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
Quality second-user test & measurement equipment

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Radio Communications Test Sets

- **Marconi 2995**
  - £1250
- **Marconi 2996**
  - £1750
- **Marconi 2999**
  - £3500

- **Anritsu MT 8820C Radio Comms Analyser 300kHz - 3GHz**
  - £6750
- **Hewlett Packard 8906A (20MHz - 40GHz)**
  - £2900
- **Hewlett Packard 89220C (20MHz - 40GHz)**
  - £4900

MISCELLANEOUS

- **Ett 2712 Spectrum Analyser (200Hz-81MHz)**
  - £3500
- **Oriel 4351A Frequency Counter**
  - £250
- **Oriel 4370A Frequency Counter**
  - £350
- **Oriel 4376A Frequency Counter**
  - £500

SPECTRUM ANALYSERS

- **Anritsu MT8820C Spectrum analyser**
  - £5250
- **Anritsu MT8820C Spectrum analyser**
  - £5750
- **Anritsu MT8820C Spectrum analyser**
  - £6250

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ECSILLOSCOOPES

- **Gould 440 20MHz, 250kHz, 2-channel**
  - £895
- **Gould 441 20MHz, 250kHz, 2-channel**
  - £1120
- **Gould 444 20MHz, 250kHz, 4-channel**
  - £1450

---

Signal Gen

- **Hewlett Packard 8643B Synthesised Function Generator**
  - £1250
- **Hewlett Packard 8643B Synthesised Function Generator**
  - £1675

Vector Signal Generator

- **Hewlett Packard 5419A RF Generator**
  - £945

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Each platinum tipped needle in these array testers from 80mm to 28mm, yet they are strong enough to puncture egg shell. News starts on page 5.

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TEST & MEASUREMENT ON A BUDGET

Richard Black discusses using a PC, a CD rewinder and a sound card for making audio bandwidth measurements with the help of various sound analysis software.

BEHIND AIDS

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.

---

MAKING DOUBLE-SIDED PCBs

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

CIRCUIT IDEAS

- **Titter in a key fob**
- **Low-cost bridge emulator**
- **Minimal loudspeakers**
- **Voice-operated recorder**
- **Electronic antenna lengthener**

NEW PRODUCTS

The month's top new products, selected and edited by Richard Wilson.

500 MHz SAMPLING FRONT END

Building on his earlier article, outlining how to make a 500 MHz scope adaptor.

Ian Hickman discusses the remaining sections needed to implement the scheme.

LETTERS

- **Star-point grounding**
- **Making your own PCBs**
- **Free USB scope software**
- **Measuring small capacitor values**
- **Homopolar response**

WEB DIRECTIONS

Useful web addresses for engineers and students.
COMPUTER CONTROLLER MEASURING INSTRUMENT

The HS801: the first 100 Mega samples per second measuring instrument that consists of a MOST (Multimeter, Oscilloscope, Spectrum analyzer and Transient recorder) and an AWG (Arbitrary Waveform Generator). This new MOST portable and compact measuring instrument can solve almost every measurement problem. With the integrated AWG you can generate every signal you want.

- The versatile software has a user-defined toolbar with which over 50 instrument settings quick and easy can be accessed. An intelligent auto setup allows the inexperienced user to perform measurements immediately. Through the use of a setting file, the user has the possibility to have an instrument setup and recall it at a later moment. The setup time of the instrument is hereby reduced to a minimum.

- When a quick indication of the input signal is required, a simple click on the auto setup function will give the user a good overview of the signal. The auto setup function ensures a proper setup of the time base, the trigger levels and the input sensitivities.

- The sophisticated cursor readouts have 21 possible read outs. Besides the usual read outs, like voltage and time, also quantities like rise time and frequency are displayed.

- Measured signals and instrument settings can be saved on disk. This enables the creation of a library of measured signals. Text balloons can be added to a signal, for special comments.

- The (colour) print outs can be supplied with three common last lines (e.g. company info) and three lines with measurement specific information.

- The HS801 has an 8 bit resolution and a maximum sampling speed of 100 MHz. The input range is 0.1 volt full scale to 80 volt full scale. The record length is 32K/64K samples. The AWG has a 10 bit resolution and a sample speed of 25 MHz. The HS801 is connected to the parallel printer port of a computer.

- The minimum system requirement is a PC with a 486 processor and 8 Mb RAM available. The software runs in Windows 3.x or 95/98 or Windows NT / 2000 / XP and DOS 3.3 or higher.

- TiePie engineering (UK): 28 Stephenson Road, Industrial Estate, St. Ives, Cambridgehire, PE17 3IU, UK Tel: 01480-460028 Fax: 01480-460340

- TiePie engineering (NL): Koperslagersstraat 37, 8601 VL NEEK The Netherlands Tel: +31 515 415 416 Fax: +31 515 418 819

- Web: http://www.tiepie.nl

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TRANSIENT RECORDER-

ARBITRARY WAVEFORM GENERATOR-
STORAGE OSCILLOSCOPE-
SPECTRUM ANALYZER-
MULTIMETER-
TRANSIENT RECORDER-

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STEADY AS SHE GOES?

...n March the London Internet Exchange (LINX) announced it had switched its 250 trillion - that's 750,000,000,000,000 - packets 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 points in Europe. Peak traffic flows at the exchange can top 14 gigabytes per second, about 140 times greater than its busiest 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.

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 unannounced 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.

A more 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 ease 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 complete the peering picture, not all ISPs possess their own network infrastructure and facilities; some merely sell others' space capacity and 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 distributed backup peering facilities. This could leave their customers at significant risk. Users of ISPs that simply rebrand another operator's product without investing in infrastructure of their own will be even more 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 dependent on the diversity of the physical routing implemented by the telephone companies. While most ISPs have multi-sourced their backbone provision reasonably adequately, the access links that connect their operation centres to the main backbone are still very vulnerable. If, say, their operation centres have a single fibre link and that link fails, then that's where the holes will appear and the collection 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 about 140 ISPs 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 November 11 scale to make it happen?

Mark Evans

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*please quote address*
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 Gigalnergy 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 due 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 Lacroute, Verizon's network president.

Fuel cells produce electricity through 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 Btu's, 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 300kW power system, also from UTC, will provide both heat and electricity for the Park's pool, lighting, air conditioning and dehumidifier systems.

Woking is recognized as one of the most ardent supporters of alternative fuel sources in the UK, particularly in 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 wide 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 QUICBC 1BCMOS chip process with a SiGe-based 'G' version. QUICBCG will enable Philips to supply IOs 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 continually timed the release of our SiGe technology to coincide with the massive explosion in broadband communications. F_1 and F_3000 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."

For amplifiers and transmission gates, the process has a 2.7V 75GHz F_1 and 100GHz F_3000, and for VCIs and interface logic a slightly slower 3.6V device. In SiGe transistors achieve 0.6dB 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 QUICBC 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 metallised with platinum to make the electrical contact. To minimise nerve damage, the needles are exceedingly thin, 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

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 simulated 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, it will be the icing on the cake."

Electronics hit a nerve

The Utah Electrode Array needles

<table>
<thead>
<tr>
<th>Number</th>
<th>100 electrodes 0.4mm apart in a 10 by 10 square grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>1.5mm long</td>
</tr>
<tr>
<td>Shape</td>
<td>Conical; 0.8mm, tapering to 2um; Pt tipped</td>
</tr>
<tr>
<td>Substrate</td>
<td>0.2mm thick</td>
</tr>
<tr>
<td>Insulation</td>
<td>2um SiN, all over except tips</td>
</tr>
<tr>
<td>Wires</td>
<td>25um diameter PTFE-insulated platinum-iridium alloy.</td>
</tr>
<tr>
<td>Impedance</td>
<td>100 and 500kΩ, at 1kHz 100mA</td>
</tr>
</tbody>
</table>

You probably know Electronics Workbench software. You may have learnt electronics engineering with it, or used its powerful, intuitive simulation and analysis tools to hone your circuit design skills. But did you know that these days, Electronics Workbench has also moved into the professional EDA market?

In fact, it's taking this market by storm. With its unparalleled resources as the world's best-selling supplier of Windows-based electronics design software, Electronics Workbench has developed a set of CAD and CAM tools that match, and in some technologies surpass, the established EDA providers.

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www.electronicsworkbench.co.uk
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 particular 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.

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

Multi-layer metallization is fabricated on the top of the circuit wafer to form four individual electrodes per mirror, which electrostatically drive the reflectors.

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

Power consumption is said to be below 1mW/mm².

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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 Electroadhesive, only a few milliamperes are needed to un-bond a joint without leaving blemishes. According to importers Electromonit, the glas was developed to temporarily attach test equipment to the outside of supersonic aircraft.

**Facts:**
- It bonds at 800A/m² dropping to 500A/m² after a few seconds.
- The bond breaks after between 5 seconds and 20 minutes, depending on the voltage and force.
- Lap shear strength is 250psi (175kg/cm²) in type E4 and 300psi for type M.

**LEDs look set to replace CCFLs in backlighting applications**

Light emitting diodes are set to out 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 Eihi 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 softly 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.

DPA1000 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 cores aim to bridge the gap between traditional DSP, FPGA, and ASICs. The reconfigurable cores can be more powerful than DSP, faster and smaller than FPAGAs, and cheaper than ASICs, it said.

Five members of the DPA1000 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 Celenica's DK1 development tools.

The current cores are designed on a 0.18um process, with 0.15um planned for the year end. Elixent has used design rules that are compatible across the TSMC, UNIC and Chartered foundries.

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- Also available for next day delivery from international distributors.

Lloyd Research Ltd has been designing gang programmers since the early 1980s.

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  - Optional: 115V/50Hz
- **PHYSICAL:**
  - H: 125mm x W: 185mm x D: 70mm
  - Weight: 5kg

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W: www.lloyd-res-research.com
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 horsepower—be it editing software, fancy audio analysis or high-end game software—is going to require a PC with a suitable sound card. In fact, it is possible to use a PC to carry out quite sophisticated audio analysis and editing with a relatively modest PC—and much less expensive cards than those normally used for sound editing. The idea is to use a sound card and sound editor in conjunction with a PC's other facilities, and to make the best use of the card's processing power. The card's sound processing power can be harnessed to perform a wide range of tasks, from simple audio analysis to the capture and display of audio waveforms.

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 rather come clean right away as a 'PC person': apologies to Mac users, but what follows refers primarily to 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 format 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.

Software for analysing captured signals

Many engineers already use mathematical packages such as Mathcad and Mathlab 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 Pro, 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...
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

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

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.

Wav and flutter
One other test quite easily carried out by my method is wav and flutter testing. Admittedly, such tests are 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 Matlab or similar for analysis. Cool Edit normally works with WAV files, but it can also import and export data in test form, which can then be read into Matlab — or any other programs that can read columns of figures — as a "PKN" 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 built into any digital replay equipment, pulses output through it will turn into distinctive windowed sine-function waves, when viewed on an oscilloscope. In general, replay and recording won't be in phase even though they are 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 wav 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.

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/stop, 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

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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
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.

T he Radio Data System – Cenelec EN50097 specification – is an insidious data signal added to VHF FM radio. It was introduced within the European Broadcasting Union (EBU) in the mid 1980s. RDS was designed to make VHF FM radio 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 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.

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

19kHz pilot frequency is it 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, whereas 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 17kHz 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 (Austrofonie 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 long 'data and 16 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 the sender relies 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 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 D, and E. 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).

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

---

**Fig. 3. Syndrome types and their hexadecimal representation.**

\[
\begin{align*}
A &= 3D_{16} \\
B &= 2C_{16} \\
C &= 25_{16} \\
D &= 26_{16} \\
E &= 29_{16}
\end{align*}
\]
The UK is allocated number C4. 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 select 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 blocks is dedicated to one type of data application and identified by a group type number from 0 to 15. Different broadcasters utilize 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.
8R 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.

**Fig. 7. Decoder information.**

<table>
<thead>
<tr>
<th>C1</th>
<th>C0</th>
<th>Decoder option</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>D3=0, mono: D1=1 stereo</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>D2=0, not binaural: D=1, binaural</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>D1=0, not compressed, D1=1, compressed</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>D0=0, static PTY, D0=1, dynamic PTY</td>
</tr>
</tbody>
</table>

logic 1, it indicates that the radio station currently being received broadcasts traffic announcements. If the traffic announcement flag, TA, is logic 1, traffic announcement is currently being broadcast by this station.

Musicspeech 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).

Most 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 block C transmits the PI number again (copy of block A).

**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.
of the labelling codes, Figs 12-14. Using the LA bit allows several radio services with different PII services to be treated by the RDS receiver as a single service during times when a common programme is carried. The PIN – or Programme Identifier - 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.

<table>
<thead>
<tr>
<th>Bit</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>09</th>
<th>08</th>
<th>07</th>
<th>06</th>
<th>05</th>
<th>04</th>
<th>03</th>
<th>02</th>
<th>01</th>
<th>00</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Group type 1A</td>
<td>B</td>
<td>TP</td>
<td>PTY programme type</td>
<td>Radio paging codes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
<td></td>
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</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Bit</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>09</th>
<th>08</th>
<th>07</th>
<th>06</th>
<th>05</th>
<th>04</th>
<th>03</th>
<th>02</th>
<th>01</th>
<th>00</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Group type 1B</td>
<td>B</td>
<td>TP</td>
<td>PTY programme type</td>
<td>Reserved for future uses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0</td>
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</table>

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

<table>
<thead>
<tr>
<th>Bit</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>09</th>
<th>08</th>
<th>07</th>
<th>06</th>
<th>05</th>
<th>04</th>
<th>03</th>
<th>02</th>
<th>01</th>
<th>00</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Group type 1B</td>
<td>B</td>
<td>TP</td>
<td>PTY programme type</td>
<td>Extended Country Code (ISO 3166)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>0</td>
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<td>0</td>
<td>1</td>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Bit</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>09</th>
<th>08</th>
<th>07</th>
<th>06</th>
<th>05</th>
<th>04</th>
<th>03</th>
<th>02</th>
<th>01</th>
<th>00</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Group type 1A</td>
<td>B</td>
<td>TP</td>
<td>PTY programme type</td>
<td>Language code (including 090=English, 12=French, 054=Welsh)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0</td>
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<td></td>
<td></td>
<td>0</td>
<td>1</td>
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</tr>
</tbody>
</table>

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 C3 C2 C1 C0 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 blank. 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 PIN 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 be used directly by the ODA. In block C, the AID (Application Identifier) number is used to uniquely identify a particular application. That 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 = 00933 in 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-hours in UTC to UTC time. 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 26 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 (Alert Layer for the European RDS-TMC) protocol. This protocol defines the coding of traffic messages by the use of a pre-defined database containing location names and events. The protocol is not language or country specific and is planned to be used across Europe. The 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 worked out, there remains the issue of who pays for the service. As the BBC is a public service broadcaster it believes the traffic information should be made freely available. However the only large scale TMC trials undertaken in this country involved the two major 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. This data is determined by the broadcaster or end user. The last 2 bits in 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, PIN number, transmitter frequencies, traffic announcement identification, and programme type. For some stations programme item number (PIN) information is transmitted. EON is implemented on type 14A group and 14B to send the information of the other radio networks. The value of the variant code (14A) determines what
**Software and pre-programmed PICs**

For those of you who don’t have a 165877 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. 25. Definition of block B for type 144 group.**

<table>
<thead>
<tr>
<th>Block</th>
<th>Group type</th>
<th>TP</th>
<th>PTY programme type for TP</th>
<th>Tuned network</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>144</td>
<td>TP</td>
<td>TP</td>
<td>Tuned network</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 26. Definition of block C for type 144 group.**

<table>
<thead>
<tr>
<th>Block</th>
<th>Group type</th>
<th>TP</th>
<th>PTY programme type for TP</th>
<th>Tuned network</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>144</td>
<td>TP</td>
<td>TP</td>
<td>Tuned network</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 27. Definition of block D for type 144 group.**

<table>
<thead>
<tr>
<th>Block</th>
<th>Group type</th>
<th>TP</th>
<th>PTY programme type for TP</th>
<th>Tuned network</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>144</td>
<td>TP</td>
<td>TP</td>
<td>Tuned network</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>TP</th>
<th>TA</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>off</td>
<td>off</td>
<td>No traffic announcements or EON.</td>
</tr>
<tr>
<td>off</td>
<td>off</td>
<td>No traffic announcements at present and EON.</td>
</tr>
<tr>
<td>off</td>
<td>off</td>
<td>Traffic announcement broadcast.</td>
</tr>
</tbody>
</table>

**Fig. 29. Definition of block B for type 148 group.**

<table>
<thead>
<tr>
<th>Group type</th>
<th>TP</th>
<th>PTY programme type for TP</th>
<th>Tuned network</th>
</tr>
</thead>
<tbody>
<tr>
<td>148</td>
<td>TP</td>
<td>TP</td>
<td>Tuned network</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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.**

- BU1923 pin 16 (clock) connect to PIC RBO pin 33
- BU1923 pin 2 (data) connect to PIC RBB pin 34
- RDS 25V (Vcc) connect to PIC pins 11, 13, 22
- RDS 0V (V-) connect to PIC pin 12, 31

**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. 33. Example of RDS groups transmitted.**

<table>
<thead>
<tr>
<th>PIC</th>
<th>RDS</th>
<th>Radio frequency</th>
<th>PS</th>
<th>TA</th>
<th>Type</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>C201</td>
<td>R1</td>
<td>BBC Radio 1</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>C202</td>
<td>R2</td>
<td>BBC Radio 2</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>C203</td>
<td>R3</td>
<td>BBC Radio 3</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>C204</td>
<td>R4</td>
<td>BBC Radio 4</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>C2A1</td>
<td>Classic.</td>
<td>Classic FM</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>C4B7</td>
<td>FOX</td>
<td>Fox FM, Oxford</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>C811</td>
<td>BBC</td>
<td>BBC Radio Oxford</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>C865</td>
<td>MIX</td>
<td>Mix 96, Aylesbury</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
</tbody>
</table>

- S = static
- D = dynamic

**ELECTRONICS WORLD June 2002**
Fig. 35. RDS-PIC components list.

The RDS-PIC circuit, Fig. 34, is not complicated and can easily be built on strip board. When constructing the circuit ensure that the crystal can be connected to OV.

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.

Connects 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 groups, the RDS data may appear on the PIC before being displayed on the radio's display.

PIC software

The PIC microcontroller software is interrupt driven with the edge of RDSL 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_4 to 35_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 byte is '1' the value from the appropriate position in the parity table is taken and multiplied with the running total using modulo-two arithmetic.

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.

PINC displays mode.
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 in 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 leaving 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 itself is 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 viewed with 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

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 added 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.

Procedure check:

The RDS parity check matrix.

The RDS parity check matrix.

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

The RDS parity check matrix.

Fig. 37. RDS parity check matrix.

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 added 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.
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 brand 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...
Registering the artwork

If equipment cost is no object, both artwork films can be reg-
istered together and both sides of the board exposed simulta-
neously. However this requires an expensive double-sided UV
exposure unit. These usually also have vacuum beds to hold art-
work and boards in close contact. The lowest-cost unit I have
seen, based at £500, 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 prob-
lems with registration.

One early method, which worked occasionally, was to expose
them 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
design, 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-protection 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, dis-
solving 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 undercutting 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-develop-
ed and etched, just as for a single-sided board.

A few sided exposure frame is needed. 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 lar-
erg than your blank circuit board, which must remain fully vis-
able. 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 this aluminium
channel sold for secondary double glazing.

Five easily-visible registration targets are placed outside the
design area, but within the black board dimensions, and coinci-
dent 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 pos-
sibility that one or other artwork film becomes accidentally
reverse aligned. Nevertheless, I still wrote clearly on each art-
work film, identifying which is the copper or board facing side.

To protect the artwork positioned centrally 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 still 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
plastic, through which it will be exposed. Ensure the board side
of this artwork is uppermost.

Remove the protective tape, previously identified with mask-
ing tape, and place this side of the board down onto your art-
work. Then remove the protective tape from the second, now
upmostern, 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, direct-
ly 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 temporari-
ously 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 Centre it over the target centres.

When the board is secured in position, remove both handles.
The ground-plane artwork film’s five targets are now care-
fully positioned over the five pre-drilled holes, ensuring all
holes are aligned with the target centres. This artwork is now
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 photosensitive to develop and mini-

mizes 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 erch resis pen.

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

Circuit is currently operating 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

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ELECTRONICS WORLD June 2002
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 a transducer, which is normally expensive.

If a conventional four-resistor bridge is constructed to emulate the sensor then the 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 $R_2$ remains approximately constant. In particular, the current through $R_1$ is always balanced and the self-heating is always balanced. Therefore there will be no thermal gradient between $R_1$ and $R_2$.
- The output signal level is easily adjusted by the value of the $R_1$ resistor. The circuit's low cost!

Bridge-type sensors are strain-gauged 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 $R_1$ equal and $R_2$, equal the sensor bridge impedance. Resistor $R_3$ can be one fixed resistor to give 0% and 100% output signal 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 $R_1$ and $R_2$ are calculated to pass 1mA then the output is 1mV per ohm set by $R_3$.

Note the switch contact resistance appears in series with $R_3$ which 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".

ATMEL 89xxx Programmers

Powerful programmer for ATMEL 8051 microcontroller family. All fuse and lock bits are programmable. Connects to serial port. Can be used with any computer and operating system. The LEDs indicate programming status. Programs BGC1051, BGC2051, BGC2052, BGC301, BGC601, BGC602, BLDIC2, BLDIC4, BLDIC5, BLDIC252, BLDIC5, BLDIC53 & BLDIC53 devices. No special software required - uses any terminal emulator program (built into Windows).

PC Data Acquisition & Control Unit

Use a PC parallel port as a Real-Time Interface Unit can be connected for cost-effective analogue and digital inputs from pressure, temperature, movement, sound, light, imaging, weight sensors, etc. (not supplied) to sensing switch and relay states. It can then process the input data and use the information to control up to 11 physical devices such as motors, sirens, other relays, servo motors & two-stroker motors.

FEATURES

- 8 digital inputs: Open collector, 500mA, 33V max.
- 16 Digital Inputs: 20mA max. Protection 1K in series, 5V supply to ground.
- 11 Analogue Outputs: 0.5V, 10 bit (0-1Vpp)
- 1 Analogue Output: 0.25V or 0-1V, 8 bit (0-1Vpp)

All components supplied including a plastic case (140mm x 110mm x 35mm) with pre-punched and silk screened header panel to give a professional and attractive finish (see photo). Windows drivers supplied. Software utilities & programming examples supplied.

Enhanced 'PICAL' ISP PIC Programmer

Kit will program virtually ALL 8 to 40 pin parallel and serial port PIC microcontrollers, in parallel to any PIC parallel port. Supplied with fully functional pre-registered PICAL, DOS and WINDOWS AVR Software packages, all components and high quality DSPTH board. Also programs certain ATMEL AVR, XSCBIXX and EEPROPM 24c devices. New devices can be added to the software as they are released. Blank chip auto detect feature for super-fast bulk programming. Hardware now supports ISP programming. A 40 pin wide ZIF socket is required to program 0.3 devices (Order Code AZIF40 £15.03)

Advanced 32-bit Schematic Capture and Simulation Visual Design Studio

ABC Mini 'Hotchip' Board

Cost is the best learning about microcontrollers! Need to do something more than flash a LED or sound buzzer? The ABC Mini 'Hotchip' Board is based on ATMEL's AVR 8535 RISC microcontroller and will interest both the beginner and expert alike. Beginners will find that they can write and test a simple program, using the ABC Mini program language, within an hour or two of connecting it up. Experts will like the power and flexibility of the ATM microcontroller, as well as the ease with which the little Hot Chip board can be "designed-in" to a project. The ABC Mini Board 'Starters Pack' includes just about everything you need to get up and experimenting right away. On the hardware side, there's a pre-assembled micro controller PC board with both parallel and serial cables for connection to your PC. Windows software includes a full Assembler, BASIC, and System program. The pre-assembled boards only are also available separately.
**CIRCUIT IDEAS**

**Tester in a key fob**

I designed this tester to be something that would take up little space, but would allow many vehicle electrical faults to be found. This simple circuit is for a key fob.

High resistance in the voltmeter is caused by the fob itself, so the unit must be used briefly to check that a significant resistance is not offered. The lead will rise to 6V, so don't hold the button down for more than a few seconds or the whole unit will melt.

The transistor has a high gain type as the push buttons have little current capacity.

<table>
<thead>
<tr>
<th>Battery to suit key fob</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2v</td>
</tr>
<tr>
<td>2k2</td>
</tr>
<tr>
<td>22Ω</td>
</tr>
<tr>
<td>Wire wound</td>
</tr>
<tr>
<td>Probe</td>
</tr>
<tr>
<td>Earth clip</td>
</tr>
<tr>
<td>1k</td>
</tr>
<tr>
<td>Continuity</td>
</tr>
<tr>
<td>1k4001</td>
</tr>
<tr>
<td>1k4001</td>
</tr>
<tr>
<td>Earth clip</td>
</tr>
<tr>
<td>1k4001</td>
</tr>
<tr>
<td>Key fob</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

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 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 the tube and probe scales are not accurate. Model makers' shapes suit this brain 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.

---

**£50 winner**

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**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 a voltage source \( V \), capacitance \( C \) and the resistance \( R \).

Values for \( V \), \( C \) and \( R \) can be calculated using:

\[
V = \frac{Ea}{2}
\]

\[
C = \frac{55h}{2}\sqrt{\frac{\ln\frac{1.135}{d}}}{d}
\]

\[
R = \frac{1600\sqrt{\frac{\lambda}{\lambda}}}{V}
\]

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 \( \lambda \) is the wavelength, also in metres. The formulae are true when the antenna is placed above a conductive surface and \( h<0.1 \lambda \).

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 resistive \( R \) is very small and the Q-factor of the quartz crystal is very large.

I simulated the circuit using PSPICE. It was assumed that \( E=40\text{mV}, h=0.4\text{m}, d=0.002\text{m}, \) and \( h=0.3\text{m} \) i.e. the signal frequency is equal to 1MHz. In this case, \( e=90\text{mV}, C=1.35\text{pF}, R=175\times10^{0}\text{Q}. \) These values were calculated by means of the formulae.

A Q2P16BMGB quartz crystal was applied. The PSPICE simulation has shown that the output voltage of the circuit is equal to 1.13V 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 applications in single-frequency receivers of remote control systems. The input resistance of those receivers must be very large to avoid shorting the quartz crystal. Such input resistance can be ensured by field-effect transistors.

S. Chekhov
Tiraspol
Moldova
G56

---

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UK
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 IC1 is working as a non-inverting follower. Audio amplifier gain can be increased by increasing the value of R2.

Signal input from the microphone feeds this preamplifier. The amplified signal is filtered and rectified by diodes D2 to produce a DC voltage over R3. Resistor R3 can be adjusted to the desired audio level, to activate the relay. This control is set to suit the operator's voice. Transistor T2 forms the delay control and DC amplifier. It can be substituted with a BD139 or SL100. Potentiometer R4 determines the time between transmitter and receiver switching. Diode D4 protects the TR1 during relay operation. Resistor R5 controls the balance between the microphone input and receiver input. Resistor R8 sets the level for operating the relay. Diodes D6, D7 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 BD1016A 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 BD1016As can be connected in series.

Switch S1 is in the recording/playback switch, while S2 which must always be on while recording resets the recorder. Switch S3 is an on/off switch for recording and playback. It must also be on while recording.

Components

Resistors:

R1 1k
R2 100k
R3 220k
R4 20k
R5 4.7k
R6 22k
R7 10k
R8 2.7k
R9,11 4.7k
R12 10k
R13 220
R14 2.2k
R15 470k

Capacitors:

C1 0.1µF
C2 0.1µF
C3 1µF
C4 10µF
C5 10µF/16V
C6 1µF/16V
C7 4.7µF/16V
C8 22µF/16V
C9 220nF
C10 1µF
C11 100nF
C12 100nF
C13 22µF/16V

Semiconductors:

IC1 LM741
IC2 BD1016A
TR1 2N2222
TR2 BC557
D1 IN414
D2 IN4007
D3 OA79

Miscellaneous:

Condenser microphone
SPST relay
Switch 1, 2, 3 - push to make switches
Speaker: 8Ω, 500mW
PCB, shielded wires and ferrite beads

Electronic WORLD June 2002

Minimal loudspeakers

This idea is more electro-acoustic than electronic, but nevertheless gains 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 this little car, the simple baffle type can yield more than satisfactory results - especially if the left and right speakers are set in 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 hardboard, 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 frame, 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 heavy or muffled with acoustic welding, 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 Fostex 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 coax 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 Fostrell 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
CS9

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WEAPON PRODUCTS
Please quote Electronics World when seeking further information.

JFET amplifier with 1.6GHz 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 converters (ADC) signals at high gains, said the company. The OPA657 also features 4.8V/V/ps input voltage noise, 5Vp input bias current and 700V/ps 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 22GHz, extending the performance range for optical networking, photodiode detection and ADC buffering applications. Other features include 7VpV/ps input voltage noise and 290V/ps slew rate. The OPA657 and OPA656 operate from 5V to 12V supplies and offer 4.5V/°C input offset drift (max) and ±70mA output current.
Texas Instruments
Tel: 0504 8161 80231
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: 0301 472 270 209
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 for zener diodes and transport voltage-sensitive devices (TVS) diodes in protecting sensitive components from incoming transients and overvoltages and electrostatic charges (ESD).
Epcos
Tel: 0870 550 5000
www.epcos.com

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 lead 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 SOIC packages. Further space-saving is achieved when soldering the device directly onto the PCB. A feature called Eiapodol 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 flexform packages with a common pitch size of 0.65mm. The initial product offering will include four OTP devices (PIC16C62B, PIC16C53A, PIC16C72A and PIC16C73B) and two flash devices (PIC16F73 and PIC16F76). Additionally devices ranging from 8-bit to 40-bit packages are also planned for 2002. There are also development tools to support the MLF device. The MPLAB In-Circuit Emulator (ICE2000) is a full-fledged emulator system. The MPLAB Integrated Development Environment (IDE) tool allows users to write, debug and optimize the PICmicro microcontroller applications for firmware product design.
Microchip Technology
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www.microchip.com

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June 2002 ELECTRONICS WORLD

June 2002 ELECTRONICS WORLD

Moist cut on resistance in cars
International Rectifier’s latest 2SY HEXFET power Mosfet offer up to 10 per cent lower on-resistance, or RDSon, over previous devices. The IRF5512/8, IRF5508S and IRF5308L for 42V automotive systems are available in the T0-220, D2PAK and TO-262 package. In addition, the Mosfet are rated for repetitive avalanche up to 175V. 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
removal of heat generated from the device more effectively, said the company. With the emergence of 42V automotive electrical systems, automotive designers need 75% -rated power semiconductor devices.

**NEWPRODUCTS**

**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 1.8V 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 core 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 is full rate ADSL is 575mW for non-overlapped applications (19.4dBm line power) and 624mW for overlapped applications (20dB line power). It is optimised for driving a 1:1:2 transformer, however, so 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).

**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 Sony 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 Sony and others. They are designed for audio playback of Dolby 5.1 plus L/R stereo mix downs, 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 multibit sigma- delta architecture. The ADCs and DACs offer sampling frequencies between 42kHz and 96kHz and are designed to run at different sampling rates. Both the WM8770 and the WM8771F are available now in a 14-pin TQFP Evaluation boards and complete reference design documentation are also available.

**Super audio CD chip set for DVDs**

Philips Electronics is offering a Super Audio CD (SACD) chip designed for DVD video players. SACD uses a sampling frequency of 2.8MHz, 64 times higher than that of CD to deliver higher quality sound. The SA7893 can support different DVD platforms with 6-channel SACD and DVD playback.

**Power controller with adjustable 12V outputs**

Philips Semiconductors’ latest CMOS power amplifier, the FAN3021, produces up to 1W of continuous output power (1.2W) 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 maximising quiescent supply current. The low power device also has a shutdown input to reduce consumption of 0.15mA. Total size of the amplifier is 0.26 mm² and the supply current is 65mA. 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 booster capacitor, or a snubber network. Other features include thermal shutdown protection, unity gain stability, and external gain configuration capability.

**Switch-mode power supply with its own diagnostics**

The latest switch-mode power supply from Bulgin Power Source incorporates remote diagnostic technology into the power supply, while also allowing remote adjustment of parameters such as battery charger current, battery state and undervoltage lockout operating points, as well as interrogating the unit for real-time operating conditions, including PSU terminal voltages, battery life, elapsed charging time and battery energy level. Output voltage range is 90 to 260V at 45 to 65Hz.

**_constraint_message**
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 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 even enter saturation point, so optimising the efficiency achieved.

WSI
Tel: 0117 9666000
www.wsi.com

Fixed-value optical attenuator
Honda Connectors is extending its MU range of optical connect-
ers with a range of fixed-value attenuators. Pitting between a standard MU-type plug and adapter, the LGA-S600 series is available in ten 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. The 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 1510-1530nm range. Return loss is 40dB or more at 1310nm.
Honda Connectors
Tel: 01782 525252
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
Teltronix 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 base stations. It provides antenna performance tests such as return loss, cable loss, and voltage standing wave ratio (VSWR).
Teltronix
Tel: 01344 382000
www.teltronix.co.uk

Boundary scan on Fast Ethernet LAN
Gorel 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 flowing licence feature allows test and ISP programming, debugging and execution to be controlled from any Windows® workstation on the network. The intention is to allow engineers to remotely test and diagnose boundary scan operations from their desktop. The controller includes a 32-bit CPU 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 handshaking bus for external synchronisation of scan operations and two independent test access ports with 100 levels which are programmable from 1.8V to 3.3V.
Gorel Electronic
Tel: 01420 82122
www.gorelelectronic.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 TX9492 RISC chip uses the firm's 200MHz MIPS-based, 1.5V TX9842 core and delivers 250Mips performance. Supplied in a 256-pin PBGA package, the processor peripherals include a dual-slot PCM-CIA interface, a PCI controller, and an AC-link controller for AC97 audio/modem codes. A direct memory access (DMA) controller, two UART chan-

nels, a serial peripheral interface (SPI), 32 general-purpose I/O ports, an interrupt con-
troller, 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 memo-

ry include an SDRAM/SyncFlash controller, an external bus controller and a NAND flash controller.
Toshiba
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Bluetooth software for non-Window applications

Cambridge Silicon Radio is offering Bluetooth software allowing programmers to embed the protocol into a range of devices running on Windows-based operating systems, such as mobile phones or PDAs. BCBS is the first software to run on the Bluetooth stack (L2CAP, RFCOMM and SDP) on the BlueCore hardware, leaving only the Bluetooth profiles to run on the host system. The following profiles are supported: Audio Gateway (AQ) profile, Dial up networking (DUN) profile and Object Push (OPP) profile. The software is also available bundled with CSR’s BlueCore single-chip, hardware reference designs and sample applications. Cambridge Silicon Radio Tel: 01223 692 669 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 by 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 LTC4 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 are available with the LBM2U3A82 and LBM2U3AB3, each with USB, UART and RS232 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 1.5, BL, DPM 2.5, BL and DPM 3.5, BL, are all available immediately with prices starting at £20.95 for low volumes and £17.54 for OEM quantities (250+)

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June 2002 ELECTRONICS WORLD
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 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 HP504A or maybe HP505A 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 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*

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 suffer, 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 than 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, is 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 intended 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 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 acquired 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 amplifier provides a succession of capacitance 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 combinations of a differentiator and an integrator results in a constant unity gain system, from 0Hz (DC) up to a frequency somewhere 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 fast-slow 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, 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 slice triggering the control bistable again for the next 10us.

When the hold-off gate reopens, the control bistable can again be triggered, initiating another fast ramp. However, this time, the input is such that 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 nifty griddle

While prone, explaining the 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 required to produce 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 Tr3 is normally off. Its collector voltage rises via R6 and R8, aiming at +70V, charging the capacitance of the open circuit coaxial cable L1 in the process.

However, the collector voltage never reaches +70V, being caught via a diode at a voltage VD2. This clamp is set at typically about +28V, depending on the particular BFR91
The circuit diagram shows the feedback loop that is used to maintain the desired output voltage. The feedback loop consists of a gain stage followed by a summing stage. The output of the summing stage is fed back to the input of the gain stage, creating a negative feedback loop. The gain stage is designed to amplify the input signal, while the summing stage adds the feedback signal to the output of the gain stage. This allows the circuit to maintain a constant output voltage even when the input voltage changes.

The trigger slicer circuit is used to generate the trigger signal. The trigger signal is used to trigger the gate of the power MOSFET when the input voltage exceeds a certain threshold. The trigger signal is generated by comparing the input voltage with a reference voltage. When the input voltage exceeds the reference voltage, the trigger signal is generated and used to trigger the gate of the power MOSFET.

The trigger slicer circuit is shown in Figure 9. The circuit consists of a comparator, a trigger circuit, and a power MOSFET. The comparator compares the input voltage with the reference voltage and generates the trigger signal. The trigger circuit is used to generate the trigger signal and the power MOSFET is used to switch the output voltage.

The trigger signal is used to trigger the gate of the power MOSFET. The power MOSFET is a high-speed switch that is used to control the output voltage. The power MOSFET is connected in a complementary arrangement with the input and output of the circuit. The trigger signal is used to turn on the power MOSFET when the input voltage exceeds the reference voltage. The power MOSFET is turned off when the input voltage drops below the reference voltage.

The trigger slicer circuit is designed to have a fast switching time and a low turn-off time. The fast switching time allows the circuit to respond quickly to changes in the input voltage. The low turn-off time ensures that the output voltage remains constant when the input voltage changes. The trigger slicer circuit is used in a variety of applications, including power supplies, inverters, and switching regulators.

The trigger slicer circuit is designed to be robust and reliable. The circuit is designed to operate over a wide range of input voltages and frequencies. The trigger slicer circuit is designed to be easy to implement and is compatible with a variety of power MOSFETs. The trigger slicer circuit is a key component in many high-speed switching power supplies.
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 IC5 generates an asymmetrical squarewave.

During the brief period when IC5 pin 6 is high, the JFET Tr3 is on and shorts out C24, resetting the ramp. During the longer period when IC5 pin 6 is low, Tr3 is off and the Howland current pump arrangement of IC6 produces a ramp, which is positive going from ground.

The two following op-amp sections are a simple biquadratic 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 R22 could be incorporated to fulfill this function. Output R provides the slow ramp to the ramp comparator, R5 providing adjustment to set the ramp excursion to +5V maximum.

Figure 9 shows the remainder of the trigger-slicing department. The slow ramp from Fig. 8 is applied at R6 direct to pin 2 of the ramp comparator IC3, another MAX 913. The fast ramp is applied to pin 3 via the buffer stage Tr4. Due to D3, the fast ramp at pin 3 always starts from below OV, thus ensuring that it always crosses the slow ramp level.

A small amount of hysteresis is again applied, via R26. When the fast ramp overtakes the slow ramp, point P, pin 12 of IC3, goes high, triggering the avalanche pulse generator Tr5 and applying a sampling pulse to Gate 1. At the same time, pin 10 of IC3 goes low, resetting the control bistable, triggering the hold-off monostable device at pin 1 of IC1 and sending pin 8 of IC2 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 OV, clamped by D3, and pin 12 of IC3 returns to OV.

After a delay of some 250µs, set by R40 and C19, pin 8 of IC3 goes low, triggering the Gate 2 control monostable device at pin 9 of the 74HC221, IC7. This output a pulse at

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, VCCOMP, +15V, +5V and -15V.

Both MAX913 comparators also require -5V, and this was produced locally by a 7805, on the trigger-slicing 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 100MHz multi-modulus prescaler ICs in stock, but these are not very suitable, as the minimum sine-wave input frequency for correct operation is 200MHz.

The device will operate down to 30µHz provided the input slew rate is faster than 100µV/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 4 - 64 prescaler would permit operation down to 6.5MHz 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!

Implementation considerations

When dealing with very high frequencies, the mechanical

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

- Heat sinks fitted

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 cur- ried out on a ground plane, Fig. 11. The square flange of a 752 BNC panel mounting socket was soldered to the edge of a fly by 6cm piece of 38BP copper clad board (ground plane A), and strengthened with a couple of triangular tin plate gussets, as shown.

Two of the diodes and resistors R4 and R5 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 R1 was mounted on the connector's centre conductor, pointing upwards and projecting through another hole in ground plane B, where IC5 was mounted. Ground-plane A was subsequently attached with earth straps to a larger piece of copperclad, 32cm by 21cm (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 low frequencies where handling them is no great problem. So the sample feedback loop of Fig. 4 was con- structed on 0.1in matrix copper-strap board. All ICs were socketed for convenience should changes be necessary. In fact, such a change was necessary; originally IC4 was a TL084, but the response of this proved too slow, so it was changed to the faster TL082A as shown.

Construction is best done in stages, starting with the power supplies, Figs. 10 and 11, 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 10% rise time.

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 x2 and x5 time constants, intermediate between the ranges provided by S1. Reducing the amplitude of the slow ramp will have the effect of increasing the effective 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. Testing the length of the pulse from the flip-flop of Fig. 7 to the maximum, the avalanche transistor pulse generator T1 should free run. The output signal will be too fast for most oscilloscopes to display, Fig. 12 shows what it looks like on my Tektronix 275A, with its rated bandwidth of 250MHz—1ms rise time, on a good day, bearing in mind its output. In theory, the pulse is rectangular in shape, but due to the rise time of a few nsec it can't 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 R4 and R5 in Fig. 3, towards minus V, is too easily seen. This is evidence that the avalanche pulse gen- erator is working.

With the 250ns trigger pulse and 750ns Gate 2 pulse turned off, Vavol should be reduced until the avalanche pulses just cease. The result will be that the output of IC5 wavers off one supply rail or the other, as IC5 integrates its own input offset.

With the 250ns and 750ns 100kHz pulses applied, the output of IC5 should sit at or very near 0V, this being the poten- tial at point A, with no external applied input at the 752 BNC socket, assuming a suitable setting of R8. Adjust this initially so that the back-off potential between CC and DD is 3V. When a plus minus 1V potential is applied to the input, the potential at IC5 output should follow the input. If the sample feedback loop gain set by R8 is too small, the loop will oscillate, and R8 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 behaviour to be tested.

A 1Vp-p 50kHz squarewave should also be applied to the BNC input socket, and should result in a 50kHz squarewave at pin 7 of trigger shaper IC6. A value for R3 is then chosen that keeps the trigger shaper return to the smallest possible amplitude of the 50kHz squarewave.

The whole timebase operation should now be working, but in view of the highly interconnected nature of these stages, some trouble-shooting may necessary, unless your construtional skills are infallible! With R5, set for the slow- est fastest ramp rate, the fast ramp should be visible at the emitter of T4, 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 Figs. 3 and 4. A 1Vp-p 5MHz squarewave connected to the BNC socket should now be reproduced on the screens of the oscilloscopes.

For best rise time without overflow, R1 and R2 need adjust- ment. Note that the setting of VClamp, R9 and R5 all inter- act, and some iteration will certainly be necessary to optimize 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 clean it up.

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e-mail I lowe@cumulusmedia.co.uk using subject heading 'Letters'.

Star point
Mr Danley 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 path rather than sharing 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 bus in parallel circuits: Hum from heaters has absolutely nothing to do with 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 the loop-return path. Loop elimination, however, is very important in order to ensure freedom from magnetically-induced disturbances. Because loop impedances may be very low - a few millihenries, 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, and do suffer damage due to huge earth-loop currents.

The explanations in the latter part of Mr Danley'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 false to condemn star-point earthing emotionally and groundlessly. In the right place, it is the preferred technique, and in any other technique, if it is used in the wrong place, it is not good news.

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

Making your own PCBs

Several letters have asserted that making PCBs is a good idea. For the other half of the project, I have knocked together the basics of a scopeFFT 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 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 USB 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 timescale.
- A Trigger on either positive or negative slope on CA, CB or AB.
- Two markers in the time domain that give time and measurements for the flagged channel.
- Frequency display based on the markers.
- Sliding DC offset so that the channels can be separated.
- Single selectable FFT channel on either CA, CB or AB.
- A left mouse button click on the FFT trace will auto locate the largest area within a 100dB amplitude.
- 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 mcscope.exe. If you are concerned about removing it then delete the files and the reg key HKEY_CURRENT_USER\Software\McScope.

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 fow@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/mcscope

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 Bath. The circuit diagram shows two d.o.d. circles, one in series with each solar panel, not just one in series with the battery. The voltage on these 'panels' were different, e.g. if the sun was shining on one and not on the other, they may try to charge each other.

Catherine
Type & Wear

Free USB scope software
Before reading the February and March issues, I had put off experimenting with USB due mainly to the need 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 and software published in March requires either absolutely no data drops 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. Others, if, as 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

scopeFFT 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 personal, non-profit making interest.

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Gang your own pots

The idea for ganging your own potentiometers in the May issue reminds me of one way power is transferred to the drive train of stream- locomotives. The wheels on both sides are connected with linking members, whose joins on the wheels are linked by 90° to each other. A similar arrangement had been
used in the fifties on the NSU-MAX motorcycles, and the camshaft was not driven by chain or gears, but with two link rods which were driven mechanically 90° out of phase.

Loth Kutsch, DL4FUC
Via e-mail

John Woodgate pointed out that there was an error in the description of the posthorn gonging scheme. There was a section that read, "Songs A and C are identical. They're about six notes or pitches. Song D 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 Podardy Homopolar Generator.

In the article I was careful in the wording of a possible "free energy" device. My experiments were quite loose and it was not using an electrolytic capacitor although some doubts were expressed.

My relationship to the late DePalma's work was mentioned because we were some 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.

McKinney's suggestion relating to the rotating magnetism is the right example: you see the wire connected to the voltage source and past the wire and then you think that the voltage is induced in that wire. So screen that wire or wire with galvanometers, electrical, with coaxial cable, or a combination of both and you can assure you that there is still measuring the same voltage.

This brings us to Mr. Ghislainze'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, routing 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 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 an AC machine.

The experiment relating to Mr. Ghislainze's second comment was carried out on 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.

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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 an AC machine.

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