rotation velocity

Position sensing

Measurement of the Earth’s Magnetic Field
ACTIVE

A-to-D and D-to-A converters

Low-power a-to-ds. Fully operational on a 2.7V supply, Philips' TDA8766 high-speed a-to-d converter offers 10-bit resolution at 20Msamples/s, the TDA8790 giving 8-bit operation at 40Msamples/s. These devices dissipate 53mW and 33mW respectively and both have a standby mode at 4mW. Differential non-linearity (step-to-step variation) is ±0.25lsb and s/n ratio 47dB. Gothic Crellon Ltd. Tel., 01734 788878; fax, 01734 776095.

Dual dac. Maxim's MAX549 dual, serial 8-bit, voltage-output digital-to-analogue converter uses one 2.5-5.5V supply, taking about 150µA or under 1µA when shut down. Its interface operates at up to 10MHz and is compatible with 3-wire SPI, QSPI and Microwire standards. An input shift register is of 16 bits: eight for data and the rest for selection and control. There is an internal power-on reset to zero all registers. Maxim Integrated Products UK Ltd. Tel., 01734 303988; fax, 01734 305911.

Linear integrated circuits

Isolation amplifier. An isolation amplifier from Analog Devices, the AD215 features 1.5V rms isolation voltage, 120kHz bandwidth and -80dB thd. There is an uncommitted op-amp for input buffering or amplification, which drives low-impedances and has offset trim. The 115V dc power supply is on-chip and can provide 110mA for various front ends or transducers. Analog Devices Ltd. Tel., 01932 266000; fax, 01932 247401.

Memory chips

Folding rams. Framms are foldable, rigid-assembly memory modules, which means that you can fold them in two to maximise memory density or, to put it another way, to cram more in. EDI4G3232F and EDI4G3632F are 32Mb-by-32 and 32Mb-by-36 types respectively, both drums meeting the 72-pin smimm standard. They are direct replacements for existing modules. EDI (UK), Tel., 01276 472637; fax, 01276 473748.

Microprocessors and controllers

New 28 microcontroller. The 28 family is not yet for the chop, for Zilog has introduced new members, the Z86C02/02L02 which are 8-bit devices having 512byte of rom and 64byte of ram. Operating frequency is 8/16Hz and the supply is 3-5V for the C52, 4.5-5.5V for the E52 and 1.3-3.6V for the L version. There are 14 tio lines and five vectored prioritised interrupts from five different sources, 14 digital inputs at cmos level and a fast instruction pointer. Options include a software-enabled permanent watchdog timer and an oscillator taking RC timing, a crystal or ceramic resonator, LC tuning or an external drive. Gothic Crellon Ltd. Tel., 01734 788878; fax, 01734 776095.

PC/104 expansion. Industrial expansion modules from Arcom for machine and automation applications provide combinations of digital and serial i/o and have either built-in signal conditioning or an interface to the standard Signal-Conditioning System. The AM104 range is used with Arcom's PC/104 processor boards or any compatible host. There are four digital functions with combinations of 16 opto-isolated inputs and outputs or relay outputs, a 32-channel bit-programmable i/o and a model having four programmable comms channels. All come with a free driver library with its C source code. Arcom Control Systems Ltd. Tel., 01223 411200; fax, 01223 410457.

Communications controllers

Mitsubishi's M37733/4/5 are 16-bit microcontrollers meant for DECT and portable communications and featuring direct output external bus signalling and a 32kHz dual clock. These devices are based on the 7700 series core and have a cpu and bus interface. The M37734 runs at 25MHz to give 150ns cycle time. Incorporates 103 basic instructions and has 60kbyte of rom and 104kbyte of ram. Power supply is 2.7-5.5V. M37733/5 are compatible and also have three serial i/o and a 10-bit a-to-d converter. Gothic Crellon Ltd. Tel., 01734 788878; fax, 01734 776095.

Television components

Catav amplifiers. For cable television, Motorola has two hybrid amplifiers for 750MHz, the MWX7222/7226, giving from 24V and giving power gains of 27dB and 29dB, broadband noise figure of 6.5dB and good stability. Motorola. Fax, 01354 688248.

Closed-tolerance lasers. NEL's lasers are for use in the safe detection of toxic and flammable gases. For this purpose, the emitted wavelengths must be accurate to within ±1 nm, and wavelengths must be safe detection of toxic and flammable gases. For this purpose, the emitted wavelengths must be accurate to within ±1 nm, and wavelengths must be...
register. Its function in life is to convert a 622Mbs serial, 8-bit-wide input to 77Mbs parallel output. Power needed is 265mW from 3.3V, and there is a 6-synch input for data realignment and framing as part of the interface to the real world. Maxim Integrated Products UK Ltd. Tel., 01734 303393; fax, 01734 305511.

Optical devices
Quad photodiodes. ISQ204 photodiodes by Isocom consist of four low-power devices in the one package, each offering isolation resistance of 5x10^12 and peak differential voltage between input and output of 7.5kV. Drive current needed is 0.5mA for full output, at which level current transfer ratio is 50%, rising to 100% at 1mA. Output saturation voltage is 0.4V. Isocom Components Ltd. Tel., 01429 863609; fax, 01429 863581.

Passive components
High-value resistors. Philips' VR37 and VR68 series of high-value, high-voltage metal-glate resistors now meet all relevant standards, including VDE 0860 and BS 415. Temperature coefficients are under 200ppm. Values subject to the approval are 510KΩ-11MΩ, the full range being 100KΩ-220MΩ over the two ranges. Philips Components. Tel., 00 31 40 722790; fax, 00 31 40 724547.

Data line chokes. Surface-mounted, four-element chokes for the protection of data on lines in noisy environments are introduced by Siemens, giving up to 90% saving in space over leaded types. These chokes are primarily for the 50 basic access and 5FM multiplex interface of an ISDN system, but will find application in other areas as well, such as CAN buses in vehicles. Inductances in the range vary from 4 by 470μH to 4 by 4.7mH. A variety of characteristics is available for the different applications. Siemens plc. Tel., 01344 396313; fax, 01344 396721.

Audio products
Single-chip surround-sound codec. The first single-chip surround-sound codec to support Dolby Digital Surround (AC-3) and Dolby Pro Logic is available from Crystal Semiconductor. CS4226 contains 95dB stereo a-to-d converters, six d-to-a converters, each with its volume control (which only varies volume at zero-crossings to minimise clicks) a mono a-to-d converter and a Sony/Philips digital interface format receiver, the chip replacing up to nine earlier ICs. The SPPD40 receiver supports stereo pcm data and compressed 5.1 channel AC-3 and MPEG audio. Crystal Semiconductor Corporation. Tel., (USA) 001 512 442 7555; fax, 001 512 445 7581.

Connectors and cabling
Microwave connectors. Transrado has a range of coaxial terminations for commercial microwave equipment in SMA and N forms. Both types cover 0-3GHz, have resistance and impedance of 50Ω ±5%, are rated at 1W and exhibit a voltage standing wave ratio of between 1.08 and 1.2 over the frequency range. The type N has a peak power rating of 500W for 1µs and the smaller SMA 100W for 1µs. Transrado Ltd. Tel., 0181-997 8880; fax, 0181-997 0116.

Cabling wall sockets. HideOut multimedia wall outlets by AMP are a convenient method of hiding and protecting connections to mixed-media cabling in networks and telephone systems. The face plate is flat and almost flush with the wall and the cables enter the bottom edge, so being protected from furniture. The sockets use exiting AMO inserts for ST and SC fibre connections and Cat. 3 and 5 unshielded and shielded twisted-pair cables. They take four copper and two fibre cables or four fibre connections. AMP. Tel., 0181-9542356; fax, 0181-954 7467.

Displays
High-contrast lced. Using a black mask, Deniston has increased the contrast of transmissive lcdn to 100:1 in displays with bright led or fluorescent backlighting. The first available provides a total of 20 digits and 12 graphics symbols for use in consumer equipment, displays with red and green backlighting, allowing viewing in all lighting conditions from a distance of 5m. Results are similar to those from a vacuum fluorescent display, but with a lifetime of 50,000 hours. Deniston Perdix. Tel., 01959 700100; fax, 01959 700300.

13-in colour lcdn. NEC's NL12810/AC20-07 13in colour lcdn is meant principally for cad and desktop workstations, providing a high-brightness display to a resolution of 1280 by 1024. It is an active-matrix type working from rgb input, with built-in backlight and inverter and giving a good viewing angle. Vertical screen expansion (multiscan) allows images of different resolutions to fill the display. Sunrise Electronics Ltd. Tel., 01908 263999; fax, 01908 263003.

Filters
If filter for DECT telephones. An if wave-filter from Siemens takes up 30% less surface area than the QCC10 case; the B4539 measures 9.1 by 4.8 by 1.8mm.
offers a 1ms peak hold, dB and dBm readings and has a backlit display. Thurlby Thandar Instruments Ltd. Tel., 01480 412451; fax, 01480 450409.

High-voltage oscilloscope amp. Gould's DP9010 is a differential amplifier for floating, high-voltage measurement on a grounded oscilloscope. Its bandwidth is 0-80MHz and the differential Inputs are balanced to 1V; 20V; cmr with direct input is 70dB at 1MHz. Gould Instrument Systems Ltd. Tel., 0181-500 1000; fax, 0181-501 0116.

Interfaces

Keypad, driver micro interface. Rohm's BU9768K interface controller contains all keypad and I2C driver functions in one device, operating on a three-wire bus back to the microprocessor, which is relieved of lower performance. It handles much of the routine and can therefore be of lower performance. It handles much of the routine and can therefore be relieved of lower performance. It handles much of the routine and can therefore be relieved of lower performance.

Vibration sensors. Used with a zero base, the 41LF7101 vibration sensors by Monitran are certified by BASEFA as being safe for use in all hazardous areas and gas groups, being rated to EEx ia IIC 16. These piezoelectric devices with internal electronics give an ac output of 100mV/g and can be processed in a DIP plug-in mounted unit to give a 4-20mA current-loop signal. They are made in stainless steel and sealed, a choice of attachments for mounting being available. Monitran Ltd. Tel., 01494 816569; fax, 01494 812256.

Material

Anti-static plastic compound. TBA ECP is shortly to announce some new static-dissipating plastic compound that can be moulded and made in many colours, as opposed to earlier versions which have also been in any colour as long as it was black. Some of them were coloured, but only because they were moulded with additives which did not last. This new material is injection moulded ASS alloy with a resistivity of around 10^12 ohm/square, with the appropriate static decay characteristic. The company offers a moulding service. TBA Industrial Products Ltd. Tel., 01706 47718; fax, 01706 46170.

Literature

Programmable analogue, imp of San Jose, offers the Electrically programmable Analog Circuit Design Handbook, which describes these epac devices that are the analogue equivalent of field-programmable gate array. It also provides application notes and development tool details, with a collection of seminar reprint. Imp also offers Animal Magic, which is Windows-based design software for analogue and mixed signal epacs.

Drams on cd. A cd-rom from NEC provides all details on all NEC drams and srams, including 64M devices. NEC Electronics (UK) Ltd. Tel., 01908 691133; fax, 01908 670290.

Cleaning fluids. Since the more ferocious solvents formerly used to clean electronic assemblies are now banned under the Montreal Protocol, new ones are now appearing. Loctite, for example, has Loctite 7070 and Loctite 7063, both alternatives to 1,1,1-Trichloroethane. 7070 is for open tanks and brush use, drying in around two minutes and pervading the air with a scent of lemons, while 7063 dries in 15 seconds and is very good at cutting through oil; it has to be used in closed tanks and doesn't smell of lemons, so far as we know. Both types come in air-rechargeable aerosols, pump sprays, cans and drums. Loctite UK Ltd. Tel., 01707 821000; fax, 01707 821200.

Heat-shrink tubing. Methode offers ShrinkMate (why do so many people insert a capital half-way through a name?), which is heat-shrink tubing based on polymer thick-film silver ink technology to give efficient connections and eliminate emc problems on signal and power lines. The material is easily applied using a heat gun or oven and is meant for use on spliced cables or connectors.

Keylock switches. EAO offers a new range of multiposition keylock switches to the O4 Series of push-buttons. Bezels are round or square and the switches come in a variety of forms from three-position, 60° throw, to 12-position, 30° throw, with up to 16 contacts. EAO-Highland Electronics Ltd. Tel., 01444 236600; fax, 01444 236641.

Digital wattmeter. Yokogawa's W7130 is a three-phase wattmeter with three input modules for independent measurement on each phase. Bandwidth is 0-50kHz to allow measurement on pwm variable-speed drives. High-speed measurement is followed by calculation of effective power, apparent power, reactive power, power factor and phase individually and for the three-phase system. The instrument carries out 32-bit FFTs using a rectangular window and analyses harmonic content of voltage, current and power waveforms by amplitude and by phase to the fundamental. The W7130 has an RS 232 interface. Marton Instruments Ltd. Tel., 01494 459200; fax, 01494 535002.

Please quote "Electronics World" when seeking further information.
where it gives a circumferential seal round the cable shielding and the base of nearly every connector type, also obviating the need to solder braided cable shielding. Shielding rating of a connector so treated is 40-82dB over the 30-1000MHz range. Methode Electronics Europe Ltd. Tel., 01389 732123; fax, 01389 732777.

Printers and controllers
Fast thermal printer. Star Micronics TMP-200 is a high-speed device for ovens, it provides easy access to the head with a view to simple maintenance. It prints at eight dots/mm, at up to 1.5m/s and there are options of auto-cutter and interface boards. Paper feed is from the rear or bottom. Roxburgh Electronics Ltd. Tel., 01724 281770; fax, 01724 281650.

Production equipment
Ultrasonic cleaning. Since some of the cleaning agents previously in use are no longer available, some cleaning manufacturers are needed to give the same results with new, flammable solvents. Caresonics has new equipment for this purpose which enable these viscous-sounding solvents to be used harmlessly by providing interlocking lids, purging and venting, and automatic timing. Solvent is contained under the tank, is pumped in for use and then pumped out again before the lid can be opened. Heat is not needed. Care Ultrasonics Ltd. Tel., 0151-356 4013; fax, 0151-356 4037.

Vacuum cleaner. Among life’s minor irritations are items of equipment that have been computer-designed to be virtually impossible to clean, such as keyboards and cameras. Jessop, in an effort to ease the stress, have introduced the Mini Vacuum battery-powered cleaner kit, which also blows, possibly through various nozzles and brushes. It has a dust bag and an array of clothes, sprays, tissues and cotton buds to further the process. It costs £9.99 from Jessop Photographic Shops. Jessup Group Ltd. Tel., 0116-232 0033; fax, 0116-232 0066.

Power supplies
60V dc-to-dc. Elnit-shielded on all sides of an aluminium case, Amplicon’s RW Series of 50-60V dc-to-dc converters are current-mode types and dc-to-dc converters are the most efficient of 83% from 10-72V input. There are 48V models for telecoms use with case to positive, 24V ones for process control and 12V versions for use in vehicles. Single, dual and triple versions combine 5V ±12V and ±15V in various ways and the units have a remote on/off control. They switch at 300kHz, are isolated to 500V dc and are short-circuit protected, with an auto-start. Temperature coefficient is ±0.02%/°C, stability ±0.05%, ripple and noise 1% pk-pk and transient response 500us. Amplicon Liveline Ltd. Tel., 0800 525 335 (free), fax, 01273 570215.

Integrated power supply. Working without external components, National’s LM2625 is said to be six times more reliable than a psu module, provides a power density of 35W/in³ and meets Class B of CISPR 22 for radiated emissions. It handles inputs up to 40V and gives output of 1A from 3.3V and 5V at 80% efficiency and is protected against overvoltage, shorts and high temperatures. Avnet Access. Tel., 01462 480888; fax, 10262 488567.

Low-voltage Schottkys. New Schottky diodes from Philips are for use in 3V and 3.3V switch-mode power supplies and have a 0.33V forward drop at rated forward current. Low capacitance and no stored charge in nickel-silicide junctions make them suitable for high-frequency use. PBY11025ST is a single diode rated at 20A and PBY15125ST/2025ST dual types rated at 15A and 20A respectively, all withstand 25V reverse. Philips Semiconductors (Eindhoven). Tel., 03 30 41 2722901; fax, 03 30 41 274285.

New Klippon range. Weidmuller Klippon has a new range of psus, including switched-mode types and dc-to-dc converters, and with 60% efficiency at around 100W. It covers a large number of standards and CE marked. All the s-m types have short-circuit, thermal, overvoltage and inrush protection, universal ac and dc inputs and various of load units, including a 1A unit in an EG case, claimed to be the smallest available. Weidmuller (Klippon Products) Ltd. Tel., 01795 569099, fax, 01732 844444.

Minute 40W supply. XP’s NL40A is claimed to be the smallest emc-compliant 40W supply available, measuring 4.25 by 1.25 by 1.25in and meeting low-voltage Directives and EN65022 for conducted noise. The company ascribes its power density of 3W/in³ to a new type of switch-mode operation and a fixed switching frequency, together with a patented integrated boost flyback topology. Input is universal and nine models cover output of 5V single to 5V with ±15V triple. XP plc. Tel., 01734 845515; fax, 01734 843423.

Radio communications products
Broadband amplifiers. Advanced Control Components Inc. announces a range of ultra-broad-band and cable amplifier for mobile communications between 10MHz and 4000MHz. AGAM 8928 and 7932 both give 1W and are meant for use in link test or integration into test systems. Frequency ranges are 10-2500MHz and 100-4000MHz, both including the cellular, SMR and PCN/PCS bands. Gain of the 7932 is 36dB ±5dB, while the compact 7932 has a 24dB ±1dB gain. There are also three 10-octave amplifiers in rack-mount form covering 100-500MHz, 500-1000MHz and 1000-2000MHz. Anglia Microwaves Ltd. Tel., 01277 630000, fax, 01277 631111.

Protection devices
Shielded windows. Emc shielding for gloveboxes and other transparent areas is available from TBA ECP. Conductive coatings based on indium tin oxide are applied to glass or plastic such as polycarbonate and acrylic and give conductivity down to 102Ω/square and up to 80% transparency. Tearing exists to coat complex shapes and coatings can extend up to 350 by 320mm. The company also makes windows using fine wire meshes or metal oxide interlayers in laminated glass or plastic. TBA Industrial Products Ltd. Tel., 01706 477718; fax, 01706 46170.

Switches and relays
Miniature relay. A miniature, hermetically sealed relay from Finder, the Series 33, meets BT47 and BT51 specifications and is suitable for most telecommunications applications. It is rated at 250V ac for resistive loads and comes with 20mW (BT47) or 40mW coil voltages of between 5V and 48V dc. Two changeover contacts are silver-plated and power consumption is 125VA; maximum switching frequency is 600cycles/ch. AX Electronic Component Distribution. Tel., 01403 240055; fax, 01403 256567.

Relay Reed. CP Clare’s MVS Series of reed relays use the company’s M4H bounce-free, mercury-wetted reed switch and have a life of up to 10¹⁰ operations at low to intermediate levels. Contact resistance is stable at ±5Ω over the 100mΩ rated figure, maximum switching voltage 1kV and switching current 2A (carry current 3A). Several of the devices in the range are fitted with diodes as an option and one has an electrostatic shield. Clare UK Sales. Tel., 01823 352541; fax, 01823 352779.

Semiconductor relays. Matsushita would like to point out that its PhotoMos relays do not suffer from most of the disadvantages found in electromechanical ones or even thyristor or transistor types, while providing true relay switching. You can get versions to switch very low currents or up to more than 4A, with multiple contact arrangements of the n.o. or n.c. type. Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231559.
W9S keyboard. A new version of Cherry's keyboard, the Model 3000, works with Windows 95 and gives a better choice of "feel." It has 104 or 105 keys, two or three of them for Windows use, and the F and J keys are dished for touch typists, the 5 key on the numeric pad having a dimple for the same reason. A dil switch on the numeric pad having a dimple is dished for touch typists, the 5 key for the same reason. A dil switch on the numeric pad having a dimple is dished for touch typists, the 5 key for the same reason. A dil switch on the numeric pad having a dimple is dished for touch typists, the 5 key for the same reason. A dil switch on the numeric pad having a dimple is dished for touch typists, the 5 key for the same reason.

Bipolar Hall switch. Allegro offers the 3134 low-hysteresis, bipolar Hall-effect switch for automotive and industrial use. It has a novel Schmitt trigger built in which compensates for temperature changes to maintain trigger and release points. Further compensation is provided by magnetic switch points that become more sensitive with temperature. Also on-chip are a voltage regulator, a quad Hall generator, temperature compensation, an amplifier and a buffer and open-collector output stage. Allegro MicroSystems Inc. Tel., 01932 253355; fax, 01932 246622.

High-current relay. Matsushita's LK relay is designed to handle inrush currents of up to 200A. It permits rapid switching between coil and contacts to improve creepage, to give a 6mm clearance and to provide noise immunity. It measures 24 by 25 by 11mm, is rated at 5A, 277V ac and will withstand 10kV surge. Matsushita Automation Controls Ltd. Tel., 01908 231555; fax, 01908 231599.

Snap switches. Cherry has two new switches in its Snap Switch range. The D48 high-power microswitch operates at up to 10kV, has a current rating of 21A at 240V, long life and silver contacts, while the D2 type has a contact gap of over 3mm to take high inrush currents; this one switches continuous loads of 16A at 380V, with short-period overloads. Cherry Electrical Products Ltd. Tel., 01582 763100; fax, 01582 768883.

Sealed switches. C&K offers a range of sealed toggle, rocker and push-button switches, which are available with both through-hole and surface-mountings to withstand flow-solder, vapour phase and infrared reflow operations. All have ultrasonically sealed bodies, O-ring bases and epoxy sealed terminals. Roxburgh Electronics Ltd. Tel., 01724 281770; fax, 01724 281650.

Transducers and sensors

Optical encoder. HS Series optical shaft encoders by Control Transducers are of low cost and are meant for use on machinery for feedback and positioning. The range covers resolutions from 96 to 2048 lines per revolution in 16 models. The encoders measure from 1mm to 2in diameter with mounting plates and two ball bearings handle speeds up to 10,000rpm. Components such as cable, line drivers, power supplies are available. Control Transducers. Tel., 01234 217704; fax, 01234 217893.

Audible alarms. Kingsgate piezoceramic alarms operate from dc and provide the requisite racket while measuring only 13.8mm diameter, and even more racket from 42mm types. They come with flying leads or pins to standard formats, most of them being sealed for soldering and cleaning. Roxburgh Electronics Ltd. Tel., 01724 281770; fax, 01724 281650.

More audible alarms. Piezoceramic alarms from Fujij also make a very loud noise — 105dB from 5V rms and are only 2mm thick and use less power while doing it than many others. Connection is by flying lead, through-hole or surface mounted. Distributed Micro Technology Ltd. Tel., 01276 33391; fax, 01276 36703.

Current measurement. JJ Systems announces a range of flexible transducers for contactless current measurement, which take the form of air-cored, toroidal winding, the Rogowski coil. JJ Systems takes the form of a conductor carrying from 1A to 1MA to give an accurate waveform reproduction for oscilloscope or dvm; the coil is completed by plug and socket. Frequency range is 0.1Hz-1MHz with an accuracy within 1%. Sensitivity is insensitive to the position of the coil. JJ Systems Ltd. Tel., 01256 615111; fax, 01256 896100.

Software

Maths library. MathTools announces Matcom v.2 maths library, a C/C++ maths library having many features of its math functions, including basic unary and binary operations, indexing, signal processing, linear algebra and 2D and 3D graphics. Matcom is supported E-mail info@mathtools.com; fax, 001 215 957 1719.

Image analysis. Image-Pro Plus from Media Cybernetics, which runs on all Windows variants and Mac 7, provides accurate image processing and analysis of monochromic, grey scale and 24-bit colour images. It has a range of counting, sizing, statistical and image-enhancement tools and is meant to be used in any area where an image can help one to understand a process, to make comparisons or to identify objects. Examples are measuring areas, perimeters, roundness, population density, display measurements as histograms, calculate line areas; perform FFTs; read files from a camera, disk or cd. And a great deal more. DataCell. Tel., 01268 415415; fax, 01268 415400.

Virtual instruments. The result of cooperation between ComputerBoards Inc. and Hewlett-Packard brings together a range of data acquisition boards (ISA or PCI/ICIA) for the pc at low cost, and H-PS HP-VEE software, the total package enabling the design and realisation of virtual instruments at much lower cost than has been common. The software allows the creation of programs graphically rather than by writing code and will run existing C, Basic and Pascal programs; it supports hundreds of GP I and VXI plug-in instruments, all drivers being supplied. Adept Scientific Micro Systems Ltd. Tel., 01462 480055; fax, 01462 480213.
Designing reliable

In this second article*, Ray Fautley runs through the steps necessary to design a reliable half-wave rectifier psu.

In the conventional half-wave rectifier, alternating voltage is applied to diode D, where it is rectified and the output smoothed by the reservoir capacitor C. The fundamental frequency of the ripple voltage is the same as the supply frequency, Fig. 1.

The half-wave rectifier is mainly used for low-current supplies. This is because the dc load current flows through the mains transformer secondary winding. If this current is too high, it can produce saturation of the transformer core. This current thus lowers transformer efficiency.

Table 1. Using the percentage ripple voltage to find value X.

<table>
<thead>
<tr>
<th>V, %</th>
<th>X</th>
<th>0.1</th>
<th>0.3</th>
<th>1.0</th>
<th>3.0</th>
<th>5.0</th>
<th>10</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>1783</td>
<td>1784</td>
<td>1652</td>
<td>1602</td>
<td>1573</td>
<td>1502</td>
<td>1342</td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>855</td>
<td>814</td>
<td>807</td>
<td>791</td>
<td>776</td>
<td>739</td>
<td>654</td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td>565</td>
<td>556</td>
<td>525</td>
<td>513</td>
<td>505</td>
<td>481</td>
<td>432</td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>422</td>
<td>404</td>
<td>392</td>
<td>386</td>
<td>379</td>
<td>364</td>
<td>322</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>334</td>
<td>330</td>
<td>315</td>
<td>305</td>
<td>303</td>
<td>288</td>
<td>258</td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>278</td>
<td>274</td>
<td>261</td>
<td>257</td>
<td>253</td>
<td>243</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>241</td>
<td>236</td>
<td>221</td>
<td>219</td>
<td>216</td>
<td>211</td>
<td>186</td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>206</td>
<td>203</td>
<td>193</td>
<td>190</td>
<td>187</td>
<td>180</td>
<td>163</td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>186</td>
<td>183</td>
<td>171</td>
<td>168</td>
<td>166</td>
<td>160</td>
<td>145</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>164</td>
<td>159</td>
<td>155</td>
<td>152</td>
<td>150</td>
<td>144</td>
<td>131</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>81</td>
<td>80</td>
<td>76</td>
<td>75</td>
<td>74</td>
<td>72</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>53</td>
<td>52</td>
<td>50</td>
<td>49</td>
<td>49</td>
<td>47</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td>40</td>
<td>39</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>36</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>32</td>
<td>31</td>
<td>30</td>
<td>29</td>
<td>29</td>
<td>28</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>26</td>
<td>25</td>
<td>24</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td>22</td>
<td>21</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td>19</td>
<td>18</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>9.0</td>
<td>17</td>
<td>16</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>15</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>7.6</td>
<td>7.4</td>
<td>7.2</td>
<td>7.0</td>
<td>6.9</td>
<td>6.8</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>5.0</td>
<td>4.9</td>
<td>4.7</td>
<td>4.6</td>
<td>4.5</td>
<td>4.5</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>3.6</td>
<td>3.5</td>
<td>3.4</td>
<td>3.3</td>
<td>3.3</td>
<td>3.0</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>2.8</td>
<td>2.7</td>
<td>2.6</td>
<td>2.5</td>
<td>2.5</td>
<td>2.3</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>2.2</td>
<td>2.1</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>1.8</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>1.8</td>
<td>1.7</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.4</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>1.4</td>
<td>1.4</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.1</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>1.2</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>0.9</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>1.0</td>
<td>1.0</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>

*Ray's first article, in the September issue, ran through design steps for a full-wave bridge rectifier.

Design steps for a half-wave rectifier
1) Specify required dc output voltage at full load \( E_{dc\text{(load)}} (V) \).
2) Specify required maximum load current \( i_{load} (A) \).
3) Specify maximum ripple acceptable \( V_{ripple} (V) \).
4) Specify the ac mains supply voltage \( V_{ac\text{(rms)}} (V) \).
5) Specify the frequency of the ac mains supply \( f (Hz) \).
6) Determine the value of the equivalent load resistance \( R_L \): 
   \[ R_L = E_{dc\text{(load)}} / i_{load} \] 
   where \( E_{dc\text{(load)}} \) is the design value of the dc output voltage. This is the voltage across the load \( E_{dc\text{(load)}} \) added to the voltage drop across the rectifier diode: 
   \[ E_{dc\text{(load)}} + V_{rec} \] 
   and \( V_{rec} \) is the 0.9V drop across the rectifier diode.
   So: 
   \[ R_L = \frac{E_{dc\text{(load)}} + 0.9}{i_{load}} \]
7) Determine the average current through the diode, \( I_d \). As all the current must flow through the diode: 
   \[ I_d = i_{load} \]
8) Determine a value for the source resistance of the supply, \( R_s \). As only low-current supplies are being considered the...
rectifiers

resistance of the transformer windings will predominate. Thus: \( R = R_{sec} + R_{pf}/N^2 \)
If the transformer winding resistances are not known, assume that \( R_i \) is about 5% of \( R_{sec} \). Then: \( R_i = R_{sec} \times 5/100 \).

9) Calculate the ratio of \( R_i \) to \( R_L \) as a percentage: \( R_i/R_L \times 100\% = 5\% \), as assumed in (8).

10) Determine percentage ripple voltage from the specified maximum ripple voltage and the dc output voltage:
\[ V_{\%} = \frac{V_{(rms)}}{E_{dc(out)}} \times 100\% \]

11) From Table 1, determine the value of \( X \) required to provide the percentage ripple voltage, \( V_{\%} \) in (10) above, for \( R_i/R_L \% \) calculated in (9). If the figures for \( V_{\%} \) and \( R_i/R_L \% \) are not exactly the same as those found in the table headings, then the required value for \( X \) must be interpolated as described in (11) for the bridge-rectifier design procedure (September issue).

12) Calculate the value of the reservoir capacitor \( C \), required to provide the ripple voltage \( V_{(rms)} \) from:
\[ C = \frac{X}{2\pi f \times R_i} \times 10^{12} \mu F \]

13) Find the nearest standard value for the reservoir capacitor \( C \), close to or preferably just above, the value calculated in (12). If the value is different from that in (12), call it \( C_1 \) and determine a new value for \( X \) (call it \( X_1 \)) from:
\[ X_1 = \frac{2\pi f R_i C_1}{10^6} \]

14) From Table 2, determine the value of \( Y \) for \( X \) in (11), or \( X_1 \) in (13), and \( R_i/R_L \% \) in (9).

15) Determine the transformer secondary voltage \( V_{sec(rms)} \) required, from the value for \( Y \) in (14):
\[ V_{sec(rms)} = \frac{E_{sec}}{\sqrt{2} \times Y} \]

<table>
<thead>
<tr>
<th>( X )</th>
<th>( R_{sec}/C % )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>0.1</td>
<td>0.31</td>
</tr>
<tr>
<td>0.2</td>
<td>0.32</td>
</tr>
<tr>
<td>0.3</td>
<td>0.32</td>
</tr>
<tr>
<td>0.4</td>
<td>0.32</td>
</tr>
<tr>
<td>0.5</td>
<td>0.33</td>
</tr>
<tr>
<td>0.6</td>
<td>0.34</td>
</tr>
<tr>
<td>0.7</td>
<td>0.35</td>
</tr>
<tr>
<td>0.8</td>
<td>0.36</td>
</tr>
<tr>
<td>0.9</td>
<td>0.37</td>
</tr>
<tr>
<td>1.0</td>
<td>0.38</td>
</tr>
<tr>
<td>1.5</td>
<td>0.44</td>
</tr>
<tr>
<td>2.0</td>
<td>0.49</td>
</tr>
<tr>
<td>2.5</td>
<td>0.54</td>
</tr>
<tr>
<td>3.0</td>
<td>0.57</td>
</tr>
<tr>
<td>4.0</td>
<td>0.63</td>
</tr>
<tr>
<td>5.0</td>
<td>0.68</td>
</tr>
<tr>
<td>6.0</td>
<td>0.71</td>
</tr>
<tr>
<td>7.0</td>
<td>0.74</td>
</tr>
<tr>
<td>8.0</td>
<td>0.77</td>
</tr>
<tr>
<td>9.0</td>
<td>0.79</td>
</tr>
<tr>
<td>10</td>
<td>0.80</td>
</tr>
<tr>
<td>15</td>
<td>0.86</td>
</tr>
<tr>
<td>20</td>
<td>0.89</td>
</tr>
<tr>
<td>25</td>
<td>0.91</td>
</tr>
<tr>
<td>30</td>
<td>0.92</td>
</tr>
<tr>
<td>40</td>
<td>0.94</td>
</tr>
<tr>
<td>50</td>
<td>0.95</td>
</tr>
<tr>
<td>60</td>
<td>0.96</td>
</tr>
<tr>
<td>70</td>
<td>0.97</td>
</tr>
<tr>
<td>80</td>
<td>0.97</td>
</tr>
<tr>
<td>90</td>
<td>0.98</td>
</tr>
<tr>
<td>100</td>
<td>0.98</td>
</tr>
<tr>
<td>200</td>
<td>0.99</td>
</tr>
<tr>
<td>300</td>
<td>0.99</td>
</tr>
<tr>
<td>1000</td>
<td>1.00</td>
</tr>
</tbody>
</table>

where \( E_{sec} = E_{dc(out)} + V_{rec} \)
\[ E_{sec} \times 0.707 \times Y \]

16) Determine the peak voltage, or peak inverse voltage, that the rectifier diode must withstand. For the half-wave rectifier, the peak inverse voltage varies with the degree of load. The worst case occurs when the load is zero or very low.

Table 2. Using \( X \) and \( R_{sec}/C \) find the value of \( Y \).

Decimal 1996 ELECTRONICS WORLD 981

continued over...
25) Transformer volt-amp, or \( V_{VA} \) rating
\( V_{VA} \) decide size of the transformer:
\[
T_{A}=V_{vdc}\text{rms}V_{I_{rms}}
\]
26) Transformer requirements:
\( V_{VA} \) rating \( V_{VA} \) (25)
primary winding \( V_{pdc}\text{rms} \) (4)
secondary winding \( V_{sdc}\text{rms} \) (15)
secondary current \( I_{sdc} \) (24)
27) When a suitable transformer has been chosen, measure resistance of both windings. If measured source resistance:
\[
R_{ext}=R_{w}+\frac{R_{p}}{N_{p}^2}+R_{r}
\]
is less than \( R_{r} \) calculated in (8), then an external resistor \( R_{ext}=R_{r}+R_{b} \) must be added, see (28), to limit \( I_{r} \) to the value found in (20).
28) If external resistor \( R_{ext} \) was found necessary in (20) or (27) to be fitted between the rectifier and the reservoir capacitor \( C \) or \( C_{1} \) to limit the switch-on current to \( I_{max} \), its value will be:
\[
R_{ext}=\frac{V_{dc}\text{rms}}{I_{max}}-R_{r}
\]
29) Power \( P_{r} \) dissipated in \( R_{ext} \) (if used) is given by:
\[
P_{r}=(I_{rms})^2R_{ext}
\] A suitable resistor should have a power rating of about twice the value of \( P_{r} \) for reliable operation.
30) If external resistor \( R_{ext} \) is used, regulation of the supply can be improved by adding a shorting-out device as recommended for the bridge rectifier circuit in Figs. 2 and 3 of my first article.

A worked example
Here is a worked example for a half-wave rectifier design to be used as a bias supply of 100V at 10mA.
1) \( E_{dc\text{load}}=100V \)
2) \( I_{dc\text{load}}=10mA \)
3) \( V_{pdc}\text{rms}=1.0V_{\text{rms}} \)
4) \( V_{sdc}\text{rms}=240V_{\text{rms}} \)
5) 50kHz
6) \( R_{L}=E_{dc\text{load}}/I_{dc\text{load}} \)
where \( E_{dc\text{load}}=E_{dc\text{load}}+V_{rec} \)
\( =100+0.9=100.9V \)
so \( R_{L}=100.9/10=10.09\Omega \)
7) \( I_{rms}=I_{dc\text{load}}=10mA \)
8) \( R=I_{rms}^2/5=10.09\Omega \)
9) \( R_{R}=100/5=20\Omega \)
10) \( V_{r}\%=V_{sdc}\text{rms}/100/E_{dc\text{load}}\% \)
Table 3. Find value Z here to determine current through the rectifier.

<table>
<thead>
<tr>
<th>X</th>
<th>Rs/RL%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.02</td>
</tr>
<tr>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>0.10</td>
<td>1.00</td>
</tr>
<tr>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>6.00</td>
<td>6.00</td>
</tr>
<tr>
<td>7.00</td>
<td>7.00</td>
</tr>
<tr>
<td>8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>9.00</td>
<td>9.00</td>
</tr>
<tr>
<td>10.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>

Table 4. Value W is needed to find peak current.

<table>
<thead>
<tr>
<th>X</th>
<th>Rs/RL%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.02</td>
</tr>
<tr>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>0.10</td>
<td>1.00</td>
</tr>
<tr>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>6.00</td>
<td>6.00</td>
</tr>
<tr>
<td>7.00</td>
<td>7.00</td>
</tr>
<tr>
<td>8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>9.00</td>
<td>9.00</td>
</tr>
<tr>
<td>10.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>

In a subsequent article, Ray will describe the steps needed for designing full-wave centre-tapped rectifier circuits. The September issue contained the procedure for full-wave bridge rectifiers.
**Dictionary of Communications Technology**

Terms, definitions and abbreviations
Gilbert Held, 4-Degree Consulting, Macon, Georgia, USA

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

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

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

**Data Processing Digest**
ISBN 0471 95542 6, 512pp, hardback, UK £68.50, Europe £73, ROW £85

**Applied Cryptography**
2nd Edition
Protocols, Algorithms and Source Code in C
Bruce Schneier, Security Consultant and President of Counterpane Systems, USA

This revision of the programmer’s and system designer’s guide to the practical applications of modern cryptography provides the most comprehensive, up-to-date survey of modern cryptographic techniques, along with practical advice on how to implement them.

**New to this edition:**
- Detailed treatment of the US government’s Clipper Chip encryption program
- New encryption algorithms (e.g. ‘GOST’) recently obtained from the former Soviet Union
- More detailed information on incorporating algorithms and programming fragments into working software
- The latest developments in the fields of message authentication (‘digital signatures’) and digital cash.

ISBN 0471 12843 7, 810pp, hardback, UK £59, Europe £64, ROW £78
ISBN 0471 11709 9, 810pp, paperback, UK £44, Europe £49, ROW £63

**Data and Image Compression**
4th edition
tools and techniques
Gilbert Held, 4-Degree Consulting, Macon, Georgia, USA

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

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

**Testing, Troubleshooting and Tuning Local Area Networks**
Techniques and tools to isolate problems and boost performance
Gilbert Held, 4-Degree Consulting, Macon, Georgia, USA

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

ISBN 0471 95860 8, 275pp, hardback, UK £37.50, Europe £40, ROW £50

**Wireless Information Networks**

Wireless Information Networks organises all major elements of wireless technology—cableless and cellular telephony, Personal Communications Systems (PCS), mobile data networks and Wireless Local Area Networks (WLANs), presenting them from a logical, systems engineering perspective. Technical material is thoroughly integrated with special applications and focuses on four main areas: Wireless standards and descriptions of systems and products; Measurement and modelling of radio and optical wave propagations; Wireless transmission techniques and Wireless multiple access techniques.

**Contents:**

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

**Handbook for Digital Signal Processing**
S.K. Mitra, University of California and J.F. Kaiser, Bell Communications Research, New Jersey, USA

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

Contents: Introduction; Mathematical Foundations of Signal Processing; Linear Time-Invariant Discrete-Time Systems; Finite-Impulse Response Filter Design; Digital Filter Implementation Considerations; Robust Digital Filter Structures; Fast DFT and Convolution Algorithms; finite Arithmetic Concepts; Signal Conditioning and Interface Circuits; Hardware and Architecture; Software Considerations; Special Filter Designs; Multirate Signal Processing; Adaptive filtering Spectral Analysis; Index.

ISBN 0471 61995 7, 1302pp, hardback, UK £110.50, Europe £118, ROW £138

Diode Lasers and Photonic Integrated Circuits
L. A. Coldren and S. W. Corzine, both of the University of California, Santa Barbara, USA.

Diode lasers are found in numerous applications in the optoelectronics industry,

telecommunications and data communications, ranging from readout sources in compact disc players to transmitters for optical fibre communications systems. This new title provides a comprehensive treatment of diode laser technology, its principles and theory, treating students as well as experienced engineers to an in-depth exploration of this fast growing field.

ISBN 0471 11875 3, 620pp, hardback, UK £63.50, Europe £67, ROW £78

All prices are fully inclusive of packing and delivery

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

Please supply the following titles:

<table>
<thead>
<tr>
<th>Qty</th>
<th>Title or ISBN</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** All prices on these pages include delivery and package **

Total

Name

Address

Postcode

Telephone

Method of payment (please circle)

Access/Mastercard/Visa/Cheque/PO

Cheques should be made payable to Reed Business Publishing

Credit card no

Card expiry date

Signed

Please allow up to 28 days for delivery
Music in Mind

In response to Ian Hickman's challenge in the October 1996 issue, to why his gyroscope headphone system did not work on stereo, I offer the following thoughts.

Firstly, there is more to head movement than just delay shift. The area is signal - rich and the ear is turned toward the sound source is increased in level at high frequencies, while the other ear receives less high frequency. This is due to the head attenuating the directional signal.

Secondly, and perhaps more importantly, is that classical recordings are made for reproduction on loudspeaker systems. In stereo, two techniques for obtaining the stereophonic effect exist: intensity differencing and time differencing. If the signal from the left speaker arrives at the ear earlier than the signal from the right speaker, the apparent source location is shifted to the left. For a source to be perceived to be entirely at the left or right, quite large time differences are needed.

In practice, it appears that stereo through time differences gives a more widespread - and often more pleasing - stereo sound on loudspeakers than does intensity stereo. Also, the omnidirectional microphones suitable for this technique are superior. As a result, most classical music recordings use time -difference stereo.

The microphones are spaced about a meter or so apart, giving spatial cues containing time differences of up to 3ms between the left and right speaker. As you can imagine, adding some 150µs extra delay to this difference to obtain an in -front localisation on head phones, as Ian did in his experiment, would not have a noticeable effect.

If this theory is right, there should be a solution. Try listening to a stereo recording with intensity differences solely. I think that recordings from Nimbus would demonstrate this. The clue is to look for recordings that are made using coincidental, or nearly coincidental, microphone techniques. Maybe a special artificial head-recording would do.

It would be interesting to see whether this theory gives any result.

Eelco Grimm
Editor
Pro -Audio Magazine

Congratulations to Ian Hickman for his attempts at correcting for head rotation with headphone listening. The use of the piezo -vibrating gyroscope is a worthwhile contribution.

However, the parameters under control are inadequate and I suggest the reason why sound sources remain stubbornly localised within the head.

The secret of localisation with headphones is the accuracy to which the required signals can be reconstructed at the entrance to the ear canal, to match those produced by a real -life source. It is well known that an external sound source will have two associated transfer functions between the source and each ear. These are called the head related transfer functions, or hrtfs. Each point in space has a unique pair of hrtfs (one for each ear) with respect to head orientation. The transfer functions are influenced by the head shape, pinna geometry and, to a lesser extent, the effect of the torso. Even more frustrating is that each listener will have a unique set of transfer functions, although fortunately there is some degree of commonality between listeners, though head size can play a role too.

When the head rotates with respect to an external point source, the transfer functions change dynamically. Any system that is intended to recreate the correct ear signals must therefore include a knowledge of these filters and an ability to process them dynamically. Computing purely on a basis of amplitude and time differentials is insufficient to recreate accurate out -of-head spatialisation. This also implies that information that is encoded using normal stereo will not readily be amenable to such processing. Binaural sources obviously have an advantage, but even when the head rotates the signals are so interwoven that they cannot accurately be processed into their correct perspective, although better results should in theory be possible.

Mr Hickman, however, should not feel too disheartened. I have heard several systems claiming to do this with low -cost electronics, some using multiple drive unit headphones, and all have failed to impress. The only system (for me) so far to work using an orientation measurement was demonstrated to me by Dr Mike Hollier at British Telecom Research Laboratory. The system used the 'Huron' manufactured by Lake, which is a digital filter costing £6,000 or so and capable of very long impulse responses that can be controlled dynamically. The system incorporates a set of hrtfs and a positional sensor is located on the headphones. Listening in real time to a person talking into a microphone, and rotating my head, an external image was perceived that was localised accurately within the room's frame of reference.

Note, however, that the Huron is a bit of overkill in this application. Its power is intended to incorporate the long impulse responses that are encountered when simulating a large acoustic environment where the aim is to be able to move around within an artificially created space. This is the acoustic wing of virtual reality.

So, any working system must use real -time dop and include accurate hrtf data. It must also use appropriate headphones, preferably feeding directly into the ear canal as a microphone, and rotating my head, an external image was perceived that was localised accurately within the room’s frame of reference.

Note, however, that the Huron is a bit of overkill in this application. Its power is intended to incorporate the long impulse responses that are encountered when simulating a large acoustic environment where the aim is to be able to move around within an artificially created space. This is the acoustic wing of virtual reality.

Any working system must use real -time dop and include accurate hrtf data. It must also use appropriate headphones, preferably feeding directly into the ear canal as a microphone, and rotating my head, an external image was perceived that was localised accurately within the room’s frame of reference.

Note, however, that the Huron is a bit of overkill in this application. Its power is intended to incorporate the long impulse responses that are encountered when simulating a large acoustic environment where the aim is to be able to move around within an artificially created space. This is the acoustic wing of virtual reality.

So, any working system must use real -time dop and include accurate hrtf data. It must also use appropriate headphones, preferably feeding directly into the ear canal as a microphone, and rotating my head, an external image was perceived that was localised accurately within the room’s frame of reference.

Note, however, that the Huron is a bit of overkill in this application. Its power is intended to incorporate the long impulse responses that are encountered when simulating a large acoustic environment where the aim is to be able to move around within an artificially created space. This is the acoustic wing of virtual reality.

So, any working system must use real -time dop and include accurate hrtf data. It must also use appropriate headphones, preferably feeding directly into the ear canal as a microphone, and rotating my head, an external image was perceived that was localised accurately within the room’s frame of reference.

Note, however, that the Huron is a bit of overkill in this application. Its power is intended to incorporate the long impulse responses that are encountered when simulating a large acoustic environment where the aim is to be able to move around within an artificially created space. This is the acoustic wing of virtual reality.

So, any working system must use real -time dop and include accurate hrtf data. It must also use appropriate headphones, preferably feeding directly into the ear canal as a microphone, and rotating my head, an external image was perceived that was localised accurately within the room’s frame of reference.

Note, however, that the Huron is a bit of overkill in this application. Its power is intended to incorporate the long impulse responses that are encountered when simulating a large acoustic environment where the aim is to be able to move around within an artificially created space. This is the acoustic wing of virtual reality.

So, any working system must use real -time dop and include accurate hrtf data. It must also use appropriate headphones, preferably feeding directly into the ear canal as a microphone, and rotating my head, an external image was perceived that was localised accurately within the room’s frame of reference.

Note, however, that the Huron is a bit of overkill in this application. Its power is intended to incorporate the long impulse responses that are encountered when simulating a large acoustic environment where the aim is to be able to move around within an artificially created space. This is the acoustic wing of virtual reality.

So, any working system must use real -time dop and include accurate hrtf data. It must also use appropriate headphones, preferably feeding directly into the ear canal as a microphone, and rotating my head, an external image was perceived that was localised accurately within the room’s frame of reference.

Note, however, that the Huron is a bit of overkill in this application. Its power is intended to incorporate the long impulse responses that are encountered when simulating a large acoustic environment where the aim is to be able to move around within an artificially created space. This is the acoustic wing of virtual reality.

So, any working system must use real -time dop and include accurate hrtf data. It must also use appropriate headphones, preferably feeding directly into the ear canal as a microphone, and rotating my head, an external image was perceived that was localised accurately within the room’s frame of reference.
WOLVERHAMPTON BRANCH
NOW OPEN AT WORCESTER
WHITMORE TEL: 01902 23039

CENTRAL POINT PC TOOLS
Award winning software, 1,000
voice clips, memory controller, disc replication, file management,
low level formatting, backup scheduler, disc deterioration, on-line
calculations, 35 to 45 minutes depending on the speed of the
computer, password protection, encryption, comprehensive manual supplied.
£8.99 ref. SA32.

GOT AN EXPENSIVE BIKE? You need one of our safety alarms, they look like a standard water bottle, but open the top, insert a key to
activate a motion sensor alarm built inside. Fits all standard bottle
holders. £9.99 ref. SA11.

EMERGENCY LIGHTING KIT
Complete with 2 double bulb floodlights, built in charger and auto switch. Fully tested. £19.99 head etc.

USUALLY SEALED ACETIC ACID BATTERIES
Two sizes currently available this month. 12V 1Ah £1.87 and 6V 8Ah
(essential for emergency lighting and spot lighting purposes).

ELECTRONIC WIRELESS VIDEO BUG KIT
Transmits video and audio signals from a miniature CCTV camera (invaluable
to any legitimate firm who wishes to check his competitors out).

WIRELESS VIDEO BUG KIT
Transmits video and audio signals from a miniature CCTV camera (invaluable
to any legitimate firm who wishes to check his competitors out).

SURVEILLANCE TELESCOPE
Superb Russian telescopic version of Nikon. 13 deg angle of view, focussing range 1.5m to infinity. 2 AA batteries
still give a range of up to 100 metres. A single PP3 will probably give
you up to half the range. £14.99 ref. EP10.

GALLIUM ARSENIDE FISHEYE PHOTO DIO DES COMPLETE
and 12v operated deadlock (keys included) £10 ref LOT99

ZENITH 900 X MAGNIFICATION MICROSCOPE
Zoom, mechanism, adjustable time delay, relay output, put a coinslot on
their look! Ikea standard water bottle, but open the top, insert a key to
activate a motion sensor alarm built inside. Fits all standard bottle
holders. £9.99 ref. SA11.

ZENITH 900 X MAGNIFICATION MICROSCOPE
Zoom, mechanism, adjustable time delay, relay output, put a coinslot on
their look! Ikea standard water bottle, but open the top, insert a key to
activate a motion sensor alarm built inside. Fits all standard bottle
holders. £9.99 ref. SA11.
Feedback feedback please

Having built two new power amps and then found out that in use their gain was about 12dB too much, I shuddered at the thought of all the work involved to redesign for the lower gain. I thought for the umpteenth time that there must be a simpler way, like using low gain linear stages with little or no overall negative feedback.

I was happy with the output stage, Fig. 1, which is a fet version of the Texas Instruments Texan amplifier and has been described in *EW* + *WW*, April and September 1990. It needed a bit of experimentation with *R*1 to get equal positive and negative half cycles, open loop, but that is all it needed. Applying negative feedback to give a gain of four, the stage has quite a reasonable performance, except that the output impedance is about 12Ω. Also, when loaded, the stage distorts because there is nothing to increase the drive. I tried all sorts of comparators to apply feedback only when there was a difference between input and output, but none worked effectively.

I was about to give in when I came across a reference to an error cancelling technique by Hawksford in the *Siliconix MOSpower Applications Handbook* (Application 6.6.3).

Figure 2 gives the theory and Fig. 3 the way I applied it. Having got the gains right, the results were astounding.

If the gain from P-R-Q to P is less than unity, Z,q will have some small value. If the gain is unity, Z,q will be close to zero. If the gain is slightly greater than unity, Z,q will have a negative resistance characteristic. The gain from P-S-P must be the reciprocal of the closed-loop gain of the corrected amplifier.

During testing, it was found that a capacitive load of more than 22nF caused a high output at high frequency. This was a surprise as the output stage itself would have happily driven a 10μF at 1kHz.

More experimenting gave the feeling that this was not parasitic oscillation, but rather amplified and filtered noise. While loading the output with increasing values of capacitor, the output of A1 became increasingly noisy until it burst into oscillation at about 2MHz. Putting a small capacitor across the output filters out the high frequency noise at that point (22nF=3R6 at 2MHz). This would mean that the noise at S would be cancelled in A1 by noise from P and would be fed back as a signal. I am not entirely happy with that idea since there is not much noise at those points anyway. Resistor R15 is chosen to give required gain.

I would welcome your comments on this technique.

K H Ellis
Wolverhampton
England

---

**Fig. 1. Output stage - fet version of TI's Texan.**

---

**Fig. 2. Hawksford's error-cancelling technique.** Output stage has -error signal added to it. Input signal has +error added to it and so cancels the error out. S1 creates the error signal.

**Fig. 3. Application of Hawksford's error-cancelling technique.** Gain in 12, maximum power into 4.5Ω is 35W and bandwidth is 5Hz to 50kHz.
portable X ray machine plans Easy to construct and 2.5 times the efficiency of X ray machines, cash for experimental purposes. Not a toy for minor! £12/set Ref. F/MM5.


gravity generator plans This unique plan works on FM too! Discretion advised. £8/set Ref. F/MM5.

infrared blaster plans Projects a project a considerable distance requires adult supervision £6 F/ELM2.

electric man plans Shock people with the touch of a button! £12/set Ref. F/MM5.

parabolic dish microphone plans Listen to distant sounds and voices, open windows, sounds in hard to get to or remote premises. £12/set Ref. F/MM5.

ultrasonic blaster plans Allows you to alter electronic circuits and focus them to ultra sensitive electronics. Plans also show an additional electronic very interesting science project. £10 Ref. F/MM5.

2 for 1 multifunctional high frequency and high DC voltage, solid state Tesla coil and variable frequency transistor generator. Operates on 9-12v, many possible experiments. £10 Ref. F/MM5.

transmitter plans The ultimate bug! Have your phone on and listen on the radio at the same time! £8 Ref. F/MM5.

ultrasonic blaster plans Has a number of practical applications, such as identifying people, making glass invisible, etc. £12/set Ref. F/MM5.

portable X ray machine plans Is it safe to be exposed to X rays at home? £12/set Ref. F/MM5.


microscope plans Uses simple Idt £3 ref EF34.

Venus fly trap kit Grow your own carnivorous plant with this kit £3 of EP34.

F-6 micro solar panel 12v 15x30mm 130ma. Bargain price just £8.99 ref MAG31B.

microcircuit power pack Plans 10 metres for £4.99 ref MAG51A.

beaker light kit Kit makes a beaker float in the air! £8 ref MAG10.

rocky lights Unusual things these, two pieces of rock that glow when rubbed together! £12.99 ref MAG12.

simple Idt £3 ref EF34.

Venus fly trap kit Grow your own carnivorous plant with this kit £3 of EP34.

Venus fly trap kit Grow your own carnivorous plant with this kit £3 of EP34.

David Hume University Press

David Hume University Press

David Hume University Press
ARTICLES FOR SALE

SUPPLIER OF QUALITY USED TEST INSTRUMENTS

'C771ki.

CONTACT
Cooke International
ELECTRONIC TEST & MEASURING INSTRUMENTS
Unit Four, Fordingbridge Site, Main Road, Barnham,
Bognor Regis, West Sussex, PO22 0EB, U.K.
Tel: (+44)01243 549111/2 Fax: (+44)01243 542457

ARTICLES WANTED

TOP PRICES PAID
For all your valves, tubes, semi conductors and IC's.

Langrex Supplies Limited
1 Mayo Road, Croydon
Surrey CR0 2GP
TEL: 0181-684 1166
FAX: 0181-684 3056
MINISTRY OF DEFENCE
ASSISTANT TELECOMMUNICATIONS
TECHNICAL OFFICER (ATTO)

Royal Air Force Sealand is Europe’s premier electronic repair facility. We have vacancies for Assistant Telecommunications Technical Officers for permanent positions.

In addition to RAF Sealand based posts some successful candidates will need to spend time at RAF North Luffenham, Leics, on detached duty effective from their start date until Autumn '97 to receive training before the work is transferred to Sealand. An ability to work at heights of 12 metres or more is a requirement, however, a short training course is available. Many of the North Luffenham jobs also involve regular duty travel both within Great Britain and abroad attracting the usual departmental allowances.

The ATTO grade is part of the Defence Engineering and Science Group within the Ministry of Defence and is primarily concerned with aspects of repair and maintenance of aircraft avionics and electronics, and Ground Radio Support Services.

QUALIFICATIONS

An EC approved EngTech qualification at Stage 1 in an appropriate electronics or telecommunications specialism or equivalent, plus 3 years recent relevant experience which may include a period of study/training.

or

BTEC/SCOTVET NC in Electronics or Telecommunications plus 3 years recent relevant experience which may include a period of study/training.

Selected applicants will be required to take an aptitude test.

The aptitude test has been upgraded and previous applicants are welcome to re-apply.

SALARY

The salary ranges from £12,865 pa to £16,168 pa with starting salary being determined by experience. The grade maximum is £19,477. The range between £16,168 and £19,477 must be attained through performance in the grade.

GENERAL

The Civil Service is an Equal Opportunities Employer.

A 'No Smoking In Work Areas' policy is in force at RAF Sealand.

HOW TO APPLY

For an application form and further details please send a large stamped addressed envelope to:
Manning and Recruitment/ATTO
No. 30 MU
RAF Sealand
Deeside
Flintshire CH5 2LS.

The last date for sending out application forms is 22 November, 1996.

ELECTRONICS ENGINEER

Qualified Engineer required, with proven design experience in HF & VHF communications equipment, especially receivers. Ability to combine software and hardware expertise advantageous.

An exceptional opportunity for the selected candidate, who will be in at the start of a new venture, future prospects being limited only by the individual’s success.

The candidate will push a product design from the ‘A’ model through to production with minimal support, therefore a high level of commitment and expertise is required.

A generous salary commensurate with experience is available.

Location: Sussex

Please reply in writing to:
Box No. 300, Electronics World, Room L329, Quadrant House,
The Quadrant, Sutton, Surrey SM2 5AS

Valves, and CRTs AVAILABLE

ONE MILLION VALVES stocked for Audio, Receiving, Transmitting & RF Heating. Rare brands such as Mullard & GEC available. Also MAGNETRONS, KLYSTRONS, CRTs and SOCKETS.

Large stocks of Russian & Sovtek items.

Please ask for our free catalogues of valves or CRTs.

Valves, etc. WANTED

Most types considered but especially KT88 (£48), PX4/PX25 (£50), KT66 (£35), KT77 (£15), EL34 (£10), EL37 (£9), ECC83 (£3).

Valves must be UK manufacture to achieve prices mentioned. Also various valvera equipment e.g. Garrand 301, (up to) £80.

Ask for a free copy of our wanted List.

BILLINGTON EXPORT LTD., Billingshurst, Sussex RH14 9EZ.
Tel: 01403 784961 Fax: 01403 783519

VISITORS STRICTLY BY APPOINTMENT.

WE WANT TO BUY!!

IN VIEW OF THE EXTREMELY RAPID CHANGE TAKING PLACE IN THE ELECTRONICS INDUSTRY, LARGE QUANTITIES OF COMPONENTS BECOME REDUNDANT. WE ARE CASH PURCHASERS OF SUCH MATERIALS AND WOULD APPRECIATE A TELEPHONE CALL OR A LIST IF AVAILABLE.

WE PAY TOP PRICES AND COLLECT.

R. HENSON LTD.
21 Lodge Lane, N.Finchley, London N12 8JG.
5 Mins, from Tally Ho Corner.

TELEPHONE
0181-445-2713/0749
FAX 0181-444-5702
ELECTRONIC UPDATE

Contact Malcolm Wells on 0181-652 3620

A regular advertising feature enabling readers to obtain more information on companies' products or services.

New Flight Electronics International Catalogue Set

You now have access to the world's latest:
- Electronics Training Equipment
- Microprocessor Training Equipment
- Test and Measurement Equipment
- PC Cards

via "Flights" latest catalogue set.

We are specialists in the provision of innovative top quality electronics trainers, breadboards, test and measurement, PC cards and microprocessor evaluation equipment.

Our extensive range covers every need, call today for your free catalogue set.

NEW Feedback T&M Catalogue

The latest edition of the Feedback Test & Measurement catalogue is now available. Over 60 pages packed with more than 800 products divided into over 20 sections. The catalogue is indexed for both product and manufacturer and is fully illustrated. Whether you are looking for an individual product, a complete workolution, or a solution to a particular Test & Measurement need the NEW Feedback catalogue will solve your problems, send for a copy NOW!

LabVIEW 4.0 Brochure.

LabVIEW Graphical Programming for Instrumentation, illustrates how users can increase productivity and save money by using LabVIEW to null virtual Instrumentation systems. The brochure includes examples of real-world test and measurement, process monitoring and control applications developed with LabVIEW.

NATIONAL INSTRUMENTS,
For your FREE brochure call 01635 523545

NEW JENSEN TOOLS CATALOGUE

Colourful new Catalogue, hot off the press from Jensen Tools, presents unique new tool kits for servicing and maintenance of communications equipment. Also latest test equipment from many major manufacturers. Includes hard-to-find tools, PC/LAN diagnostics, bench accessories, static control, technical manuals and more.

Ring 0800 8333246 or Fax 01604 785573 for a free copy.
Jensen Tools, 10-12 Ravens Way, Northampton NN3 9UD
**8051 MICROCONTROLLERS + FLASH**

**MICRO-PRO 51**

State-of-the-art programmer for the 8051 family
- Programming support for the entire Atmel 89C and 89S microcontroller families
- Also supports many Philips, Intel, Dallas & Siemens 8051 derivatives
- Field programmable hardware updates for future device support

Order code: MP51 SYS £125.00

**Microcontroller in-circuit re-programming adaptor**

Now you can re-program the entire Atmel microcontroller family in-circuit!

No more re-moving chips - ideal for 8051 single-chip project development.

Supplied with AT89C1051 and AT89C2051 + 11.0592 MHz Crystal.
(Requires Micro-Pro 51 programmer to operate - see above)

Order code: AD-MICRO-ICR £125.00

**89C-1051/2051 Microcontroller Demo Module**

A feature-packed development board with integrated power plug, LED, صف/صف/صف/صف/صف, and 10-pin IDE compatible interface.

Order code: AT-89C1051-Demo £59.00

**89C-1051/2051 Microcontroller OEM Module**

An ideal development platform for use on-site for evaluation can be developed into custom products.

Order code: AT-89C1051-DEMO £29.00

**Package Adaptors**

**PLCC 44-pin adaptor**

Suitable for most 8051 derivatives

Order code: AD-PLCC44-A £65.00

**SOIC 20-pin adaptor**

Suitable for Atmel AT89C1051 & AT89C2051

Order code: AD-SOIC20-A £75.00

Please enquire for our full range of adaptors

**The Atmel 8051 FLASH microcontroller family**

<table>
<thead>
<tr>
<th>Atmel Port Code</th>
<th>80C51</th>
<th>89LVC51</th>
<th>89C52</th>
<th>89LV52</th>
<th>89C55</th>
<th>89LV55</th>
<th>88K252</th>
<th>85C2051</th>
<th>85C1051</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Code ROM (Bytes)</td>
<td>4K</td>
<td>4K</td>
<td>8K</td>
<td>8K</td>
<td>2K</td>
<td>2K</td>
<td>2K</td>
<td>1K</td>
<td>1K</td>
</tr>
<tr>
<td>RAM (Bytes)</td>
<td>128</td>
<td>128</td>
<td>256</td>
<td>256</td>
<td>256</td>
<td>256</td>
<td>256</td>
<td>128</td>
<td>128</td>
</tr>
<tr>
<td>Flash EPPROM</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>In-system re-programmable</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>I/O Pins</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Watchdog timer</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Interrupt sources</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Serial UART (full duplex)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Analogue comparator</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Data pointers</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Package Pins (DIL)</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

- Atmel microcontrollers feature on-chip re-programmable FLASH code memory
- FLASH is electrically erasable in under 15ms (no need for UV eraser)
- 89C51/52/55/52 are drop-in FLASH replacements for the generic 87C51/87C52 devices
- 89C55 has a single-chip 8051 in a 20 pin package, even retaining the serial port

**C81 STARTER SYSTEM**

- Optimising C Compiler
- Macro Assembler
- Software Simulator
- Device Programmer
- Sample Devices
- Hardware/Software Documentation

FREE Atmel CD ROM data book

- System supplied with 1 x Atmel AT89C1051 and 1 x AT89C2051 Microcontrollers
- C-compactor + Assembler output restricted to 2k total program code.

Order code: AT-89C051-ST

**UPGRADE TO 8K VERSION NOW AVAILABLE**

**SALES: 01204 492010 TECHNICAL: 01204 491110 FAX: 01204 494883 (INTERNATIONAL DIALLING CODE +44 1204)**

Equinox reserves the right to change prices & specifications of any of the above products without prior notice. All prices are exclusive of VAT and carriage.
Dataman S4

Compare the Dataman S4 with any other programmer and you'll see why it's the world's undisputed number one.

S4 is capable of programming 8 and 16-bit EPROMs, EEPROMs, PEROMs, 5 and 12V FLASH, Boot-Block FLASH, PICs, 8751 Microcontrollers and more. S4 also emulates ROM and RAM as standard!

S4 is the only truly hand held programmer that ships complete with all emulation leads, organiser-style manual, AC charger, spare library ROM, both DOS and Windows terminal software, and arrives fully charged and ready to go! Who else offers you all this plus a three year guarantee?

Customer support is second to none. The very latest programming library is always available free on the Internet, and on our dedicated bulletin boards. Customers NEVER pay for upgrades or technical support.

Dataman-48

Our new Dataman-48 programmer adds PinSmart® technology to provide true no-adaptor programming right up to 48-pin DIL devices. Dataman-48 connects straight to your PC's parallel port and works great with laptops.

Coming complete with an integral world standard PSU, you can take this one-stop programming solution anywhere!

As with S4, you get free software upgrades and technical support for life, so now you don't need to keep paying just to keep programming.

The Dataman S4 and Dataman-48 programming kit includes everything you need to get your programming done. You can even try them out for 30 days and if you don't agree that these are the most effective, most useful, most versatile additions you can make to your programming toolbox, we will refund your money in full.

Hotline: 01300 320719

Dataman Programmers Ltd, Station Road, Maiden Newton, Dorset DT2 0AE. UK
Telephone +44/0 1300 320719 Fax +44/0 1300 321012 BBS +44/0 1300 321095 (24hr)
Modem V.34/V.42/B/E.161 home page: http://www.dataman.com FTP: ftp.dataman.com Email: sales@dataman.com

CIRCLE NO. 163 ON REPLY CARD