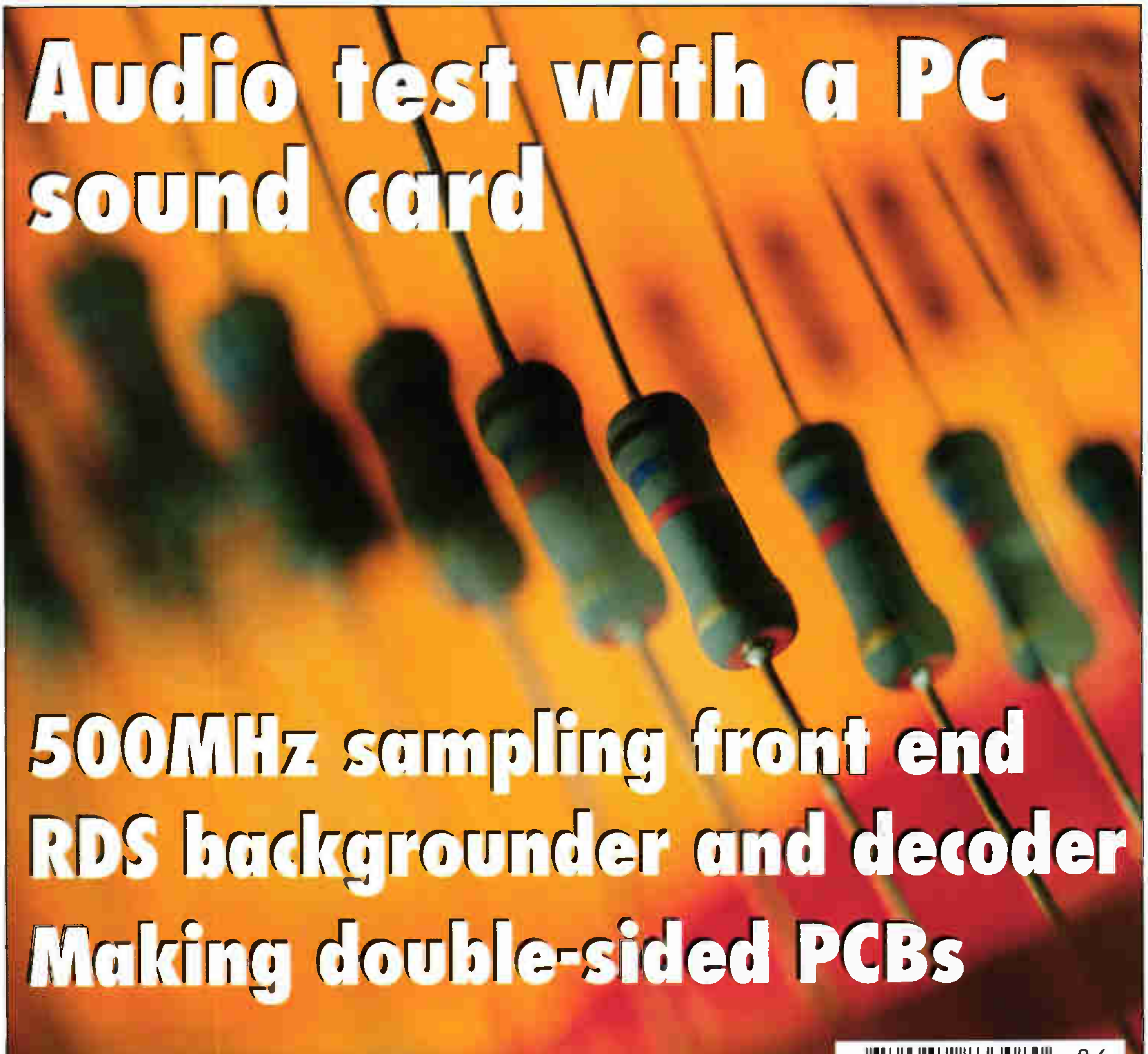
The month's top new products - page 39

ELECTRONICS WORLD

JUNE 2002 £2.95



Audio test with a PC sound card

500MHz sampling front end

RDS backgrounder and decoder

Making double-sided PCBs

Circuit ideas:

Simple fault tester, Low-cost bridge emulator, Voice activated recorder, Electronic antenna lengthener

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Quality second-user test & measurement equipment

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Hewlett Packard 83640L (10MHz - 40 GHz) Synth. swept signal generator	**£15000**
Hewlett Packard 8349B (2 - 20 GHz) Microwave Amplifier	**£2500**
Hewlett Packard 8508A (with plug-in 85082A-2GHz) Vector Voltmeter	**£2500**
Hewlett Packard 3324A synth. function/sweep gen. (21MHz)	**£2250**
Hewlett Packard 3314A Function Generator 20MHz	**£1250**
Hewlett Packard 8904A Multifunction Synthesiser (opt 2+4)	**£1950**
Hewlett Packard 4278A 1kHz/1MHz Capacitance Meter	**£3750**
Hewlett Packard 53310A Modulation Domain Analyser (opts 1&31)	**£6750**
Hewlett Packard 4191A R/F Impedance Analyser (1-1000MHz)	**£4995**
Hewlett Packard ESG-D3000A (E4432A) 250 kHz-3GHz) Signal Gen.	**£6995**
Hewlett Packard 3325B Synthesised Function Generator	**£3250**
Hewlett Packard 3326A Two-Channel Synthesiser	**£3000**
Marconi 6310 – programmable sweep generator (2 to 20GHz) – new	**£2500**
Marconi 6311 Prog'ble sig. gen. (10MHz to 20GHz)	**£2995**
Marconi 6313 Prog'ble sig. gen. (10MHz to 26.5GHz)	**£4750**
R&S SMG (0.1-1GHz) Sig. Generator (opts B1+2)	**£2750**
Rohde & Schwarz SM1Q-03B (opt11,12,14,20,B42) Vector Signal Generator (300kHz-3.3GHz)	**£8500**

OCSILLOSCOPES

Gould 400 20MHz - DSO - 2 channel	£695
Gould 1421 20MHz - DSO - 2 channel	£425
Gould 4068 150MHz 4 channel DSO	£1250
Gould 4074 100MHz - 400 Ms/s - 4 channel	£1100
Hewlett Packard 54201A - 300MHz Digitizing	£750
Hewlett Packard 54600A - 100MHz – 2 channel	£675
Hewlett Packard 54502A - 400MHz – 400 MS/s 2 channel	£1600
Hewlett Packard 54810A 'Infinium' 500MHz 2ch	£3500
Hewlett Packard 54520A 500MHz 2ch	£2750
Hameg 205-2 20MHz DSO	£495
Hitachi V152/V212/V222/V302B/V302F/V353F/V550BV650F	from £100
Hitachi V1 100A - 100MHz - 4 channel	£750
Intron 2020 - 20MHz. Dual channel D.S.O (new)	£450
Iwatsu SS 5710/SS 5702 -	from £125
Kikusui COS 5100 - 100MHz - Dual channel	£350
Lecroy 9314L 300MHz - 4 channels	£2750
Meguro MSO 1270A - 20MHz - D.S.O. (new)	£450
Philips PM3094 - 200MHz - 4 channel	£1500
Philips 3295A - 400MHz - Dual channel	£1400
Philips PM3392 - 200MHz - 200Ms/s - 4 channel	£1750
Philips PM3070 - 100MHz - 2 channel - cursor readout	£650
Tektronix 465 - 100MHz - Dual channel	£295
Tektronix 464/466 - 100MHZ - (with AN. storage)	£295
Tektronix 475/475A - 200MHz/250MHz	from £400
Tektronix 468 - 100MHz D.S.O.	£500
Tektronix 2213/2215 - 60MHz - Dual channel	£300
Tektronix 2220 - 60MHz - Dual channel D.S.O	£850
Tektronix 2235 - 100MHz - Dual channel	£500
Tektronix 2221 - 60MHz - Dual channel D.S.O	£850
Tektronix 2245A - 100MHz - 4 channel	£700
Tektronix 2440 - 300MHz/500MS/s D.S.O.	£2100
Tektronix 2445/2445B - 150MHz - 4 channel	£800
Tektronix 2445 - 150MHZ - 4 channel +DMM	£850
Tektronix TAS 475 - 100MHz - 4 channel	£850
Tektronix 7000 Series (100MHZ to 500MHZ)	from £200
Tektronix 7104 - 1GHz Real Time – with 7A29 x2, 7B10 and 7B15	from £1950
Tektronix 2465/2465A /2465B - 300MHz/350MHz 4 channel	from £1250
Tektronix 2430/2430A - Digital storage - 150MHz	from £1250
Tektronix TDS 310 50MHz DSO - 2 channel	£750

SPECTRUM ANALYSERS

Advantest 4131 (10kHz – 3.5GHz)	£3750
Ando AC 8211 - 1.7GHz	£1500
Avcom PSA-65A - 2 to 1000MHz	£750
Advantest/TAKEDA RIKEN - 4132 - 100KHz - 1000MHz	£1350
Hewlett Packard 8596E (opt 41, 101, 105,130) 9KHz - 12.8GHz	£9950
Hewlett Packard 8756A/8757A Scaler Network Analyser	from £900
Hewlett Packard 853A Mainframe + 8559A Spec.An. (0.01 to 21GHz)	£2500
Hewlett Packard 182T Mainframe + 8559A Spec.An. (0.01 to 21GHz)	£2000
Hewlett Packard 8568A (100Hz - 1500MHz) Spectrum Analyser	£3000
Hewlett Packard 8567A -100Hz - 1500MHz	£3400
Hewlett Packard 8752A - Network Analyser (1.3GHz)	£4995
Hewlett Packard 8754A - Network Analyser 4MHz -1300MHz)	£1500
Advantest R3272 Spectrum Analyser (9kHz-26.5GHz)	£12000
Anritsu 54154A Scalar Network Analyser (2-32GHz)+detectors+SWR	£9950
Anritsu 54111A Scalar Network Analyser (0.001-3GHz) +dets+SWR	£7000
Hewlett Packard 8753B+85046A Network An + S Param (3GHz)	£6500
Hewlett Packard 8713C (opt 1 E1) Network An. 3 GHz	£6000
Hewlett Packard 70001A/70900A/70906A/70902A/70205A - 26.5 GHz Spectrum Analyser	£7000
Hewlett Packard 3561A Dynamic signal analyser	£2950
Hewlett Packard 35660A - Dynamic signal analyser	£2500
Hewlett Packard 8753A (3000KHz - 3GHz) Network An.	£3250
Hewlett Packard 3582A (0.02Hz - 25.5kHz) dual channel	£1500
Hewlett Packard 8590A (opt 01, 021, 040) 1MHz–1.5MHz	£2500
Hewlett Packard 8560A (50MHz–2.9GHz) High performance with Tracking Generator option (02)	£5500

Radio Communications Test Sets

Marconi 2955	£1250
Marconi 2955B/60B	£3500
Marconi 2955A	£1750
Marconi 2955R	£1995
Anritsu MT 8801C Radio Comms Analyser 300kHz - 3GHz (opt 1,4,7)	£6500
Hewlett Packard 8920B (opts 1,4,7,11,12)	£6750
Schlumberger Stabilock 4031	£2750
Schlumberger Stabilock 4040	£1300
Racal 6111 (GSM)	£1250
Racal 6115 (GSM)	£1750
Racal 6103 (GSM) Digital Radio Test Se	£6250
Rohde & Schwarz CMTA 94 (GSM)	£4500
Rohde & Schwarz CMT 55 (2GHz)	£7500
Rohde & Schwarz CMT 90 (2GHz) DECT	£3995
Rohde & Schwarz CMD 57 GSM test set (opts B1/34/6/7/19/42/43/61	£7995
Wavetek 4103 (GSM 900) Mobile phone tester	£1500
Wavetek 4106 (GSM 900, 1800, 1900) Mobile phone tester	£2000

TELNET

IFR A7550 - 10KHz-GHz - Portable	£1750
Meguro - MSA 4901 - 30MHz - Spec Anaylser	£600
Meguro - MSA 4912 - 1MHz - 1GHz Spec Anaylser	£750
Tektronix 2712 Spec Anaylser (9KHz - 1.8GHz)	£3250
Tektronix 492P (opt1,2,3) 50KHz - 21GHz	£3500
Wiltron 6409 - 10-2000MHz R/F Analyser	£1250

MISCELLANEOUS

EIP 548A 26.5GHz Frequency Counter	£1995
Gigatronics 8541C Power Meter + 80350A Peak Power Sensor	£1750
Gigatronics 8542C Dual Power Meter + 2 sensors 80401A	£2500
Hewlett Packard 53131A Universal Frequency counter (3GHz)	£850
Hewlett Packard 85024A High Frequency Probe	£1000
Hewlett Packard 8642A – high performance R/F synthesiser (0.1-1050MHz)	£2500
Hewlett Packard 3335A – synthesiser (200Hz-81MHz)	£1995
Hewlett Packard 436A power meter and sensor (various)	from £750
Hewlett Packard 339A Distortion measuring set	£750
Hewlett Packard 3457A muli meter 6 1/2 digit	£850
Hewlett Packard 3784A - Digital Transmission Analyser	£3750
Hewlett Packard 5385A - 1 GHz Frequency counter	£495
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Hewlett Packard 6622A - Dual O/P system p.s.u	£1250
Hewlett Packard 6624A - Quad Output Power Supply	£2000
Hewlett Packard 6632A - System Power Supply (20v-5A)	£695
Hewlett Packard 8350B - Sweep Generator Mainframe	£1500
Hewlett Packard 8656A - Synthesised signal generator	£750
Hewlett Packard 8656B - Synthesised signal generator	£995
Hewlett Packard 8657A - Synth. signal gen. (0.1-1040MHz)	£1500
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Hewlett Packard 8657B - 100MHz Sig Gen - 2060 MHz	£3950
Hewlett Packard 8657D - XX DQPSK Sig Gen	£3950
Hewlett Packard 4276A LCZ Meter (100MHz-20KHz)	£1400
Hewlett Packard 5350B 20KHz Microwave Freq.Counter	£2000
Hewlett Packard 11729B/C Carrier Noise Test Set	from £2500
Hewlett Packard 53151B Microwave Freq. Counter (26.5GHz)	£3400
Hewlett Packard 5351B (pt 1 & 6) Microwave Freq.Counter (26.5GHz)	£3000
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Ballantine 1620A 100Amp Transconductance Amplifier	£1750
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Marconi 2840A 2 Mbit/s Transmission Analyser	£1100
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Leader 3216 Signal generator 100KHz -140MHz - AM/FM/CW with built in FM stereo modulator (as new) a snip at	£650
Rohde & Schwarz NRV dual channel power meter & NAV Z2 Sensor	£1000
Rohde & Schwarz FAM (opts 2,6 and 8) Modulation Analyser	£4250
Tektronix ASG100 - Audio Signal Generator	£750
Wavetek 178 Function generator (50MHz)	£750
Wayne Kerr 3245 - Precision Inductance Analyser	£1850
Bias unit 3220 and 3225L Cal.Coil available if required.	(P.O.A)
Wayne Kerr 6245 - Precision Component Analyser	£2250
Wayne Kerr 3260A + 3265A Precision Magnetics Analyser with Bias Unit	£5500

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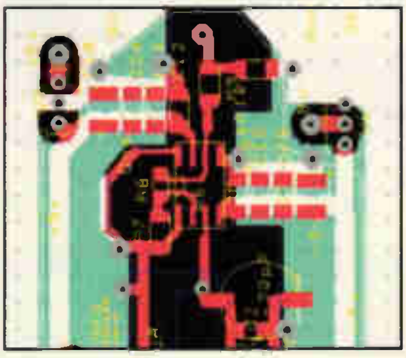
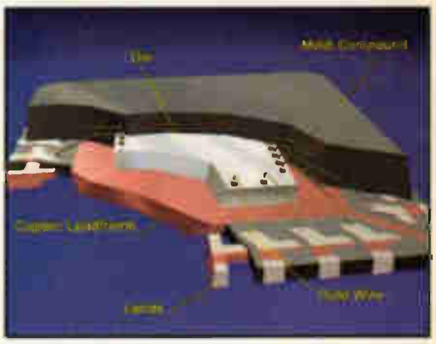
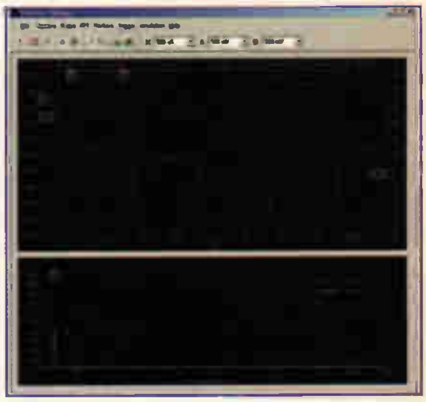
Each platinum-tipped needle in this array tapers from 80μm to 2μm, yet they are strong enough to puncture egg shell. News starts on page 5.

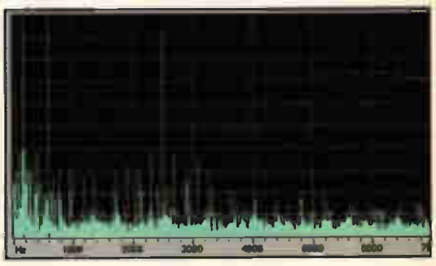




PICmicro one-time-programmable and flash microcontrollers now come in packages that are not much bigger than the chip itself. This, and more exciting new products are featured, starting on page 39.



Jason Back has developed oscilloscope software that he's making available to readers free of charge – details in Letters, starting on page 56.



Sound cards and CD rewriters are high-performance pieces of kit, but we tend to take them for granted because they're so cheap. Richard Black looks at ways of using such hardware – together with some low-cost software – for analysing audio-band signals. Page 12.

July issue on sale 6 June

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Steady as she goes?

In March the London Internet Exchange (LINX) announced it had switched its 250 trillionth – that's 250,000,000,000,000th – packet of data since its foundation in 1994. It also claims to handle up to 96 per cent of UK Internet traffic.

That's no mean achievement – especially as LINX is also the largest Internet exchange point in Europe. Peak traffic flows at the exchange can top 14 gigabits per second, about 140 times greater than its closest UK rival.

Please understand, I'm not knocking the organisation's success. It's highly commendable – but disturbing too when you consider the number of eggs assembled in just one basket.

It was last September's terrorist attacks (I could not avoid mentioning them!) that brought the resilience of the Internet into question. Until then the Internet was probably the last thing you'd expect to fail. Its diversity and built-in redundancy were designed to ensure its survivability; resilience was a key feature of its very nature. In theory.

Events in New York City dispelled this notion and proved that the Internet was perfectly capable of collapsing, even if the failures and logjams that resulted didn't command prominence in the news. The investigations held afterwards uncovered major limitations in the UK Internet infrastructure as well.

It is even rumoured that Her Majesty's Government then gave rather more attention than hitherto to the well-being of the Internet. For anyone reliant on the Internet its strength should now be a matter of prime concern.

Britain has had its share of home-grown Internet incidents. Last October LINX reported that an uncorrected broadcast flood unexpectedly knocked out much of the UK's inter-carrier Internet traffic. Normally, the deluge of traffic would have been corrected automatically but a router fault meant the problem prevented virtually all inter-ISP communication for most of one day.

Interestingly, while traffic through LINX was reduced a trickle on that day, traffic through the Manchester Network Access Point—the UK's second major peering point—rocketed by 400 per cent. Without MaNAP the problem would have been far worse.

The only reliable approach for securing the Internet and all the business that depends on it is duplication and diversity, not concentration. It helps, of course, to understand the precise details of the infrastructure and mechanisms that together form 'the Internet' and hence where the true threats reside.

It then becomes evident that the relative exposure of different ISPs does vary quite significantly and whilst individual users may have little interest in these matters, collectively it's a matter of great concern.

Vulnerability lies both in the 'pipes' that carry Internet traffic and in the exchanges where Internet Service Providers (ISPs) connect with one another and hand over traffic, an activity known as 'peering'. The very largest Tier 1 ISPs tend to have their own private peering points, whereas smaller ISPs tend to use communal (public) exchanges.

To complicate matters further, not all ISPs possess their own network infrastructure and facilities; some merely resell others' spare capacity and are thus 'virtual' ISPs.

Major ISPs are aware of the need to examine their peering capacity at multiple points of presence but many others have not recognised the need to use geographically distanced backup peering facilities. This could leave their customers at significant risk. Users of ISPs that simply re-brand another operator's product without investing in infrastructure of their own will be very vulnerable when problems occur.

Even then, greater dispersal of peering and mirroring facilities will not alone guarantee the Internet's survival under pressure, as it's still totally dependant on the diversity of the physical routing implemented by the telephone companies. Whilst most ISPs have multi-sourced their backbone provision reasonably adequately, the access links that connect their operations centres to the main backbone are still very vulnerable. If, say, their operations centre has a single fibre link and that link fails, then that's where the holes will appear. Similarly, collocation centres need to ensure greater survivability of their links to the backbone network.

Last year, on 20 November, BT's Colossus IP backbone network suffered catastrophic failure and affected not just BT but many other providers too. Even if ISPs use multiple upstream providers, they may find that both of their diverse suppliers use the same duct in the same ring. When one suffers failure, so does the other: network ISP diversity should never be confused with fibre diversity.

Enough of this doom and gloom; we can be grateful that the Internet works most of the time. But if we want it to work all of the time we'll need a lot more investment in fibre, backup and peering facilities nationwide. Will it take a major disaster on the September 11th scale to make it happen?

Mark Nelson

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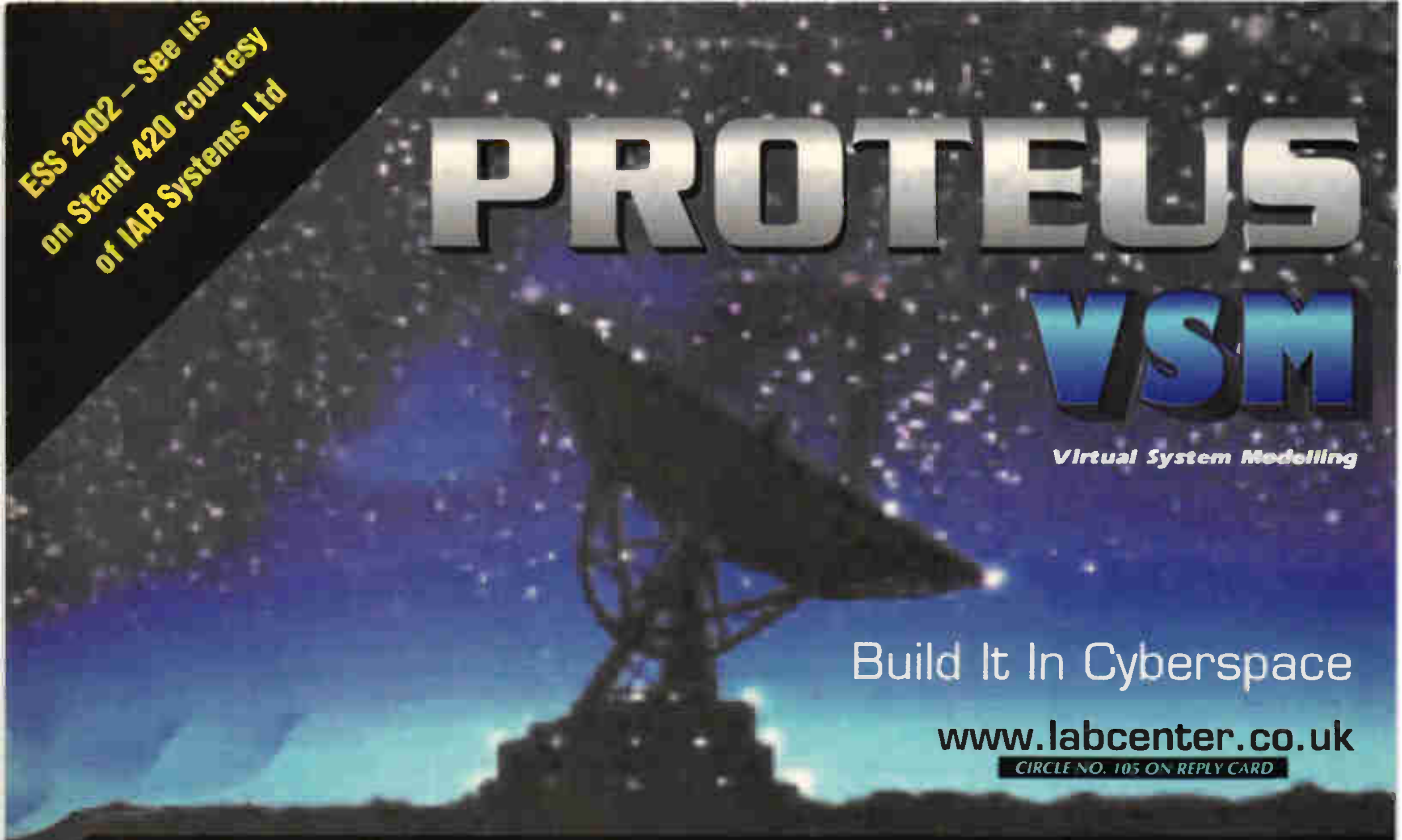

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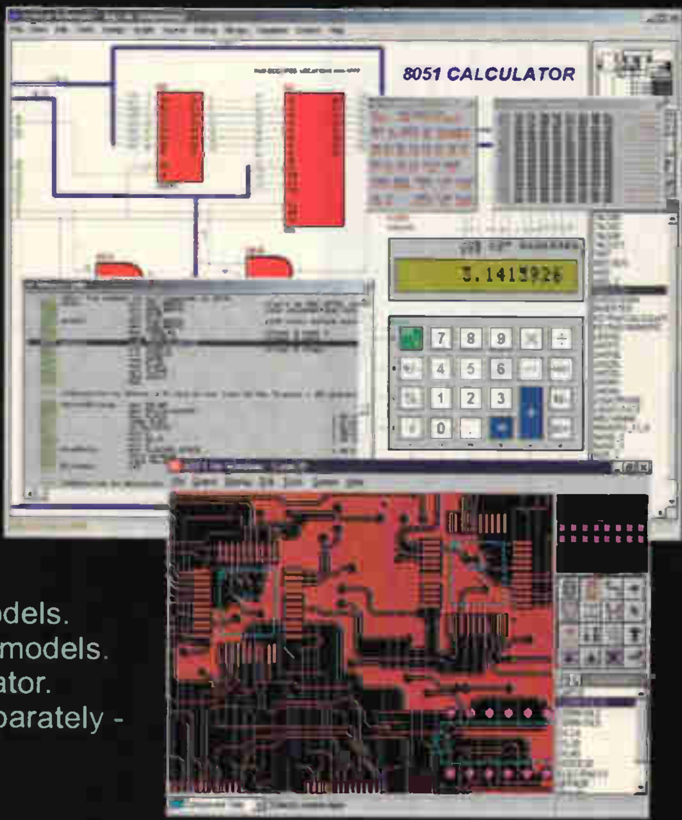

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Nickel-zinc power cell technology outperforms alkaline

Power-hungry digital cameras have prompted battery makers to develop a new type of cell for the consumer market.

To be available in AA-size, the non-rechargeable nickel-zinc batteries could easily find application in professional portable equipment.

Panasonic and Toshiba are close to production, but exact capacities are hard to come by. "The number of shots taken when using the Panasonic battery, on average, surpassed those using the Duracell M3 by 27 per cent and Energizer E2 by 47 per cent," claims Panasonic.

"Used in a digital still camera, the [Toshiba] batteries last five times longer than alkaline batteries, and work better in a low-temperature environment," said Toshiba.

Toshiba's GigaEnergy battery uses nickel oxyhydroxide for the positive electrode, a compound often used in rechargeable batteries.

GigaEnergy is due out in Japan this month and Panasonic's is out in May. Prices will be 50 per cent up on alkaline cells said Toshiba.

World's largest fuel cell supplies 1.4MW

A 1.4MW fuel-cell system – the world's largest to date – is being installed by US phone operator Verizon at a call centre in New York.

Verizon's decision to use a fuel cell system, rather than taking power from the grid, is a bold step for the firm and shows the increasing importance attached to fuel cells.

The facility handles call switching for 40 000 lines, and has over 1000 workers. Seven natural gas powered cells from UTC Fuel Cells will be capable of producing 1.4MW, while four natural gas generators will provide back-up and boost this to 4.4MW.

"We expect this fuel cell project will show us that the technology can deliver for us in terms of reliability, reducing energy costs and protecting the environment," said Paul Lacouture, Verizon's network president.

Fuel cells produce electricity though chemical processes, rather than burning the gas. This reduces pollutants to very low levels, the main by-products being heat, in this case over six million Btus, and water.

Compared to conventional electricity generating, the Verizon system will cut carbon dioxide production by around 5.5 million kilos a year.

● Last year Woking Borough Council announced that Britain's first commercial fuel cell would be installed at Woking Park in Surrey.

The 200kW power system, also from UTC, will provide both heat and electricity for the Park's pool, lighting, air conditioning and dehumidifier systems.

Woking is recognised as one of the most ardent supporters of alternative fuel sources in the UK, particularly its promotion of combined heat and power (CHP) systems.

The fuel cell is part of a larger 1.35MW project that will include a reciprocating engine and photovoltaic solar cells.

Woking also operates a 'private wire network' for its electricity, allowing spare electricity from the cell to be kept in the town, rather than fed back into the national grid.

New chips for 10Gbit/s Ethernet

Philips has boosted the speed of its already fast QUBiC4 BiCMOS chip process with a SiGe-based 'G' version.

QUBiC4G will enable Philips to supply ICs needed by the optical fibre networking industry, said the company.

"As the requirements of new markets continually evolve, so our technology portfolio adapts and grows in order to meet the specific needs of our customers", said Neil Morris, director of advanced technology at Philips. "This is one of the reasons why we have intentionally timed the release of our SiGe technology to coincide with the massive explosion in broadband communications."

F_t and F_{max} figures for transistors in the process exceed 75GHz and 100GHz respectively. This should provide the speed required for applications including network switches for 10 Gigabit Ethernet and SONET optical fibre networks.

The first chip out in the QUBiC4G is a single-chip 12.5Gbit/s optical cross-point switch called TZA2060.

For amplifiers and transmission gates, the process has a 2.7V 75GHz F_t 100GHz F_{max} transistor and for VCOs and interface logic a slightly slower 3.8V device.

Its SiGe transistors achieve 0.68dB noise figures at 2 GHz with collector currents of only 240μA. "Ideal for battery powered wireless applications in the 5 GHz to 10 GHz range," said Philips.

Impedance-matched transmission lines in the top two thick metal layers have been added to standard QUBiC features for high-speed signal routing.

Electrodes hit a nerve

Self-proclaimed cyborg Professor Kevin Warwick of the University of Reading recently had electrode attached to the nerve in his wrist.

The key technology in the connection is an implantable multi-electrode array developed at the University of Utah and made by Bionic Technologies of Salt Lake City – see picture below.

The tips of the electrodes are metalised with platinum to make the electrical contact.

To minimise nerve damage, the needles are exceedingly sharp, designed to push through tissue without tearing it, as a blunt point would, or cutting it like a chisel end. Total array volume is 4% of the block of tissue it is pushed into.

Each electrode is electrically isolated from its neighbours with glass around its base. A bonding pad on the back of the array provides a contact for the connecting wire.

The needles are strong enough to be pushed into egg shell and a special pneumatic gun ensures the array is pushed all the way home.

Warwick's current implant is a partially connected array.

If all goes well, the experiment may be repeated using a slanted version of the array, with needles between 0.5 and 1.5mm to reach nerves at different depths, with all 100 needles connected.

Eventually, surgeon Professor Brian Andrews of Stoke Mandeville Hospital, who inserted the array, would like to include processing electronics on the back of the implant.

www.bionictech.com

The Utah Electrode Array needles

Number	100 electrodes 0.4mm apart in a 10 by 10 square grid
Length	1.5mm long
Shape	Conical. 80µm, tapering to 2µm. Pt tipped
Substrate	0.2mm thick
Insulation	2µm SiN, all over except tips
Wires	25µm diameter PTFE-insulated platinum-iridium alloy.
Impedance	100 and 500kΩ, at 1kHz 100nA

What is Stoke Mandeville getting out of the deal?

Kevin Warwick's implant was inserted by Professor Brian Andrews of the famous Stoke Mandeville hospital.

The hospital is using Warwick's willingness to experiment with human-machine interaction as an opportunity to push forward its spinal injury research.

"We want a reliable way of implanting electrodes," said Andrews. "The first objective is to implant the device without damaging nerves or getting infection."

In future he hopes electronics will help restore feeling and movement to those with nerve injury. Right now he is working on the basics.

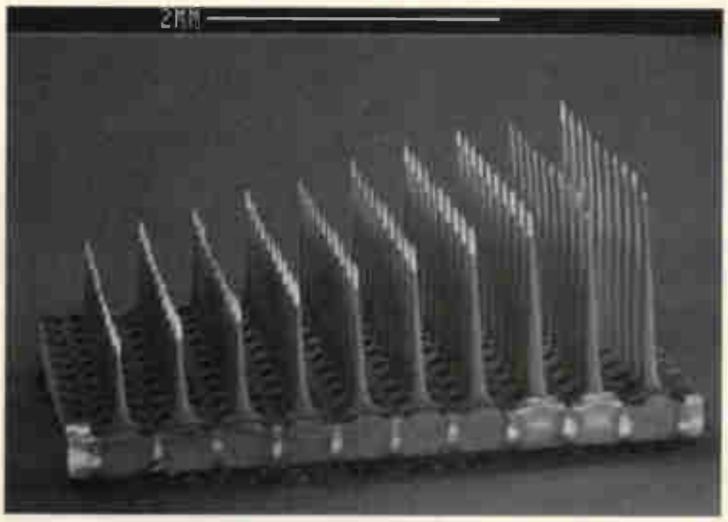
Infection is one problem. 15cm between array and wire exit wound should prevent infection creeping in. "We are hoping the skin will form a biological seal around the wires to prevent infection," said Andrews. And this seems to be happening.

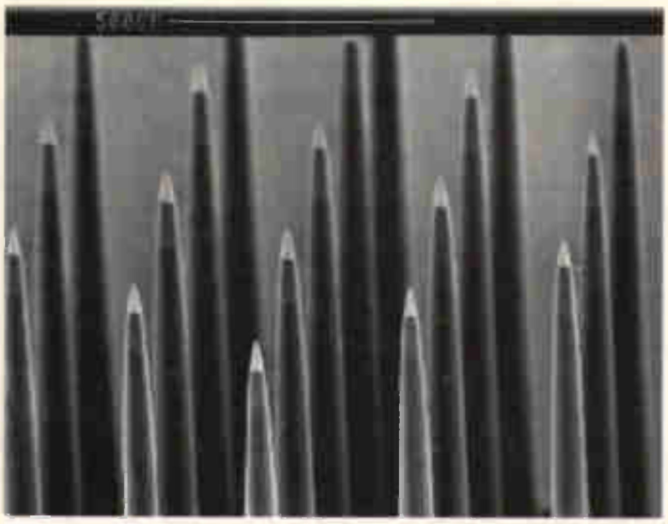
After this "we hope to pick up signals to muscles at the base of the thumb," said Andrews. The nerves will then be stimulated artificially "using pulses of a few milliamps", he added.

The question will be: "Can Kevin perceive the pulses as something to do with his hand?" asked Andrews. "For instance, the pulses may create the impression of rubbing a textured surface or pressing something."

If this happens it will be a bonus for those at Stoke Mandeville.

"The wounds are healing nicely and there is no sensory or motor loss," said Andrews. "If we get a recording we can use, it will be the icing on the cake."





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New display technology is faster than LCD and non volatile

A powder-based display than exhibits quicker response times than liquid crystal displays and is bistable has been developed by Bridgestone, the Japanese tyre giant.

Called quick response liquid powder display (QRLPD). the technology is based on a powder with what the firm describes as 'high fluidity'. The powder flows like a particulate suspension and responds very quickly to an electric field, changing the display from reflecting to light absorbent.

When subject to a field, the response times for the powder is claimed to be in the hundreds of microseconds, making it between 10 and 100 times faster than liquid crystal.

In reflective mode, the white powder reflects around 45 per cent of incident light. Importantly the display is bistable or non-volatile, so power can be removed once an image is set.

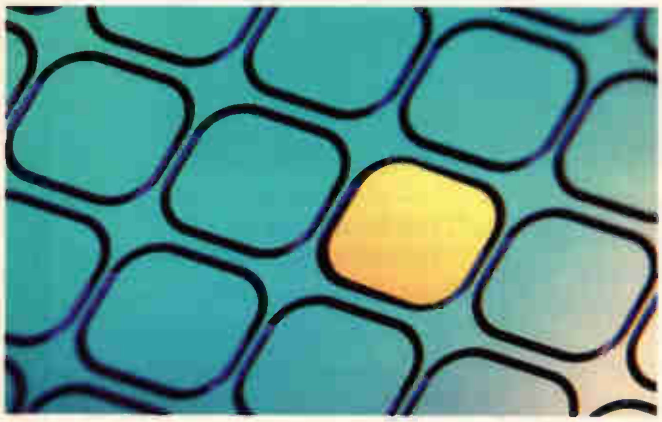
Bridgestone said the display can be driven by a simple passive matrix, rather than more expensive thin film transistor active matrix drivers.

Commercial products in mobile phones, laptops and electronic paper are expected by the firm before the end of next year.

Other firms are developing powder or particle-based displays including E Ink from the US. Its paper-like display. however, will require an active matrix with one transistor per pixel.

Steerable micromirror array has 1200 reflectors

Transparent Networks has announced this 1200 reflector steerable micromirror array, claimed to be the first with high-voltage on-chip drivers.



It is aimed at steering optical fibre signals inside routing equipment and is claimed to be scalable to 18 000 port switches.

"Our mirror array is driven by integrated electronics, which is believed to be the world's largest mixed signal IC. This single-chip design includes 4800 high-speed 15-bit D-to-A converters with 120V outputs," said Dr Janusz Bryzek, Transparent's president and CEO.

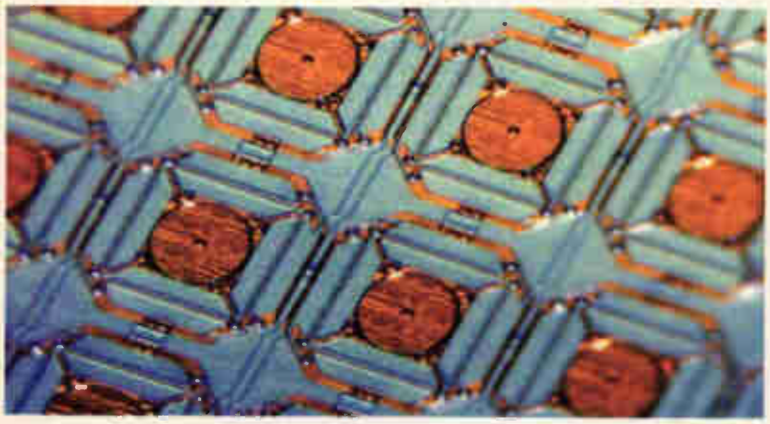
The mirrors are bulk machined. "We chose bulk micromachining technology for our integrated mirror to provide an optically flat surface enabling superior optical performance and high optical power handling capability – neither of which is achievable with surface micromachining. This future-proofs the switch and allows it to support next generation DWDM systems with over 200 wavelengths per fibre," said Bryzek.

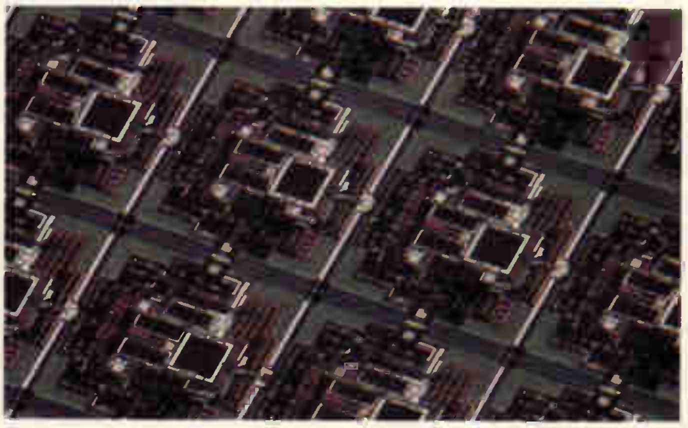
Electronics are in 1.2μm CMOS with 120V outputs and, "we implemented mechanical design in low-cost bulk MEMS process using only eight masks", said the company.

Multilayer metalisation is fabricated on a top of the circuit wafer to form four individual electrodes per mirror, which electrostatically drive the reflectors.

An integrated high-speed serial interface enables direct low-voltage communication with a commercial DSP based controller.

Power consumption is said to be below 1mW/mm^2.





Epoxy resin can be electrically un-stuck

A US company has developed an epoxy resin adhesive that can be un-stuck with a low voltage signal.

Called ElectRelease, only a few milliamps are needed to un-bond a joint without leaving blemishes.

According to importers Electromotif, the glue was developed to temporarily attach test equipment to the outside of supersonic aircraft.

Dis-bonding is a result of electro-chemical surface reactions between the amine-cured epoxy and the metal it is attached to. Ten to 50V typically undoes the joint and it works with aluminium and its alloys, low-alloy steel, stainless steel, copper and titanium.

www.electromotif.co.uk
www.eiclabs.com

Facts:
Un-bond current is 800μA/cm^2 dropping to 50μA/cm^2 after a few seconds.

The bond breaks after between 5 seconds and 20 minutes, depending on the voltage and force

Lap shear strength is 2500psi (175kg/cm^2) in type E4 and 2000psi for type M.

LEDs look set to replace CCFLs in backlighting applications

Light emitting diodes are set to oust yet another incumbent technology, this time the cold cathode fluorescent lamps (CCFLs) used to backlight liquid-crystal displays.

High-power LEDs from Lumileds will be used by Mitsubishi Electric as backlights for monitor-sized, high-resolution TFT liquid crystal displays.

"We believe that this technology will eventually replace CCFL lamps in most monitors on the market," said Eishi Gofuku, application engineering manager for Mitsubishi's LCD division.

This is perhaps the first use of LEDs to backlight large flat screens, which will be aimed at applications such as publishing and other desktop uses.

Lumileds claimed its Luxeon LEDs can self-adjust their brightness, are twice as bright as CCFLs, and provide more saturated and lifelike colours. Their 50 000 hour lifetime is up to twice that of CCFLs, said the firm.

Mitsubishi expects to have monitors on the market by the end of this year.

Accelerator speeds up signal processing

UK firm Elixent has designed hardware accelerators that can be reconfigured to implement multiple signal processing functions.

DFA1000 accelerator cores can be configured to implement functions such as FIR filters, discrete cosine transforms, or even complete JPEG and MPEG codecs.

Elixent said it will supply the cores as hard macros that interface to standard Risc processors. Interface to the cores is via the AMBA high speed bus (AHB) from ARM.

The AHB is widely used by processor and peripheral developers to use as the main system bus in chip designs.

Elixent said its cores aim to bridge the gap between traditional DSPs, FPGAs and Asics. The reconfigurable cores can be more powerful than DSP, faster and smaller than FPGA, and cheaper than Asic, it said.

Five members of the DFA1000 family range in size from 128 to 2048 arithmetic units.

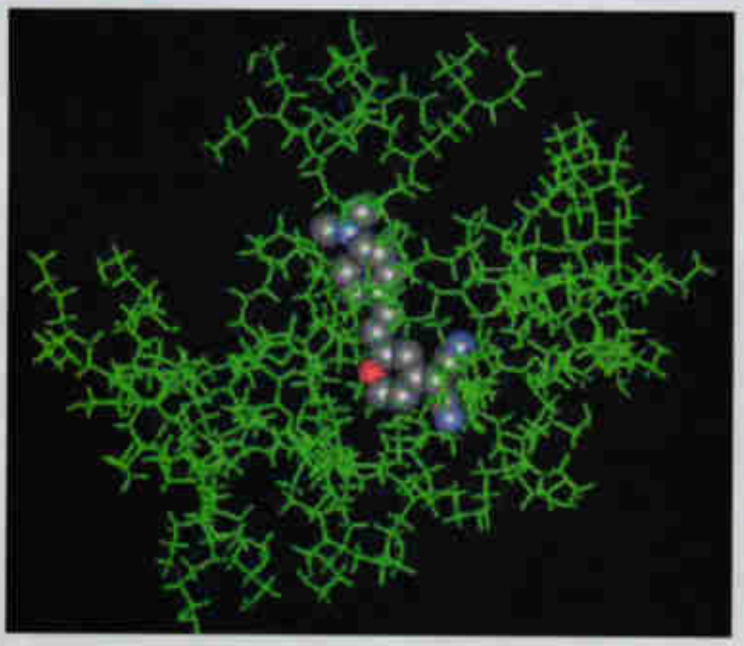
Each 4-bit arithmetic and logic unit (ALU) has its own registers and RAM. Larger data widths are accommodated by combining ALUs, while a switch matrix passes data between blocks.

Bristol-based Elixent claims the logic is several times denser than an SRAM-based FPGA, which is normally constrained by wiring.

The reconfigurable nature of the cores allows for scaling within applications. For example, a complete JPEG encoder can be created using 680 ALUs of the 1024 ALU core. Alternatively it could be split into three sections in a 256 ALU array, running at a quarter to a third of the speed.

The cores are programmed by treating the core as an FPGA and using either Verilog or through C, the latter using Celoxica's DK1 development tools.

The current cores are designed on a 0.18μm process, with 0.13μm planned for the year end. Elixent has used design rules that are compatible across the TSMC, UMC and Chartered foundries. ■



The picture shows a dendrimer from the Japanese Communications Research Laboratory and PRESTO Japan Science and Technology. It is a molecular laser, where wrapping polymers modify interaction with other molecules and allow the active fluorescent dye core to lase.

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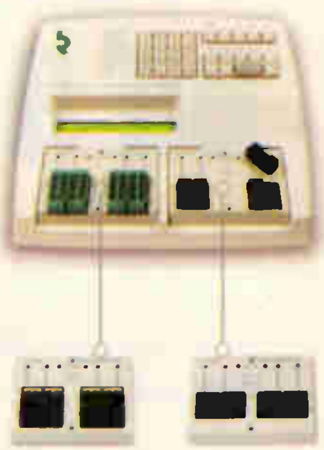

SPECIFICATIONS

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Test and measurement on a budget

Richard Black has been looking at how a PC's sound card, combined with a versatile piece of sound editing software, can be used to generate arbitrary waveforms and to make useful analyses of audio band signals.

It has become axiomatic that anything requiring computer power-per-pound is best done on a desktop computer.

In the field of electronics test and measurement their usefulness is obvious: typically these days they have pretty impressive processor power, acres of memory, practically limitless data storage space and a very high resolution display. This last should not be overlooked, since after all a major part of data acquisition and processing is being able to look at results in as much detail as required. And of course software is widely available for all kinds of tasks.

The computer is not the problem. What is considerably more taxing is how best to get the data into the computer. PCs are made in telephone numbers and cost accordingly, but data acquisition cards aren't and don't. This also applies to Macs, but I'd better come clean right away as a 'PC person': apologies to Maccies but what follows refers primarily to

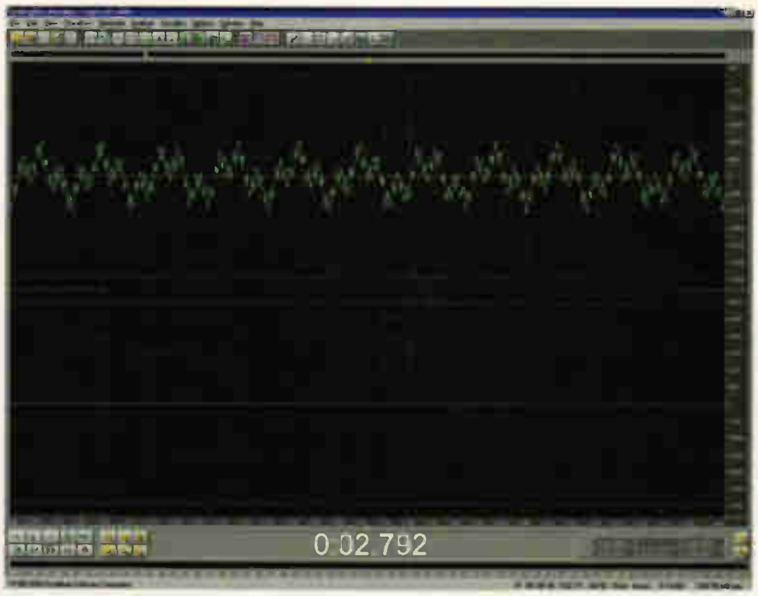


Fig. 1. General view of the Cool Edit environment.

PCs. In addition, the software required to interface with data acquisition cards has something of a reputation – not entirely deserved – for being both tricky and expensive.

So why not use the audio card of a computer as the input device? Until recently there was a very good reason why not: most such cards had pretty lousy inputs which contributed enough noise and distortion of their own to mask anything at all subtle that one might be trying to measure.

However, some of the latest cards have much better input performance, such that one can use them to record audio at quite high resolution direct to the hard disk. Using the normal CD format of 44.1kHz sampling and 16-bit resolution, this gives excellent quality from near DC to 20kHz.

As an alternative to a sound card input, it is also worth considering an audio CD recorder – stand-alone, not a PC-based burner. Costing from as little as £250, these generally have very good input circuitry and can be used as a 'data capture' unit, recording for up to 80 minutes on an inexpensive disk which, after 'finalising' to make it readable by other equipment, can then be loaded into the PC and the data transferred to the hard disk for analysis.

You'll need audio 'ripping' software to get the files off the CD and into the usual .WAV form used for audio: such software is often supplied with a CD drive or available as freeware or shareware via the Internet.

Yet another variant uses a CD recorder – or in this case even a MiniDisc recorder – as an analogue-to-digital converter, connected to the digital input of a computer's sound card by a suitable cable. Again, this benefits from the high quality inputs of the audio device.

You can't use a MiniDisc recorder as a data storage unit, though, because the format uses the 'ATRAC' data reduction system. This system may work tolerably well for audio, but it renders results useless for analysis work.

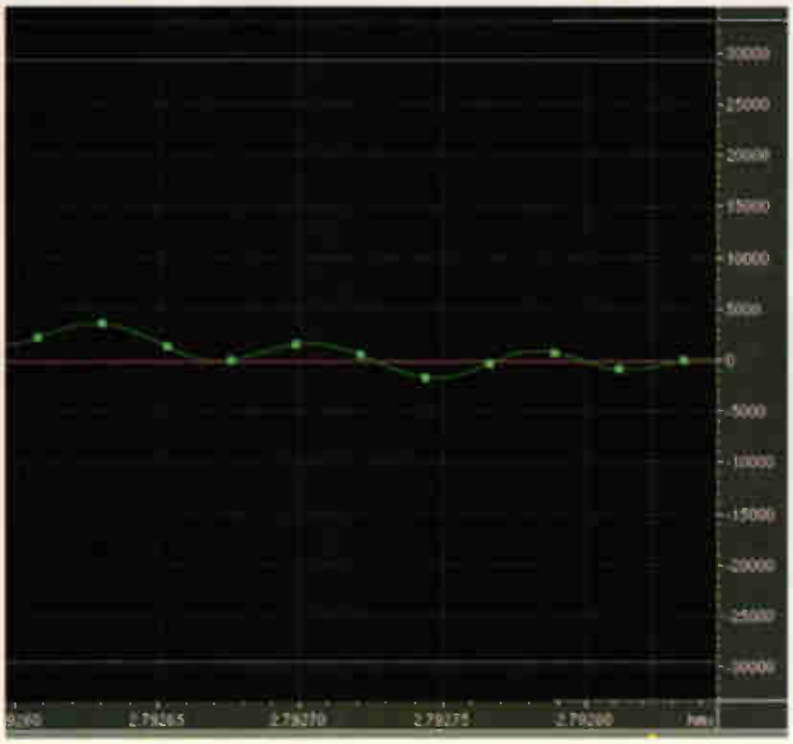


Fig. 2. High zoom factor – each square blob is one audio sample.

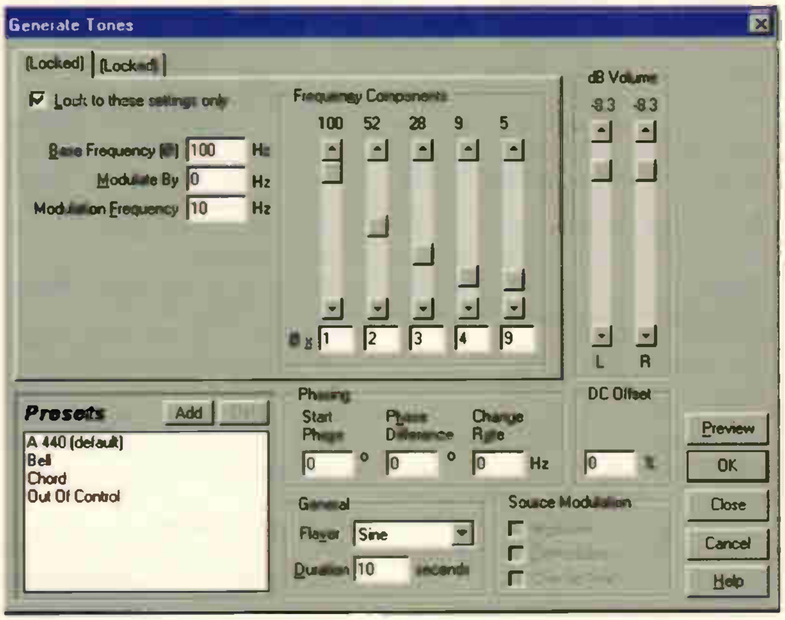


Fig. 3. Cool Edit's signal-generation window.

Software for analysing captured signals

Many engineers already use mathematical packages such as Mathcad and Matlab on a daily basis. However, one advantage of using audio files on the PC is that they can be read by dedicated audio editing software.

One of these programs in particular has several features of great usefulness in data analysis: Cool Edit, **Fig. 1**. Although it's distributed via the Internet for the extremely modest sum of $69 (from www.syntrillium.com) it is a remarkably clever bit of software.

Like any audio editing software it allows you to look at the waveform on the screen. This in itself is very useful, the more so since you can zoom in as much or as little as you want, **Fig. 2**.

What makes Cool Edit really useful is its 'Frequency Analysis' function. This is a floating fast-Fourier transform (FFT) window that displays a high-resolution frequency-domain plot of the signal around the cursor position.

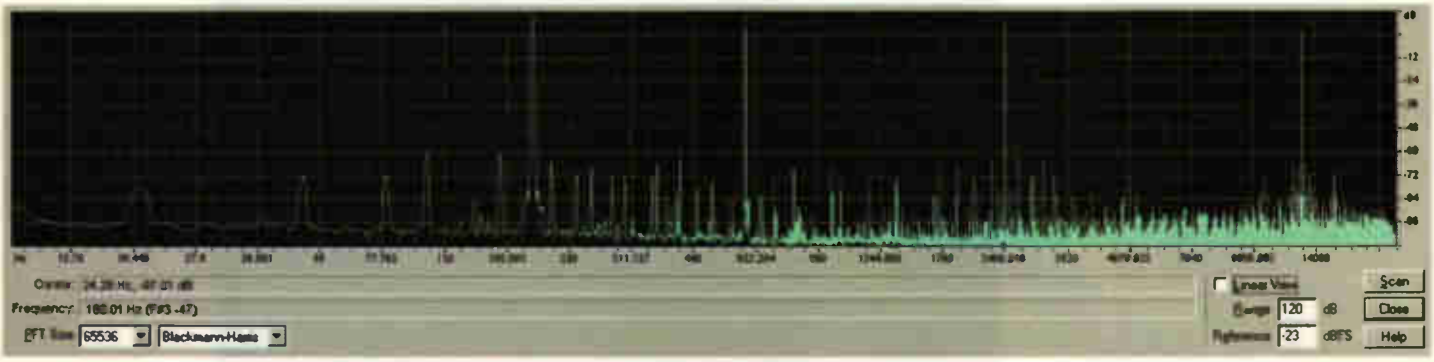
Length of the transform 'window' is variable between 128 and 65536 samples, giving more or less resolution. At lengths of up to 4096 samples the window is updated in real time as the music – or what the program interprets as music – plays through.

It is also possible to scan a selection to get an average of the FFT over a period of time. You can't output the FFT result in any storable form. You can grab the plot window with a screen-capture program though and save it for future examination.

One drawback of the FFT is that it divides the frequency band into 'bins' of equal width. So what if you want to

(a)

Fig. 4. Distortion of a real amplifier, as shown up by a four-tone test signal, a), and a version of the same analysis but with log frequency scale, b).



(b)

examine only a portion of the band? Cool Edit provides filtering and modulation functions that allow this to be done. I'll be looking at this in more detail in a second article. Also, because it intrinsically works in stereo, it gives the possibility of comparing two measurements side by side.

Producing test signals

So far I've only considered the 'response' part of test and measurement. What's of equal importance of course is the stimulus.

In simple audio testing, the commonest stimulus is a sine wave at some suitable spot frequency. Most engineers have some kind of sine generator. However, the use of Cool Edit and a CD burner (or audio output from a high quality sound card) also puts an arbitrary waveform generator into your hands, **Fig. 3**. The only restriction of this generator is the 20kHz bandwidth which we've already taken for granted in the measurements.

Cool Edit's signal generator produces sine waves of any frequency, amplitude and duration. These signals can be swept. Also, several can be added together – using cut and paste much as in desktop publishing – to produce complex multitone signals.

Avoid using digitally-generated square waves, and indeed anything else with discontinuities such as sawtooth and sine-squared waveforms. These are generated in such a way as to have high distortion due to aliasing.

Cool Edit can generate white and pink noise. At very high zoom magnifications it is possible to grab individual samples with the mouse and edit them, giving truly arbitrary generation if you've got the patience.

Produce the basic waveform, multiply it using cut and paste if necessary to obtain a useful duration. Next, save it as an audio file and use any CD burning software to make your very own test CD. I have half a dozen for various purposes.

Obviously you now need a separate CD player to play these tones out, but the chances are you have one already: most homes do. Alternatively, simply play the sound file through a high-quality sound card. Output quality is usually higher than input quality on sound cards and this can work fine.

Multitone testing

Multitone testing is perhaps the most useful facility that this technique adds to the low-budget engineer's artillery, **Fig. 4**. You can make – or buy second hand – a decent enough THD test set for not much money. Pulse and noise-based tests are reasonably amenable to simple implementation based on an oscilloscope and perhaps a relatively low-resolution digitiser of some sort.

Multitone testing, by contrast, is of little use without high-resolution spectrum analysis. This is because the intermodulation distortion it shows up is spread all over the test band, among the original frequencies. But it is a very useful and powerful technique.

In audio in particular, multitone testing is arguably the most directly relevant test of distortion since – sensibly implemented – it most closely resembles the case of real music. Significantly, it places realistic stress on equipment under test at high frequencies, without requiring the use of analysis at ultrasonic frequencies as does THD testing.

Wow and flutter

One other test quite easily carried out by my method is wow and flutter testing. Admittedly, such tests are not often necessary these days, but they are still useful for characterising LP and tape replay equipment.

Using Cool Edit's modulation and pitch-shifting functions, you can actually listen to the speed variations, much magnified. This gives you an instant handle on what might be misbehaving.

Indeed, the possibilities afforded by listening to distortion residuals, etc., are well worth investigating. OK, it's unscientific in the sense that it gives no numeric answer, but for analytical purposes in development or repair it can be an incredibly handy short-cut.

Mathematical analysis

If you are mathematically inclined you may want to take advantage of Mathcad or similar for analysis. Cool Edit normally works with .WAV files, but it can also import and export data in text form, which can then be read into Mathcad – or any other programs that can read columns of figures – as a '.PRN' raw ASCII data file.

All sorts of additional possibilities now open up such as correlation and convolution. I haven't found a need for any of these myself in this field, but someone surely will! In addition, you can at least save the results of an FFT.

A more detailed look at the possibilities afforded by Cool Edit will make up a later article. A third article will be taking the piece of audio investigation for which I originally refined these techniques as an illustrative example. This was an investigation into the alleged 'sound' of audio cable. ■

Further reading

1. K. Howard, 'The Weighting Game', *Hi-Fi News*, December 2001, pp. 78-83.
2. E. Czerwinski *et al.*, 'Multitone Testing of Sound System Components...', *J. Audio Eng. Soc.*, Vol. 49 No 11 (Nov. 2001) pp. 1011-1048 & Vol. 49 No 12 (Dec. 2001) pp. 1181-1192.
3. J.M. Risch, 'A New Class of In-Band Multitone Test Signals', *J. Audio Eng. Soc.*, Vol. 46 No 11 (Nov. 1998) p. 1037.

Note that the article by Czerwinski *et al* contains a vast list of 119 further references.

Things to watch out for

Not surprisingly, there are a few drawbacks and limitations to bear in mind – as with any cut-price solution to anything.

One of the most important things to do is to get a baseline of test equipment performance. I usually play test tones from a Rotel CD player and record the results on a Marantz CD recorder.

I made a 'calibration run' connecting the two directly together, with a four-tone test signal, to examine the intrinsic distortion: the resulting spectrum is shown in **Fig. A**. Note that the highest single distortion spike is 84dB below the highest signal spike, and over a lot of the band there is a clear dynamic range of over 100dB.

A dCS professional analogue-to-digital converter – over £5000-worth – gave the noticeably better results shown in **Fig. B**. What really surprised me though was that a £350 Sony MiniDisc recorder with digital input level control and all gave results slightly better if anything than the dCS, **Fig. C**. The MiniDisc player was used in record/pause, so there was no ATRAC processing in the path.

That pretty much covers dynamic range limitations. Frequency range is near DC to 20kHz, take it or leave it. Most audio a-to-d converters have good low-pass filters built in and are highly immune to ultrasonic interference. If you are in doubt, carry out some tests.

Because there is a low-pass filter also built into any digital replay equipment, pulses output through it will turn into distinctive windowed sine-function curves, when viewed on an ocilloscope.

In general, replay and recording won't be in phase even though they are at nominally the same frequency. As a result, pulse testing and any other investigations requiring accurate phase alignment may give odd results.

Testing of the digital version of wow and flutter, generally known as jitter, is possible but may well be limited by the jitter of the source and the a-to-d converter used, so don't bet on it. In general, a little forethought and common sense will show up most potential problems before they ever occur.

Fig. A. 'Calibration run' with Rotel CD player and Marantz CD recorder.

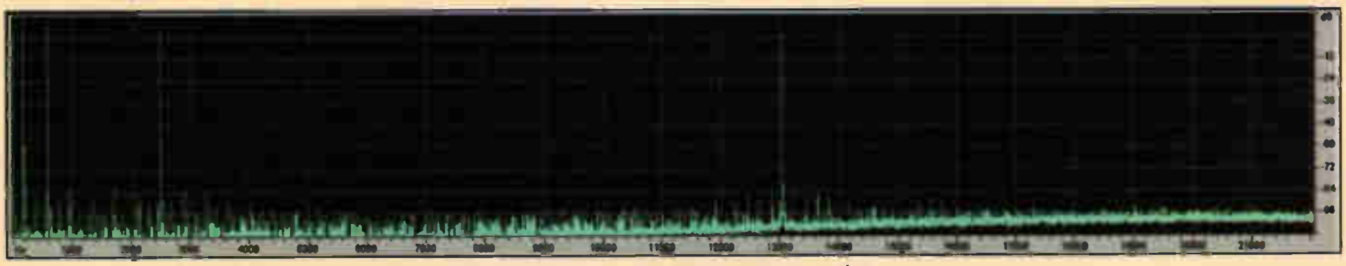


Fig. B. As Fig. A, but with dCS professional a-to-d converter replacing Marantz CD recorder.

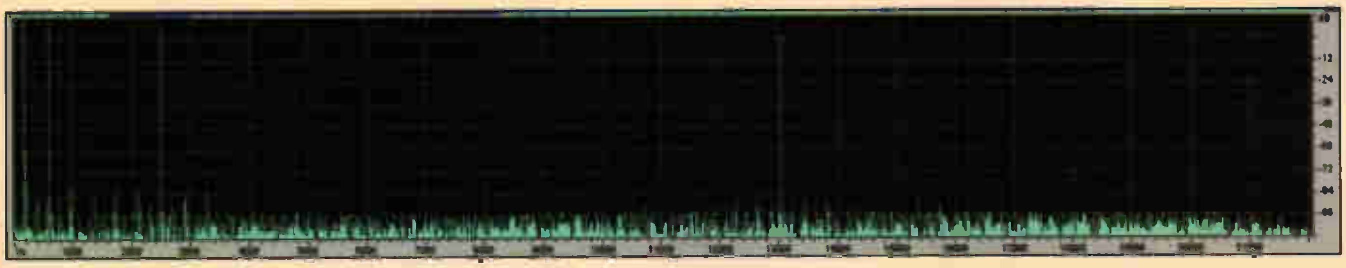


Fig. C. As Fig. A, with Sony MiniDisc recorder replacing Marantz CD recorder.

Behind RDS

There's quite a bit more information in RDS transmissions than is displayed by most RDS-equipped radios. Roger Thomas explains what the 'Radio Data System' is, and how to reveal exactly what's being transmitted.

The Radio Data System – Cenelec* EN50067 specification – is an inaudible data signal added to the VHF FM stereo signal. It was introduced within the European Broadcasting Union (EBU) in the mid 1980s.

RDS was designed to make VHF-FM radios more user friendly by providing the listener with additional information about the radio programmes available. An RDS radio can display the current radio station name and other information. All RDS radios have an eight character alphanumeric display.

A list of alternative frequencies of nearby radio transmitters that are also transmitting the same radio programme is also provided by RDS. This allows the radio to automatically re-tune itself to an alternative frequency if the current frequency is providing poor reception when driving between different transmitter coverage areas.

Automatic re-tuning is also used with traffic announcements so that when you are listening to a network station, the RDS radio will switch to a local radio station carrying traffic information when an announcement becomes available .

Project background

Originally I wanted to build a VHF-FM radio from a kit and connect the output to a single-chip RDS demodulator. I couldn't find out from the kit manufacturer whether the RDS signal would be available though.

There was a second problem. RDS demodulator chips are available from several manufacturers but all require a 4.332MHz timing crystal. I was unable to find anyone who could supply this crystal.

In the end I bought a Goodmans RDS MW/FM analogue clock radio (model GCR 1605RDS) for £25 including VAT. The term 'analogue' means that this radio has manual tuning. It is unlikely that a complete VHF-FM radio and display could be hand built for less than the cost of the Goodmans radio.

This radio incorporates an RDS demodulator chip similar to the one I had originally wanted to use – complete with the elusive 4.332 MHz crystal. No doubt there are other similarly priced RDS radios available.

It may seem daft to buy a radio that is already RDS enabled just to decode the RDS signal, but there is much data that the radio does not use or display. RDS data is taken directly from the RDS demodulator chip. This way all the RDS data is available for decoding irrespective of whether it is also being decoded by the Goodmans radio.

In this article I have given detailed information only on the RDS data groups that are being broadcast. Also, I have used hexadecimal numbers in nn_{16} form when describing the RDS data transmitted. A glossary is provided.

RDS data signal

RDS's 57kHz sub-carrier, Fig. 1, uses amplitude modulation but with the carrier suppressed. This has the advantage of using less bandwidth than if the RDS data signal were frequency modulated.

Maximum bandwidth of the RDS data signal is ±2.4kHz. Although the RDS data signal is locked to three times the

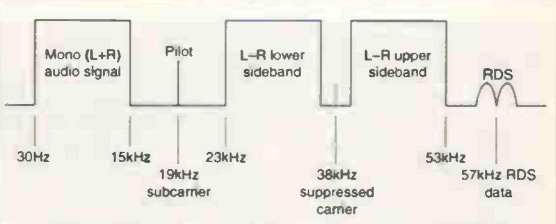


Fig. 1. Spectrum showing the stereo multiplex and RDS sub-carrier.

* Cenelec – Comité Européen de Normalisation Electrotechnique – is responsible for standardising television and radio receivers.

16 bits of data (PI number) Block A	Block A 10-bit check word +offset A	16 bits of data Block B	Block B 10-bit check word +offset B	16 bits of data Block C	Block C 10-bit check word +offset C of C'	16 bits of data Block D	Block D 10-bit check word +offset D

Fig. 2. RDS data group comprising 4 blocks of data with 26 bits per block.

19kHz pilot frequency it is not necessary to have a stereo decoder for RDS.

Each RDS data bit phase modulates the sub-carrier by ±90°. When the input data bit is '0' the output remains unchanged, when an input '1' occurs the output is the complement of the previous output.

The RDS clock frequency is obtained by dividing the transmitted sub-carrier frequency of 57kHz by 48. Consequently, the data rate is 57000/48, which represents 1187.5 bits per second. Each group takes around 88ms to transmit.

Similar VHF-FM sub-carrier data transmission systems been used for many years prior to RDS. They include MBS (Mobile Broadcast System) a Swedish radio paging system and ARI (Autofahrer Rundfunk Information) providing traffic information. However ARI is being replaced by the RDS Traffic Message Channel (TMC) across Europe.

RDS data

Each RDS data group is made up of 104 bits comprising 4 independent blocks of data. Each block is 26 bits in length with 16 bits for data and 10 bits as the check word.

Data is transmitted synchronously so there are no inter-block gaps: the data in each block is transmitted most significant bit first. There is no header data or special sequence of data to indicate start of the data block. Instead RDS decoders rely on the fact that only properly received and synchronised data will pass the check word test, **Fig. 2**.

Check word. The addition of this 10-bit error-detecting check word to each block of data allows detection of all errors of fewer than 10 bits and about 99.9% of longer error bursts.

Syndrome. In a similar data system, the result of the check word calculation previously discussed would normally be zero or all ones if the block had been received correctly. With RDS though, a 10-bit offset is added to each check word. When the data is correctly received the result will be one of the five possible syndromes.

Although the word syndrome has medical connotations it simply means a set of characteristics. These syndromes are identified as A, B, C or C', and D. The occurrence of a C' syndrome indicates that block C is a PI number without the need to reference the group type number (PI and group type are explained later).

Fig. 3. Syndrome types and their hexadecimal representation.

A	=	$3D8_{16}$
B	=	$3D4_{16}$
C	=	$25C_{16}$
C'	=	$3CC_{16}$
D	=	258_{16}

Block A. The first block of an RDS group transmitted – block A – is always the PI, or 'programme identification' – number of the current radio station. This number can also be found repeated in subsequent blocks in some group types.

A PI number is made up of the country code, the coverage area and a unique radio station reference number. It is usually quoted as a hexadecimal number, **Fig. 4**.

Fig. 4. Block A PI bit definition. This block is transmitted in every RDS group.

Bit	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Country code	Coverage area	Radio-station reference number
GB = C_{16}	0_{16} = local	Network radio stations:
	1_{16} = international	
0_{16} – not used	2_{16} = national	01_{16} – BBC Radio 1 ($C201_{16}$) PS = Radio 1
1_{16} – DE,GR,MD,MA	3_{16} = regional	02_{16} – BBC Radio 2 ($C202_{16}$) PS = BBC R2
2_{16} – DZ,CY,CZ,EE,IE	4_{16} = region 1	03_{16} – BBC Radio 3 ($C203_{16}$) PS = BBC R3
3_{16} – AD,PL,SM,TR	5_{16} = region 2	04_{16} – BBC Radio 4 ($C204_{16}$) PS = BBC R4
4_{16} – IL,MK,CH,VA	6_{16} = region 3	
5_{16} – IT,JO,SK	7_{16} = region 4	$A1_{16}$ – Classic FM ($C2A1_{16}$) PS = Classic
6_{16} – BE,FI,SY,UA	8_{16} = region 5	
7_{16} – LU,RU,TN	9_{16} = region 6	
8_{16} – PT,BG,NL,PS	A_{16} = region 7	
9_{16} – AL,DK,LV,LI,SI	B_{16} = region 8	
A_{16} – AT,GI,IS,LB	C_{16} = region 9	
B_{16} – HU,IQ,MC	D_{16} = region 10	
C_{16} – HR,LT,MT,GB	E_{16} = region 11	
D_{16} – DE,LY,YU	F_{16} = region 12	
E_{16} – ES,RO,ES,SE		
F_{16} – BY,BA,EG,FR,NO		

The PI number is fundamental to how RDS works. It is this number that the radio uses when looking for alternative frequencies in case of bad radio reception or switching to other radio stations for traffic announcements. The radio station name displayed on an RDS radio is purely for information.

Having only four bits, the country code only allows differentiation between 15 countries. It is not possible for each country to have its own number, so several countries share the same country number.

These country numbers are allocated to ensure that neighbouring countries have different numbers. For example, France is allocated F_{16}, Ireland is 2_{16}, Belgium is 6_{16}, The Netherlands is 8_{16}, and so on.

Fig. 5. Block B definition showing group type and PTY number. Functions of bits 04 to 00 depend on group type.

Bit 15	14	13	12	11	10	09	08	07	06	05
2^3	2^2	2^1	2^0	Flag	Flag	2^4	2^3	2^2	2^1	2^0
Group type				**B**	**TP**	**PTY programme type**				
0A				0		00 = NO PTY				
0B				1		01 = NEWS				
1A				0		02 = AFFAIRS				
1B				1		03 = INFO				
2A				0		04 = SPORT				
2B				1		05 = EDUCATE				
3A				0		06 = DRAMA				
3B				1		07 = CULTURE				
4A				0		08 = SCIENCE				
4B				1		09 = VARIED				
5A				0		10 = POP M				
5B				1		11 = ROCK M				
6A				0		12 = EASY M				
6B				1		13 = LIGHT M				
7A				0		14 = CLASSICS				
7B				1		15 = OTHER M				
8A				0		16 = WEATHER				
8B				1		17 = FINANCE				
9A				0		18 = CHILDREN				
9B				1		19 = SOCIAL				
10A				0		20 = RELIGION				
10B				1		21 = PHONE IN				
11A				0		22 = TRAVEL				
11B				1		23 = LEISURE				
12A				0		24 = JAZZ				
12B				1		25 = COUNTRY				
13A				0		26 = NATION M				
13B				1		27 = OLDIES				
14A				0		28 = FOLK M				
14B				1		29 = DOCUMENT				
15A				0		30 = TEST				
15B				1		31 = ALARM!				

The UK is allocated number C_{16}. Within Europe, we share this number with Croatia, Lithuania and Malta. Consequently all UK radio station PI numbers begin with 'C'.

Additional information, called 'Extended Country Code', is given in the type 1A group. This combination then allows for a unique country number.

By definition, local radio stations have a limited coverage area signified by the regional information. Some RDS radios have a 'regional' function that allows the RDS radio to re-tune to another local station within the same region.

Block B. The first four bits of block B determine the group type of the following data and the fifth bit (B) determines the group version, **Fig. 5**.

There are two versions of each group depending on the binary status of bit B: an 'A' or 'B' is appended to the group type, as appropriate. The next bit, TP, is the traffic programme flag. This bit indicates that the tuned radio programme carries traffic announcements. More about traffic announcements later.

The next five bits of block B contain the PTY, or 'programme type', number. Programme type numbers are given to radio programmes according to their content. Most RDS radios will search for a radio station broadcasting a particular type of programme.

The definitions for the rest of block B, and blocks C and D vary according to the group type.

Group types

Many different block configurations for different data applications are defined in the RDS standard. Each of the four block groups are dedicated to one type of data application and identified by a group type number from 0 to 15. Different broadcasters utilise different groups.

Fig. 6. RDS group type summary – many group types are currently not used.

Type	Function
0A	Basic tuning and switching.
0B	Basic tuning and switching.
1A	Programme item number and labelling codes.
1B	Programme item number.
2A	Radio Text (64 characters).
2B	Radio Text (32 characters).
3A	Application Identification for ODA.
3B	Open Data Application.
4A	Clock time and date.
4B	Open Data Application.
5A	Transparent Data Channels or ODA.
5B	Transparent Data Channels or ODA.
6A	In-house use.
6B	In-house use or Open Data Application.
7A	Radio Paging.
7B	Open Data Application.
8A	Traffic Message Channel.
8B	Open Data Application.
9A	Emergency Warning System or ODA.
9B	Open Data Application.
10A	Programme Type Name.
10B	Open Data Application.
11A	Open Data Application.
11B	Open Data Application.
12A	Open Data Application.
12B	Open Data Application.
13A	Enhanced Radio Paging or ODA.
13B	Open Data Application.
14A	Enhanced Other Networks information.
14B	Enhanced Other Networks information.
15A	not defined in RDS.
15B	Fast basic tuning.

Type 0 group. PS (Programme Service) is the eight character name of the radio station displayed by RDS radios. This group is transmitted more frequently than other groups as a total of four type 0A groups are required to transmit the entire PS name. Two text characters of the radio station name are transmitted in each block D.

All PS names are eight characters long; if the name is less then spaces are added. The PS is for information only, thus different radio networks may refer to the same PI number with a slightly different PS. For example, Classic FM refers to Radio 1 as BBC 1 FM (PI=C201).

Networked BBC radio stations have a dynamic programme type, where the PTY number varies according to the programme content. For example, when the news is broadcast the PTY number changes to 1, similarly when the weather is broadcast the PTY number changes to 16. The majority of commercial radio stations have a static programme type, so their PTY number does not change.

Bits C_1C_0 determine which position the character being sent occupies, and which decoder information bit (bit 02) is being transmitted.

TP and TA flags. When the traffic-programme flag, TP, is logic 1, it indicates that the radio station currently being received broadcasts traffic announcements. If the traffic-announcement flag, TA, is logic 1, a traffic announcement is currently being broadcast by this station.

Fig. 7. Decoder information.

C_1	C_0	Decoder option
0	0	D3=0, mono: D3=1, stereo
0	1	D2=0, not binaural: D2=1, binaural
1	0	D1=0, not compressed, D1=1, compressed
1	1	D0=0, static PTY, D0=1, dynamic PTY

Music/speech bit. Bit 3 in block B indicates whether music or speech is being transmitted, enabling a receiver to be set up with a different volume and tone to suit the audio content. However, the default setting is music and I have not found a station that changes the status of this flag – even when the programming is all talk. Blocks details are given in **Figs 8-10**.

Alternative frequency. Alternative frequencies, designated AF, are transmitted in block C of each group type 0A. These alternative frequencies are transmitted as a number between 1 and 204. Number 1 signifies 87.6 MHz, 2 signifies 87.7 MHz, and so on in increments of 0.1 MHz up to number 204 (107.9 MHz).

The RDS standard also covers alternative frequencies for medium and long wave but this feature does not seem to be used in the UK. All the AF codes are listed in **Fig. 11**.

If there are no alternative frequencies then either the filler code is transmitted (205) or a type 0B group is used. With type 0B group block C transmits the PI number again (copy of block A).

Fig. 11. Alternative frequency (AF) codes.

0	not used
1	87.6 MHz
2	87.7 MHz
:::	
203	107.8 MHz
204	107.9 MHz
205	filler code
206..223	not assigned
224	no AF
225	1 AF exists
226	2 AF exists
:::	
248	24 AF exists
249	25 AF exists
250	LF/MF AF follows
251..255	not assigned

Type 1 group. This group provides the extended country code and several other options. The PIN, or 'programme item number' in block D is the scheduled start time of the radio programme and enables a suitable radio to record a particular programme that the user has selected.

The radio paging option does not seem to be used in the UK. Type 1B group has the PI number in block C instead

Fig. 8. Definition of block B for type 0A or 0B group.

Bit 15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
														C_1	C_0
Group type number				**B**	**TP**	**PTY programme type**					**TA**	**M/S**	**D3**	0	0
													D2	0	1
0	0	0	0	X									**D1**	1	0
													D0	1	1

Fig. 9. Definition of block C for type 0A group.

Bit 15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Alternative frequency list of tuned network								Alternative frequency list of tuned network							

Fig. 10. Definition of block D for type 0A or 0B group.

Bit 15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Programme service name								**Programme service name**							
C_1C_0 = 00 character position 1								C_1C_0 = 00 character position 2							
C_1C_0 = 01 character position 3								C_1C_0 = 01 character position 4							
C_1C_0 = 10 character position 5								C_1C_0 = 10 character position 6							
C_1C_0 = 11 character position 7								C_1C_0 = 11 character position 8							

of the labelling codes, **Figs 12-14**.

Using the LA bit allows several radio services with different PI numbers to be treated by the RDS receiver as a single service during times when a common programme is carried. The PIN – or Programme Item Number – is the scheduled broadcast start time and day of month of the radio programme, **Fig. 15**.

Fig. 12. Definition of block B for type 1A group.

Bit															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Group type 1A				**B**	**TP**	**PTY programme type**					**Radio paging codes**				
0	0	0	1	0											

Fig. 13. Definition of block B for type 1B group.

Bit															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Group type 1B				**B**	**TP**	**PTY programme type**					**Reserved for future uses**				
0	0	0	1	1											

Fig. 14. Definition of block C for type 1A group.

Bit					
15	14	13	12	11 10 09 08	07 06 05 04 03 02 01 00
LA	0	0	0	[0] Radio Paging	Extended Country Code (GB = $E1_{16}$)
LA	0	0	1	[1] TMC identification	
LA	0	1	0	[2] Paging Identification	
LA	0	1	1	[3] Language code (including 09_{16} English, 12_{16} Gaelic, 05_{16} Welsh)	
LA	1	0	0	[4] not defined	
LA	1	0	1	[5] not defined	
LA	1	1	0	[6] For use by broadcasters	
LA	1	1	1	[7] Identification for emergency warning system channel	

LA = Linkage Actuator bit (for linking radio services)

Fig. 15. Definition of block D for type 1A and 1B groups.

Bit															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
2^4	2^3	2^2	2^1	2^0	2^4	2^3	2^2	2^1	2^0	2^5	2^4	2^3	2^2	2^1	2^0
day (1...31) if 0 then no PIN					hour (0...23)					minute (0...59)					

Type 2 group. Broadcasters can send radio text messages of up to 64 characters in length for display on a suitably equipped RDS radio. Each type 2A group carries a total of four characters, with two data blocks (C and D) each block carrying two text characters. Bits $C_3C_2C_1C_0$ determine the text character position.

The A/B flag is used to indicate whether a new text message should over write the existing message or if the display should be cleared before the new message is displayed. If the flag value changes between messages then the display is cleared.

Observing the radio text message is a good indication of the quality of the RDS signal. If any data in a type 2A group block is missing, then potentially four text characters will be missed. The same text message is broadcast several times to ensure correct reception.

Type 2B group is limited to 32 text characters as block 3 is used to transmit the PI number rather than text but type 2B group seems not to be used in the UK. Details on the type 2 group are given in **Figs 16-18**.

Type 3A group. The type 3A group gives information about which 'open data application' (ODA) groups are being carried on the current RDS transmission. An open-data application is one that has not been explicitly defined in the RDS specification. This method of allocating ODA allows additional data services to be broadcast (or data groups to be re-allocated) dynamically.

The type 3A group comprises the application group type number used by the ODA application. The 16 message bits in block B can by used directly by the ODA.

In block D, the AID (Applications IDentification) number is used to uniquely identify a particular application. This number is recognised by the radio's software and the data sent can then be correctly decoded.

These AID numbers are allocated by the European Broadcasting Union on application by the broadcaster or data provider. The number allocated is arbitrary but AID = 0093_{16} is 147 decimal and as it relates to DAB broadcasts this is rather appropriate number (Eureka 147).

Details on the 3A group are given in **Figs 19-21**.

Type 4A group. Type 4A group is transmitted every minute and is used to transmit the current time and date. The time is in 'co-ordinated universal time' (UTC) plus local time achieved by using a time offset.

Local time offset is transmitted as the number of half-hour difference from UTC. The most-significant bit determines if this is a positive or negative time offset – i.e. east or west of Greenwich longitude.

The date is transmitted in modified Julian day code, where the date is encoded as the number of days from a particular year starting from 1 March 1900 to 28 February 2100. As the date is locked to UTC time not local time, it will change at UTC midnight, as opposed to local midnight.

Figures 22-24 detail block A functions.

Type 6A group. The format of type 6A groups, when used in-house, is defined entirely by the broadcaster. I believe that this data group is used internally by the BBC to communicate the status of the network RDS equipment.

Type 8A group. Traffic message channel, or TMC, information uses type 8A group and the ALERT (Agreed Layer for the European RDS-TMC) protocol. This protocol defines the coding of traffic messages by the use of a predefined database containing location names and events.

The protocol is not language or country specific and is planned to be used across Europe. A TMC radio will require either a synthesised voice or display screen for the traffic information and will usually be integrated with a car navigation system.

Although the technical aspects of transmitting TMC have mostly been resolved there remains the issue of who pays for the service. The BBC as a public service broadcaster believes the travel information should be made freely available. However the only large scale TMC trials undertaken in this country involved the two motoring organisations and used Classic FM transmitters, with the intention of providing a subscription based service.

Type 12A group. The 'open data application', or ODA, feature allows data to be transmitted whose format has not been defined in the RDS specification. Such data is determined by the broadcaster or end user. The last 5 bits of block B and blocks C and D are available to carry data. These ODA groups are identified by type 3A group to enable a suitably equipped RDS receiver to process the transmitted data.

Type 14A group. Enhanced other network, or EON, is a feature used to update the information stored within a RDS receiver about radio services available on other radio networks. The BBC network carries information about the BBC networks and BBC local radio stations, as well as information for Classic FM. This information for the other network includes the radio station name, PI number, transmitter frequencies, traffic announcement identification, and programme type. For some stations programme item number (PIN) information is transmitted.

EON is implemented using type 14A group and 14B to send the information of the other radio networks. The value of the variant code (type 14A) determines what

Fig. 16. Definition of block B for type 2A group.

Bit

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
												C_3	**C_2**	**C_1**	**C_0**
Group type 2A				**B**	**TP**	**PTY programme type**					**A/B**	0	0	0	0
												0	0	0	1
												...	...	...	...
0	0	1	0	0								1	1	1	0
												1	1	1	1

Fig. 17. Definition of block C for type 2A group.

Bit

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Radio text message								**Radio text message**							
$C_3C_2C_1C_0$ = 0000 character position 1								$C_3C_2C_1C_0$ = 0000 character position 2							
$C_3C_2C_1C_0$ = 0001 character position 5								$C_3C_2C_1C_0$ = 0001 character position 6							
:::								:::							
$C_3C_2C_1C_0$ = 1110 character position 57								$C_3C_2C_1C_0$ = 1110 character position 58							
$C_3C_2C_1C_0$ = 1111 character position 61								$C_3C_2C_1C_0$ = 1111 character position 62							

Fig. 18. Definition of block D for type 2A group.

Bit

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
$C_3C_2C_1C_0$ = 0000 character position 3								$C_3C_2C_1C_0$ = 0000 character position 4							
$C_3C_2C_1C_0$ = 0001 character position 7								$C_3C_2C_1C_0$ = 0001 character position 8							
:::								:::							
$C_3C_2C_1C_0$ = 1110 character position 59								$C_3C_2C_1C_0$ = 1110 character position 60							
$C_3C_2C_1C_0$ = 1111 character position 63								$C_3C_2C_1C_0$ = 1111 character position 40							

Fig. 19. Definition of block B for type 3A group.

Bit

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Group type (3A)				**B**	**TP**	**PTY programme type**					A_3	A_2	A_1	A_0	B
0	0	1	1	0							Application group number				

Fig. 20. Definition of block C for type 3A group.

Bit

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Message bits (data available to the ODA)															

Fig. 21. Definition of block D for type 3A group.

Bit

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Application Identification															
AID = 0093_{16} - Cross referencing DAB within RDS (12A)															
AID = $CD46_{16}$ - ODA transmissions for RDS-TMC using 'ALERT' protocol (8A)															

Fig. 22. Definition of block B for type 4A group.

Bit

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Group type 4A				**B**	**TP**	**PTY programme type**					**Spare bits** (not defined)			**2^{16}**	**2^{15}**
0	1	0	0	0										MJD	

Fig. 23. Definition of block C for type 4A group.

Bit

15	b14	b13	b12	b11	b10	b09	b08	b07	b06	b05	b04	b03	b02	b01	b00
2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^4
Modified Julian Day Code (1 March 1900 to 28 February 2100)															UTC hour

Fig. 24. Definition of block C for type 4A group.

Bit

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
2^3	2^2	2^1	2^0	2^5	2^4	2^3	2^2	2^1	2^0	±	2^5	2^4	2^3	2^1	2^0
UTC hour code (0..23)				UTC minute code (0..59)						Local time offset (in half hour steps)					
Spare codes not used				Spare codes not used						(b05) 0 = plus, 1 = minus					

Fig. 25. Definition of block B for type 14A group.

Bit

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Group type 14A				B	TP (tn)	PTY programme type for tuned network					TP (on)	V_3	V_2	V_1	V_0
1	1	1	0	0								Variant code			

Fig. 26. Definition of block C for type 14A group.

Bit

15 14 13 12 11 10 09 08	07 06 05 04 03 02 01 00
$V_3V_2V_1V_0$ = 0000 PS (on) character position 1	$V_3V_2V_1V_0$ = 0000 PS (on) character position 2
$V_3V_2V_1V_0$ = 0001 PS (on) character position 3	$V_3V_2V_1V_0$ = 0001 PS (on) character position 4
$V_3V_2V_1V_0$ = 0010 PS (on) character position 5	$V_3V_2V_1V_0$ = 0010 PS (on) character position 6
$V_3V_2V_1V_0$ = 0011 PS (on) character position 7	$V_3V_2V_1V_0$ = 0011 PS (on) character position 8
$V_3V_2V_1V_0$ = 0100 Alternative Frequency (on)	$V_3V_2V_1V_0$ = 0100 Alternative Frequency (on)
$V_3V_2V_1V_0$ = 0101 Tuning frequency (tn)	$V_3V_2V_1V_0$ = 0101 Mapped FM frequency (on)
$V_3V_2V_1V_0$ = 0110 Tuning frequency (tn)	$V_3V_2V_1V_0$ = 0110 Mapped FM frequency (on)
$V_3V_2V_1V_0$ = 0111 Tuning frequency (tn)	$V_3V_2V_1V_0$ = 0111 Mapped FM frequency (on)
$V_3V_2V_1V_0$ = 1000 Tuning frequency (tn)	$V_3V_2V_1V_0$ = 1000 Mapped FM frequency (on)
$V_3V_2V_1V_0$ = 1001 Tuning frequency (tn)	$V_3V_2V_1V_0$ = 1001 Mapped AM frequency (on)

$V_3V_2V_1V_0$ = 1010 [10] not allocated
$V_3V_2V_1V_0$ = 1011 [11] not allocated
$V_3V_2V_1V_0$ = 1100 [12] linkage information
$V_3V_2V_1V_0$ = 1101 [13] [bit15:bit11 - PTY (on)], [bit10:bit1- reserved], [bit0 -TA(on)]
$V_3V_2V_1V_0$ = 1110 [14] Programme Item Information (other network)
$V_3V_2V_1V_0$ = 1111 [15] reserved for broadcasters use

on - other network
tn - tuned network

Fig. 27. Definition of block D for type 14A group.

Bit

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
country code of other network				coverage area of other network				radio station reference number of other network							

information is being transmitted in block C.

EON travel information

RDS receivers that implement the EON feature allow the radio to be tuned to one radio station (or listening to cd/tape) and automatically receive traffic messages from another radio station.

For example, if the traffic/travel function is selected and the radio tuned to BBC Radio 1 network. When a nearby local radio station is about to make a travel announcement the Radio 1 TA flag (14B block B bit 10) is set and the PI number of the station is transmitted in block D. This informs the EON radio that there is a traffic announcement being made on a particular local radio station.

The RDS radio will already know the frequencies associated with this PI number from previous EON data. The radio will first check that it can receive the local station and, if so, will switch from Radio 1 to the local radio station. At the end of the announcement the radio returns to Radio 1.

EON alternative frequencies are transmitted as either a frequency list, or as a mapped frequency where the tuned network frequencies are associated with frequencies of the other network. The frequency sent is not the actual frequency but a frequency code, Fig. 11.

Figures 25-27 define blocks B, C and D for type 14A.

Travel information

For the tuned programme service TP=0 flag in all groups and TA=1 flag indicates that this radio station broadcasts EON information only. This does not mean that there are no traffic announcements on the radio station; only that they are not flagged. A switch to the referenced traffic announcement on the other network is made whenever TA=1 flag is detected in type 14B group (PI for the other network is sent in block D).

Fig. 28. TP and TA traffic flags for tuned network.

TP	TA	
off	off	No traffic announcements or EON.
off	on	EON information.
on	off	No traffic announcements at present and EON.
on	on	Traffic announcement being broadcast.

See Fig. **29** for a definition of block B for type 14B.

Type 15B group. Type 15B group is referred to as fast basic tuning as the TP, TA, PTY and DI information is transmitted twice, in block B and block D. The PI number is also repeated in block C.

RDS decoder chip

The BU1923 found in the Goodmans radio is manufactured by Rohm and is a 16-pin surface-mount

Software and pre-programmed PICs

For those of you who don't have a 16F877 programmer, I can supply a pre-programmed PIC for £20. This price includes the Windows 95/98/ME software. The Windows RDS decoder software is available separately for £10. Please send an SAE to Roger Thomas at 24 Slave Hill, Haddenham, Aylesbury, Bucks HP17 8AZ for details.

Fig. 29. Definition of block B for type 14B group.

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Group type 14B				B	TP (tn)	PTY programme type for tuned network					TP	TA	not used		
1	1	1	0	1							Other network				

device. This RDS demodulator takes care of all the filtering via an eight-stage switched-capacitor type filter, **Fig. 30**. It uses a phase-lock loop to recover the data. At its output is the recovered clock and RDS data, **Fig. 31**.

There are many other similar RDS demodulator chips available from other manufacturs. Among them are the TDA7479, TDA7330B and SAA6579. All have the same basic design and provide the same clock and data output. However the pin configuration of these different chips can vary.

This RDS decoder chip is mounted on the small LCD circuit board, not on the main radio circuit board. Visually the build quality and design of the display board is different from the other boards. The display board includes a custom LCD driver and processor chip. It is likely that this display will be used in other radio products.

Wiring the RDS radio to the PIC

This 'modification' does not affect the normal operation of the radio but allows access to all the RDS data being received.

As the output from the RDS demodulator device is TTL compatible, it can be wired directly to the PIC microcontroller. PIC port pin RB0 (clock) and RB1 (data) are used as inputs and have Schmitt trigger inputs which help to ensure a clean input.

Connecting the RDS demodulator to the PIC microcontroller requires two wires – RDS data and clock signal – to be soldered to the BU1923 RDS demodulator chip. As this demodulator is a surface mount device considerable care has to be taken when soldering these wires.

Also the radio's power supply can be used to power the PIC circuit. The power supply circuit board was marked +lamp for +5V and B– for 0V but this may vary between different versions of the printed circuit board. Confirm the voltage and polarity with a multi-meter before connecting the power supply to the microcontroller.

Warning
You will need to open up the radio and solder wires directly to the display and power supply circuit boards. This will invalidate any warranty or guarantee that came with the radio.

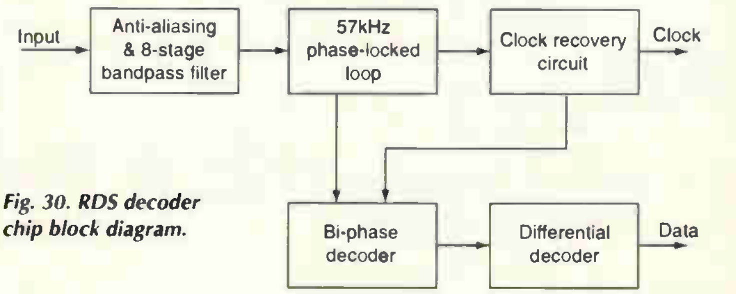


Fig. 30. RDS decoder chip block diagram.

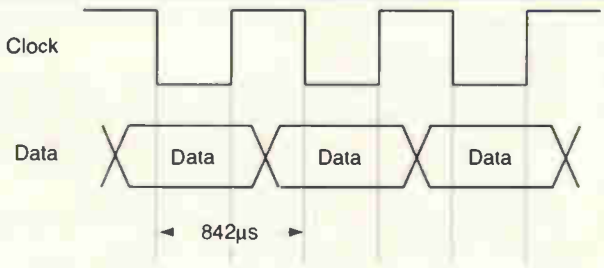


Fig. 31. RDS data can be read on either the rising or falling clock edge.

Fig. 32. Wiring between the RDS radio and PIC microcontroller. Note that this rewiring will invalidate any warranty or guarantee that came with the radio!

BU1923 pin 16 (clock)	connect to PIC RB0 pin 33
BU1923 pin 2 (data)	connect to PIC RB1 pin 34
RDS +5V (lamp+)	connect to PIC pins 1,11,32
RDS 0V (B–)	connect to PIC pins 12,31

Fig. 33. Example of RDS groups transmitted.

PI	PS	Radio station	PTY	RT	EON	TA	0A	1A	1B	2A	3A	4A	6A	8A	12A	14A	15B
C201	Radio_1_	BBC Radio 1	D	D	●		●	●		●	●	●	●		●	●	
C202	_BBC_R2_	BBC Radio 2	D	D	●		●	●		●	●	●	●		●	●	
C203	_BBC_R3_	BBC Radio 3	D	D	●		●	●		●	●	●	●		●	●	
C204	_BBC_R4_	BBC Radio 4	D	D	●		●	●		●	●	●	●		●	●	
C2A1	Classic_	Classic FM	S	D	●	●	●			●	●	●		●		●	
C4B7	_FOX_FM_	Fox FM, Oxford	S	S			●			●		●					●
CB11	BBC_Oxfd	BBC Radio Oxford	D	S	●	●	●		●	●		●	●			●	
CD86	_MIX 96_	Mix 96, Aylesbury	S	S			●			●		●					●

S – static.
D – dynamic

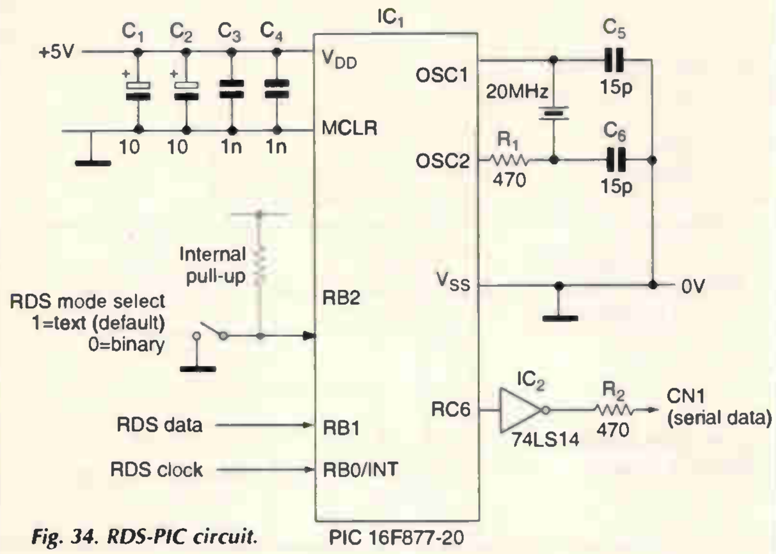


Fig. 34. RDS-PIC circuit.

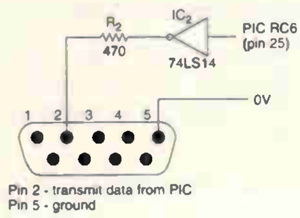


Fig. 36. CN1 serial communications wiring (9 pin 'D').

Observing RDS data

RDS transmissions started in 1984 so it can be regarded as a mature technology. It comes as a bit of a surprise that the RDS data groups transmitted vary between radio stations.

In general, the BBC makes far more use of RDS than commercial stations. For example, from my local transmitter Classic FM (101.3 MHz) with EON only lists the four BBC networks (no local BBC or other commercial stations). This is of no use for EON traffic information as the four BBC networks do not flag their own traffic announcements.

However, in recent months it has started to transmit TMC traffic data. Also Classic FM changes its radio text message more frequently than any other radio station, whereas my local radio stations (Fox FM, Mix 96 and BBC Radio Oxford) never change their text message.

Type 6A and 12A groups are transmitted by the BBC but as the format is not defined in the RDS specification the PC software displays the received data as bytes, **Fig. 33**.

RDS PIC circuit

The RDS decoder circuit, **Fig. 34**, is not complicated and can easily be built on strip board. When constructing the circuit ensure that the crystal can is connected to 0V.

Keep the wiring between the PIC and RDS radio reasonably short and use appropriate decoupling capacitors on the +5 volt line to the PIC and 74LS14 chip.

There's a built-in serial communications port in the PIC 16F877 but as the microcontroller is only sending, not receiving, data a serial interface driver chip is not needed. A 74LS04 inverter is used to invert the transmitted serial data as a serial driver would in operation invert the serial data.

Computers can generate radio interference, so the RDS radio and computer need to be kept apart. An RDS radio will start to display data after having received a pre-determined number of groups error free.

As the PIC will decode any error free group, the RDS data may appear on the PC before being displayed on the radio's display.

Fig. 35. RDS-PIC components list.

IC_1	PIC 16F877-20
IC_2	74LS14
$C_{1,2}$	10µF
$C_{3,4}$	1nF
$C_{5,6}$	15pF
$R_{1,2}$	470Ω
X_1	20MHz crystal

PIC software

The PIC microcontroller software is interrupt driven with the edge of RDS clock signal generating the interrupt on RB0. It does not matter which clock edge is used as the data is valid on both edges.

When an interrupt occurs the PIC software looks at port pin RB1 to see if the RDS data bit is '1' or '0'. This bit value is added to the RDS data already received. The RDS data is stored in 13 packed bytes, located at memory 35_{16} to 41_{16}.

After acquiring 104 bits the parity check routine is executed. Each block of 26 bits (including the check word) is checked by the use of a parity table, **Fig. 37**. Whenever any message bit is '1' the value from the appropriate position in the parity table is taken and multiplied with the running total using modulo-two arithmetic.

Fig. 37. RDS parity check matrix.

parity[01] =	200_{16}
parity[02] =	100_{16}
parity[03] =	80_{16}
parity[04] =	40_{16}
parity[05] =	20_{16}
parity[06] =	10_{16}
parity[07] =	08_{16}
parity[08] =	04_{16}
parity[09] =	02_{16}
parity[10] =	01_{16}
parity[11] =	$2DC_{16}$
parity[12] =	$16E_{16}$
parity[13] =	$0B7_{16}$
parity[14] =	287_{16}
parity[15] =	$39F_{16}$
parity[16] =	313_{16}
parity[17] =	355_{16}
parity[18] =	376_{16}
parity[19] =	$1BB_{16}$
parity[20] =	201_{16}
parity[21] =	$3DC_{16}$
parity[22] =	$1EE_{16}$
parity[23] =	$0F7_{16}$
parity[24] =	$2A7_{16}$
parity[25] =	$38F_{16}$
parity[26] =	$31B_{16}$

As the parity table contains 10-bit numbers and the internal PIC registers are 8 bit wide, this results in the software having to use two different tables. One table is the top two bits of the parity number and the other table is the remaining eight bits.

After the block-A check word calculation the result is compared with all the syndrome numbers to see if the block is valid and to determine the block sequence. If the cyclic redundancy check value is not a syndrome, then all the 104 bits of data are rippled along by one bit with the first data bit lost.

Another bit is read in and stored in the last position and the check word test re-applied until a syndrome value is received. Although it is possible to correct an error burst of up to 5 bits the software does not attempt this.

Fig. 38. Calculating received check word for each data block.

```
procedure checkA
crc = 0
if bit[1] = 1 then crc = crc XOR
parity[1]
if bit[2] = 1 then crc = crc XOR
parity[2]
:::
if bit[25] = 1 then crc = crc XOR
parity[25]
if bit[26] = 1 then crc = crc XOR
parity[26]

if crc = syndromeA then checkB
else
  ripple RDS data
  checkA
```

In theory, as the group is made up of four independent blocks, a check word failure in one block does not affect the other blocks. However the software will only decode complete groups where each block has passed the check word as this is more reliable than attempting to decode individual blocks.

PIC display modes

The PIC microcontroller software has two RDS decode modes – text or binary. With the text mode the PIC software decodes the RDS data and sends the text information to the PC via the serial port. In binary mode the PIC software sends the raw data for decoding and display by the PC software.

Display mode is selected by the logic voltage on port pin RB2. As the internal PIC pull-up resistors are enabled then leave this pin open circuit and this is the text mode (default).

For selecting the binary mode output, port pin RB2 needs to be taken to 0 volts. The status of this port pin is continually polled so that if the mode is changed then a PIC reset should not be required.

Text mode

The RDS decoded text can be viewed using the Hilgraeve HyperTerminal software that comes with the Windows operating system. Set the properties to: connect using direct to COM option, 57600 baud, 8 bits, no parity, 1 stop bit and no flow control.

The RDS text is not scrolled as the cursor is moved to the start position after each block of text is displayed. The time is set to zero whenever the PI number changes. If the HyperTerminal software is used but the PIC binary mode is selected by mistake then the screen will fill up with '1's and '0's.

With text mode selected the alternative frequencies are not decoded by the PIC software. If you are using the Goodmans radio (and tuned to an RDS signal) then these frequencies can be displayed by pressing the 'hour' button. Similarly the date is not decoded in text mode as this information is also available by pressing the 'mode' button.

Received RDS text can be saved using the 'transfer' menu and capture text option of the HyperTerminal software. Examples of edited captured text showing the radio station information and example radio text messages are shown in **Fig. 39**.

Binary mode

Instead of the PIC converting the RDS data into text, the raw data can be sent to the PC in binary mode for display. In binary mode, the PIC software still does the check word

Fig. 39. Examples of decoded RDS information saved to disk using HyperTerminal.

```
Classic  LIGHT M  (static) stereo  PI=C2A1 National, TA and EON.

EON-BBC 1 FM  POP M   PI=C201
You can reach Classic FM by telephoning 020 7343 9000...
Our address is Classic FM, PO Box 2834, W1A 5NT.
Classic FM on the internet: www.classicfm.com
Call us for music information on 08702 41 42 42
Relax - it's Classic FM             Relax - it's Classic FM
Relaxing Classics at Two....with Nick Bailey

 FOX FM   POP M   (static) stereo  PI=C4B7 Region 1, No TA or EON.
FOX FM WITH THE BEST SONGS ON THE RADIO AND NEWS FOR OXFORDSHIRE

BBC Oxfd  VARIED  (dynamic) stereo  PI=CB11 Region 8, TA and EON.
EON-BBCLondn  VARIED  PI=CC11 TP
BBC Radio Oxford - news, sport, travel and information for Oxon.

 MIX 96   POP M   (static) stereo  PI=CD86 Region 10, No TA or EON.
MIX 96 - Bucks Best Music live from Aylesbury 24 hours a day
```

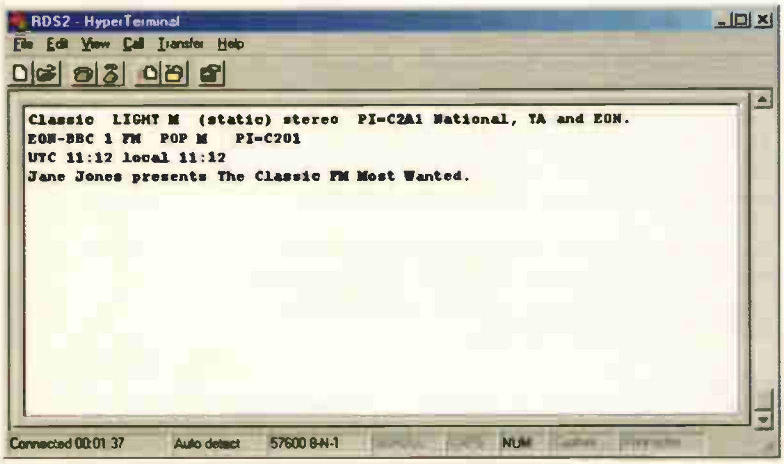


Fig. 40. Screen of HyperTerminal showing Classic FM RDS data decoded by the PIC in text mode.

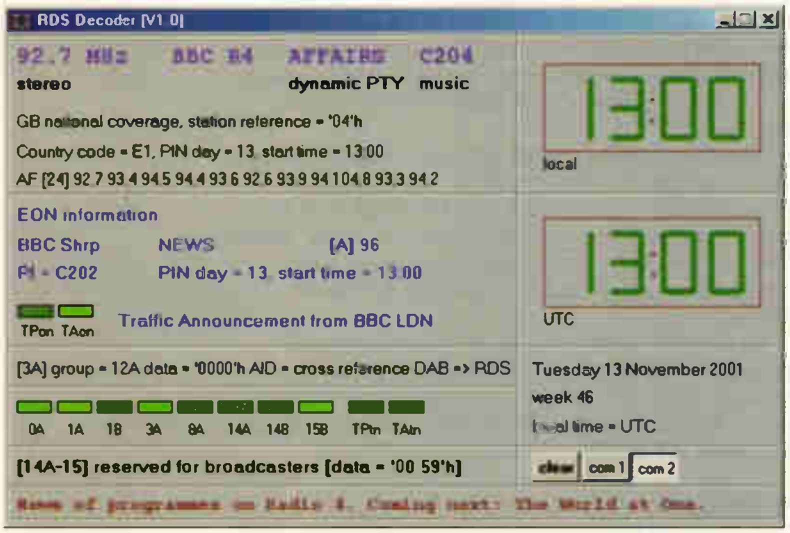


Fig. 41. Screen of Windows program showing Radio 4 RDS data (binary mode).

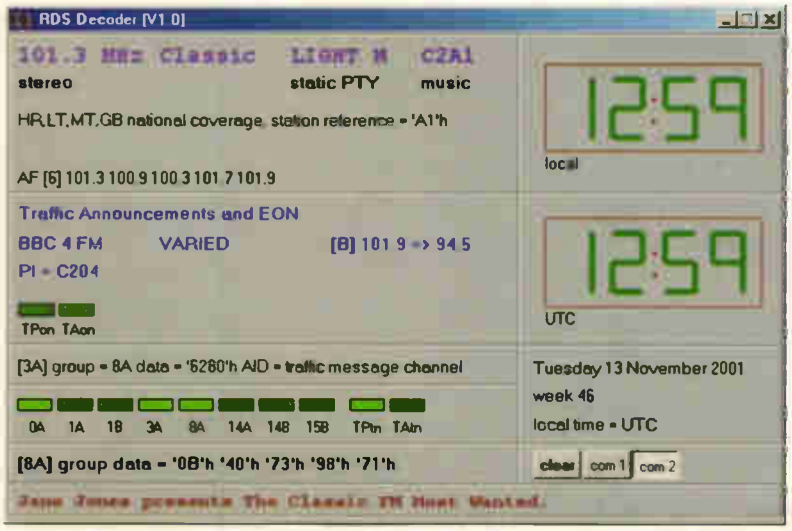


Fig. 42. Screen of Windows program showing Classic FM with TMC data being transmitted (binary mode).

calculation and will only send a complete data group that is error free.

The binary data is sent as ASCII characters '0' and '1', with an 'S' synchronisation character sent as the first byte to indicate start of a data block. Unlike the text mode, the binary mode decodes and displays all the RDS data received. Note that Windows software for carrying out this task is only available from the author.

Figures 41 & 42 show Windows displays produced by the binary software.

PIC programming

The RDS Decoder hexadecimal code file (rds.hex) is available by e-mail from j.lowe@cumulusmedia.co.uk. Please use the subject heading 'RDS hex file'.

If the PIC programmer is being used in conjunction with Microchip's MPLAB software then select the import to memory option from the file menu. Find the appropriate directory and select the rds.hex file. To view the hex code that will be programmed into the PIC16F877 select from the Window menu (located at the top of the MPLAB form) the 'Program Memory' option to show the Program Memory Windows.

This option will display the object code, choose the 'Hex Code Display' option from the top left icon of the Program Memory Windows. This will show that the beginning of the PIC program is where all the various text messages are stored, starting with the PTY text.

These text messages can be altered using the 'modify' option from the Windows menu but the new message must be exactly the same length as the old message otherwise the following messages will not be displayed correctly. Use Export Memory option from the file menu to save the modified hex file.

When programming the flash PIC ensure that the PIC configuration options are set to the following – oscillator mode is set to HS (high speed), watchdog timer is off and power up timer enabled. ■

RDS glossary

AID	Application IDentification.
AF	Alternative Frequency.
ARI	Autofahrer Rundfunk Information.
CT	Clock Time and date.
DAB	Digital Audio Broadcasting.
DI	Decoder Information.
ECC	Extended Country Code.
EON	Enhanced Other Networks.
ODA	Open Data Application.
ON	Other Network.
PI	Programme Identification.
PIN	Programme Item Number.
PS	Programme Service.
PTY	Programme Type.
RDS	Radio Data System.
RT	Radio Text.
TA	Traffic Announcement.
TN	Tuned Network.
TDC	Transparent Data Channel.
TMC	Traffic Message Channel.
TP	Traffic Programme.

Hexadecimal listing for RDS decoding using a PIC 16F877 20MHz microcontroller

This is the PIC16F877 hex code is for the RDS Decoder. This PIC code is intended for personal use only; any commercial use requires written permission from the author.

```
:02000000A7292E
:08000800AA00030E8312AB00F5
:100010002008AC009A222C08A0002B0E8300AA0E08
:100020002A0E090020344E344F34203450345434D6
:100030005934203420342034 4E34453457345334 2A
:1000400020342034413446344634413449345234 27
:1000500053342034203420344934 4E3444344F3421
:1000600020342034203453345034 4F3452345434F8
:1000700020342034453444345534 4334413454 34EA
:10008000453420342034443452344134 4D344134E6
:1000900020342034433455344C345434553452 34A1
:1000A0004534203453344334493445344E34433496
:1000B00045342034203456344134523449344534A4
:1000C00044342034203450344F3450342034 4D34B0
:1000D00020342034203452344F3444334B342034D1
:1000E0004D34203420344534413453345934203491
:1000F0004D3420344C344934473448345434 20345B
:100100004D3420344334 4C3441345334533449 3423
:100110004334533 44F3454344834453452342034 07
:100120004D3420345734453441345434483445 3404
:1001300052342034463449344E3441344E344334FE
:100140004534203443344834493444C3444345234F4
:1001500045344E34203453344F3443344934413 4DD
:100160004C3420345234453444C34493447344934C7
:100170004F344E34503448344F344E34453453420 34A8
:1001800049344E34203454345234413456344534 96
:100190004C3420344C3445344934533455345234 7F
:1001A00045342034203420344A3441345A345A34CB
:1001B000203420344334 4F3455344E345434523484
:1001C000593420344E3441345434493 44F344E344D
:1001D00020344D3420344F344C344434493445 3485
:1001E0005334203420344634 4F344C344B342034 90
:1001F0004D34203444344F344334553 44D344534 35
:100200004E34543420342034543445345334 54342C
:10021000203420342034413 44C344134523 44D3471
:100220002034213407346434793 46E3461346D34CD
:1002300069346334063473347434 613474346934 27
:1002400063340634733474346534723465346F3413
:100250000 04346D346F346E346F34053420342034FC
:10026000503449343D3405344C346F346334613494
:10027000 6C340D3449346E347434653472346E34F5
:1002800061347434693 46F346E3461346C340834DE
:100290004E34613474346 9346F346E3461346C3488
:1002A0000083452346534673469346F346E346134E1
:1002B0006C340C344E346F34203454344134203494
:1002C0006F34723420344534 4F344E3403344534 63
:1002D0004F344E340A34543441342034 61346E34 53
:1002E00064342034453444F344E34063 45434413 46D
:1002F00020346E346F3477340734523465346734C5
:100300069346F346E342034093454344134203429
:10031000733474346134723474342034073454 3494
:1003200041342034653 46E34643420340434553 41C
:100330005434433420340734203 46C346F34633401
:1003400061346C342034033420345434503 47927ED
:1003500061DBD290B1DBC290B11F80A7808FA3CB3
:10036000031DBC290030F800F90A79080A3C031D76
:10037000BC290030F9003124D32968080319D32996
:10038000C10DC00DBF0DBE0DBD0DBC0DBB0DBA0D19
:10039000B90DB80DB70DB60DB50D3130031C3030A9
:1003A000AD007427E8037A1CE229E421061DD9294F
:1003B000E229B40A3408C83C031DE2294330AD00E9
:1003C0007427B401A829A7297A105A08EB005B0802
:1003D000EC005C08ED005D08EE00AF266A08033C07
:1003E00031D992A6908D83C031D992A5D08EB0072
:1003F0005E08EC005F08ED006008EE000310EE0DF3
:10040000ED0DEC0DEB0D0310EE0DED0DEC0DEB0D08
:10041000AF266A08033C031D992A6908D43C031DD2
:10042000992AFA106008EB006108EC006208ED0000
:100430006308EE000310EE0DED0DEC0DEB0D031057
:10044000EE0DED0DEC0DEB0D0310EE0DED0DEC0DC5
:10045000EB0D0310EE0DED0DEC0DEB0DAF266A0864
:1004600023C031D382A69085C3C031D382AFA1433
:100470006A08033C031D412A6908CC3C031D412A3C
:10048000FA14FA1C992A6308EB006408EC0065086A
:10049000ED006608EE000310EE0DED0DEC0DEB0D1A
:1004A0000310EE0DED0DEC0DEB0D0310EE0DED0D4B
:1004B000EC0DEB0D0310EE0DED0DEC0DEB0D03103F
:1004C000EE0DED0DEC0DEB0D0310EE0DED0DEC0D45
:1004D000EB0DAF266A08023C031D992A6908583CB7
:1004E00031D992A5A08B5005B08B6005C08B700DE
:1004F0005D08B8005E08B9005F08BA006008BB007C
:100500006108BC006208BD006308BE006408BF004B
:100510006508C0006608C100061D922AAE220030A0
:10052000E700992A5330AD0074276830E8000030A6
:10053000B40008000314861C0310E60DE50DE40D5D
:10054000E30DE20DE10DE00DDF0DDE0DDD0DDC0D47
:10055000DB0DDA0DE70A7A148B10080038083E39F3
:10056000EB000310EB0C6B08003C031DB92A4E2373
:10057000D02A6B08043C031DBF2A0C23D02A6B0829
:1005800083C031DC52AE822D02A6B081C3C031D29
:10059000CB2AB823D02A6B081D3C031DD02AD122B8
:1005A00008007B10B9187B147A173E08EC003F084E
:1005B000ED004008EE000310EC0CED0CEE0C031007
:1005C000EC0CED0CEE0C6D08D5006E08D6000800A2
:1005D0003E08EC003F08ED004008EE006D083F3992
:1005E000D800FA10EE1BFA146E087839D9000310FF
:1005F000D90C0310D90C0310D90C0310EC0CED0C22
:10060000EE0C0310EC0CED0CEE0C6D08F039D7007D
:10061000D70E3D1A571608003908EC003A08ED00CD
:100620000310ED0DEC0D0310ED0DEC0D0310EC0DB2
:100630000310EC0D6C083F39A03E84003B08EC0031
:1006400003C08ED003D08EE000310EE0DED0DEC0D45
:100650000310EE0DED0DEC0D0310EE0DED0DEC0D98
:100660000310EE0DED0DEC0D6C088000840A6D0892
:1006700008000840A3E08EC003F08ED004008EE00D0
:100680000310EC0CED0CEE0C0310EC0CED0CEE0C6E
:100690006D088000840A6E0880000800 3908EC00AC
:1006A0000310EC0C0310EC0C0310EC0C6C08B20003
:1006B00030083602003 0031DFF3E0319602BAC27C3
:1006C00031083502003 0031DFF3E0319682BAC27AB
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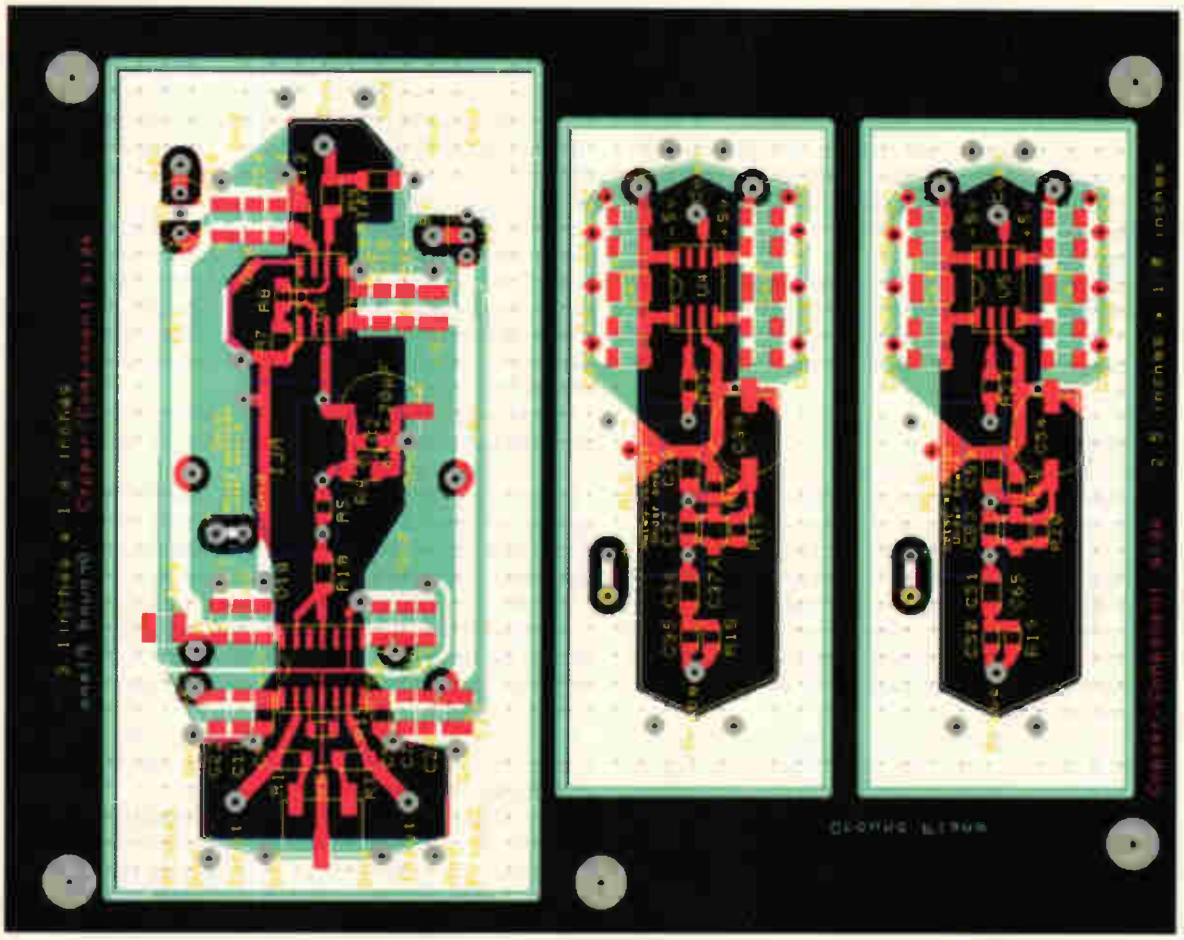

Fig.1. This artwork composite was used to generate both copper side and groundplane artwork films for my 'Differential RF Probe' design, published in the December 2001 issue. Note the five registration targets. These appear co-located on both films. To permanently clarify each film's identity and orientation, text identifying copper side and ground plane is printed on the relevant film.

Making double-sided PCBs

Cyril Bateman describes how to get round the problem of aligning films when producing one-off double-sided circuit boards.

In my last article on making PCBs, in the May issue, I described low cost DIY methods to create the artwork needed for use with UV photo sensitive, single-sided, boards. Each of these basic steps is also applicable to producing two-sided boards. All that's needed is the additional artwork for the second side.

This second article details the additional techniques needed to make a double sided printed board. It should be read in conjunction with my previous article on single-sided printed circuit boards, in order to be complete.

The double-sided board problem

Unless you can ensure accurate registration of both artworks with each other and with the board for both of the UV exposures needed, the board will not be usable. I speak from personal experience.

Before adopting the method described here, I produced more scrap than usable double-sided prototype boards. Boards were scrapped due to poor registration or one damaged side.

For many years, and still today, if a prototype board can be produced as single sided, that remains my preferred choice. It was only when designing my recent series of double-sided high-frequency RMS meter and probe designs, published in the August, October, November and December 2001 issues of *Electronics World*, that I decided I should find a solution to end this problem.

Designing two-sided boards presents little more difficulty than does designing single-sided boards. It can in fact be much easier and quicker. Many computer design packages include a usable auto-router, which will at least arrange most tracks for you. This however will most certainly result in creating many tracks requiring vias, needed to connect tracks between each board face.

Using DIY methods, plated-through hole vias are not really practical. Through holes are easily replaced though by Harwin Track Pins, inserted into 1mm holes and soldered on both sides of the board. Available as Maplin part FL82D[1], they were used to avoid plated-through holes, in the abovementioned double-sided printed board designs.

In contrast, designing single-sided boards to avoid using wire links – or at least using as few wire links as possible – can be difficult. To date, each of my single-sided boards has been carefully hand routed. All attempts to use my auto router having failed.

Registering the artwork

If equipment cost is no object, both artwork films can be registered together and both sides of the board exposed simultaneously. However this requires an expensive-double sided UV exposure unit. These usually also have vacuum beds to hold artwork and boards in close contact. The lowest cost unit I have seen, listed at £600, is not exactly within many DIY budgets.

Consequently for my budget I accepted having to expose one side at a time, using two quite separate exposures. This need for two separate exposures was the cause of all my original problems with registration.

One early method, which worked occasionally, was to expose then develop one side only. The maker's protective film or paper, left on the second side, prevented its exposure to light and developer.

Each artwork film was provided with registration drill pads, located outside the finished board area. Using the developed image, these location holes were drilled and used to register the second side artwork for its exposure. Developing this second side without damaging the first side image was the reason for almost all my rejects.

I tried re-protecting the developed image, using self adhesive films, before developing the second side. This resulted in only partial success. Frequently, the developer wicked between the adhesive film and the developed image, along track edges, dissolving parts of the resist image.

I also tried developing and fully etching the first side, leaving the maker's protective films in place on the second side. Again this was only partially successful. Without adequate protection during immersion for the second etch, the first side continued to etch, causing severe undercut of any tracks or ground plane.

In hindsight, an aerosol spray of board protection lacquer might have provided better protection than using self adhesive films, but at the time I didn't think to try some.

Modified technique for smaller boards

With the quite small boards and much narrower tracks needed for my recent articles, neither method worked. I searched Internet looking for better ideas, but with no success. After some thought I decided that only one immersion in developer or etchant could be allowed.

Using low-cost methods, this required pre-aligning the board and both artworks, then maintaining this alignment throughout the two separate exposures. Both sides could then be co-developed and etched, just as for a single-sided board.

A two sided exposure frame is neecded. This frame must keep both artworks in intimate contact with the board faces. The photo resist on one side of the board is exposed, then the the frame is turned over to expose the other side.

You will need two pieces of 3mm thick glass, one sized larger than your blank circuit board, which must remain fully visible. The second should be some 5cm larger in both directions.

All cut-glass edges must be covered to support the glass and protect your hands. For this I used lengths of thin aluminium channel sold for secondary double glazing.

Five easily-visible registration targets are placed outside the design area, but within the blank board dimensions, and coincident on both artwork films. One target is placed near each board corner and one centrally along one longer side, **Fig. 1**.

This arrangement of five registration targets reduces the possibility that one or other artwork film becomes accidentally reverse aligned. Nevertheless, I still write clearly on each artwork film, identifying which is the copper or board facing side.

With the track-side artwork positioned correctly over the board, I use a sharp probe to pierce through the centre of each artwork target and the board's protective film, thus marking the board's top copper. I drill small holes through the board at these marked positions. This top copper side is identified by a short length of masking tape.

The track-side artwork is taped firmly onto the larger piece of glass, through which it will be exposed. Ensure the board side of this artwork is uppermost.

Remove the protective tape, previously identified with masking tape, and place this side of the board down onto your artwork. Then remove the protective tape from the second, now uppermost, side of the photo resist coated board.

With the track side of your board facing down, the pre-drilled board is positioned so that all five target centres are visible through the pre-drilled holes. Taking care to not overlap into the design area, the board is securely taped in position, directly onto the artwork.

I hold the glass frame, artwork and board up so that daylight from a shaded north facing window penetrates through the drilled holes, to facilitate registration.

A partially folded strip of masking tape is placed temporarily on the etch resist on each longer side, clear of the design area. This tape acts as 'handles' to aid moving the board into position and to avoid fingernail damage of the resist surface. When the board is secured in position, remove both handles.

The ground-plane artwork film's five targets are now carefully positioned over the five pre-drilled board holes, ensuring all five holes are aligned with the target centres. This artwork is also carefully taped into position. The smaller exposure glass is then fixed onto this sandwich, ensuring artworks and board remain in intimate contact, using spring clamps. The design area of both sides of your board must be clearly visible through the glass.

Both sides can now be exposed in turn.

Developing and etching

This method produces good, well registered, double-sided boards. It is suitable for use with surface mount ICs down to eight-lead micro-SOIC size.

When both sides have been exposed, the board is removed from this sandwich and processed as described for a single sided board.

A photographic developing tray having small ridges along the bottom allows the underside photoresist to develop and minimises any scratching. Since the ground plane is usually easier to 'touch up' I prefer to develop with the track side uppermost. Before etching, any minor resist scratches can be quickly 'touched in' using an etch resist pen.

The board can now be finished following the methods already outlined for single-sided boards. ■

Cyril is currently developing a low-cost DIY PCB drilling machine. We hope to have a description of this later in the year.

Reference

1. Harwin track pins Maplin Electronics part FL82D, http://www.maplin.co.uk

Fact: most circuit ideas sent to *Electronics World* get published

The best circuit ideas are ones that save time or money, or stimulate the thought process. This includes the odd solution looking for a problem – provided it has a degree of ingenuity.

Your submissions are judged mainly on their originality and usefulness. Interesting modifications to existing circuits are strong contenders too – provided that you clearly acknowledge the circuit you have modified. Never send us anything that you believe has been published before though.

Don't forget to say why you think your idea is worthy.

Clear hand-written notes on paper are a minimum requirement: disks with separate drawing and text files in a popular form are best – but please label the disk clearly.

Send your ideas to: Jackie Lowe, Highbury Business Communications, Anne Boleyn House, 9-13 Ewell Road, Cheam, Surrey SM3 8BZ

Precision low-cost bridge emulator

This circuit emulates a precision bridge type sensor, with the adjustment of a single resistor. During testing and commissioning of sensor conditioning circuits or data acquisition systems, that interface to 'bridge' type sensors – including pressure transducers and strain gauge load cells – it can be very useful to be able to emulate the sensor in some way without actually using transducer, which is normally expensive.

If a conventional four-resistor bridge is constructed to emulate the sensor then precision low-temperature coefficient resistors are required. Even then, bridge balance can be effected by thermal gradients across the resistors also it is difficult to generate stable millivolt output signals by unbalancing the bridge.

To overcome these problems I developed the simple five-resistor arrangement shown in **Fig. 1**, and have found it very useful on many occasions.

This circuit has four significant advantages:

- The circuit performance is relatively insensitive to resistor tolerance unlike a conventional bridge. A moderate imbalance between R_1 and R_2 will generate a common-mode input offset voltage, but does not produce a significant change in the signal output. The following instrumentation amplifier cancels the common mode offset resulting in minimal output offset voltage.
- For small output voltages the current through R_1, and R_5 remains approximately constant. In particular, the current through R_1 is always balanced and so the self heating is always balanced Therefore there will be no thermal gradient between R_1 and R_2. This is evident by virtue of negligible output voltage drift in practice.
- The output signal level is easily adjusted by the value of a single resistor R_5.
- The circuit's low cost!

Bridge-type sensors are ratiometric devices and produce millivolts of output for volts of excitation – 10mV output per volt of excitation at sensor full scale for example, i.e. 100:1 input/output ratio, my circuit is basically a differential potential divider and importantly is also ratio metric.

Example

The circuit can be made to present the same input and output impedances as a bridge sensor by making R_1+R_2 and R_1+R_4 equal the sensor bridge impedance. Resistor R_5 can be one fixed resistor to give 0% and 100% output signals or two equal value series resistors giving 0%, 50%, 100%, or say four to give 0.25, 50, 75, 100% switched outputs, **Fig. 2**.

A simple option is to use a low value 'decade resistor box' for R_5 and if R_1 and R_2 are calculated to pass 1mA then the output is 1mV per ohm set by R_5.

Note the switch contact resistance appears in series with R_1 and therefore has little effect on the milli-voltage produced by the dummy sensor.

My colleagues encouraged me to submit this idea. Over the years, my colleagues have referred to it as the 'Jaques Bridge'.

Dennis Jaques
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£75 winner

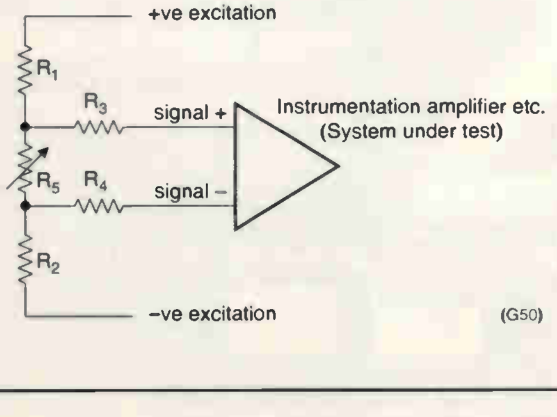

Fig. 1. This simple five-resistor arrangement emulates a conventional bridge, but doesn't need precision resistors.

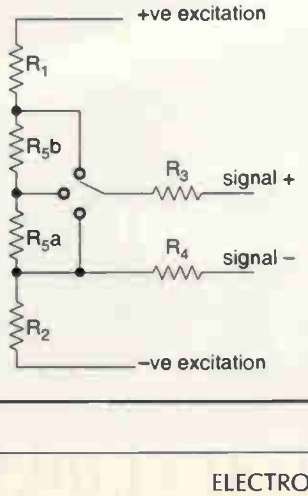

Fig. 2. Resistor R_5 can be one fixed resistor to give 0% and 100% output signals, or two equal value series resistors giving 0%, 50%, 100%, or say four to give 0.25, 50, 75, 100% switched outputs.

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All components provided including a plastic case (140mm x 110mm x 35mm) with pre-punched and silk screened front/rear panels to give a professional and attractive finish (see photo). with screen printed front & rear panels supplied. Software utilities & programming examples supplied.

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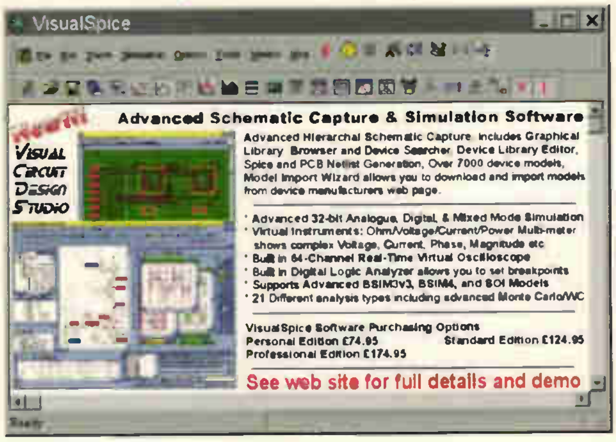


Serial Port Isolated I/O Controller

Kit provides eight relay outputs capable of switching 5 amps max and four optically isolated inputs. Can be used in a variety of control and sensing applications including load switching, external switch input sensing, contact closure and external voltage sensing. Programmed via a computer serial port, it is compatible with ANY computer & operating system. After programming, PC can be disconnected. Serial cable can be up to 35m long, allowing 'remote' control. User can easily write batch file programs to control the kit using simple text commands. NO special software required – uses any terminal emulator program (built into Windows). Screw terminal block connections. All components provided including a plastic case with pre-punched and silk screened front/rear panels to give a professional and attractive finish (see photo).

Order Ref	Description	inc. VAT ea
3108KT	Serial Port Isolated I/O Controller Kit	£54.95
AS3108	Assembled Serial Port Isolated I/O Controller	£69.95

Full details of these items and over 200 other projects can be found at www.QuasarElectronics.com

QUASAR ELECTRONICS Number 1 For Kits

www.QuasarElectronics.com

Credit Card Sales: 01279 467799

Tester in a key fob

£50 winner

I designed this tester to be something that would take up little space, but would allow many vehicle electrical faults to be found at the side of the road.

With no button pushed, the unit is a voltmeter with the led illuminating if between 3 and 30V is applied to the probe.

High resistance in the voltage source – caused by corroded contacts for example – can be detected by pushing the 'load' button. This causes about 0.5A to be drawn from the source. If the LED dims significantly, the source is high impedance.

Pressing the 'continuity' button allows a simple conductivity test to be made. Anything below a few kilohms will light the led. In this state, the earth clip is positive, so the unit can also be used to check rectifier diodes.

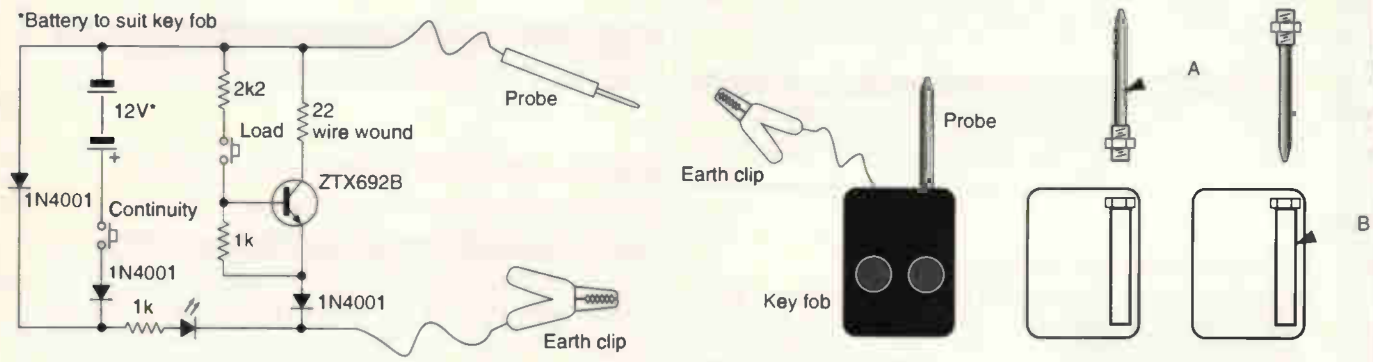
The 'load' part of the circuit is only intended to be used briefly to check that a terminal is not offering significant resistance. As such, the 22Ω resistor can be a small 2W type that will fit in a key fob case. The real power dissipation is 6W, so don't hold the button down for more than a few seconds or the whole unit will melt.

The transistor has to be a high-gain type as the push buttons have little current capacity and there is half an amp flowing in the collector. Reducing the resistor to 10Ω draws 1A and give the voltage source a better test, but increases the chance of melt-down.

Other power sources, such as a 3V lithium cell, could be used with appropriate resistor changes, but at 3V the unit will no longer check rectifiers.

Two button key-fob cases are available from most electronics catalogues. The unit is short-circuit protected and can withstand over 25V.

Steve Bush
Via e-mail



Circuit diagram of the handy tester, top, and its construction below. Details (b) and (c) in the lower diagram show how the probe can be stored inside the fob for safety when not in use.

Part A is the probe. It is made from threaded brass stud. The thread is filed off over most of the length of the rod. A small threaded portion is left at the opposite end to the probe tip. A nut is fixed in the middle of this portion of thread.

Part B is a small brass tube that's glued inside the key fob. It has a nut soldered on one end. When the probe is in use, the lower thread portion in diagram (b) is screwed into the tube's nut. When the probe is not in use, the bulk of the probe slides into the tube and the lower part of the thread in diagram (c) holds the stored probe in place.

Note that tube and probe scales are not accurate. Model makers' shops supply thin brass tubing. I actually filed the corners off the nut and inserted it into the end of the brass tube. This is stronger than butting the nut on the end.

A lengthening circuit for a short antenna

Output voltage of a short receiving antenna can be substantially increased by adding a quartz crystal, connected to the antenna as shown.

Assume that the height of the vertical wire antenna is many times shorter than the wavelength. In that case the antenna can be replaced by the equivalent circuit containing voltage source *e*, capacitance *C* and the resistance *R*.

Values for *e*, *C* and *R* can be calculated using:

$$e \approx \frac{Eh}{2}$$

$$C = \frac{55h}{\ln\left(\frac{1.15h}{d}\right)}$$

$$R = 160\pi^2 \frac{h^2}{\lambda^2}$$

Here, *E* is the electric field strength, [V/m], *h* is the geometrical height of the antenna, *d* is the diameter of the antenna wire in metres and λ is the wavelength, also in metres. The formulas are true when the antenna is placed above a conductive surface and $h/\lambda<0.1$.

Capacitance *C* and the inductance of the quartz crystal form the series-resonant circuit. Output voltage of that circuit is many times larger than input voltage *e* because resistance *R* is very small and the Q-factor of the quartz crystal is very large.

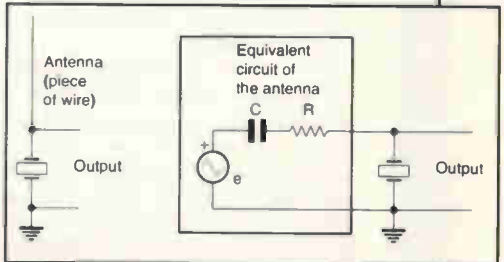
I simulated the circuit using PSPICE. It was assumed that E=1 mV/m, h=0.1m, d=0.002m, and λ=300m – i.e. the signal frequency is equal to 1MHz. In that case, e=0.05mV, C=1.35pF, R=1.75 x 10^{-4}Ω. These values were calculated by means of the formulas.

A QZP1MEG quartz crystal was applied. The PSPICE simulation has shown that the output voltage of the circuit is equal to 1.13mV at the resonance frequency. Output voltage of the same antenna without the quartz crystal is 0.05mV. So the quartz crystal increased the output voltage 22.6 times. That is identical to lengthening of the antenna.

Put another way, an antenna of 0.1m with the quartz crystal ensures the same output voltage as an antenna of 2.26m long without the quartz crystal.

The circuit is convenient for application in single-frequency receivers of remote control systems. The input resistance of those receivers must be very large to avoid shunting of the quartz crystal. Such input resistance can be ensured by field-effect transistors.

S Chekcheyev
Tiraspol
Moldova
G56



Intelligent voice-operated switch with recorder

One of the main features of this voice-operated recorder is its low cost. It also consumes little power, it's compact and it's simple.

As the block diagram makes clear, op-amp IC_1 is working as a non-inverting follower. Audio amplifier gain can be increased by increasing the value of R_2.

Signal input from the microphone feeds this preamplifier. The amplified signal is filtered and rectified by diodes $D_{1,2}$ to produce a DC voltage over R_3. Resistor R_4 can be adjusted to the desired audio level, to activate the relay. This control is set to suit the operator's voice.

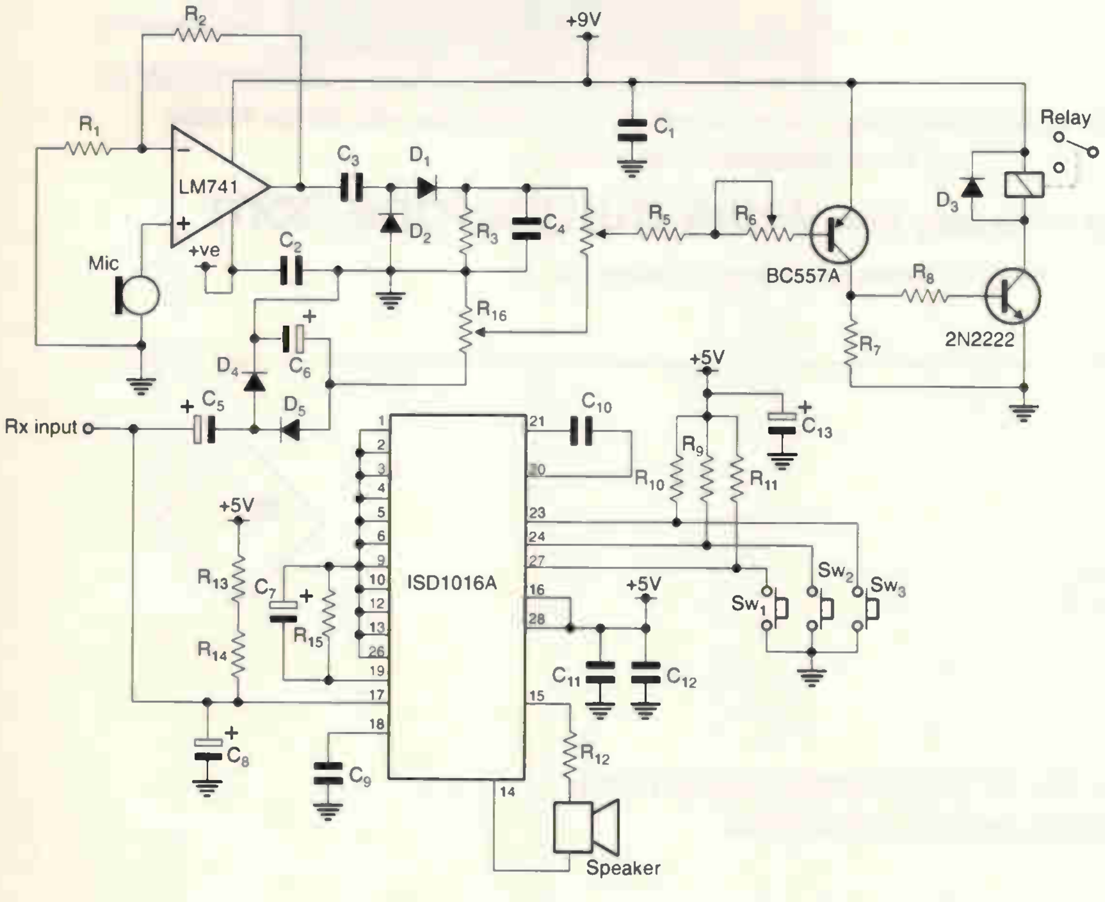
Transistor Tr_2 forms the delay control and DC amplifier. It can be substituted with a BD139 or SL100. Potentiometer R_6 determines the time between transmitter and receiver switching. Diode D_2 protects the Tr_1 during relay operation.

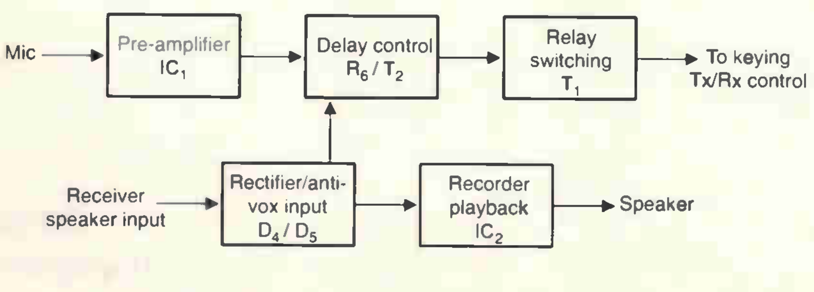
Resistor R_4 controls the balance between the microphone input and receiver input. Resistor R_{16} sets the level for operating the relay. Diodes $D_{4,5}$ produce a signal that prevents false operation of the transmitter while receiving is active.

The last digits of the IC's part number give the recording time in seconds. For example, the ISD1016A has a recording time of 16 seconds. If you want a longer recording time then an IC with more capacity can be used. Alternatively, two ISD1016As can be connected in series.

Switch S_1 is the recording/play back switch, while S_2 which must always be on while recording resets the recorder. Switch S_3 is an on/off switch for recording and play back. It must also be on while recording.

P M Prabhu
Kerala
India
G51





Components

Resistors:

R_1	1k
R_2	100k
R_3	220k
R_4	20k
R_5	4.7k
R_6	22k
R_7	10k
R_8	2.7k
$R_{9,10,11}$	4.7k
R12	10
R13	220
R14	2.2k
R15	470k

Capacitors:

C_1	0.1μF
C_2	0.1μF
C_3	1μF
C_4	10μF
C_5	10μF/16V
C_6	1μF/16V
C_7	4.7μF/16V
C_8	22μF/16V
C_9	220nF
C_{10}	1μF
C_{11}	100nF
C_{12}	100nF
C_{13}	22μF/16V

Semiconductors

IC_1	LM741
IC_2	ISDI016A
Tr_1	2N2222
Tr_2	BC557
$D_{1,2}$	1N914
D_3	1N4007
$D_{4,5}$	OA79

Miscellaneous:

Condenser microphone
SPST relay
Switch l, 2, 3 – push to make switches
Speaker – 8Ω, 500mW
PCB, shielded wires and ferrite beads

Minimal loudspeakers

This idea is more electro-acoustic than electronic, but nevertheless may prove useful to many readers.

Loudspeakers using a plain baffle fell from favour many years ago, as the box enclosure took over. However, with a little care, the simple baffle type can yield more than satisfactory results – especially if the left and right speakers are set into two corners of a room.

Extreme economy of construction means that one can afford rather better drive-units than if lots of timber is required – as in the case of traditional boxes. Another feature of the design is that floor-stands that raise the drivers to ear-level are readily incorporated. You don't have to fix brackets or shelves.

The basic principle is illustrated, where the drive-unit is screwed to the back of a sheet of chipboard, block-board, MDF or whatever. If you must use 3mm hard-board, it is worth adding the horizontal reinforcing bars.

Apart from cutting the round hole, very minimal carpentry skills are needed. The baffle is simply glued and nailed to the battens, or fixed with screws if preferred. Common two-core cable is held with a couple of staples, so as not to strain the electrical connections. Make sure that you end up with correct phasing (polarity), and left-right placing.

The chief criticism of baffles, unless of infinite size, is that air from the back sneaks round the edges and mixes with the useful air at the front. This effect is only significant at low frequencies. For the application – running PC audio off a sound-card – the results are more than adequate.

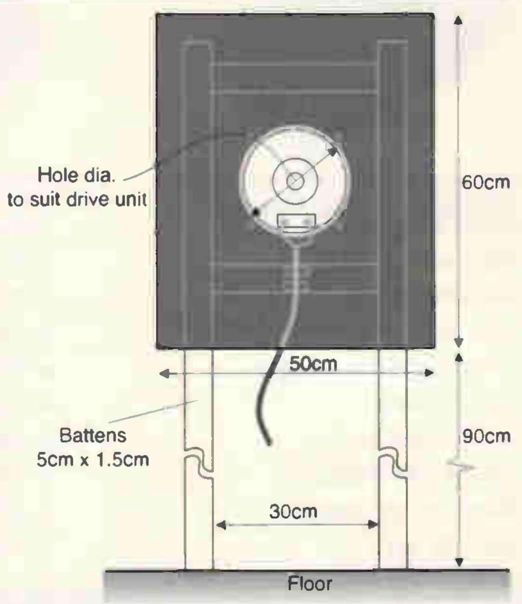
A further advantage is that the sound is 'open', not 'boxy' or muffled with acoustic wadding, and thus rather less electrical power is required for a given sound pressure level.

The table gives a selection of eight-inch (20cm) drive units that are readily available. The best value for money is the Farnell 10W type. A pair of these performed remarkably well with a PC.

For use with a hi-fi amplifier, the 20W version might be safer. However, the 40W twin cone unit from CPC is better in my view, and it's cheaper.

The units from RS and from Maplin seem to have rather limited frequency ranges, at the low and high ends respectively. Interestingly, the 10W units from Farnell were even sensitive enough to give moderate sound levels when connected to the headphone socket of a personal CD player.

C J D Catto
Cambridge
G58



If your woodwork isn't up to it, try using just a baffle. Low-frequency performance isn't too good, but if you place the speakers in the corner of the room, it can be adequate. In addition to being low cost, box-less speakers don't suffer from cabinet resonances and non linearities due to pressure within the enclosure.

Comparison of low-cost speakers from large distributors.

Supplier	Outer diameter	Cont. power	Freq. response	Stock no	Price ea.
RS	198mm	20W	90Hz-20kHz	267-6823	£10.65
Farnell	203mm	10w	50Hz-12kHz	453-110	£6.40
Farnell	210mm	20W	54Hz-16kHz	562-348	£10.49
CPC	205mm	40W	50Hz-15kHz	LSL200WTC	£8.53
Maplin	203mm	100W	50Hz-5kHz	RC9IY	£25.52

All 8Ω impedance. Prices excluding post & packing and VAT.

NEWPRODUCTS

Please quote *Electronics World* when seeking further information

JFET amplifier with 1.6GHz gain/bandwidth

Texas Instruments has introduced a JFET amplifier with a gain bandwidth of 1.6GHz. The Burr-Brown device combines a voltage feedback amplifier with JFET-input technology to enhance dynamic range for wideband transimpedance applications or driving analog-to-digital converter (ADC) signals at high gains, said the company. The OPA657 also features 4.8nV/√Hz input voltage noise, 5pA input bias current and 700V/μs high slew rate. The device's JFET-input stage eliminates input bias current errors, said the company. A unity-gain stable version is also available and offers a bandwidth of 230MHz (GBW) for optical networking, photodiode-detection and ADC buffering applications. Other features include 7nV/√Hz input voltage noise and 290V/μs slew rate. The OPA657 and OPA656 operate from ±5V to ±12V supplies and offer 6μV/°C input offset drift (max) and ±70mA output current.

Texas Instruments
Tel: 0049 8161 803311
www.ti.com

FM-stereo receiver in a single chip

Philips Semiconductors has launched a family of single chip stereo radios which are adjustment free and can tune into European, US and Japanese FM bands. The first chips to be released will be the TEA5767 and the TEA5768 for mobile handset applications.

Philips Semiconductors
Tel: 0031 40 272 2091
www.ti.com

A double-deck head

Epcos has introduced a series of multilayer varistors (MLV), which it calls Cera Diodes (CD). The range has been designed as a substitute foe zener diodes and transient voltage surge (TVS) diodes in protecting sensitive components from incoming transient overvoltages and

electrostatic charges (ESD).The diode range is available in three sizes of packages depending on type: 0603 single line, 0508 dual line and 0612 quad array. According to the supplier the dual CD 0508 package offers a 58 percent saving in board space compared with a dual TVS diode in a SOT23 package.
According to the supplier, the multilayer varistors improve on conventional zener and TVS diodes with bi-directional clamping, higher surge current handling capability, and lower capacitance as a function of bias voltage and temperature.

Epcos
Tel: 08705 550500
www.epcos.com

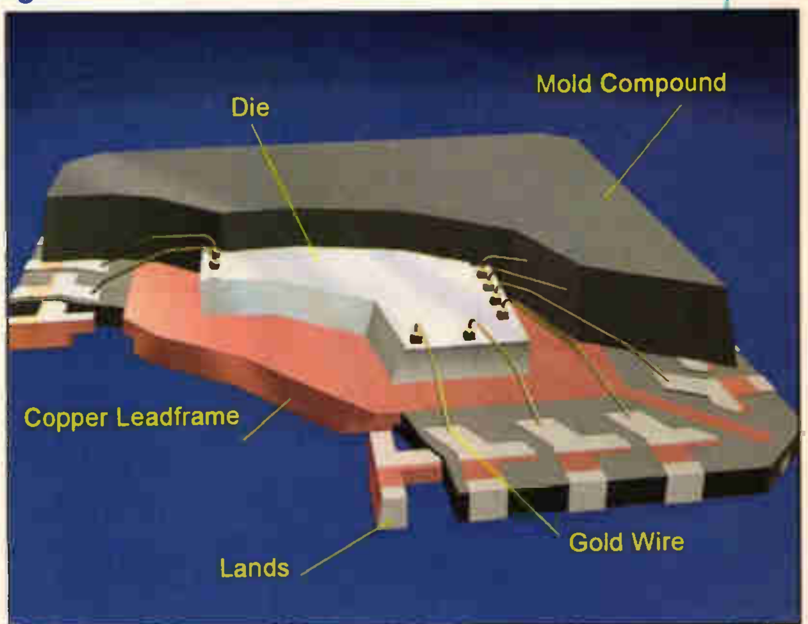
Mosfets cut on resistance in cars

International Rectifier's latest 75V HEXFET power Mosfet offer up to 10 per cent lower on-resistance, or $R_{DS(on)}$, over previous devices. The IRF3808, IRF3808S and IRF3808L for 42V automotive systems are available in the TO-220, D2Pak and TO-262 package. In addition, the Mosfets are rated for repetitive avalanche up to 175°C. They are Q101-qualified and are characterised for automotive applications. RDS(on) of these devices is rated at 7mΩ. The low 0.45°C/W thermal resistance in the TO-220 package enables the

Microcontrollers in near chip-scale package

Microchip Technology has introduced micro-leadframe (MLF) packaged versions of a number of its PICmicro one-time programmable (OTP) and flash microcontrollers. The package design does away with the need for conventional side leads and the company calls it a near chip-scale package. According to the company, the design means that devices are 50 per cent smaller than typical SSOP packages. Further space-saving is achieved when soldering the device directly onto the PCB. A feature called ExposedPad technology, provides a die paddle which is exposed and can be soldered directly to the printed circuit board. The first devices will be available in 28-lead 6x6mm packages with a common pitch size of 0.65mm. The initial product offering will include four OTP devices (PIC16C62B, PIC16C63A, PIC16C72A and PIC16C73B) and two flash devices (PIC16F73 and PIC16F76). Additional devices ranging from 8-lead to 40-lead packages are also planned for 2002. There are also development tools to support the MLF devices. The MPLAB In-Circuit Emulator (ICE) 2000 is a full-featured emulator system. The MPLAB Integrated Development Environment (IDE) tool allows users to write, debug and optimise the PICmicro microcontroller applications for firmware product designs.

Microchip Technology
Tel: 0118 921 5858   www.microchip.com



Please quote *Electronics World* when seeking further information

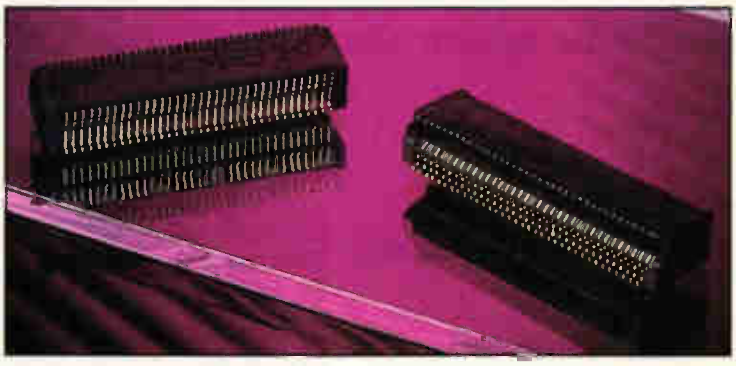
removal of heat generated from the device more effectively, said the company. With the emergence of 42V automotive electrical systems, automotive designers need 75V-rated power semiconductor devices.
International Rectifier
Tel: 020 8645 8003
www.irf.com

ADSL drivers get efficient amp

Analog Devices has developed an amplifier architecture which it claims can improve power efficiency in ADSL (asymmetrical digital subscriber line) line drivers. Called the Adaptive Linear Power (ALP) architecture, it anticipates the signal peaks and so raises the internal supply voltage when peak power is needed. The first implementation is the AD8393, a 575mW, single-supply ADSL line driver. It can achieve over 18V of signal on a single 12V supply, said the company. The line driver is designed for driving DMT (discrete multi-tone) signals onto a twisted pair line with a crest factor (peak to RMS ratio) range of 3.3 to 6.4, while operating from only a single +12V supply. The full power dissipation of the AD8393 for full rate ADSL is 575mW for non-overlapped applications (19.8dBm line power) and 624mW for overlapped applications (20.4dBm line power). It is optimised for driving a 1:1.2 transformer: however, it has sufficient output current to drive up to a 1:2 transformer, said the company. It is sampling in 28-lead TSSOP (thin-shrink small outline packaging) or 32-lead 5x5 mm CSP (chip-scale packaging).
Analog Devices
Tel: 0032 11 300 635
www.analog.com

70-pin SMT connector

Molex has released its 70-pin PCB mounted edge card connector. Intended to enable the emerging 10Gbit family of z-axis plugable transceivers, this connector will support the proposed IEEE 10Gbit Ethernet Standard (IEEE 802.3ae 10GbE). The 10Gbit/s transceivers must be Z-axis plugable to the host PCB using this style surface mount edge card connector.
The connector will offer alignment posts for stable placement on the PCB and standoffs for PCB post-solder cleaning. The design will provide the option for connector placement on either side of the PCB. This connector will support transceiver variants 850nm serial, 1310nm serial, 1310 WWDM and 1550 serial transceivers.
Molex
Tel: 01252 720751
www.molex.com



Flash programming on a network

Data I/O's FlashPAK is a networked flash memory programming system. It is a four-site system which offers network control to manual flash programming environments, providing tracability. The system uses the same programming language and engine as Data I/O's ProLINE-RoadRunner automated inline programming system. It is a tabletop programming system having four sites for simultaneous programming of up to four fine-pitch flash memory devices. Features include auto-start ganged socket actuation.
Data I/O
Tel: 01280 700262
www.directinsight.co.uk

MPEG-2 cores handle four video streams

Amphion Semiconductor is offering MPEG-2 demultiplexing and multi-stream decoders for designing into digital video Asics and SoCs. The CS6804 Multi-source MPEG-2 Demux can simultaneously handle four transport stream inputs from independent sources, with up to 4 video and 4 audio packetised elementary streams per input source. The CS6652 and CS6654 MPEG-2 video decoders perform simultaneous decoding of up to 2 or 4 video elementary streams (ISO/IEC 13818-2 compliant), supporting both main profile at main level (MP@ML) and 4:2:2P@ML professional standard video. The decoders can be configured to handle a single elementary stream at 4:2:2P@HL, and optional 'lite' versions are available that decode and store only essential parameters from the MPEG-2 video stream. According to the company, off-loading video from the DSP or general purpose processor lets the designer build a more exciting application while spending fewer resources.
Amphion
Tel: 028 9050 4040
www.amphion.com

Audio codecs for sound

Wolfson Microelectronics has announced two 24-bit, 8-channel audio codecs for surround sound applications. The WM8770 and WM8771 are the first products to come from the firm's alliance with Sanyo Electric. The codecs integrate all the necessary ADCs, multiplexing, DACs and volume control for multichannel audio. They are designed to work in conjunction with surround sound decoder DSPs from Sanyo and others. They are designed for audio playback of Dolby 5.1 plus L+R stereo mix down, and Dolby EX 6.1 or 7.1 applications typically required for new AV receiver products. Both codecs integrate an 8-channel MUX with stereo ADC and 8-channel DAC. The WM8770 also integrates an independent 8-channel analogue volume control. Both the 24-bit codecs are based on the firm's proprietary multi-bit sigma-delta architecture. The ADCs and DACs offer sampling frequencies between 8kHz and192kHz and are designed to run at different sampling rates. Both the WM877lFT and the WM8771FT are available now in a 64-pin TQFP. Evaluation boards and complete reference design documentation are also available.
Wolfson Microelectronics
Tel: 0131 272 7000
www.wolfsonmicro.com

Please quote *Electronics World* when seeking further information

Super audio CD chip set for DVDs

Philips Electronics is offering a Super Audio CD (SACD) chip for design into DVD-video players. SACD uses a sampling frequency of 2.8MHz, 64 times higher than that of CD to deliver higher quality sound. The SAA7893 can support different DVD-platforms with 6-channel SACD and DVD playback.
Philips Electronics
Tel: 0031 40272 2091
www.semiconductors.philips.com

1W output CMOS power amp

Fairchild Semiconductor's latest CMOS power amplifier, the FAN7021, produces up to 1W of continuous output power (1.5W peak) with supply voltages from 2.0V to 5.5V. The device uses an adaptive bias current control circuit to minimise crossover distortion while also minimising quiescent supply current. The low power device also has a shutdown current consumption of 0.15A. Total harmonic distortion is 0.2 per cent typical and power supply rejection ratio is 65dB. For audio applications there is also a built-in popping noise reduction circuit to reduce unexpected speaker noise when the system's power is turned on or off. According to the supplier, the device does not require an output coupling capacitor, a bootstrap capacitor, or a snubber network. Other features include thermal shutdown protection, unity gain stability, and external gain configuration capability.
Fairchild Semiconductor
Tel: 01793 856831
www.fairchildsemi.com

Power controller with adjustable 12V outputs

Siliconix has introduced a multi-output, sequence-selectable power-supply controller for mobile computing and communications applications. With up to 95% conversion efficiency achieved with synchronous rectification, the low-noise Si9137 DC-to-DC controller features fixed 3.3V and 5V outputs and a 500mA adjustable 5V to 12V output set by an external resistor divider. Other features include programmable output sequencing, a 3.3V reference for precision analogue circuits, a 5V/30mA linear regulator output for Mosfet gate voltage control, and output current limit and over/under voltage protection. Operational frequency is 300kHz, and output voltage regulation is ±3% over the combined line voltage, load current, and temperature extremes.
Vishay
Tel: 0191 5144155
www.vishay.com

Enclosure with custom moulding

Serpac has introduced a range of enclosures, featuring a four piece design and interchangeable end panels. Manufactured from robust ABS (UL 94 HB), the A-Series enclosures feature four insert areas where holes, recesses, legends can actually be moulded-in to customer specifications. Available in sizes 108 x 66 x 22.2mm, 108 x 66 x 28.3mm, 134.9 x 85.1 x 38.1mm, 134.6 x 129.5 x 43.5mm, 180 x 127 x 33.3mm and 180.9 x 127 x 41.1mm, the enclosures are assembled by four or six self-tapping screws. Mounting pillars are provided in the top and base parts for fitting PCBs.
Serpec
Tel: 01489 583858
www.serpec.co.uk

VoIP gateway in 360 ports

Motorola Computer Group has introduced its first range of application-ready voice over IP communications gateways. The ComStruct IGP series is designed to scale from 120 ports to 20,000 ports per shelf. The first gateway in the series is the IGP1000, offering up to 360 ports of compressed VoIP in a CompactPCI chassis. The application-ready system includes an application processor board, multiple packet voice processor boards, a high availability operating system, and the firm's FACTMG gateway development software.
Motorola
Tel: 01509 634461
www.motorola.com

3G basestation power amplifier optimises efficiency

Wireless Systems International has introduced a 3G mobile basestation digital power amplifier which it claims is capable of delivering more than 15 per cent efficiency (depending on the required CDMA signal statistics) from a

Switch-mode power supply with its own diagnostics

The latest switch-mode power supply from Bulgin Power Source incorporates remote diagnostics and power-management facilities that are intended to enhance system reliability and also to minimise the need for on-site maintenance. Designed for battery-backed mission-critical applications in the telecommunications, networking, industrial control and utilities sectors, the 560W stand-alone unit provides a 28V main output for powering the load, a 27V battery charging output and a 12V auxiliary output. Via the built-in RS232 serial interface, the system operator can carry out remote adjustment of parameters such as battery charging rate, battery low and undervoltage lockout operating points, as well as interrogating the unit for real-time operating conditions, including PSU temperature, battery life, elapsed charging time and battery energy level. Input voltage range is 90 to 264V at 45 to 66Hz.
Bulgin Power Source
Tel: 01522 500511
www.bulginpower.co.uk

Please quote *Electronics World* when seeking further information

48V DC supply. According to the supplier, as well as supporting this efficiency at high power levels the amplifier's design will also retain its efficiency at typical operating power levels well below the peak. It is based on the firm's proprietary digital pre-distortion amplifier design which supports what it calls built-in clipping. This means that RF power devices do not ever enter saturation point, so optimising the efficiency achieved.
WSI
Tel: 0117 9066200
www.wsi.com

Thick-film resistor with 0.5 per cent tolerance

Offering tolerances of 0.5 per cent, the latest addition to Rohm's family of miniature, extended temperature chip resistors, the MCR01 thick-film rectangular chip resistors, are available with resistance values from 100Ω to 910kΩ in the E24 series with a temperature coefficient of 100ppm/°C. The devices are supplied in miniature 0402 (1005) size packages and can be used with voltages of up to 50V. Suitable for industrial systems and other applications in harsh environments, the 0.5 per cent tolerance MCR01 devices will operate at temperatures of between –55°C and 125°C.
Rohm
Tel: 01908 282 666
www.rohm.co.uk

Fixed-value optical attentuator

Honda Connectors is extending its MU range of optical connectors with a range of fixed-value attenuators. Fitting between a standard MU-type plug and adapter, the LGA-S600 series is available in six attenuation values: 1, 3, 5, 10, 15 and 20dB. Tolerances range from ±0.5dB for the smallest attenuator, up to ±2.0dB for the 20dB version, while wavelength dependence is characterised as between 0.5 and 1.5dB max. The devices are designed for use with 9.5/125SM optical fibres operating at frequencies of 1310nm or the 1510-1620nm range. Return loss is 40dB or more at 1310nm.
Honda Connectors
Tel: 01793 523388
www.hondaconnectors.com

Battery charger generates 900mA

Ansmann's latest NiCd/NiMH battery generates a 900mA charging current that can be supplied to each of four cells. AAA, AA, C and D type batteries can be charged. The Powerline 5 charger incorporates a microcontroller-based charging system which controls levels. Also a defined pre-discharge can be triggered which the company said is useful to counter any loss of capacity in NiCd cells that can reduce lifetimes. The unit will then automatically recharge once the cells are fully discharged.
Ansmann
Tel: 01279 838205
www.ansmann.de

Test kit for antennas

Tektronix has added an antenna test capability to its field maintenance tools for wireless communications networks. The YBA250 antenna and transmission line tester module for the NetTek field tool adds the capability to execute antenna and transmission line tests supplementing existing features including radio frequency (RF) and modulation measurements for basestations. It provides antenna performance tests such as return loss, cable loss, and voltage standing wave ratio (VSWR).
Tektronix
Tel: 01344 392000
www.tektronix.com

Boundary scan on Fast Ethernet LAN

Goepel Electronic has launched its first boundary scan controller for Fast Ethernet (IEEE802.3) LANs. It is the first in a series of boundary-scan test and in-system programming devices running on a LAN. Available from distributor BSE UK, the LAN 1149.1 controller when combined with Cascon's floating licence feature allows test and ISP programming, debugging and execution to be controlled from any Windows workstation on a network. The intention is to allow engineers to remotely test and diagnose boundary scan operations from their desktop. The controller includes a 32-bit PIO to control signals on the unit under test which are not accessible by boundary scan, TCK frequency programmable from 100kHz to 30MHz, a two wire handshake bus for external synchronisation of scan operations and two independent test access ports with I/O levels which are programmable from 1.8V to 3.6V.
Goepel Electronic
Tel: 01420 82122
www.bseuk.co.uk

64-bit processor runs at 250 Mips

Toshiba's latest 64-bit MIPS-based embedded processor is targeted at would-be 32-bit processor applications which require the extra performance. The TX4925 Risc chip uses the firm's 200MHz MIPS-based, 1.5V TX49/H2 core and delivers 250Mips performance. Supplied in a 256-pin PBGA package, the processor peripherals include a dual-slot PCMCIA interface, a PCI controller, and an AC-link controller for AC97 audio/modem codecs. A direct memory access (DMA) controller, two UART channels, a serial peripheral interface (SPI), 32 general-purpose I/O ports, an interrupt controller, three 32-bit timer/counter channels, a 44-bit real time clock (RTC), and a high-speed serial Concentration Highway Interface (CHI) are also provided.
Controllers for external memory include an SDRAM/SyncFlash controller, an external bus controller and a NAND flash controller.
Toshiba
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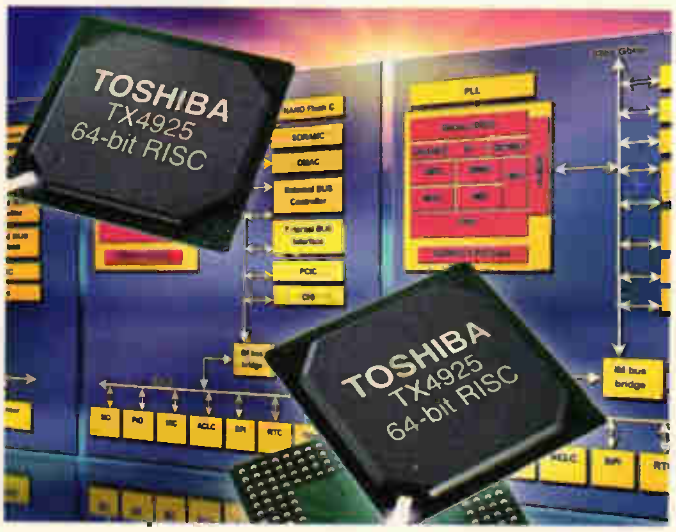

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Bluetooth software for non-Windows applications

Cambridge Silicon Radio is offering Bluetooth software allowing designers to embed the protocol into a range of devices not running on Windows-based operating systems, such as mobile phones or PDAs. BCHS is the first software to run the Bluetooth stack (L2CAP, RFCOMM and SDP) on the BlueCore2 hardware, leaving only the Bluetooth profiles to run on the host system. The following profiles are supported: Audio Gateway (AG) profile, Dial up networking (DUN) profile and Object Push (OPP) profile. The software is also available bundled with CSR's BlueCore2 single-chip. hardware reference designs and sample applications.

Cambridge Silicon Radio
Tel: 01223 692 689
www.csr.com

Miniature Bluetooth 1.1 module is compact

Murata claims to have one of the smallest Bluetooth 1.1 transceiver modules measuring 13.1mm x 10.5mm x 2.3mm. Complying with specification version 1.1, the Blue Module incorporates the RF and baseband IC, LNA, antenna switch, flash memory and crystal oscillator on to a LTCC (low temperature, co-fired ceramic) substrate. Integrated within the substrate are the band pass filter, balun and matching components. The design requires only an antenna for a Bluetooth qualified product.The first devices in the range available are the LBMA2U3AB1, LBMA2U3AB2 and LBMA2-U3AB3, each with USB, UART and BCSP interfaces.

Murata
Tel: 01252 772144
www.murata.com

Meter modules get a facelift

Lascar has lowered the price and added to the features of its 10 series meter display modules which include LED backlighting as standard and an integral negative rail generator allowing measurement of floating voltages or those referenced to the meter's own supply. The

modules feature a snap-in mounting method and are available in 3 sizes ranging from a 5.5mm digit height to 11mm. The DPM 1AS-BL, DPM 2AS-BL and DPM 3AS-BL are all available immediately with prices starting at £20.90 for low volumes and £12.54 for OEM quantities (+250). ■

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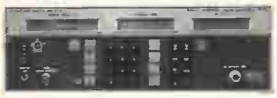

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500MHz sampling front end

Building on his earlier article, outlining how to make a 500MHz scope adaptor, Ian Hickman here discusses the remaining sections needed to implement the scheme. It turns out that these are as tricky and even more complicated than the sampling circuit described earlier.

As I mentioned in my earlier article*, back in the 1950s oscilloscopes struggled to provide a bandwidth of 50MHz: 25MHz was nearer the norm. A notable Tektronix model, with the aid of a special plug-in, managed 85MHz. It was considered remarkable in its day.

Strange to relate, then, that in the late 1950s an oscilloscope appeared which boasted the then incredible bandwidth of 2000MHz. This Hewlett-Packard instrument, whose model number was HP260 or maybe HP280 I think, was an entirely new breed of device, called a 'sampling oscilloscope'.

This instrument achieved its remarkable performance by giving up the quest to handle the incoming signal in real time. Instead, it used a very high-speed gate, operated by a very narrow pulse, to sample the signal at intervals.

Such a same scheme is still used today in digital *sampling* oscilloscopes: not to be confused with digital storage oscilloscopes. Both types are discussed in reference 1.

The technique was refined over the years by both Hewlett-Packard and Tektronix, leading to instruments with a bandwidth of 14GHz by the 1970s, and more recently, of 50GHz. But like the original models, indeed like all sampling oscilloscopes, these are limited to operating on continuous, repetitive signals. Clearly the technique does not, by its very nature, lend itself to capturing transients, or fast one-off events of any kind.

*March 2000 issue, 'Towards a 500MHz scope adaptor'

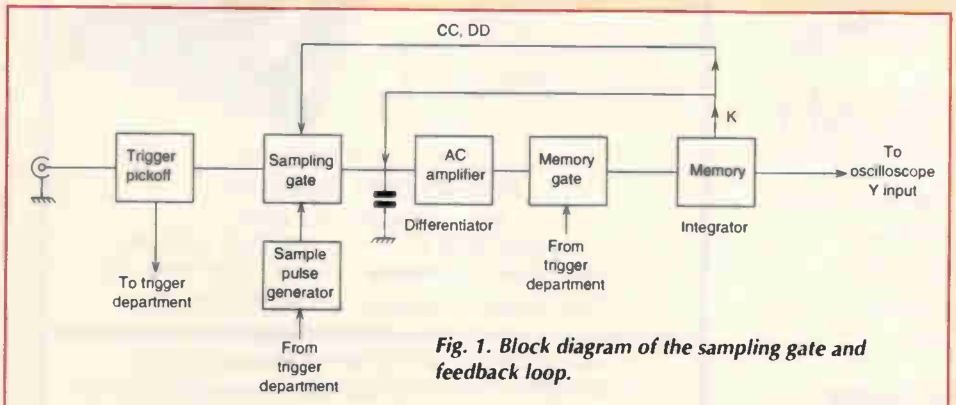


Fig. 1. Block diagram of the sampling gate and feedback loop.

You'll need an oscilloscope and...

As the subsystem described here uses an oscilloscope as the display device, you will obviously need one if you intend to experiment in this field. A scope with a modest bandwidth will suffice, although it will need an external X input facility.

If you intend to build the scope add-on described below, you will also need a fair amount of electronic knowledge and experience; it is not a project for the inexperienced or the faint-hearted. With any project of this complexity, some trouble-shooting and problem solving will inevitably be called for.

The basics

Given a sampling circuit, such as that described in reference 2, it must be triggered in such a way that succeeding samples build up a slowed down replica of the original waveform, rather after the manner of a stroboscope.

A trigger circuit derives the timing of the sample pulses from the input waveform, or from a divided down version – i.e. sub-harmonic – of it. Just how this is managed, in such a way as to build up the waveform, was a problem not addressed in the earlier article. That work dealt only with the sampling circuit.

The circuitry to produce the necessary timing of the sampling pulses is the main topic of this article, although the essence of the earlier article is repeated here. While the earlier article may still be of interest, it doesn't matter whether you have access to it or not; all the necessary information for the intrepid experimenter is contained in the following pages.

The circuit described in the earlier article is capable of taking exceedingly short samples of the signal. The sampling gate is briefly opened by a pulse about one nanosecond wide, which corresponds to a Nyquist bandwidth of 500MHz. The arrangement is shown in the block diagram in **Fig. 1**.

Input signals are connected to a storage capacitor by the sampling gate. The shorter the time for which the gate is open, the higher the achievable bandwidth. But with an open time as brief as a nanosecond, the capacitor only has time to charge up to a few

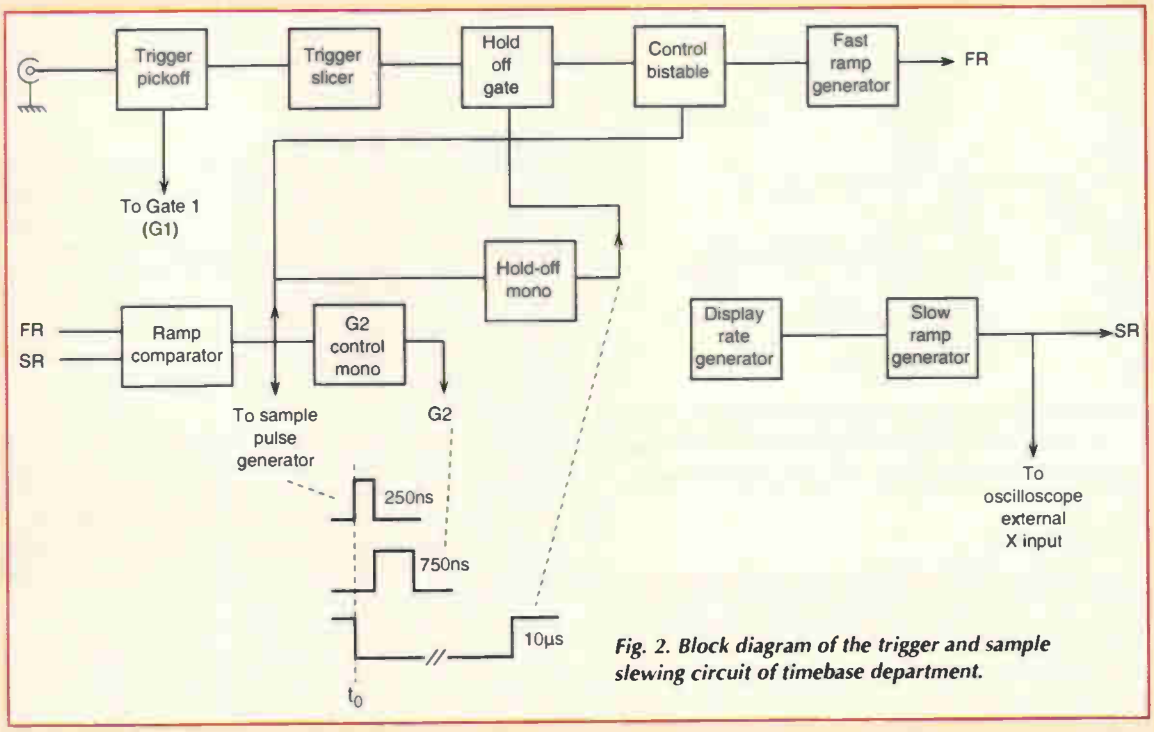


Fig. 2. Block diagram of the trigger and sample slewing circuit of timebase department.

percent of the input voltage. The voltage on the capacitor is then amplified by a factor sufficient to make up the shortfall, giving a measure of the actual input voltage at the instant the sample was taken.

However, the required information is not the absolute value of the capacitor voltage, but the *difference* between the current sample and its predecessor. So the amplifier is AC coupled, thus it acts as a *differentiator*. Its output voltage is stored via a second gate, in a memory capacitor.

The memory *accumulates* the successive capacitor difference voltages; thus it is an *integrator* and its output represents the value of the input signal at the moment the last sample was taken. The combination of a differentiator and an integrator results in a constant unity gain system, from 0Hz (DC) up to a frequency somewhat below the Nyquist rate.

Figure 2 shows the all-important trigger processing section. A fraction of the input signal energy, about 10%, is picked off and fed to a trigger slicer circuit. This produces a squared up version of the input signal and, via the hold-off gate, will trigger the control bistable, initiating a positive-going 'fast ramp'.

The display-rate generator produces a fixed frequency high enough to avoid flicker, and with a very asymmetrical mark space ratio. During the mark period, a positive-going 'slow ramp' is produced, resetting rapidly during the short space period. The slow ramp is fed out to the external X input of the display oscilloscope.

Both the fast and the slow ramp are fed to the ramp comparator, so that as soon as the fast ramp crosses the level of the slow ramp, a narrow sample pulse is produced. At this same time t_0, the control bistable is reset and the hold-off monostable is triggered. The latter closes the hold-off gate, preventing the output of the trigger slicer triggering the control bistable again for the next 10µs.

When the hold-off gate reopens, the control bistable can again be triggered, initiating another fast ramp. However, this time, the t_0 at which the fast ramp crosses the slow ramp level will be delayed rather more relative to the trigger that started the fast ramp. This is because the slow ramp voltage will have increased since the previous trigger.

Thus successive samples are taken at slightly later points on the input waveform, building up a pattern across the screen, representing the input waveform, but in 'equivalent time' rather than real time. Clearly, the flatter the slow ramp, the smaller are the successive delays, and the closer together the samples cluster on the input waveform.

Ultimately, with a nearly flat 'slow ramp', all samples would be taken at almost the same point on successive samples of the waveform, and it is thus easy to produce an impressive figure for the 'equivalent sampling rate'.

The nitty gritty

While true, the preceding explanation is very simplistic. When the fast ramp crosses the slow ramp level, in addition to triggering the sampling pulse and resetting the control bistable, the ramp comparator output generates a 250ns pulse. This in turn triggers the Gate 2 control monostable, producing a 750ns pulse; see Fig. 2.

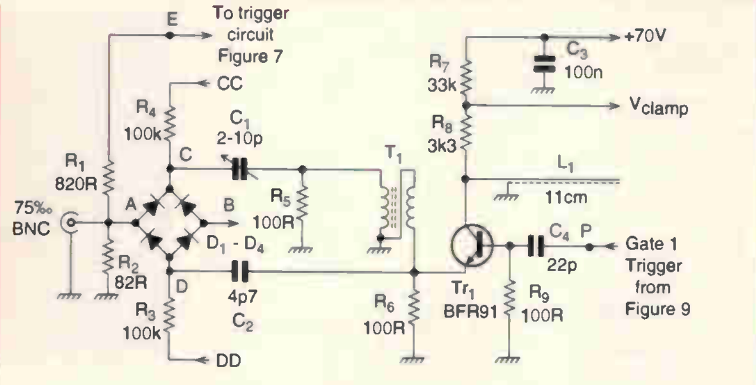
The 750ns pulse opens Gate 2, the memory gate in Fig. 1. The reasons for the various delays and pulse widths will become apparent later, but they are crucial to the operation of the overall system. To see just how, one must turn from block diagrams to the circuitry in detail, and the place to start is at the beginning of the signal processing chain, Fig. 3.

Circuit details

Figure 3 shows Gate 1 and its associated components. Early sampling oscilloscopes used a high-impedance probe, with the sampling circuit actually mounted at the end of a cable, in the probe head. This was never entirely satisfactory, resulting in 'kick-out', i.e., fast edges injected into the circuit under test at the sampling rate, from the sampling gate.

This design uses a low-impedance input, 75Ω, intended to be driven by an active probe, such as described in reference 3. Transistor Tr_1 is normally off. Its collector voltage rises via R_7 and R_8, aiming at +70V, charging the capacitance of the open circuit coaxial line L_1 in the process.

However, the collector voltage never reaches +70V, being caught via a diode at a voltage V_{clamp}. This clamp is set at typically about +28V, depending on the particular BFR91



T_1, 3T + 3T 8 thou. EnCu on Siemens 2 hole balun core B62152-A8X30, A_L = 2300
D_1 - D_4, BAR28. E: to Trigger slicer, L1, miniature 50ohm PTFE insulated coax.
B: G1 output to sample feedback loop circuitry. CC - DD, gate G1 back-off voltage.

Fig. 3 Circuit of the sampling gate.

used. This is just below the transistor's avalanche breakdown voltage, and well above the manufacturer's recommended rated maximum.

When a positive-going trigger pulse arrives, the transistor starts to conduct. But due to the high electric field strength within the device, the few initial carriers multiply rapidly, and the transistor becomes effectively a short circuit.

The voltage stored on the transmission line is then divided between the 50Ω source impedance of the line, the impedance in the emitter circuit of Tr_1, and the voltage drop across the transistor, which is not inconsiderable. More on the operation of avalanche pulse generators can be found in reference 4.

The impedance in the emitter circuit of Tr_1 consists of R_6 and, via T_1, R_5 together with the diodes $D_{1\text{-}4}$ forming Gate 1. These diodes are normally reverse biased by the 'back-off voltage' between points CC and DD, but conduct briefly during the pulse, momentarily connecting point A to point B.

Pulse length is determined by the two-way transit time of the transmission line L_1. This is about 1.1ns, depending on the velocity of propagation in the particular type of 50Ω coaxial cable used.

Since the next sample is normally not taken until many complete cycles of the input waveform later, the back-off voltage must be greater than the peak to peak excursion of the input; otherwise the Gate 1 diodes would conduct at the wrong time. So the amplitude of the available pulse from the avalanche pulse generator limits the peak to peak input voltage the system can accept.

Making up the short-fall

As I mentioned earlier, the capacitor that stores the output of Gate 1 can only charge up to a fraction of the input voltage during the very brief sampling pulse. To maximise this voltage, the Gate 1 storage capacitor is made very small.

Indeed, you will look for it in vain in either Fig. 3, or in Fig. 4. In fact, it consists solely of the stray capacitance at the output of Gate 1, which comprises the input capacitance of IC_{1a}, the self capacitance of R_{10} and R_{11}, and the capacitance to the rest of the world of the lead connecting Gate 1 output to point B in Fig. 4.

Being so small, this storage capacitance can store the new voltage level out of Gate 1 only very briefly, before it would leak away via R_{11}, returning the voltage at the non-inverting input of IC_{1a} to ground potential. But before that has a chance to happen, the new level is applied by the buffer amplifier IC_{1a}, via C_5 and R_{12}, to non-inverting amplifier IC_{1b}. The gain of this is set to X, where 100/X is the percentage sampling efficiency of Gate 1.

Thus the voltage at point H equals what the output of Gate 1 would have been, had its sampling efficiency been 100%. But due to the finite response speed of IC_{1a} and IC_{1b}, this desirable state of affairs takes an appreciable fraction of a microsecond. For this reason, the 750ns wide pulse which opens Gate 2 is delayed by 250ns, as shown in Fig. 2.

During the time that Gate 2 is open, IC_{1c} integrates the voltage at point H. The time constant of the integrator, in conjunction with the gain of IC_{1b}, set by R_{13}, is such that the voltage at the output of IC_{1d} reaches a level equal to the input voltage at point A, when the sample was taken.

Unity gain amplifier IC_{1d} is included, as the integrator is an inverting circuit. Non-inverting integrators, such as the de Boo integrator, are well known, but not so convenient in this arrangement, where the integrator input is left open circuit between pulses.

Having extracted the true value of the input, it is necessary to set up the front end to measure the change in input voltage at the time the next sample is taken. This takes two steps. The first consists of charging up the tiny Gate 1 output storage capacitor to the current input voltage, which is achieved via R_{10}.

However, it is also necessary to centre Gate 1 itself on this

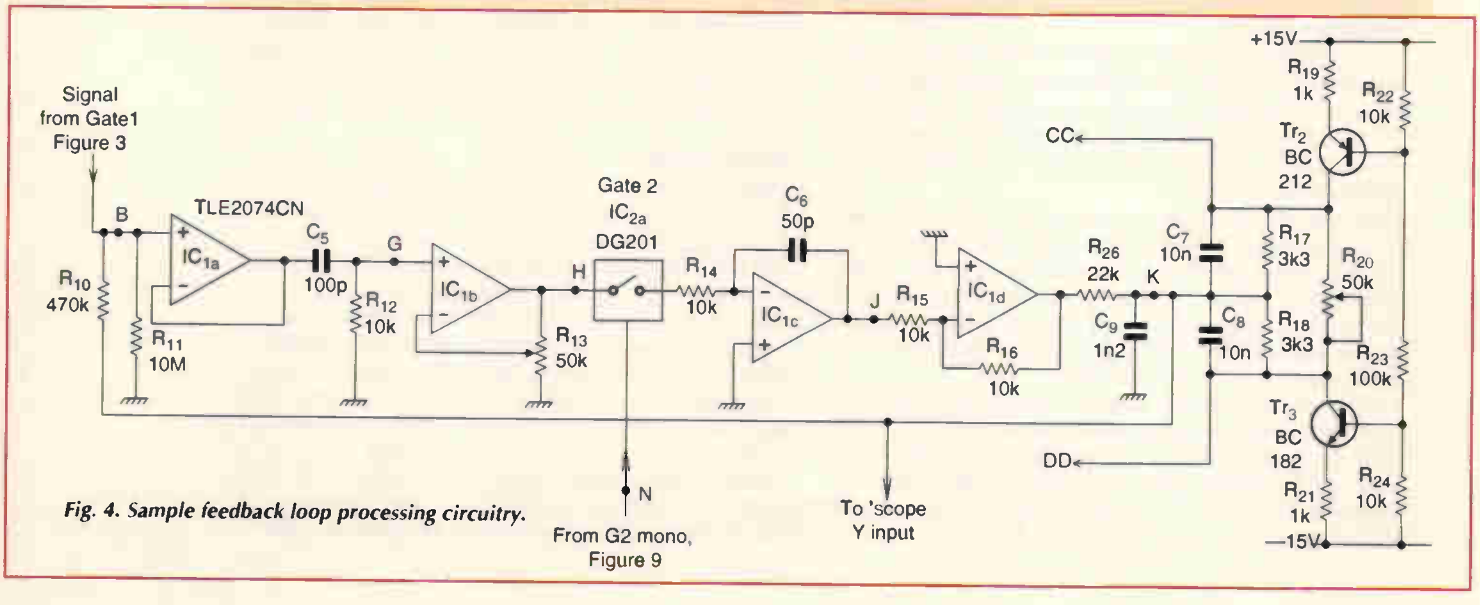


Fig. 4. Sample feedback loop processing circuitry.

voltage, and this is performed by adjusting the voltages CC and DD. The amplitude of the back-off voltage is set by the volt drop, caused by constant current generators $Tr_{2,3}$, across R_{17}, R_{18} and R_{20}. But the level at which this constant difference sits, is determined by the output voltage of IC_{1d}.

Positive or negative?

Response from point B to point K is, as described above, positive. And the output voltage at point K is fed back to point B. This sounds like positive feedback, and indeed it is.

However, the inclusion of passive lag R_{16} and C_9 delays this positive feedback, so that it is virtually ineffective during the period that Gate 2 is open. But during the minimum 10μs delay between samples caused by the hold-off monostable, the voltages at points B, CC and DD all settle to the appropriate values and, crucially, point G returns to ground. Thus when the next sample is taken, purely the difference between it and the previous one is applied to IC_{1b}.

To see how the system works as a whole, consider the case where the input is at 0V for a period, and then makes a step change to, say, +1V. In **Fig. 5**, the left hand diagram shows what happens if the overall gain of the sample feedback loop, as set by the efficiency of Gate 1 sampling, the setting of R_{13}, the length of Gate 2 opening and the time constant of the integrator, is too high. The result is that the supposedly accurate estimate of the true input voltage is also too high.

Following the step, the system will adjust to correct the overshoot, but by too much again: the loop is under-damped. Thus over the next few samples, the output will settle to accurately reflect the input. So, considered in the long term, the feedback is negative. Unlike a normal underdamped negative feedback loop, the frequency of the ring is independent of circuit parameters. It is simply half the sample frequency, as shown.

The right diagram in Fig. 5 shows what happens, on the other hand, if the sample feedback loop gain is too low. The response is now over-damped. When correctly set up, the sample feedback loop will correctly acquire the true amplitude of the input in a single step.

Despite the overall effect being one of negative feedback, the positive feedback aspect is responsible for some deterioration of the signal to noise ratio of the waveform as reconstructed. This appears in the form of jitter, or sample-to-sample noise. The displayed pulses are then not all at exactly the correct level, a perennial problem with sampling oscilloscopes.

Slewing the samples

Figure 6 shows the sequence of events as the system samples an input waveform. The capital letters by the waveforms refer to corresponding points on the circuit diagrams of the trigger/sample slewing department, detailed below.

The trigger slicer produces an on/off waveform from the input signal. This is applied to the hold-off gate, a two input NAND gate. At some point, the 10μs hold-off period expires and the other input to the gate changes from logic 0 to 1. This permits the output of the gate to go negative, either immediately if the slicer output is already high, or when it next does so.

On the next negative-going edge the hold-off gate output is sent high, triggering the control bistable, which initiates a fast ramp. When the fast ramp level passes that of the slow ramp, several thing happen. A Gate 1 sampling pulse is generated, and at the same time, the control bistable is reset.

A 250ns delay is initiated, and the trigger hold-off monostable device is retriggered, preventing further triggers for 10μs. The trailing edge of the 250ns delay pulse triggers the Gate 2 control monostable device, and the sequence of events described in the previous section unfolds.

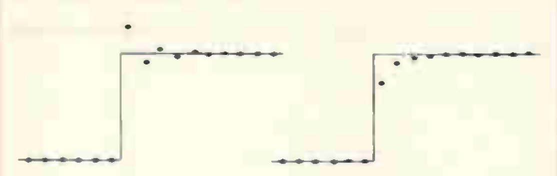


Fig.5. Showing the effect of excess sample feedback loop gain (left) and low loop gain (right).

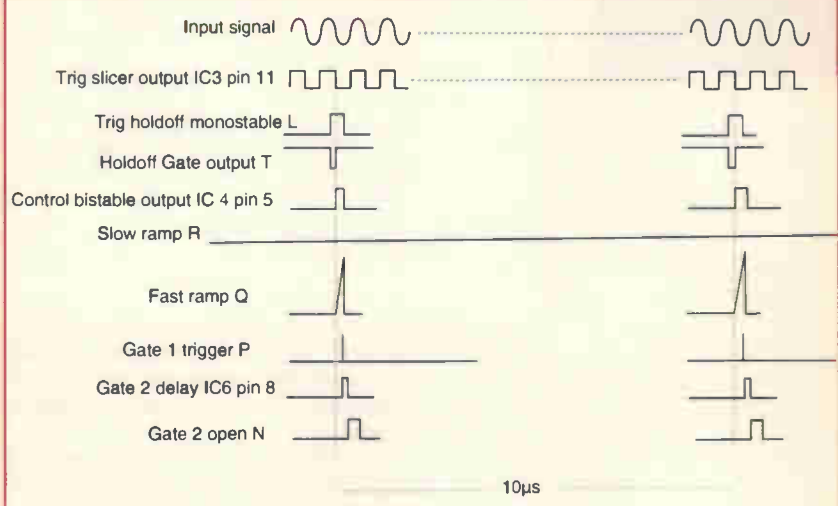


Fig. 6. Timing diagram showing how the slow ramp slews (delays) successive samples.

Trigger/slewing circuitry

Figure 7 shows the front end of the triggering department. Resistor R_1, R_2 and R_{27} provide a 75Ω input resistance, with one eleventh of the input voltage available to the MAX913 trigger slicer IC_{10}.

To ensure clean switching, a small amount of positive feedback is applied, providing a small degree of hysteresis. The positive feedback is applied to the non-inverting input, being positive by virtue of being taken from the complementary Q\ output.

Resistor R_{28} is fitted to maintain the maximum trigger sensitivity despite the attenuation due to R_1 and R_{27}. With a MAX913 having zero offset voltage, its value would be 1MΩ, the same as R_{31}. With the particular MAX913 used in the prototype, the required value turned out to be 3.3MΩ.

The trigger slicer output is taken via one section of IC_3 to the input, pin 10, of the hold-off gate. The intermediate gate is a left over from the development phase, being one of various superfluous gates or inverters sprinkled around the system for the same reason.

Assuming the input from the hold-off monostable device, point L, is high, a negative edge at pin 10 will produce a positive one at pin 8, triggering the control bistable IC_4. The Q output of IC_4 at pin 5 then goes high, permitting constant current generator Tr_4 to charge C_{15}, with C_{16} if a slower fast ramp is required.

Switch S_1 permits the selection of equivalent timebase speeds of 1, 10 or 100ns/division on the display scope. Capacitor C_{13} and C_{14} provide additional decoupling for the fast ramp generator. Any variations in fast ramp timing will cause the sampling points to vary, contributing to a jittery displayed trace.

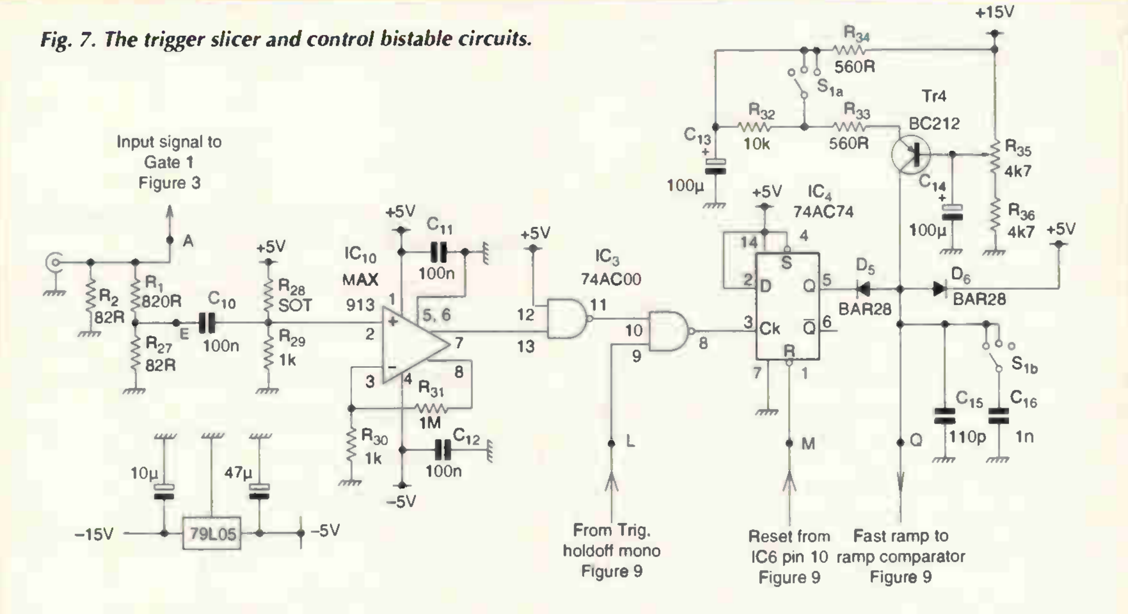


Fig. 7. The trigger slicer and control bistable circuits.

The fast ramp generator output at Q is applied to the ramp comparator, but before considering that, **Fig. 8** shows how the slow ramp is generated. The 555 timer IC_8 generates an asymmetrical squarewave.

During the brief period when IC_6 pin 6 is high, the JFET Tr_5 is on and shorts out C_{24}, resetting the ramp. During the longer period when IC_6 pin 6 is low, Tr_5 is off and the Howland current pump arrangement of IC_{9a} produces a ramp, which is positive-going from ground.

The two following op-amp sections are a simple bounding circuit, which prevents the slow ramp output at S greatly exceeding +5V. Output S is applied to the X input of the display oscilloscope.

On my scope, in XY mode input channel 1 doubles as the X input, so its input attenuator and VARiable control were used to adjust the sweep to 10 divisions full screen. In other cases, an additional pot like R_{55} could be incorporated to fulfil this function. Output R provides the slow ramp to the ramp comparator, R_{55} providing adjustment to set the ramp excursion to +5V maximum.

Figure 9 shows the remainder of the trigger/slewing department. The slow ramp from Fig. 8 is applied at R direct to pin 2 of the ramp comparator IC_5, another MAX 913. The fast ramp is applied to pin 3 via the buffer stage Tr_6. Due to D_7, the fast ramp at pin 3 always starts from below 0V, thus ensuring that it always crosses the slow ramp level.

A small amount of hysteresis is again applied, via R_{39}. When the fast ramp overtakes the slow ramp, point P, pin 12 of IC_6, goes high, triggering the avalanche pulse generator Tr_1 and applying a sampling pulse to Gate 1. At the same time, pin 10 of IC_6 goes low, resetting the control bistable, triggering the hold-off monostable device at pin 1 of IC_7 and sending pin 8 of IC_6 high.

Output from the hold-off monostable device at point L closes the trigger hold-off gate for the next 10μs. With the control bistable now reset, the fast ramp returns to a little above 0V, clamped by D_5, and pin 12 of IC_6 returns to 0V.

After a delay of some 250ns, set by R_{40} and C_{18}, pin 8 of IC_6 goes low, triggering the Gate 2 control monostable device at pin 9 of the 74HC221, IC_7. This outputs a pulse at

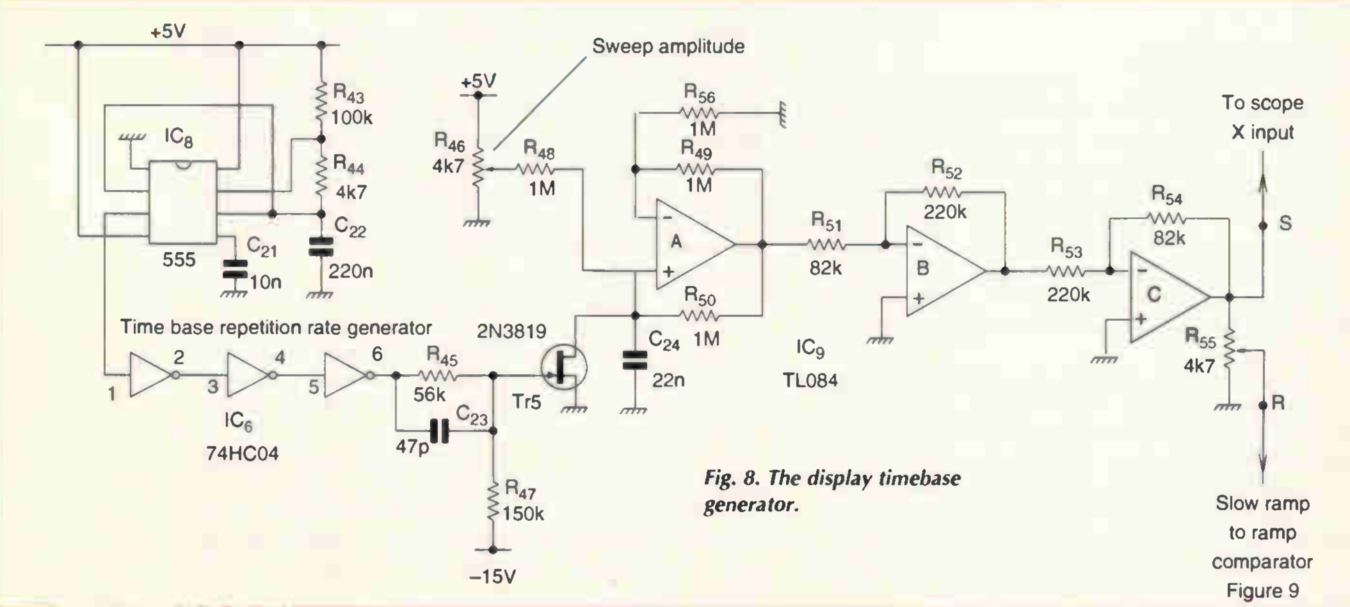


Fig. 8. The display timebase generator.

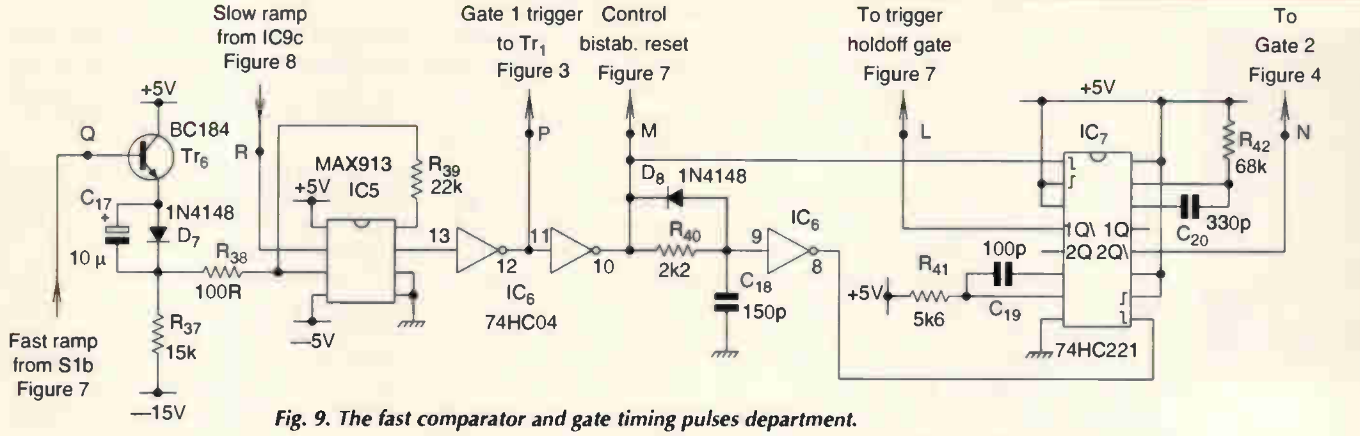


Fig. 9. The fast comparator and gate timing pulses department.

N, opening Gate 2 for 750ns.

And there matters rest for the next 10µs at least, until the control bistable is retriggered. In the mean time, the voltage levels at all points around the sample feedback loop settle to steady values, ready to process the next sample.

Power supplies

The suite of stabilised power supplies shown in **Fig. 10** was built and tested as a separate module. It supplies the various voltages required by the subsystem, namely +70V, V_{clamp}, +15V, +5V and –15V.

Both MAX913 comparators also require –5V, and this was produced locally by a 79L05, on the trigger/slewing logic board, see Fig. 7.

The MAX913 operates at frequencies up to 150MHz. If you are contemplating higher input frequencies, either a faster device would be required, or a prescaler could be used to divide the input down by a factor of two or more.

A suitable prescaler is incorporated in many synthesiser ICs designed for use in the GSM, DCS/PCS bands, etc. I have a couple of SP8715 1100MHz multi-modulus prescaler ICs in stock, but these are not very suitable, as the minimum sinewave input frequency for correct operation is 200MHz.

The devices will operate down to 0Hz provided the input slew rate is faster than 100V/µs, so should prove suitable if preceded by a fast slicer circuit, perhaps PECL. Note that due to the hold-off gate, the maximum sample rate is 100kHz. So a ÷64 prescaler would permit operation down to 6.4MHz at the maximum sample rate – and lower if fewer samples across the screen were acceptable.

For frequencies lower than this, the oscilloscope used as the display should be able to handle the signal on its own!

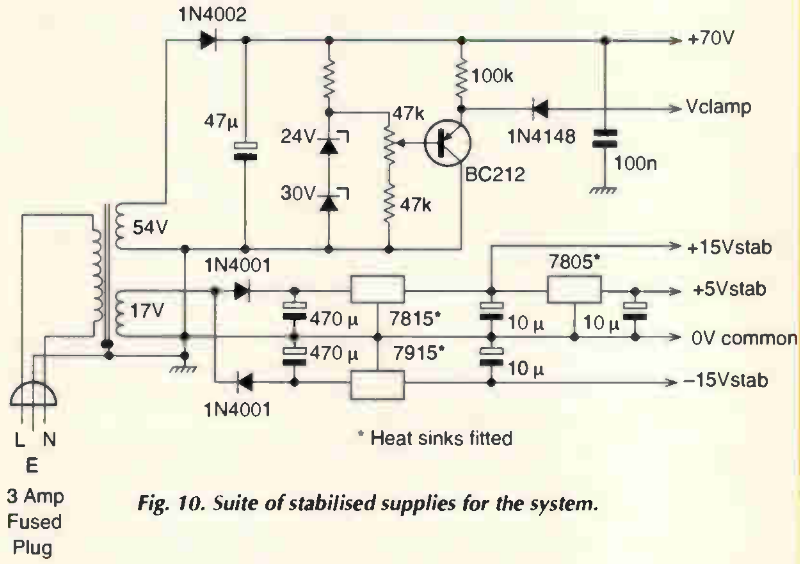


Fig. 10. Suite of stabilised supplies for the system.

Implementation considerations

When dealing with very high frequencies, the mechanical

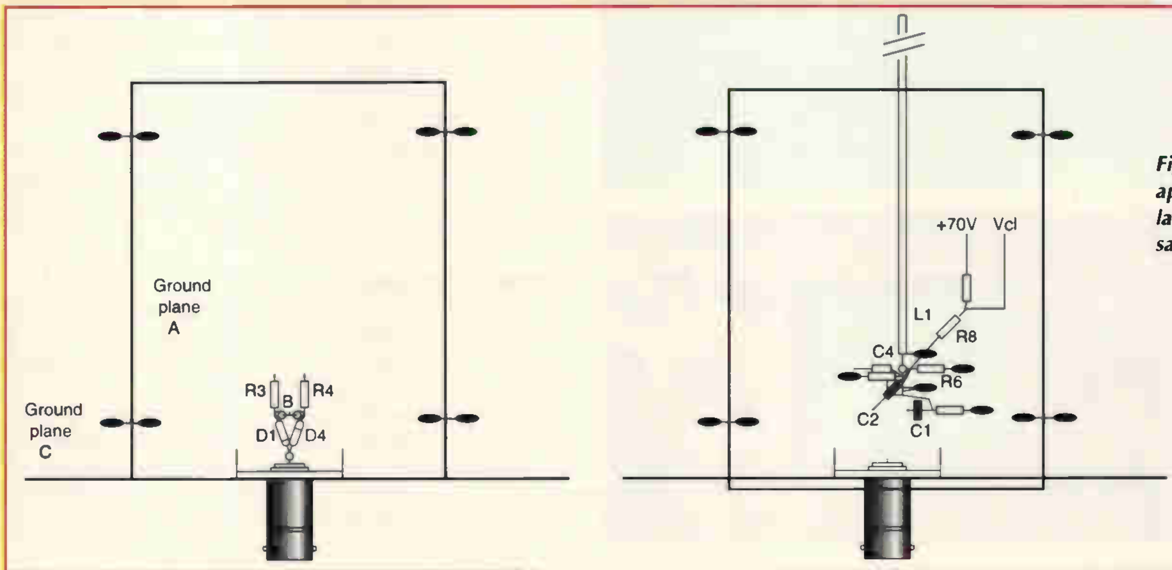


Fig. 11. Indicating approximately the layout used for the sampling gate.

design of a circuit becomes of crucial importance. Construction of the critical Gate 1 circuitry of Fig. 3 was carried out on a ground plane, **Fig. 11**. The square flange of a 75Ω BNC panel mounting socket was soldered to the edge of a 6cm by 8cm piece of SRBP copper clad board (ground plane A), and strengthened with a couple of triangular tin plate gussets, as shown.

Two of the diodes and resistors R_3 and R_4 were mounted as shown, on the connector's centre conductor. The other two diodes were mounted pointing upwards, so that point B sits in a hole in another piece of copperclad (ground plane B, not shown), mounted on metal pillars, above the first.

Remaining components of Fig. 1 were mounted on, or just above the ground plane, as shown separately, for clarity, in the right-hand sketch of Fig. 11.

Resistor R_1 was mounted on the connector's centre conductor, pointing upwards and projecting through another hole in ground plane B, where IC_{10} was mounted. Ground-plane A was subsequently attached with earth straps to a larger piece of copperclad, 20cm by 20cm (ground plane C), as indicated. That completed the critical part of the layout.

The beauty of the sampling scope is that once the samples are taken, they can be processed almost at leisure – certainly at lowish frequencies where handling them is no great problem. So the sample feedback loop of Fig. 4 was constructed on 0.1in matrix copper-strip board.

All ICs were socketed for convenience should changes be necessary. In fact, such a change was necessary; originally IC_1 was a TL084, but the response of this proved too slow, so it was changed to the faster TLE2074 as shown.

The trigger/slewing logic was made up on a standard logic IC prototyping board. The present arrangement is not very satisfactory though, due to the lead lengths this involves between the different modules.

Construction is best done in stages, starting with the power supplies, Fig. 10, and then proceeding to the circuitry of Figs 3 and 4. The remaining sections may then be constructed also, or you may prefer to get each section working, as described below, before proceeding to the next section.

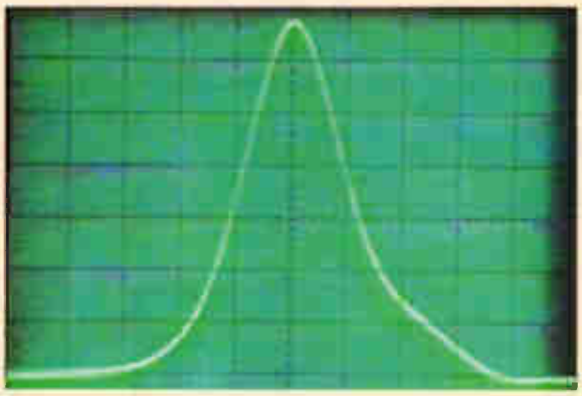


Fig. 12. The sampling pulse, viewed on an oscilloscope of bandwidth inadequate for the purpose.

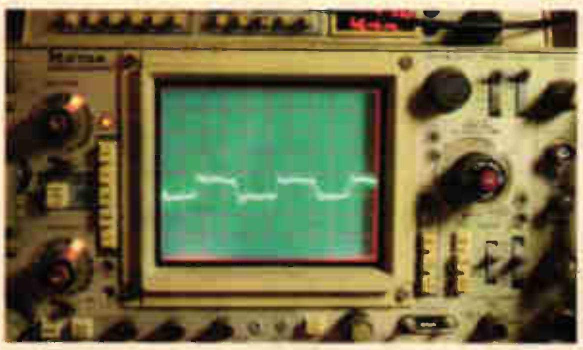


Fig. 13. Display of a squarewave with a 1ns rise time.

Setting up

A temporary test unit will be needed, producing the 250ns and 750ns pulses at a 100kHz repetition rate, shown in Fig. 2 and the bottom two traces of Fig. 6. With V_{clamp} set near maximum, the avalanche transistor pulse generator Tr_1 should free run.

The pulse itself will be too fast for most oscilloscopes to display; **Fig. 12** shows what it looks like on my Tektronix 475A, with its rated bandwidth of 250MHz – 1.4ns rise time, on a good day, bearing in mind its age.

In theory, the pulse is rectangular in shape, but due to the rise time of a 475A, it cannot accurately portray the pulse, and never actually reaches its full amplitude. However, if the pulse itself is too fast to see, the recovery of the potential at the junction of R_7 and R_8 in Fig. 3, towards V_{clamp}, will be easily seen. This is evidence that the avalanche pulse generator is working.

With the 250ns trigger pulse and 750ns Gate 2 pulse turned off, V_{clamp} should be reduced until the avalanche pulses just cease. The result will be that the output of IC_{1d} wanders off to one supply rail or the other, as IC_{1c} integrates its own input offsets.

With the 250ns and 750ns 100kHz pulses applied, the output of IC_{1d} should sit at or very near 0V, this being the potential at point A, with no external applied input at the 75Ω BNC socket, assuming a suitable setting of R_{20}. Adjust this initially so that the back-off potential between CC and DD is 3V.

When a plus or minus 1V potential is applied at the input, the potential at IC_{1d} output should follow the input. If the sample feedback loop gain set by R_{13} is too great, the loop will oscillate, and R_{13} should be backed off until this ceases.

The circuitry of Fig. 8 should now be tested; this module operates purely in a stand alone capacity, and should present no problems. Now add in the circuitry of Figs 7 and 9, enabling the full timebase department to be tested.

A 1Vp-p 50kHz sinewave should be applied at the BNC input socket, and should result in a 50kHz squarewave at pin 7 of trigger slicer IC_{10}. A value for R_{18} can then be found, that keeps the trigger slicer running down to the smallest possible amplitude of the 50kHz sinewave.

The whole timebase department should now be working, but in view of the highly interconnected nature of the various stages, some trouble-shooting may necessary, unless your constructional skills are infallible! With S_1 set for the slowest fast ramp rate, the fast ramp should be visible at the emitter of Tr_6, even on a scope having a modest rise time.

With the timebase department working, the Gate 1 and Gate 2 pulses, points P and N in Fig. 9, should be connected to the corresponding points in Fig. 3 and 4. A 1V p-p 5MHz squarewave connected to the BNC socket should now be reproduced on the screen of the oscilloscope.

For best rise time without overshoot, R_{13} will need adjustment. Note that the setting of Vclamp, R_{20} and R_{13} all interact, and some iteration will certainly be necessary to optimise the performance. Clearly, the 5MHz test squarewave should have very fast rise and fall times; a string of 74AC series inverters can be used to sharpen it up.

Further development

As will be all too clear from the circuit diagrams, the system is still at an experimental stage. An obvious improvement would be the addition of ×2 and ×5 timebase ranges, intermediate between the ranges provided by S_1.

Reducing the amplitude of the slow ramp will have the effect of increasing the equivalent sample rate: effectively increasing the equivalent timebase speed. The mean level of this reduced amplitude slow ramp can then be adjusted, between the limits of 0V and +5V, giving in effect a variable timebase delay, permitting closer examination of any part of the input waveform.

But probably the greatest prize would result from further work on the avalanche pulse generator. Halving the length of the pulse forming line L_1 would give pulses around 500ps long, increasing the Nyquist rate to around 1GHz. However, I do not know whether the BFR91 device would still then be suitable, and of course the shorter opening of Gate 1 will halve the sampling efficiency.

While in principle, this can be compensated by increasing the loop gain with R_{13}, the increased positive feedback will inevitably increase the amount of vertical jitter of the displayed points on the screen.

I have experimented with a BFR520 at Tr_1, a device with an f_t of 9GHz, against the 5GHz of the BFR91. But its lower avalanche voltage limits the available amplitude of the sampling pulse. This in turn limits the usable range of the back-off voltage, setting a limit on the maximum input amplitude the system can accept.

The intention is to use the system with an active probe using the MAX4005, described in reference 3. This has a gain of ×0.5, so that 5V logic signals only require a 0 to +2.5V signal handling range for Gate 1.

All in all, the project has proved a fascinating challenge, and shows very definite promise. As an example, **Fig. 13** shows the display of a squarewave of about 28MHz. This was produced by a generator I designed, using a PECL direct digital synthesiser chip type SP2002, clocked at 1268MHz. There is evidence of a degree of jitter in the display, which is doubtless due to the poor layout of the prototype, mentioned earlier.

The SP2002 device data sheet gives lots of data on the sine outputs, but fails to specify the rise time of the squarewave outputs. However, this should not substantially exceed the clock period and should therefore be 1ns or less.

It appears that there are several points on the displayed rise time, but this is because the exposure used for Fig. 13 has covered several successive sweeps of the display. It seems that the rise time of the system really is about 1ns.

In oscilloscope applications, rise time is generally a much more key specification than bandwidth, and this system looks very promising in that respect. ■

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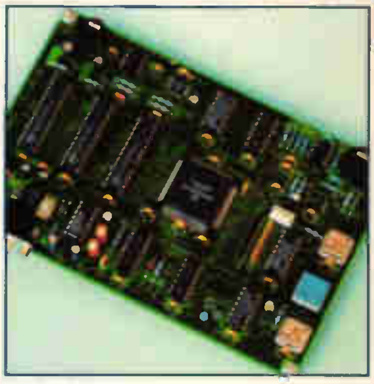

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Star point

Mr Darney is unduly critical of star-point grounding in the April 2002 issue. His arguments seem to centre on RF equipment, where the technique is indeed normally unsuitable and a ground-plane technique is far preferable.

However, in other circumstances, the essential advantage of star-point earthing is very significant. This advantage is that each sub-circuit has its own return current path – not shared by any other circuit.

Thus large return currents, and the associated voltage drops, can be kept separate from low-current circuits, and distorted or noisy currents can be kept separate from clean ones.

Several of his statements should be challenged in order to dispel confusion:

Star-point earthing and hum in valve/tube circuits: Hum from heaters has absolutely nothing to do with the use of star-point earthing. It would still be there, maybe worse, with ground-plane earthing. This worsening is due to the creation of loops, in which the magnetic fields due to the heater wiring induce circulating currents - see below.

Zero-volt reference is an *essential* concept in circuit theory; it even appears as the 'bottom line' in circuit diagrams drawn with British conventions. Because any finite conductor has inductance, *only* a point can be the zero-volt reference; any other point on a ground plane or return conductor has a finite voltage with respect to the zero point unless the current is zero.

Avoidance of loops: Star-point earthing eliminates shared return-current paths as well as loops. Loop elimination, however, is very important in order to ensure freedom from magnetically-induced disturbances. Because loop impedances may be very low – a few milliohms, small induced voltages can result in quite large currents, and all or some fraction of such currents can wreak havoc in sensitive circuits.

Enclosures: Not all equipment, by any means, is housed in a metal enclosure these days.

Loops in systems: Interconnected equipment using unbalanced interconnections is in fact extremely vulnerable to interference caused by earth-loop currents. This is why balanced interconnections, or at least differential input circuits, are preferred. Systems used in proximity to high-power equipment, where high-current mains faults can occur, can and do suffer damage due to huge earth-loop currents.

The explanations in the latter part of Mr Darney's letter are concerned only with high-frequency and transient effects. They do not apply at low frequencies, where, for example, skin depth is equal to or greater than conductor diameter.

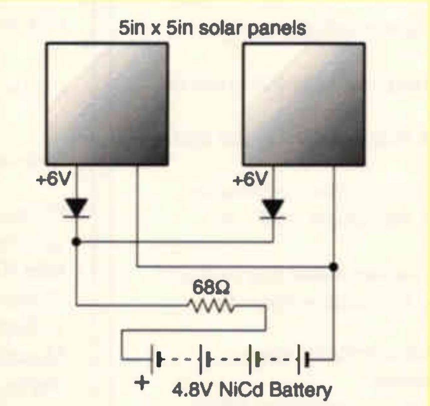
It is futile to condemn star-point earthing emotionally and groundlessly. In the *right* place, it is the preferred technique. Like any other technique, if it is used in the wrong place, it is not good news.

John Woodgate
Via e-mail
http://www.jmwa.demon.co.uk

Solar power charger: correction

In the April issue, there was a circuit idea entitled, 'Solar power battery charger that works on a cloudy day' by Malcolm Lisle. The circuit diagram should have shown two diodes, one in series with each solar panel, not just one in series with the battery. If the voltage on the two panels were different, e.g. if the sun was shining on one and not on the other, they may try to charge eachother.

Malcolm Lisle
Gateshead
Tyne & Wear



Making your own PCBs

Seeing Cyril Bateman's article on making PCBs in the May 2002 Electronics world reminds me that I successfully applied a silkscreen layer to my home-made PCBs as follows:

1) Print the silkscreen layer onto OHP clear film.
2) Photocopy the film upside down. A reversed image is then obtained on paper.
3) The paper is placed face down on the component side of the PCB, taking great care with registration

I tried two methods of transferring the image to the PCB:

1) Flooding the paper with acetone or other solvent and pressing down hard achieved good results – not very environmentally friendly!
2) Carefully ironing the back of the paper with a hot iron achieved good results. Peel back the paper carefully and if any of the image hasn't transferred, replace it and apply the iron again.

If the image is obtained via a Laserjet printer or photocopier, then the resulting silkscreen layer is waterproof.

Tom Scharf CEng MIEE
Principal Design Engineer
Cooper Security Ltd

Regarding Cyril Bateman's PCB article in the May 2002 issue, when laser-printing PCB artwork, don't waste money on expensive laser

Free USB scope software

Before reading the February and March issues, I had put off experimenting with USB due mainly to the time needed to get to grips with the quite complicated specification.

After browsing the FTDI web site and reading the company's application data, it became clear that FTDI had taken the pain away from full-speed USB data transfer.

I immediately ordered one of the USB modules and was told that there would be a three week delay due to high demand – proof of a successful article but slightly frustrating nevertheless.

The good people at FTDI sent me some chip samples so that I could build one from scratch. This is underway. If demand is so high, then maybe there is a similar demand for some software to go with the kit.

The proposed hardware solution published in March requires either absolutely no data dropouts or an even number of packets lost. If this doesn't happen, the scope traces will swap during the trace.

As the February article stated clearly that data delivery is not guaranteed using this mode, then maybe there is room to develop the hardware further to include channel identification and some simple data error detection to help remove any discontinuities in the time domain. Otherwise, at the full data rate, the main use for this kit will be single shot applications. This topic could be far from over.

The reason for this email was to offer an alternative for the other half of the project. I have knocked together the basics of a scope/FFT software package that currently operates on simulated data. I am writing this for my own pet project and I am willing to release it to those of you who are interested, free of charge.

Note that the software's copyright remains with me, and you are only allowed to use it for your own personal, non profit-making interest.

I am also willing to develop the software further, adding more features if I get some good feedback. Looking at some of the commercial packages that are available my offering provides a comparable starting point and could be developed into a very useful tool.

The basic features have been tested on Windows 95, 98, 2000 and XP, but not NT4. They are:

- Two scope channels each with independent full scales on the same timebase.
- A Trigger on either positive or negative slope on Ch.A or Ch.B.
- Two markers in the time domain that give time and measurements for the triggered channel.
- Frequency display based on the markers.
- Sliding DC offset so that the channels can be separated.
- Single selectable FFT channel on either Ch.A or Ch.B.
- A left mouse button click on the FFT trace will auto locate the largest amplitude within ±10 bits.
- Simulation uses a sine on ch. A and a square on ch. B. Frequency can be swept.

To use the software, copy all of the files to a directory and run mscope.exe. If you are concerned about removing it then delete the files and the reg key HKEY_CURRENT_USER\software\MScope.

Operation is straightforward, with tool tips providing some information. Just start the simulator and the acquisition and off you go.

Jason Back
Via e-mail

To obtain the software, e-mail j.lowe@cumulusmedia.co.uk. Please note that the file is around 1Mbyte unencoded and will take a while to download using a standard modem. www.sevenlands.co.uk/mscope

transparencies or specialised films. Use tracing paper, available in A4 pads from any stationer.

Get the thickest stuff you can find – at least 90GSM – to avoid crinkling. The fact that it's translucent as opposed to transparent doesn't matter as long as you ensure the toner side faces the PCB.

Toner adhesion and density are excellent, 50 tracks/inch being easily achievable form a 600DPI laser. I'm told it also works well with some ink jets printers – those from HP in particular.

For a detailed article on all aspects of PCB making on my web site www.electricstuff.co.uk.

Mike Harrison
White Wing Logic
Loughton
Essex

I found the article 'Making Single-Side PCBs' an excellent piece of work by Mr Bateman.

When I first started making PCBs, it seemed a bit like a black art. Some attempts were perfect whilst others ended in disaster. Over a period of time, I've devised a system that works for me and I now have a 99% success rate.

Two points sprang to mind while I was reading the article though.

Firstly, the tubes used in UV light boxes only reach their peak output when warm. I always pre-warm the unit for five minutes or so to make sure the tubes have reached their nominal operating temperature. Note that these UV tubes degrade with age. So exposure times need to be increased as the tubes get older.

Also, I've spent a considerable amount of time in finding an acceptable method of transferring my artwork to the PCB. I have tried the multiple-pass technique as described without much success.

Printing multiple copies of the same artwork and placing these between the light source and the PCB has also been less than satisfactory. The best media I've found is Parchment Paper which looks like a thick tracing paper. It's used in needle work and available in A4 size sheets, 150g/m^2 weight and seems to be obtainable from most craft shops.

Printing on Parchment Paper with my (cheap) bubble jet printer produces a perfect image and for a 100 by 160mm board. Only 2.5 minutes of UV exposure time is required to provide consistent results.

Parchment Paper is quite cheap. The type I use is manufactured by Pergamano (www.Pergamano.com)

Joe Farr
Via e-mail

Gang your own pots

The idea for ganging your own potentiometers in the May issue reminds me of the way power is transferred to the drivetrain of steam-locomotives. The wheels on both sides are connected with linking members, whose joints on the wheels are displaced by 90° respective to each other.

A similar arrangement had been

used in the fifties on the NSU-MAX motorcycle. There. the overhead camshaft was not driven by chain or gears, but with two link rods which were driven mechanically 90° out of phase.

Lutz Kutscha, DL6FCU
Via e-mail

John Woodgate pointed out that there was an error in the description of the potentiometer ganging scheme. There was a section that read, "Strips A and C are identical. They're about 5mm thick on the prototype. Strip B is similar, but a little longer. Strips A and C are linkage arms from hardboard." The last sentence should have read, "Strips D and E are linkage arms from hardboard." Apologies.

Homopolar response

I would like to reply to the many letters on the subject of the Faraday Homopolar Generator.

In the article I was careful in the wording of a possible "free energy device". My experiments were quite lossy and I could not endorse such a claim although some doubts were expressed.

The reference to the late DePalma's work was mentioned because he was one of the few who went into the constructional details of the machine and was worthwhile for such, rather than for any other claim of "free energy". However the main emphasis of the article was on experiments and their unusual results.

Mr McKinney's suggestion relating to the rotating magnet/disc is the right example: you see the wire connected to the voltmeter flying past and you think that the voltage is induced in that wire. So screen that wire or wires, magnetically, electrically, with coaxial cable, or a combination of them and I can assure you that you will still measure the same voltage.

This brings us to Mr Ghislanzoni's experimental suggestions: both of the experiments I discussed were carried out – together with many more – before I wrote the article. I tried to limit the loop area as much as possible, twisting the pair as far as it was physically possible: there was no variation of the measured voltage when tested on the DC machines. There was indeed a large variation though when it was applied to the AC machines.

Twisting eliminates the induced voltage, but not the homopolar voltage, which is anyway at least two orders of magnitude smaller. This is what makes it difficult to discriminate in an AC machine.

The experiment relating to Mr Ghislanzoni's second comment was carried out using an electrolytic capacitor rotating together with the combination magnet/disc. During rotation, the capacitor was brought in contact with the rim and centre of the disc and then isolated again. The disc was then stopped and the voltage across the capacitor measured: it was always zero.

Mr Robinson seems to have little trust in the screening of the wires: As I said, they were effective in AC machines but did practically nothing with DC machines.

In what I called a "pulsing generator", Fig. 4a), you will find two signals: one is the classic induced voltage with a positive peak just before reaching the magnet. It is zero when the wire is exactly in the middle of the magnet and a negative peak when it leaves the magnet.

At the same time, there is a much smaller unidirectional signal – the homopolar signal – that is normally zero. It reaches a peak when the wire is the middle of the magnet and then returns to zero: screening helps to eliminate the induced voltage so only the homopolar voltage is left: the better the screening the clearer you see the homopolar voltage. I am not able to explain this residual voltage with classic theory. Maybe Mr Robinson will.

Dom Di Mario
Milan
Italy

PSU for electrostatic speakers

Regarding the circuit idea 'Switching EHT generator for ES loudspeakers' in the previous issue, I am concerned not to read any warnings for the use of this circuit which under the wrong circumstances could produce a very nasty electric shock.

Less than a milliamp at these voltages can be fatal. Correctly built and with all parts of the EHT insulated it should be perfectly safe. However, I would recommend including a series resistor – of as high a value as possible – between the voltage source, V_{out}, and the outside world.

For an electrostatic speaker, this current limiting would also help protect the electrostatic membrane in the event of a flashover should the speaker be overdriven.

In a circuit of this type, I would also recommend placing a zener across the collector-emitter terminals of the switching transistor, Q_1. This should be of a voltage about 5% to 10% greater than the normal fly-back pulse when the circuit is operating correctly with its feedback control loop. In a failure mode, where the control loop no longer functions, this will prevent the circuit from generating significantly higher EHT voltages.

Note that the zener should be generously rated for wattage as it must be capable of sinking the output from the fly-back pulse over an extended period of time (e.g. TO220 case size).

Susan JL Parker AMIEE, Consultant
London
Via e-mail

Measuring small capacitor values

I read the article from Michael Slifkin and Shai Kriegman in the March issue 2002 entitled 'Measuring capacitance'. It was a pleasure to read, as it described concepts as well as design aspects.

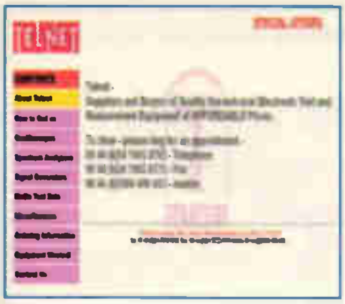
I was pleasantly surprised to read that the authors are currently working on an improved design, where two identical oscillator circuits have to be used. One of the two oscillators will be detuned by the unknown capacitance and then the beat frequency of the oscillators will be measured to determine the unknown value.

The authors think that this method will be especially useful in measuring very low values of capacitance. It is. In the July/August 1996 issue of *Electronics World* I described a capacitance meter in an article called 'C-Meter resolves to 0.1pF'. This design involves two identical oscillators.

Outputs from the oscillators are XOR-ed to provide an error signal. This signal is proportional to the small detuning of the oscillator carrying the unknown capacitance.

I have to say this idea works very well for me till today and I really can measure very low capacitance values. I will be very interested to read the future article of the two authors with a similar – I hope – implementation involving the mixing of the two frequencies. ■

Emil Vladkov, PhD
Sofia
Bulgaria



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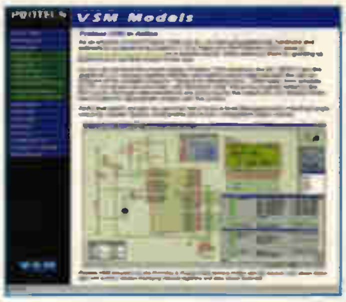

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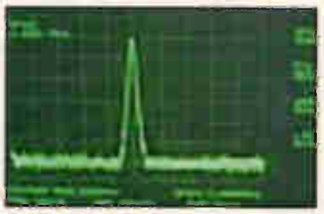

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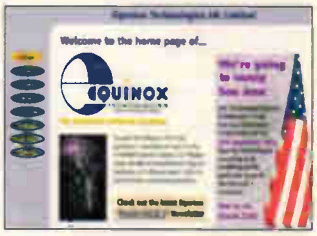

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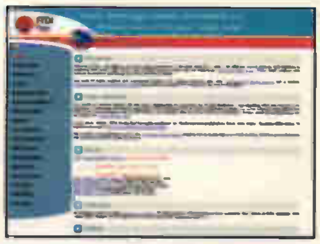

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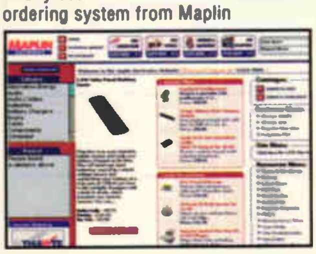

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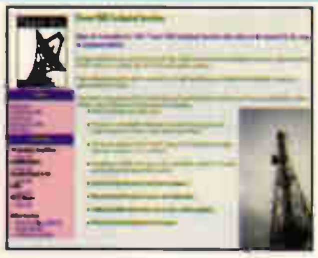

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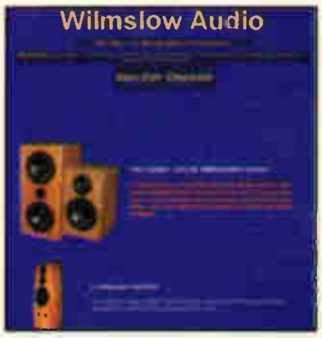

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