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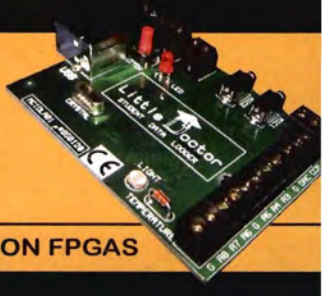

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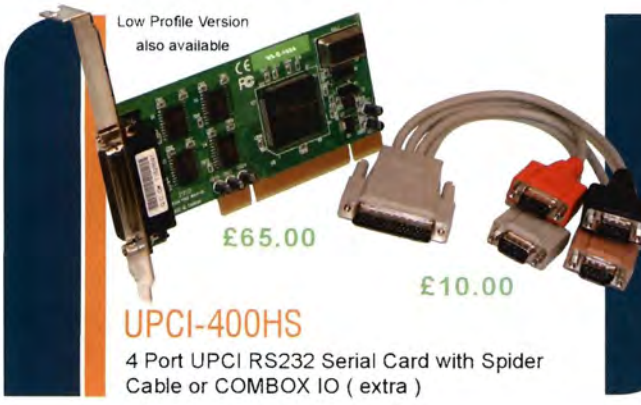

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Getting the Hotspot climate right

Around 8% of WiFi (IEEE 802.11) hotspots worldwide are free. This figure is as high as 17% in the US. Apart from some free municipal WiFi hotspots, most of the free WiFi access points are 'organic', i.e. they have been provided by local coffee and book shops, restaurants, airports and hotels, and not the traditional comms operators.

There's evidence that when a coffee shop offers a free WiFi hotspot, revenues per user increase on average €5; whilst in hotels, free WiFi service seems to increase room bookings.

At present, WiFi hotspots are normally accessed with laptops and some PDAs. But this will change soon to engulf all portable electronic devices – digital still cameras, handheld game consoles and mobile phones; projections have it that by 2009 nearly 85% of all new mobile phones will be WiFi-enabled.

However, as anybody who has tried to access a WiFi hotspot at an airport will tell you, it's not always an easy thing to do. Normally, there is more than one WiFi network in the vicinity, but if you are unlucky you may connect to none. If however you manage to attach to one (there's a limit to the number of devices that can connect to a hotspot), it's more likely than not that you'll need to register or have a password and username ready. If they are not free, then you'll have to provide payment details too. And if you have to do this with your Gameboy or mobile phone each time you come across a WiFi network, well, nobody is likely to spare the time or the effort.

In itself, the process is a nuisance. All users want as easy a connection to the Internet as with their PCs.

Having WiFi networks accessed for free would help, but whoever is keeping that network alive will need to get paid for it one way or another. Coffee shops may sell more coffees, and hotels may book more rooms but is this enough? One solution is to tie the WiFi roaming experience to the mobile phone account (the SIM), or, potentially, it could be offered to 'communities', such as Skype users, or football club fans that may have paid for the service beforehand.

Either way, WiFi is getting well established. It has not been around for long, but it is showing signs that it is here to stay. So, the most important aspect of WiFi would be for the users to have a good and uniform experience – easy and seamless. If this is the case, they may not even mind paying a little something for it.

Svetlana Josifovska
Editor

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Video targeted with Fairchild's new op-amps

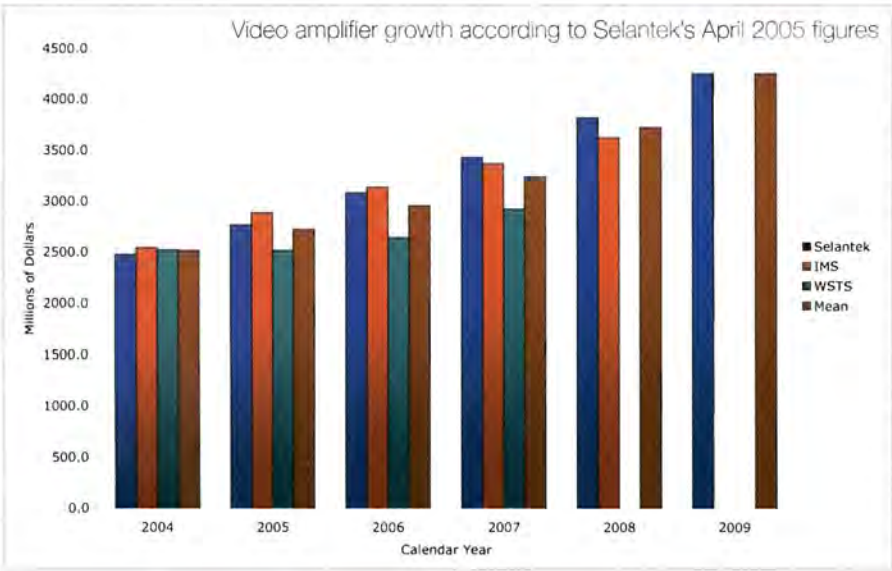
Video is the new buzzword among the ranks of IC suppliers and Fairchild Semiconductor is one of the latest such companies to announce a new generation of operational amplifiers aimed at the video market.

"[Unit sales of] Set-top boxes are ramping up; [sales of] LCD and plasma screens are increasing – I don't see any of these [curves] flattening at least until 2010 and we are focusing on picking up [such] new designs," said David Fry, market development manager for consumer systems at Fairchild Semiconductor. "The [high] volumes are in consumer electronics now, just like they used to be in telecoms, PCs and mobile communications. These [consumer applications] are the first markets we will be focusing on with our [new] video amplifiers."

The amplifier market is growing at a steady CAGR of 9% and of that the video amplifier market is rising at an average of 12% CAGR, expected to reach nearly £700m in 2009, according to market research figures from Selantek.

Fairchild wants the lion's share of this segment and has resorted to developing a new semiconductor process for high-speed analogue devices such as video amplifiers, drivers, multiplexers and cross-point switches. The process is 6th generation BiCMOS, where vertical NPN and PNP transistors have a matched fT of 8.5GHz for high speed. The process was developed at Fairchild's South Korean facility.

The new device family consists of single, dual and quad high-speed, 2.5V to 12V, rail-to-rail amplifiers – the FHP3130/3230/3430 – suitable for standard definition television applications, and triple and quad voltage feedback amplifiers – the FHP3350/3450 – suitable for high-definition TV, even the 1080i/1080p standard. According to Fry, the devices' 0.07% differential gain and a 0.03-degree phase error improve video quality.



Mobile WiMax on track to reach users

The WiMax Forum, an industry-led, non-profit body set up to promote the adoption of interoperable broadband wireless standards, is on track in delivering all of the tasks on its roadmap for the IEEE 802.16e wireless standard.

The protocol was approved at the end of last year; silicon is sampling now; certification testing has already begun; and mobile operators are already planning commercial trials for the second quarter of next year, with the first networks expected to be deployed by the year-end.

"Some 150 members are preparing trials already and Korea is leading here. So far, the focus has been on the lower layers of the protocol – the MAC and PHY. But, we are going to work on the layers that'll allow seamless switch-over between different networks," said Dean S. K. Chang, chairman of the service providers' working group at the WiMax Forum and product management director at Aperto Networks.

The WiMax Forum currently counts 360 members, nearly eight times as many when it first started two years ago.

One of its objectives is to harmonise the frequency band in which the 802.16e protocol can operate seamlessly across the world. "If there are too many frequency bands, it'll be more difficult to bring the costs down of the WiMax [equipment] as OEMs will have to develop different front ends," said Chang. "The 3.5GHz is the most popular frequency band for WiMax. We are seeing other frequency bands too, but hopefully we can work on a homogeneous frequency band across the world."

The WiMax Forum believes that the "sweet spot" for users is having "personal broadband", which this standard will help deliver.

Chip companies fail to provide data on products

Chip companies are failing to provide full data for some of their earlier products due to cost savings, even though engineers cannot work without accurate information.

John Fielding, who runs the consultancy B&G Electronics in South Africa said that several big names in the industry are not supplying key data, which leaves him short in his designs. "Several manufacturers' data sheets are so lacking in detail; and the stuff they do contain is not much use to a design engineer," he said. "Among these are Philips, Infineon and Vishay."

For example, Fielding complained that Vishay's low-noise, dual-gate Mosfets for VHF and UHF applications came with data sheets that give inadequate data to use in computer simulation software.

Specifically, he said, while the data sheets claimed "excellent cross-modulation performance" there was no information on how the parameters were determined. "This is a fundamental requirement," he added.

But Rudolf Rupp, an applications engineer with Vishay, said the firm was not equipped to provide the data in the way and quantity some engineers wanted them in.

"Creating more data would create extra costs for us," he said. "We would have to do more testing. People can get these components cheaper elsewhere, so we decided not to create more data."

Reiner Schonrock, an Infineon spokesperson, defended his company's position too. "We think we can give all the necessary information to our customers." He added that Infineon had an international call centre that was capable of providing all the information customers needed.

Philips, on the other hand, only issued a prepared statement. It said: "Philips has expert technical support in place for customers on a worldwide basis. The technical support includes web-based product information and technical support, field application engineers, technical sales engineers and product application engineers. These resources are located across the globe to provide timely support to the engineering design community."

Lack of data or data being given in the wrong format keeps infuriating many design engineers, but firms like Vishay say that it is all down to keeping their costs low, especially for the older products.

"If that is their attitude," said Fielding, "I suggest they give up this market and go onto something else. Their company is run by bean counters and not by engineers."

HC-SDMA enters Europe with iBurst

Personal Broadband Australia (PBBA), the owner and operator of iBurst, a wireless wide-area broadband service, is aiming to unleash its brainchild on a whole generation of new enterprise and commercial applications, including building sites, offices and the emergency services.

This high-speed, secure, mobile wireless access technology has been running in Australia since 2004. Some 18 months ago, it was also introduced to Belfast, Ireland, on a small scale basis, using only one base station. Now the service will be upgraded to offer data rates of 2Mbit/s (even to a device moving at speeds of up to 70mph), and the trial expanded.

"We've discovered all sorts of uses suitable for commercial and enterprise applications; police cars using mobile surveillance whilst on the move; engineers using it for communicating on buildings sites and other unusual uses that need secure communication inside and outside," said Jim Cooney, CEO of PBBA. "We haven't analysed what it may mean to the consumer yet."

There are several multiple access and duplexing techniques for delivering spectrum-efficient mobile services: Frequency Division (FDMA), Time Division (TDMA), Code Division (CDMA), Frequency and Time Division Duplex (FDD and TDD). iBurst combines TDMA and TDD, and adds Spatial Division signal processing to the mix to create a 'personal cell' for each user, who no longer has to 'hunt' for a hotspot as with WiFi.

"The coverage of the iBurst base station is greater [than in WiFi] and, at between $30 and $70, the cost to the operator is cheaper than WiFi, UMTS or EV-DO HSDPA," said Cooney. "iBurst generates the radio 'signature' of the user and not just their positioning. It distinguishes from the different 'echoes' it receives when a signal leaves a laptop and reflects off buildings and into the base station."

iBurst has been defined by ETSI as High Capacity - Spatial Division Multiple Access (HC-SDMA) with adaptive antenna systems. It is a development of earlier systems that have been available in the Asia-Pacific for several years but are unknown in Europe. The very latest versions are now in full commercial operation in Australia and South Africa and ventures are being planned in several other countries.

The first European iBurst base station is positioned at the Innovation Centre of the Northern Ireland Science Park in Belfast

Deployment of MEMS in mobile handsets reached $157m in 2005, with this figure exceeding $1bn by 2010, says high-tech research house In-Stat. In addition to the microphones and bulk acoustic resonators that have dominated the MEMS market to date, there are emerging opportunities for inertial sensors (principally accelerometers) and several types of RF components including band/mode switches, matching elements (such as digital varactors) and oscillators, says the firm.

* * *

Over 8,000 new cleanrooms will be built this year, says research organisation McIlvaine. The largest projects are found in the fast growing flat panel display industry, where some 300,000 ft^2 of such facilities are being built. The semiconductor industry also constructs large sized cleanrooms for chip production, where a Class 1 facility costs over $700/$ft^2$.

The US is still in lead with the number of active projects, but China is hot on its heals, likely to overtake the US soon, as it becomes a centre for disk drive manufacturing at the expense of Singapore, Thailand and Malaysia.

* * *

A report on fuel cells published by energy industry think-tank, Energy Business Reports, states that the global commercial fuel cell market will reach $2.5bn by 2009. Electric power generation is emerging as a large-scale commercial market for fuel cells and is expected to represent more than half of all demand in 2008. Aerospace and motor vehicle applications may lag somewhat in the near term, but are projected to grow rapidly between 2008 and 2013. The portable electronics market is expected to report the strongest advances over the next decade.

* * *

Manufacturing firms in the UK's South East struggle to recruit the right people, battle road congestion, cope with the cost of crime and face dramatically escalating energy prices to the point of looking overseas, says a survey conducted by EEF South. Nearly 30% of manufacturing businesses in the region have considered relocating overseas and many have started to actively recruit overseas for key positions.

"In many ways, manufacturing [in the South East] is reaching a crossroads," said David Seall, EEF South Chief Executive.

New array processors make a video debut

Array processors are making a comeback with several new devices being launched at present, aimed mainly at parallel applications such as video and wireless basestations.

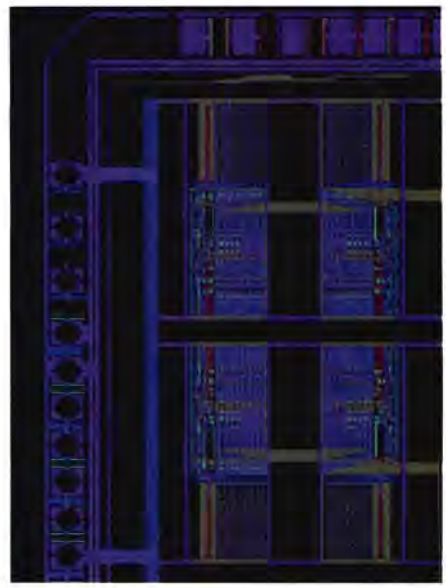
Element CXI has developed an array processor that can be programmed directly from algorithmic design tools such as SPW and The MathWorks. The company was formed last year by engineers from reconfigurable company Quicksilver. "We want a silicon substrate that is scalable like an FPGA but with a better price and power [consumption] than an FPGA," said Paul Master, CEO of Element CXI.

The architecture consists of a variety of functional blocks such as multipliers, arithmetic units and barrel shifters that can be combined into a cluster, with a state machine that connects to other clusters via a packet-based network-on-chip (NoC) approach. This allows clusters to be re-programmed on the fly to replace areas that fail. Although the design is three years behind other arrays, such as those from picoChip and Elixent that are more established in the market, the main difference is the use of a graphical tool such as SPW for programming.

The chip provides 5.7GOPS per cluster, performing a total of 205GOPS for a 36-cluster device.

Similarly, the developer of the Forth programming language, Charles Moore, has created his own array processor for digital video and wireless applications, along with a new variant for programming parallel systems called VentureForth. "I'm still very pleased with Forth; it's the nicest language for programming, even 30 years later," said Moore.

The chip, developed at California start-up Intellasys, is a 6 x 4 array of 18-bit (rather than 16-bit) processors that run Forth natively, each with a dual stack, local ROM and RAM that run asynchronously, depending on the output of the nearest neighbour. The nodes on the outside have I/O pads that can be programmed to be serial links or even to be a digital to analogue converter so that the chip can be connected directly to an antenna in a low cost, software-defined, radio design.



The Intellasys array processor runs Forth natively

A single chip can decode six channels of standard definition digital TV. It will start shipping by the year-end at $10 in volumes.

In Bucharest, Romania, Prof Gheorge Stefan, chief scientist of Connex Technology, has been developing an array processor for video processing, and in particular HDTV. The CA1024 has 1024 processing elements in an array, each with a 16-bit ALU with eight accumulator registers and 256 words of memory. "The market is a fast evolving domain and ASICs are not a good solution for this [digital TV] domain," he said.

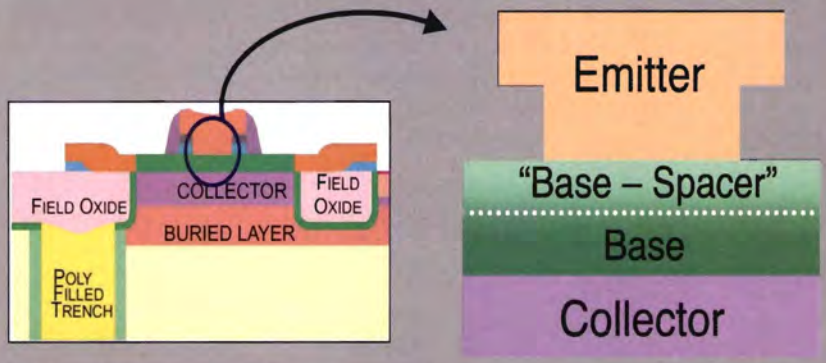
Running at 200MHz, the chip can perform 200GOPS, with internal bandwidth of 400Gbyte/s and external I/O of 3.2Gbyte/s. This means it can decode two channels of H.264 HDTV in real time, using four MIPS processor cores for the video pre- and post processing, audio processing, transport multiplexing and the system control. The company has developed its own extension of C for programming, called Connex Programming Language (CPL), for handling extra data structures such as scalar vectors. There is also an extension of CPL for handling the speculative execution of code on the array.

National Semiconductor strengthens its interface portfolio

National Semiconductor says it is in the second place in the world of interface product suppliers, after Texas Instruments (TI). Now, it aims to strip TI of its title as Number One with a strengthened emphasis on interface products.

Although interface is a very broad field, with up to 40 different segments fitting into the category, National has a firm strategy in place of how to become Number One, consisting of customised semiconductor processes, carefully chosen applications and high-precision, low-power product families.

"We never talked [to journalists] about interface before and yet this is a $1.75bn market and some 15% of our business comes from this field," said Robert Hinke, European marketing director. "Year on year, this market grows at 16% – the fastest growing segment in the standard linear product group."



Patented 'Base Spacer' achieves maximum frequency with lowest power through balancing capacitance and base depth

According to National's executives, the growth in this sector is driven by five factors: digital television content, wireless broadband, the distribution of video, enhanced healthcare and homeland security.

To deliver a family of high-speed buffers and multiplexers for such applications, National has updated a bipolar CMOS (BiCMOS) process, using silicon germanium and called it BiCMOS8. It is a 0.25µm process, tweaked for low power yet high frequency performance. The company used boron, germanium and carbon dopants in the base of the bipolar transistor to create additional capacitance for maximum frequency performance.

The first devices fabricated in this process are multi-gigabit, four-channel buffers (DS42BR400 and DS25BR400) and multi-gigabit, dual multiplexers (DS42MB200 and DS25MB200). Each input buffer has been given its own input equaliser for signal conditioning. The firm says this compensates for up to 5dB transmission loss and it results in a low output jitter at 25ps. Deterministic jitter is further reduced with an adjustable de-emphasis at the outputs. With such conditioning, the signals can travel up cables of 15m.

Power consumption is 140mW per channel, one of the industry's lowest, even though supported data rates reach 4.25Gbit/s.

TSMC has unveiled an extensive 65nm Design-for-Manufacture (DFM) Compliance Design Support Ecosystem driven by a manufacturing-based unified data format. The tool will channel DFM capabilities through selected EDA tools directly to designers' workstations.

The unified format aligns tools such as Lithography Process Check (LPC), Chemical Mechanical Polishing (CMP) Analysis and Critical Area Analysis (CAA) to TSMC's manufacturing data format. This allows designers to use the same DFM data file irrespective of the tool or vendor. It also enables simplified use, management and updates to DFM analyses using these tools.

* * *

Fujitsu is developing a bio-based polymer with good heat resistance, pliability and high impact resistance. It has demonstrated its technology in a prototype mobile phone chassis.

The firm worked in collaboration with Toray Industries, and last year it introduced the world's first notebook PC with chassis made of a corn-based bio-based polymer.

More commercial outlets are turning to bio-based polymers as an alternative to conventional plastics made from petroleum; bio-based polymers have a lower environmental burden.

* * *

NEC has managed to install computer graphics (CG) agents into various electronic devices, facilitating interaction between robots and CG agents. The new enables users to talk to their robots at home and then hand the robot's memory over to a corresponding CG character in a car navigation system, on a PDA or laptop when the user leaves home. In the future, users will be able to empower agents, which understand each user's preferences and interests, to operate their devices.

NEC demonstrated its new technology in the PaPeRo CG, a new virtual "friend" (below).

Toshiba in a tools deal but leaving out the processor

UK-based configurable core vendor ARC has licensed its front-end Arcitect tool minus the processor technology to Toshiba.

Arcitect will be used to configure Toshiba's MeP processor typically used for digital TV, audio and mobile phone applications. So far, the MeP has been used in-house and for ASIC customers, but Toshiba sees the Arcitect deal bringing in more customers for MeP, especially from the embedded market where volumes of billion units are the norm.

Interestingly, Toshiba already has configurable technology in its MeP portfolio. Three years ago it licensed the D-fabrix technology from Bristol-based firm Elixent and invested in the company. Now, the Arcitect acquisition puts the Elixent deal in doubt. In 2005 Toshiba made a prototype chip called the ET1. It incorporated D-Fabrix and MeP and it was demonstrated to customers. However, the chip is still under evaluation.

"We are still evaluating D-fabrix," said Yutaka Murao, general manager of telecom and custom LSI at Toshiba. "Specific commercialisation plan is not yet decided."

TOP 10 TIPS GUARDING INTELLECTUAL PROPERTY

ⓘ Steps for the designer:

- Don't be complacent. Utilise the most secure programmable logic technology available to minimise potential attacks at the physical level. Of all commercially available technologies, volatile SRAM-based FPGA technologies are the least secure. Non-volatile FPGAs offer the most secure solution.
- If your design uses dedicated inputs and outputs, make sure that you have guarded against simple I/O scan attacks. Such attacks attempt to reverse-engineer a design by cycling through a large number of possible inputs and then monitoring the outputs to determine the internal logic functions.
- Employ procedures to implement and track IP and programming changes to limit exposure of your designs in the manufacturing channel. Whenever possible limit third party access to critical design information.
- Consider adding digital "watermarks"/"fingerprints" to your design. These are unique features or attributes of the design that can later be used to prove that a design claimed by a competitor to be "independently" developed is really a copy.
- If outsourcing production, take steps to ensure that additional units are not produced without your knowledge. Overbuilding is among the most common forms of design theft.
- Use trusted silicon vendors to implement the design. Such devices programmed in a secure environment protect customers' proprietary IP.

ⓘ Steps for management:

- Establish a security policy that defines corporate security goals, this is a critical first step. Make sure that all employees understand the need for security and the company's commitment to vigorously defend its intellectual property rights. Make security part of your corporate quality goals.
- Take steps at the designer level to ensure designs do not leave with an employee but remain company property.
- With the rise of broadband connectivity, more design work can now be done remotely. If employees are working remotely, ensure all design work is done using a secure centrally-accessed server that also serves as a depository for any relevant EDA tools.
- As a last resort, don't be afraid to use the legal system to pursue those who are infringing on your intellectual property.

This month's Top Ten Tips were supplied by Martin Mason, director of silicon product marketing at Actel (www.actel.com).
If you want to send us your top five or ten tips on any engineering and design subject, please write to the Editor at EWeditor@nexusmedia.com

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E&OE

Ideas stimulate innovation

Innovation is key to progress and a solid economy, says ARM founder, **Sir Robin Saxby**

The DTI defines innovation as the successful exploitation of new ideas. It often involves new technologies or the application of new technologies, but not always.

Many of the most successful business leaps have employed existing technology in innovative ways. Examples include the move to digital mobile phones away from analogue, which gained momentum in the mid 90s. The innovation was to create the international standard GSM that enabled global communication on portable devices. The Apple iPod, which uses standard MP3 and system chip technology in the hardware, benefited from the introduction of iTunes that provided connection to the Internet for getting album track information and purchasing music on line.

ARM microprocessors use conventional chip technology with good design but the most significant innovation was the open licensing business model, which allowed a small start-up from Cambridge, UK, to become the global standard for embedded microprocessors in system chips.

A poster I recently saw on a building in Shanghai said: "Innovation is the soul for national progress", so it would be unwise to suggest that the UK is the only economy focused on innovation.

In the last century the world has been transformed by profound innovation and technological deployment in all areas including transport, communication, space exploration and energy. But it is during the next couple of decades, with better understanding of biotechnology, that we are likely to see even more exciting developments, especially in the areas of drug delivery, curing the sick, body implants, bionic eyes and cures for brain related diseases, as well as being able to allow an ever aging population to live more healthy and active lives.

The world's biggest source of manufacturing capability today is China, and India has become the leader for global technology outsourcing of computer related services. We should also recognise that these economies are already innovating. For example, I've seen karaoke mobile phones and intelligent bus stops in China and low-cost PDAs for impoverished villages in India.

The UK has an excellent history of Nobel Prize winners and creative talent in design and media. However, it's clear that the UK's prosperity depends on its ability to become a global innovation leader. To do this, it is imperative that we foster a national culture of advancement by rewarding our innovators and entrepreneurs.

The talent is here. The recently released 2005 UK Innovation Survey from the DTI highlights the strong science, engineering and technology base and excellent research being undertaken here. The survey shows 57% of enterprises in the UK are active in developing or implementing innovation, an increase of 14% from 2001. According to the report, electrical and precision engineering are the most innovative industries with 85% of enterprises surveyed being 'innovative active'.

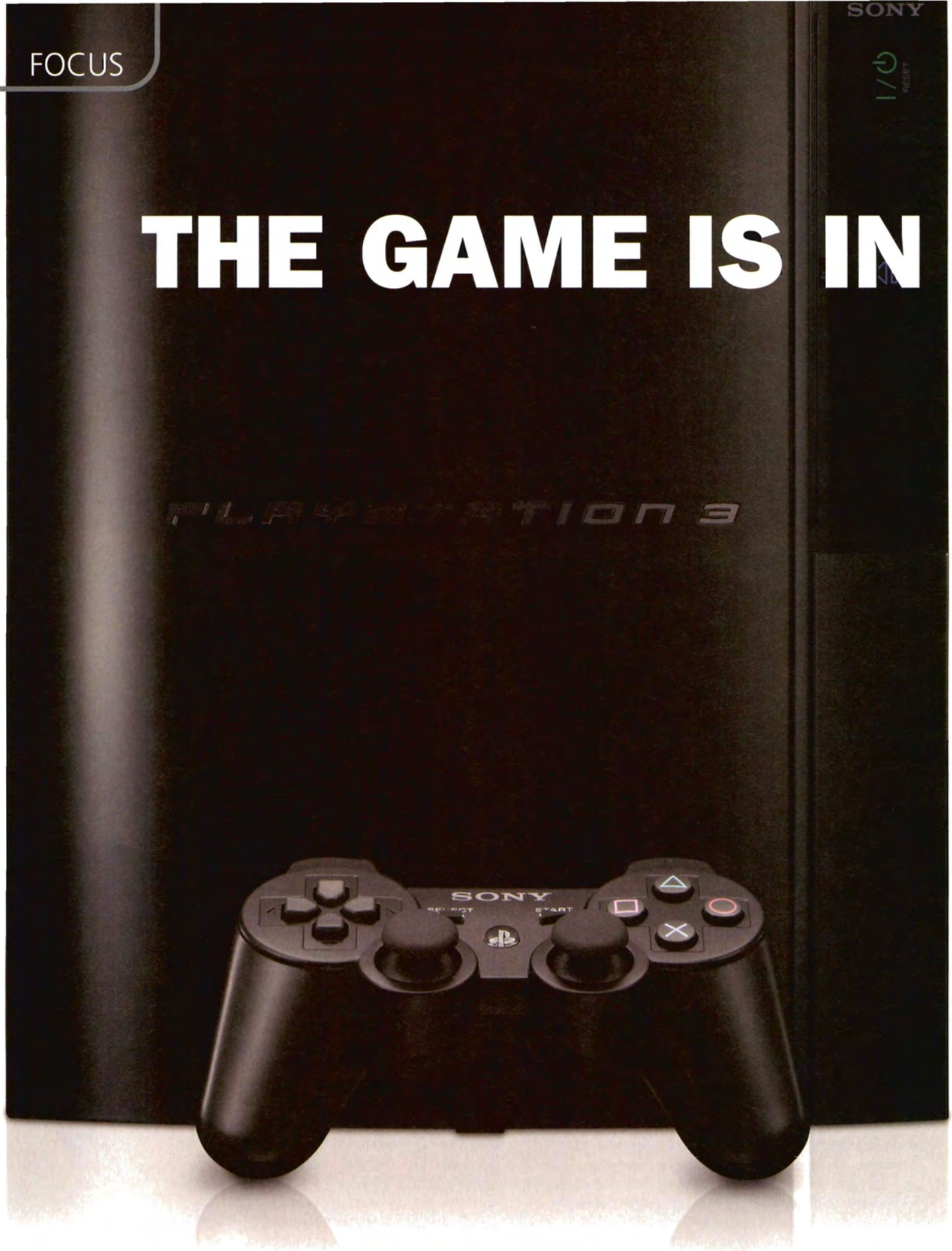
> **"There is no question that innovation is the life blood of a strong economy"**

However, it shows that the record of knowledge transfer and exploitation by business has generally been weak. Cost has been cited as the most commonly regarded barrier to innovation, including the direct resource cost of innovation activities, their perceived economic risk and the cost of acquiring finance.

But with the Government committed to investment in R&D and the creation of knowledge based economy, now is the time for innovators to come forward.

The information age has transformed the way we live and it is innovation that will take us to the next growth area, be it in biotechnology, energy or nanotechnology. The UK has a great tradition of innovation and I look forward to seeing how today's companies are meeting the challenge of creating and implementing effective changes.

THE GAME IS IN



"In the world of interaction, every realistic operation can be simulated in a computerised game. Through play of such simulation, any person can learn very quickly and efficiently in a virtual way" – Sen Huang, CEO, PixArt Imaging

THE EXPERIENCE

By Keri Allan

Even though the first of the 'next generation' of videogame consoles is already on the shelves globally, this year's Electronic Entertainment Expo (E3) in Los Angeles still had its fair share of hardware announcements in store.

Although the Xbox 360 will have a year's head start on its competition – which comes in the form of Sony's PS3 and Nintendo's Wii – it may still have to fight to retain dominance in the gaming world. Release dates of pre-Christmas 2006 have been announced for both competitors' machines and further technical stats and technologies have been announced for all three of the machines.

This year's biggest shouter had to be Nintendo, who wowed the world by allowing attendees hands-on gaming with the renamed Wii console, originally codenamed Revolution. Truly a revolutionary move in gaming, this company has sidestepped the fight for more power and pixels on screen and focused on the gameplay experience instead. 'New ways to play games' is pretty much a Nintendo tag-line these days, but it's a refreshing point of view for the industry.

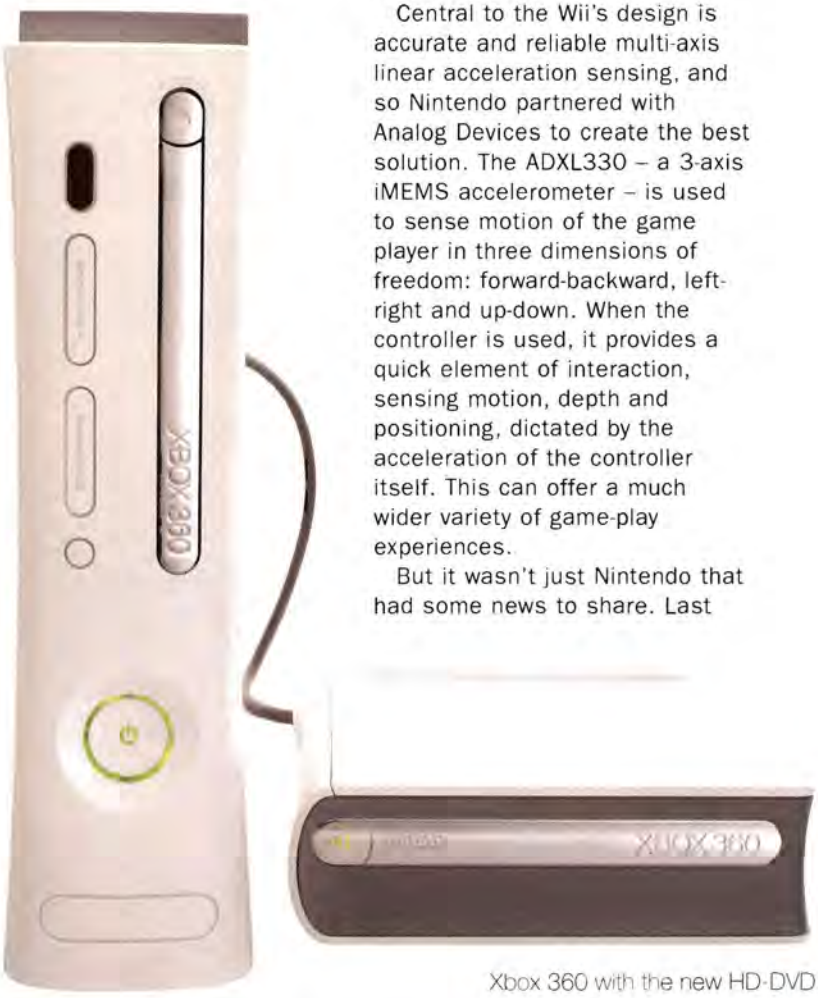
As a means to an end, it's the Wii's controllers that are truly aiding this new gaming experience. Its Remote controller – a single-handed controller that looks like a TV remote and is as simple to use, and Nunchuk controller – an attaching 'joystick', rely on sensing and tracking technology to deliver a game that involves not only buttons but movement too. "Ultimately, it's about the experience of playing the game," said Rob Saunders, marcoms manager at Nintendo Europe. "We put our R&D investment where we thought it would do the most good – by reinventing the connection between player and game; in other words, supporting the development of a completely new and innovative controller."

PixArt Imaging, Taiwan-based developer of CMOS sensors, has provided the object tracking technology, whilst Analog Devices and STMicroelectronics have supplied the 3-axis ADXL330 iMEMS acceleration sensor and user interface.

PixArt's Multi-Object Tracking engine (MOT sensor) technology can track multiple objects in a quick and responsive way. "In the world of interaction, every realistic operation can be simulated in a computerised game. Through play of such simulation, any person can learn very quickly and efficiently in a virtual way. Integrated tracking technology from proven vendors like PixArt will enhance the gaming experience for the overwhelming majority of all-generation gamers," said Sen Huang, CEO, PixArt.

Central to the Wii's design is accurate and reliable multi-axis linear acceleration sensing, and so Nintendo partnered with Analog Devices to create the best solution. The ADXL330 – a 3-axis iMEMS accelerometer – is used to sense motion of the game player in three dimensions of freedom: forward-backward, left-right and up-down. When the controller is used, it provides a quick element of interaction, sensing motion, depth and positioning, dictated by the acceleration of the controller itself. This can offer a much wider variety of game-play experiences.

But it wasn't just Nintendo that had some news to share. Last



Xbox 360 with the new HD-DVD drive

year Sony left gamers puzzled when it first displayed its PS3 controller (above), which had moved away from the industry standard of the PlayStation Dual Analog Controller to a more curved, even boomerang-esque design. It seems Sony went back to the drawing board, as this year, the classic design has returned, but with some new technical highlights. Gone is the DualShock rumble capabilities (as according to Sony they interfere), instead replaced with a highly sensitive six-axis sensing system. In addition to the '3-posture-axis' of roll, pitch and yaw, 3-dimension acceleration information (X, Y, and Z) can be detected precisely and in real-time. In addition to standard key input available in existing controllers, this new technology will allow for more natural and more intuitive play as, similarly to the Wii's Remote, the players' body movements will also affect their game-play. This is the first time Sony has included a sensor in its controller and tried to beat Nintendo to the punch by going one better, and offering 6-axis, rather than the Wii's 3-axis.

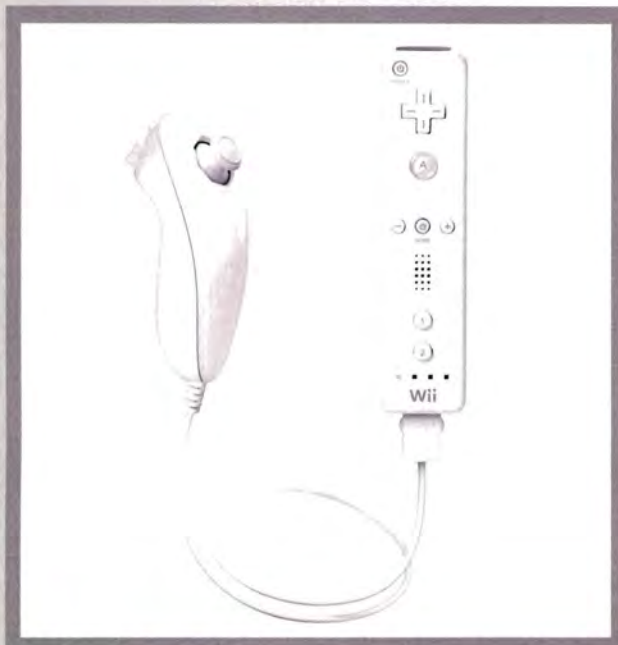
"I'm expecting that every game uses this function in some way," says president of Sony Computer Entertainment Worldwide Studios, Phil Harrison. "We all move the controller when we play, whether you're playing a racing or football game. Now, for the first time, we can also capture the primary input, such as the analogue sticks, as well as the secondary movements the gamer makes, and then combine the two. This is an important advantage that only the PlayStation 3 controller offers."

Although the Xbox 360's controller is old news, Microsoft wasn't going to be left out, and so had some peripheral announcements of its own. This year will see the launch of its Xbox Live Vision video camera. There's nothing amazingly new about this technologically, however it will add another dimension to online or community gaming and, moving forward, it will use mapping technology to allow gamers to put their own faces into games.

In addition to the improvements made to peripherals, other technological discussions have also been taking place over the next generation of gaming, including the move to High Definition (HD) format. The Blu-ray/HD-DVD war continues on the consoles as Sony and Microsoft try to make gamers accept their supported formats as standard. Sony is launching the PS3 with an in-built Blu-ray drive (which many people believe is the reason behind the console's high price – £425 in the UK), and Microsoft will be launching its external HD-DVD drive later this year, giving gamers the choice of watching HD movies too.

However, Nintendo will sit this one out – at least for now. "While aspects like HD are compelling propositions – and we are not opposed to it – it didn't make sense for us [to enter this field] at this time," said Saunders. "The household penetration of HDTV sets is still quite low. Plus the cost, development time and added power resources needed would only add to the cost for the consumer, many of whom could not even enjoy the technology on

New videogames lifestyle



Wii's new style controller

their standard televisions."

Another key change to game consoles is the use of Wi-Fi. "Wii is Wi-Fi compatible out of the box," says Nintendo's Saunders. "The console is Internet-ready, which will allow numerous types of playing, whether it's with others across the globe or downloading new game data or other information. We will also offer an optional web browser from Opera to allow web surfing and enable game developers to enhance games with real-time content. We have not announced all of our Wi-Fi capabilities at E3. However, rest assured we are currently working on a number of Wi-Fi compatible games," he adds. Using the Remote, gamers will be able to navigate websites using the Opera browser in-between gaming session (also being made available for gamers on Nintendo's handheld console, the DS).

Opera's cross- platform web browser technology is known for its small size, performance and standards compliance. It is based on the same core as the Opera desktop browser, but it is faster in rendering web pages on the Nintendo DS. "Within just five seconds of turning on the system, the Nintendo DS is already fully operational. This makes it the ideal device to enable people to swiftly obtain the latest information from the Internet, wherever they are," said Masaru Shimomura, Deputy General Manager of Nintendo's R&D department.

Sony announced that the PS3 will also offer a browser, and with more to come from all camps, it looks like the competition is heating up. The latest generation of game consoles is taking advantage of all manner of technological options, which makes it a very interesting market to watch. Whether these functions and possibilities are what gamers want is the million dollar question. Only time will give us the answer.

Wii's remote function

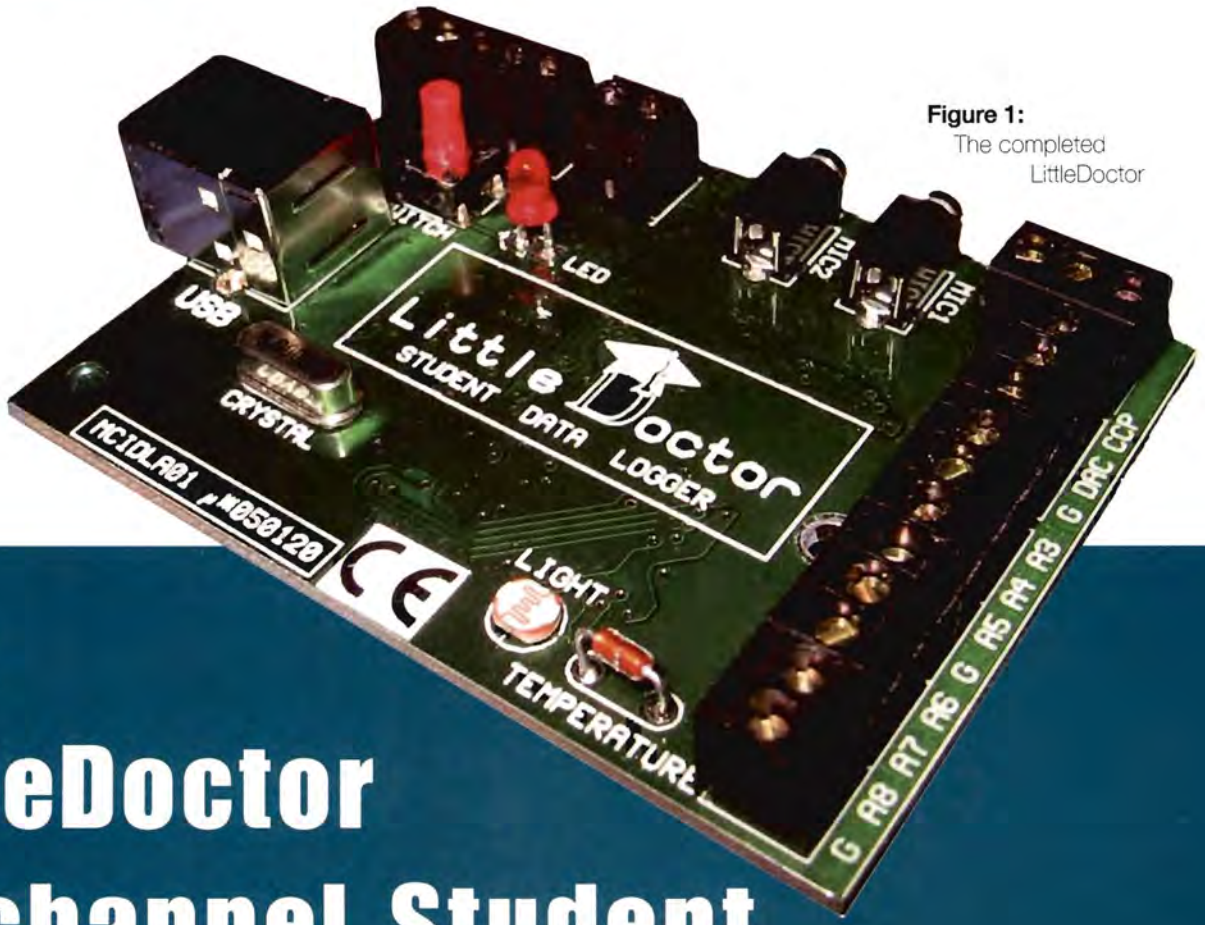


Figure 1: The completed LittleDoctor

The LittleDoctor 15-channel Student Data Logger

In this article, **Michael Bailey** describes an economical automatic data logging unit called the "LittleDoctor", which can be easily made and adapted by anyone

The proliferation of personal computers has greatly increased the feasibility of computerised data logging. This has been beneficial to many people, particularly those involved in science education. In the UK, recent changes in secondary-level syllabuses have mandated the use of automatic data logging in some experiments. The market has moved to accommodate these new demands, offering a broad array of equipment which varies widely in accuracy, speed and price. This article describes an economical unit called the "LittleDoctor" (shown in **Figure 1**) which you can make or adapt for yourself.

A data logger is essentially an analogue-to-digital converter (ADC) with a computer interface. With a little ingenuity, there really is no limit to the number of experiments that can be performed with even a simple unit. To pick two random examples, with an external thermistor, a data logger can plot temperature vs time on a graph as water melts and later boils; also, using a simple light gate, you can measure the speed of a dynamics trolley before and after a collision.

The unit described in this article uses the Microchip PIC18F1220 microprocessor, which boasts a 10-bit ADC and a CCP module. It has a USB interface using the FT232BM chip. **Figure 2** shows the complete circuit schematic, whilst the PCB layout is shown in **Figure 3**.

Circuit Description

U2 provides an analogue voltage reference of 4.096V and a 6MHz crystal provides a time reference that is shared between the PIC18F1220 and FT232BM chips.

Eight analogue inputs are multiplexed via U6 to one processor input, AN4. A pull-up resistor, R13, can be programmed to connect dynamically to any of these analogue inputs. This expands the unit's capability by allowing it to measure resistance among other things.

Two of these eight inputs are "internal", being connected to an LDR and thermistor to measure ambient light and temperature. You can connect your experiments

SPECIFICATION

USB interface, powered via USB
Screw terminal connections
10-bit voltage resolution
1% basic voltage accuracy
Up to 4750 samples/s
8 analogue voltage inputs, high impedance, range 0 to 4.096V
x10 amplifier on two inputs, Zin = 100kΩ, range 0 to 0.4096V
Internal temperature (calibrated) and light sensors (uncalibrated)
Three digital on/off inputs, Zin = 1MΩ, one is operated by push button
Frequency counter digital input, Zin = 1MΩ, Schmitt, up to 15MHz
Time interval digital input, Zin = 1MΩ, Schmitt, up to 89s, 5.3s resolution
Analogue output (e.g. sine wave) 0 to 3V, up to 1.46kHz in 5.7Hz steps
Variable frequency digital output, up to 1.5MHz, choice of three duty cycles
On-off power output with LED, 5V up to 50mA
Graphs any inputs simultaneously with zoom, pan and co-ordinate display
Exports data in CSV format suitable for importing into Microsoft Excel

directly to the remaining six analogue inputs through screw terminals mounted on the board. These inputs generate meaningful values for voltages in the range 0V to 4.096V, but are protected against excess voltage from -5V to +10V.

There are two additional, dedicated, PIC analogue inputs with x10 DC pre-amplifiers. These generate meaningful values from 0V to 0.4096V, but are still protected from excess voltage from -5V to +10V.

There are also three digital (on/off) inputs and one "power" digital output capable of driving an external circuit.

Finally, there are two screw terminals labelled "CCP" and "DAC", which are used with the microprocessor's CCP feature (see EW January 2006, "Tips 'n' Tricks" section). There are several ways to use this feature effectively. It can generate a pulse waveform of varying frequency or duty cycle; it can synthesise one or two analogue sine waves of audio frequency via a low-pass filter with output marked "DAC"; or, used as an input, it can accurately measure the time interval between rising or falling edges of a waveform.

USB Interface

The royalty-free FDT2XX driver for the FT232BM chip is available from the FTDI web site. The board allows for U8, a small EEPROM, which can be used to nominate the USB device. If this is omitted, the device will work but possibly not at the same time as another USB device which uses an FDTI chip without an EEPROM. If you decide to use the EEPROM, it can be programmed via the USB port using a tool that can be downloaded from the FTDI website (www.ftdichip.com).

Apart from installing the driver, there is nothing else that has to be set up to make the USB function.

PIC Firmware

My firmware was written in assembly code using the Microchip MPLAB-7 environment. The main objectives in developing this code were to maximise the rate at which analogue samples were taken and to ensure timing integrity. The firmware runs in a tight loop, triggered by a timer to give the sampling time. Once triggered, samples from each input are collected as quickly as possible and a packet of data is assembled which contains the time, as defined by the crystal, and the sample values. In this way, the measured time is not dependent upon the vagaries of the USB interface and the PC's software.

The sampling speed is limited by my choice of a 6MHz clock and the serial data flow between the PIC and USB chips. It could have been improved by using the FT245BM chip, which has a parallel interface, but that would take more PIC pins, leaving fewer for data input.

There is far too much in the firmware to explain everything in detail here. However, it may be of particular interest that the analogue sine wave output option is achieved by modulating the duty cycle of the PIC's PWM output with a directly synthesised sine wave based on a look-up table, followed by a 3-pole low-pass filter. Although this is a standard technique and relatively easy to implement, it is still very satisfying to see in operation (see Figure 5).

PIC Programming

The board includes a 0.1" edge connector for in-circuit serial programming of the PIC chip. You will need a suitable PIC programmer such as the Microchip PIC-Start. I chose to make my own programmer.

The programmer will need an "object file" (see end of article), or you might want to re-assemble my source code using MPLAB, freely available from www.microchip.com. You can either program the PIC before soldering, in which case you will need the correct SOIC adapter for your programmer, or you can program it after assembly via the edge connector provided and a suitable adapter, which you can make yourself. The edge connector fingers can be identified on the underside board layout, Figure 3, as follows:

P1	MCLR = Vpp (programming voltage)
P2	VDD = +5V
P3	GND = 0V
P4	RB7 = PGD (programming data)
P5	RB6 = PGC (programming clock)
P6	leave open circuit, or short to GND to stop USB chip applying reset pulse

PC Software

I wrote my software in Microsoft Visual Basic 6. My aim was to make as much as possible available in a single window to avoid switching windows during use (see Figure 4). If you think this makes the appearance too cluttered, it would be relatively easy to change the appearance or, indeed, to completelyMy software operates in one of two modes.

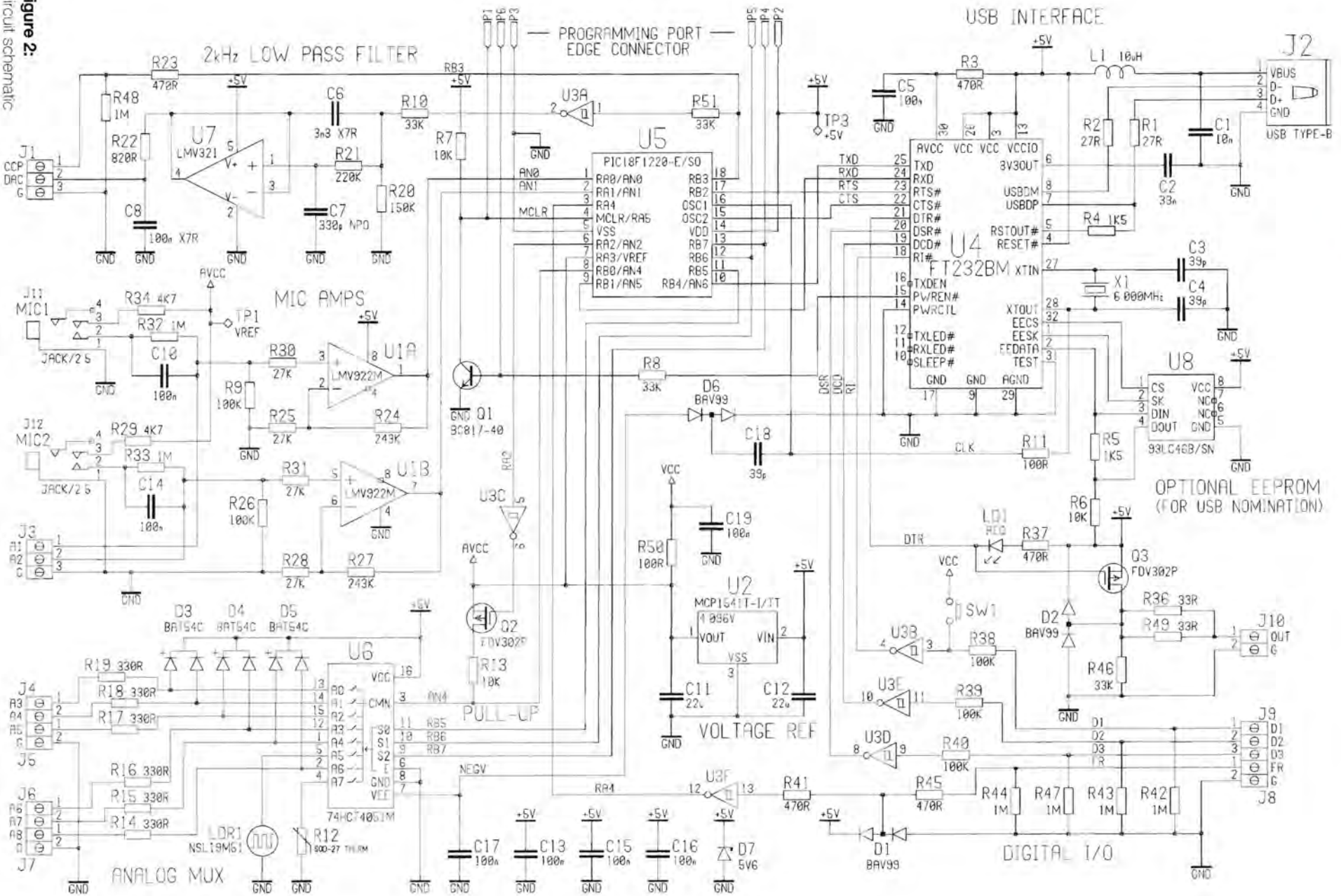


Figure 2: Circuit schematic

In "record" mode, it is reading the data coming from the LittleDoctor by making frequent calls to the USB driver and displaying the interpreted results. At the press of a button the data may be logged to a hard disk file.

In "playback" mode, the software reads a previously recorded log file.

When recording to file or replaying, the data can be displayed graphically against time. The usual zoom and pan controls are provided. Figure 5 shows the display being used to measure the interval between two points on a recording of the unit's synthesised sine wave output.

It is possible to copy the displayed graph to the clipboard, print a high resolution version of it, or export the data itself to a CSV file, which can be opened with Microsoft Excel for further processing. I did not provide advanced graphing features, such as X-Y plotting, logarithmic scaling or adding a "best-fit" line, since this is so much easier to do with Excel.

Note: More details about the PCB and other elements of this project can be supplied by the author via the Electronics World editorial office. Please email EWeditor@nexusmedia.com

Figure 3a: Bill of materials

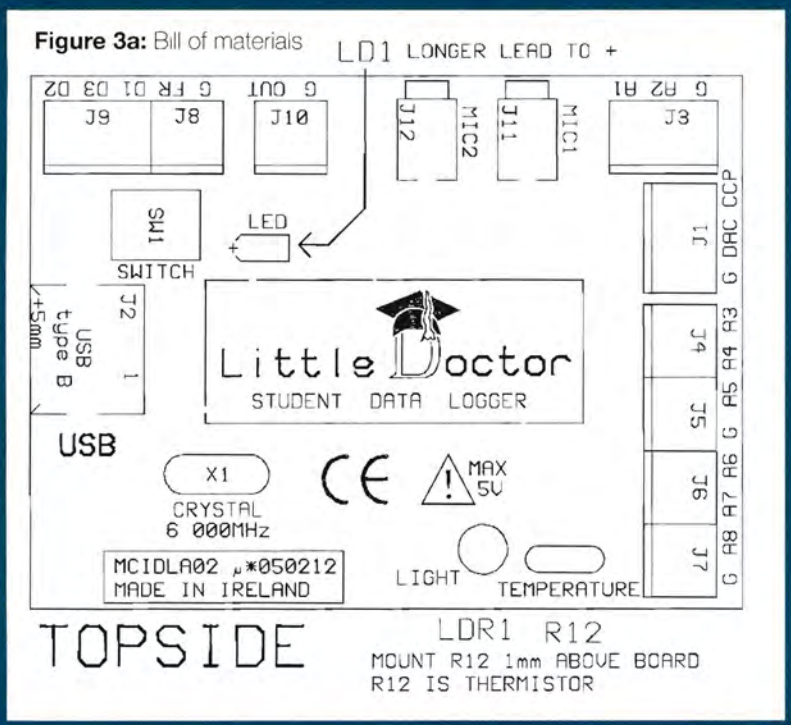


Figure 3b: Component layout

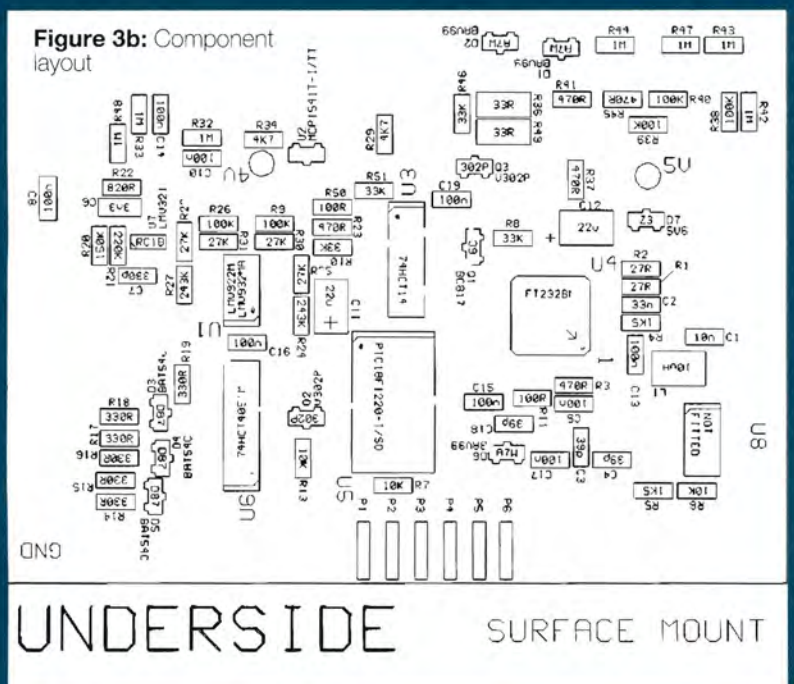


Figure 4: Software main screen

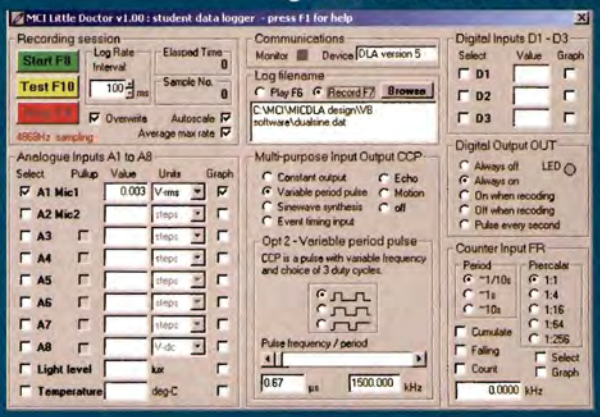
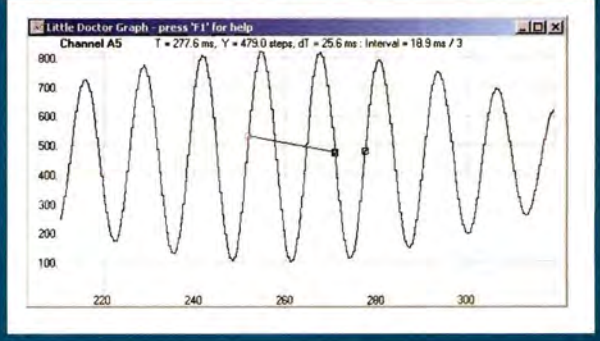


Figure 5: Software graph screen



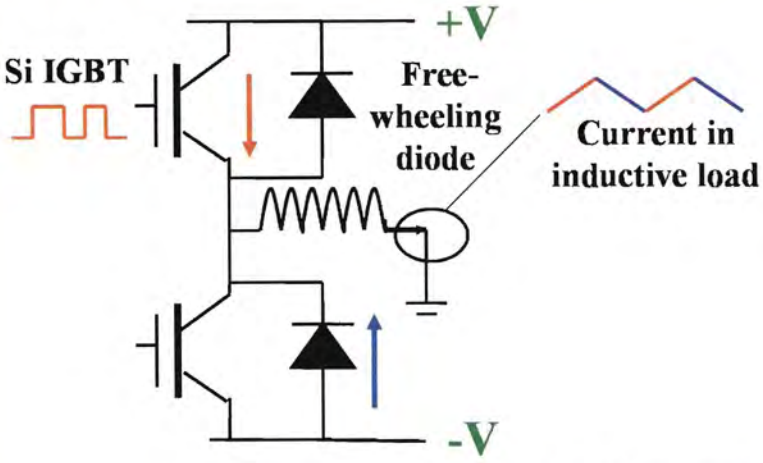


Figure 1: Power inverter circuit

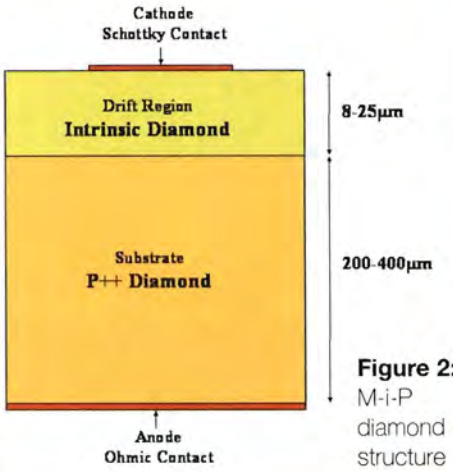


Figure 2: M-i-P diamond structure

DIAMOND SCHOTTKY DIODES *for Power Electronics*

Mihai Brezeanu and Jeremy Rashid of University of Cambridge, Antonella Tajani of Element Six Limited and Anthony Garraway of Dynex Semiconductor Limited explain that synthetic diamond is the perfect solution for high-power electronic devices

For thousands of years, natural diamonds have sparked the imagination of people all around the world. Their capability to disperse light better than any other precious material, their amazing resistance to corrosion by acids and salts, and their outstanding hardness have fascinated people and given birth to numerous legends and myths (as presented by Robert M. Hazen in "*The diamond makers*").

In the 19th century, as the industry was developing rapidly, scientists became interested in using the diamond's remarkable properties. However, the extremely high cost of natural diamond stones made their widespread industrial scale use almost prohibitively expensive. Thus, the need for synthetic diamond emerged.

'Producing' Diamonds

Who produced the first synthetic diamond sample is still a controversial subject. Scientists at the General Electric Company's research laboratories in Schenectady, New York, are commonly acknowledged to have been the first to succeed in synthesising diamond, in December 1954. The experiment was successfully repeated in the next two weeks (H.T. Hall, "*The Synthesis of diamond*", Journal of Chemical Education) and the results published in July 1955 in Nature by F.P. Bundy, H.T. Hall, H.M. Strong and R.H. Wentorf in "*Man-made diamonds*".

However, it is now known that pieces of synthetic diamond were first obtained nearly two years earlier, on the 16th of February 1953, in Sweden, within a research project of the former Swedish company ASEA (ASEA is now part of the multinational ABB and, during the 1970s, its diamond synthesis unit was acquired by Element Six). The machine used in the experiment had been designed by the inventor of the refrigerator, Baltzar von Platen, and was extremely complicated. Any mistake in its operation needed many days of effort before it could run again. Due to the lack of success in consistently reproducing the experiment and trying to avoid the synthesis procedure unravel, ASEA decided not to make their results public. Therefore, the General Electric team is officially recognised as being the first to synthesise diamond.

Over the subsequent decades, many ways of making

synthetic diamond have been developed and today 80% of the diamonds used in industry are man-made. The largest application area by volume is in the cutting, grinding and polishing of rock where diamond's outstanding hardness is exploited.

Diamond also has outstanding optical properties (one of the reasons it makes such a good gem stone). Its transparency to electromagnetic radiation from the ultra-violet to beyond the microwave region, combined with its abrasion resistance, resulted in it being chosen as the window for the infrared spectrometer on board the Viking spacecraft that landed on Mars in 1975.

Electrical Properties of Diamond

Diamond, being a material of extremes, also has remarkable electrical properties. The thermal conductivity (24W/cmK) is the highest among semiconductors. Compared to Silicon Carbide (SiC) and Silicon (Si), the maximum electric field (10MV/cm) is three times and, respectively, 25 times larger. The measured carrier mobility in intrinsic diamond ($3800cm^2/Vs$) is the highest reported value for holes among bulk semiconductors, as presented by J. Isberg et al in "*High carrier mobility in single crystal plasma-deposited diamond*", Science, and "*Temperature dependence of hole drift mobility in high-purity single-crystal CVD diamond*" at the CVD Diamond Films Conference in Hasselt in 2005.

There is, however, a downside: the structure of diamond, which confers its extreme properties, also makes it very difficult to incorporate dopant atoms, indeed only boron, which yields p-type characteristics (i.e. hole conduction), goes in with an activation energy low enough (0.37eV) to allow some conduction at room temperature. Consequently, the design of devices is tricky, making bipolar devices nearly impossible to be made from diamond, unless only high temperature operation is required, leaving unipolar devices as the best option.

For a long period of time, this drawback, together with the rather high concentrations of impurities and defects in synthetic diamond, made it unattractive for electronic devices.

A major breakthrough in the development of diamond material suitable for electronic devices was made in 2002, when Element Six reported using a Chemical Vapour Deposition (CVD) process to grow high

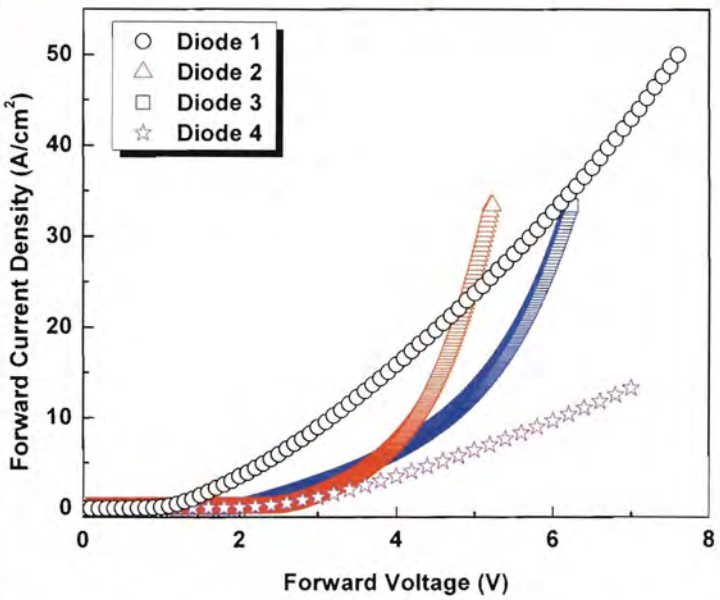


Figure 3: Experimental on-state characteristics for four M-i-P diamond structures grown by Element Six and measured by Dynex Semiconductors (Diode 1), University of Cambridge (Diodes 2 and 3) and Element Six (Diode 4)

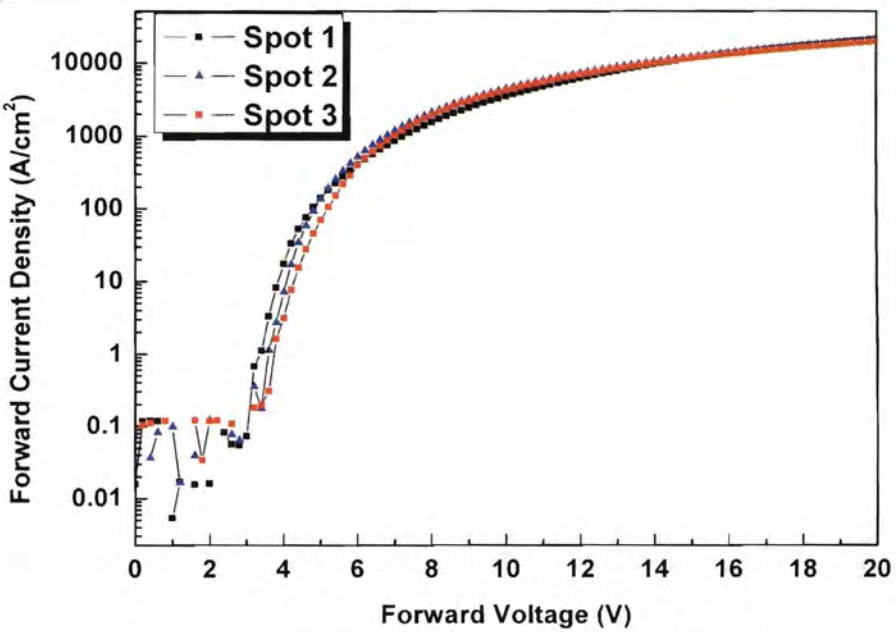


Figure 4: On-state characteristics of three diodes fabricated on the same diamond sample, with limited area Schottky contacts

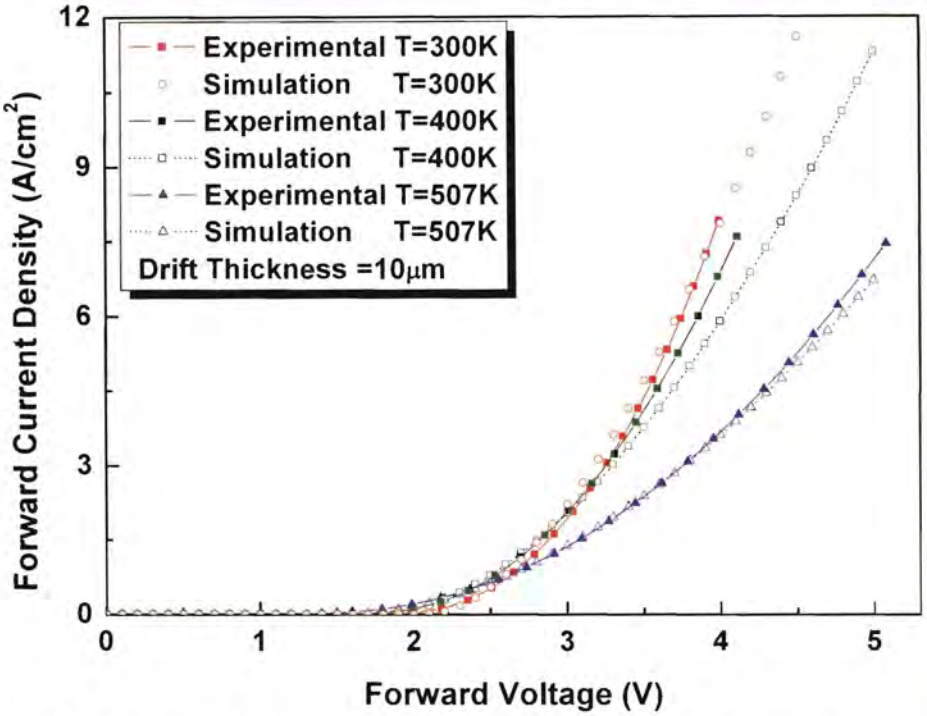


Figure 5: Measured and simulated on-state characteristics at different temperatures

quality, synthetic, single crystal (SSC) diamond containing controlled concentrations of boron dopant atoms. This has triggered hopes for obtaining viable and competitive diamond devices.

Research has mainly focused on unipolar structures: MEtal Semiconductor Field Effect Transistors (MESFETs), Junction Field Emitter Transistors (JFETs) (A. Aleksov et al, "*Diamond diodes and transistors, Semiconductor Science and Technology*", (2003), and especially on Schottky Barrier Diodes (SBDs).

The main advantage of a unipolar structure is that the turn-on and turn-off times are significantly lower when compared to bipolar devices. This is due to the absence of minority carriers, which have no longer to be injected in the 'ON' state and then extracted from the region sustaining the breakdown voltage in order to turn 'OFF' the device. The switching losses are, therefore, significantly lower. On top of that, a diamond SBD has the advantage of being able to block high off-state voltages with relatively thin structures (due to its high breakdown field), and to work at high temperatures (due to its very high band gap, 5.47eV, and outstanding thermal conductivity), as presented by D.J. Twitchen et al in "*High-voltage single-crystal diamond diodes*", IEEE Transactions on Electron Devices, 2004.

One of the key niches where diamond could significantly outperform competitors such as silicon carbide and gallium nitride is as a high frequency device. The cut-off frequency (i.e. maximum operating frequency) of an electronic device is proportional to the carrier saturation velocity and the maximum sustainable electric field. Diamond has a saturation velocity comparable to those of other wide band gap semiconductors ($2.5x10^7$cm/s for GaN, $2.0x10^7$cm/s for 4H-SiC and diamond, $0.86x10^7$cm/s for Si) and a significantly larger breakdown field (10MV/cm for diamond, 5MV/cm for GaN, 3MV/cm for 4H-SiC and 0.41MV/cm for Si), properties which make it a potential candidate for high-frequency applications (G.A.J. Amaratunga, "*A dawn for carbon electronics?*", Science, Vol. 297).

Devices, made using thin diamond films, have been already demonstrated to operate at 8.1GHz. These are the first diamond devices capable of operating as an amplifier in the mm region. A new generation of solid-state amplifiers capable of handling more than 10W at operational frequencies in excess of 10GHz are now in sight.

The M-i-P Structure

High-voltage, high-current density, high-temperature and high-frequency: these seem to be the key words for defining the application area in which diamond devices might be suitable. Switch mode power supplies and hybrid vehicle drives are applications in which the use of diamond diodes might prove essential. Here, high efficiency is essential and the ability to operate at elevated temperatures in adverse thermal environments is highly desirable.

The Si Schottky diode is a solution commonly used for the freewheeling diodes in such systems (**Figure 1**). However, at voltages above 200V, Si Schottky diodes are unviable. Therefore, Si p-i-n or pn diodes are used instead.

The conductivity modulation allowed for by bipolar injection can overcome the resistance introduced by the requirement for a thick blocking region. In 2001, Infineon introduced the first commercially available SiC Schottky diodes, capable of withstanding 300V and 600V, when reverse biased, and delivering 20A and 6A, respectively, in on state. A second supplier, Cree, followed short time later, introducing a 1200V SiC diode. Having higher breakdown strength, saturation velocity and thermal conductivity, SiC SBDs are now the leading candidate for replacing Si p-i-n devices (J.W. Parlour, "*Energy efficiency: The commercial pull for SiC devices*", International Conference for Silicon Carbide and Related Materials, ISCRSM 2005).

With their significantly superior electronic properties, diamond SBDs could be the ideal challenger to the SiC structures in the near future. While the off-state performance is expected to be superior to SiC, the high on-state resistivity, due to the depth of boron acceptor level in diamond leading to a low room temperature concentration of free charge carriers available for conduction, might seriously affect the overall performance of diamond diodes. In order to overcome this problem, an M-i-P (Metal-intrinsic semiconductor, P++ doped semiconductor) structure can be employed (**Figure 2**) (G.A.J. Amaratunga, "*High Voltage Synthetic Single Crystal Diamond metal – intrinsic – p+ (MIP) Diodes*",

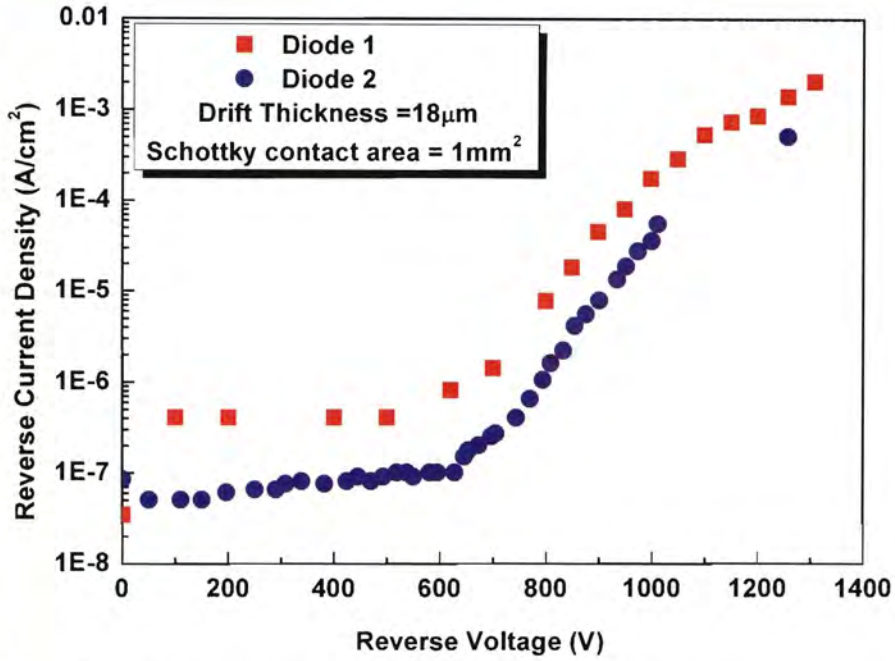


Figure 6: Off-state experimental characteristics for two M-i-P structures fabricated on the same sample

Diamond and Related Materials Conference, 2005).

The main difference between the M-i-P structure and the typical power high-voltage SBD is that the voltage blocking (drift) region of the first configuration is undoped (intrinsic), while in the second it is lightly-doped. The extremely high hole-mobility in the intrinsic diamond layer (four times larger than the electron mobility in SiC) can compensate for the lack of carriers to yield an acceptable conductivity. In diamond, increasing the boron concentration leads to metallic, rather than semiconductor behaviour (S.J. Rashid et al, "*Numerical and experimental analysis of single crystal diamond Schottky barrier diodes*", Proceedings of the International Symposium on Power Semiconductor Devices and ICs, ISPSD 2005, pp 315-318.

For doping concentrations larger than $3*10^{20}cm^{-3}$, all the impurity ions are ionised at room temperature and the semiconductor becomes metallic. In the M-i-P structure, a highly doped substrate layer (10^{19}–$10^{20}cm^{-3}$ boron concentration) is used as the free carrier source from which current is injected into the intrinsic layer under forward bias.

Another reason for choosing an intrinsic drift layer is the non-linear variation of the on-state current with the field applied across the i-layer. When the anode is positively biased, the holes are injected from the highly doped substrate into the thin drift region (8–25μm thick). Because the concentration of the injected carriers cannot be charge-balanced in the intrinsic layer, the conduction is space-charge limited. The Mott-Gurney law gives the dependence between the forward current and the forward voltage:

$$J_F = \frac{9}{8}\varepsilon_D \mu_p \left(\frac{{V_F}^2}{{L_i}^m}\right)$$

where J_F and V_F are the forward current density and voltage, respectively, ε_D is the relative permittivity of diamond (5.7), μ_p the hole mobility, L_i the thickness of the drift layer and m is a constant between 2.3 and 2.7. The non-linear variation of J_F with V_F is another factor that, together with the high intrinsic carrier mobility, can compensate the high activation energy of the impurities.

As the forward voltage increases above a certain threshold, the current ceases to be space-charge limited and starts obeying the I-V law predicted by the thermionic emission theory:

$$J_F = J_0\left[\exp\left(\frac{qV_F}{nkT}\right)-1\right]$$

where J_0 is the saturation current density, k is Boltzmann's constant, T is the temperature and n is the ideality factor, which determines the departure of the current versus voltage curve from the ideal Schottky barrier diode characteristic (ideally n =1).

Theoretical and Experimental Results

Compared with Si, SiC or Gallium Nitride (GaN), research on diamond electronic devices is still at an early stage. Many issues still need to be addressed before drawing firm conclusions regarding the true potential of diamond in practical semiconductor devices. The methods of making synthetic single-crystal diamond have improved dramatically in the last few years, but there is still room for improvement in crystal quality for enhanced electronic performance. To this end, an extensive study regarding the type and concentration of defects which affect device performance is under way. Another critical area requiring more research is how to make reliable contacts on diamond devices. Gold and aluminium are currently the metals preferred for Schottky contacts, whilst sandwiches of two (Ti/Al) or three (Ti/Al/Au) metals form good ohmic contacts. However, these contact structures and their deposition processes are still being optimised.

Experimental measurements carried out in three laboratories on different diamond Schottky diodes grown by Element Six confirm that current densities up to $50A/cm^2$

can be achieved (**Figure 3**). Taking into account the limited amount of development work carried out so far this is an encouraging result. The ideality factors (*n*) for the four diodes presented in Figure 3, are in the range 2.24–5.52. Recently, diamond diodes with ideality factors in the range 1.5–1.8 have been also produced. At first sight, these values are far from the performances of either Si or SiC devices, where *n* approaches its ideal value, 1. However, in a space charge diode, where the effective depletion layer (intrinsic layer) does not change under forward bias conditions, the higher *n* value is expected due to greater recombination. For this reason, other parameters should be considered in order to adequately characterise the performance of diamond SBDs.

Larger current densities are measured with limited area Schottky contacts (**Figure 4**). Three different diodes on the same sample exhibited currents of 100A/cm^2 at 5V, within the superlinear region of the on-state characteristics, clearly showing the capability of diamond as a semiconductor material.

A major requirement for power device development and design is the capability to have accurate, physics based, simulations. For diamond, this is another area in which there is need for further research, in terms of obtaining and calibrating physical parameters from experiments, for further inclusion in simulators.

When defining diamond as a semiconductor, several models have to be taken into consideration. The mobility versus doping and temperature variations have been implemented for SSC diamond. A model for the incomplete ionisation of dopants has been formulated. When these models are used in industry-standard simulation software, reasonable agreement with experiment is obtained (**Figure 5**), at different temperatures. When increasing the temperature, both the mobility in the intrinsic layer and the current density decrease significantly.

The deviation between the measured and the simulated data is in the range of 2.4%–8.4%, an acceptable starting point from which to progress towards device design optimisation through simulation.

Off-state measurements have proven the capability of diamond to block large off-state voltages with thin drift regions. With gold Schottky contacts and 10–15μm thick intrinsic regions, breakdown voltages (BVs) in the range 1000–1200V (**Figure 6**) are obtained. Significantly larger BVs (up to 4.1kV) are achieved with gold probe measurements on the same samples, without contact formation, suggesting that there remains room for further improvement of contacts.

Thus far, all the experimental investigations have been performed on non-terminated structures. Finding a suitable termination for high voltage diamond devices is another challenging task, taking into account the lack of n-type regions, which prohibits the use of conventional techniques, such as field rings or junction termination extensions. When a proper termination structure is developed, the breakdown capability of the devices is expected to improve by as much as 70%.

Focus for Ongoing Research

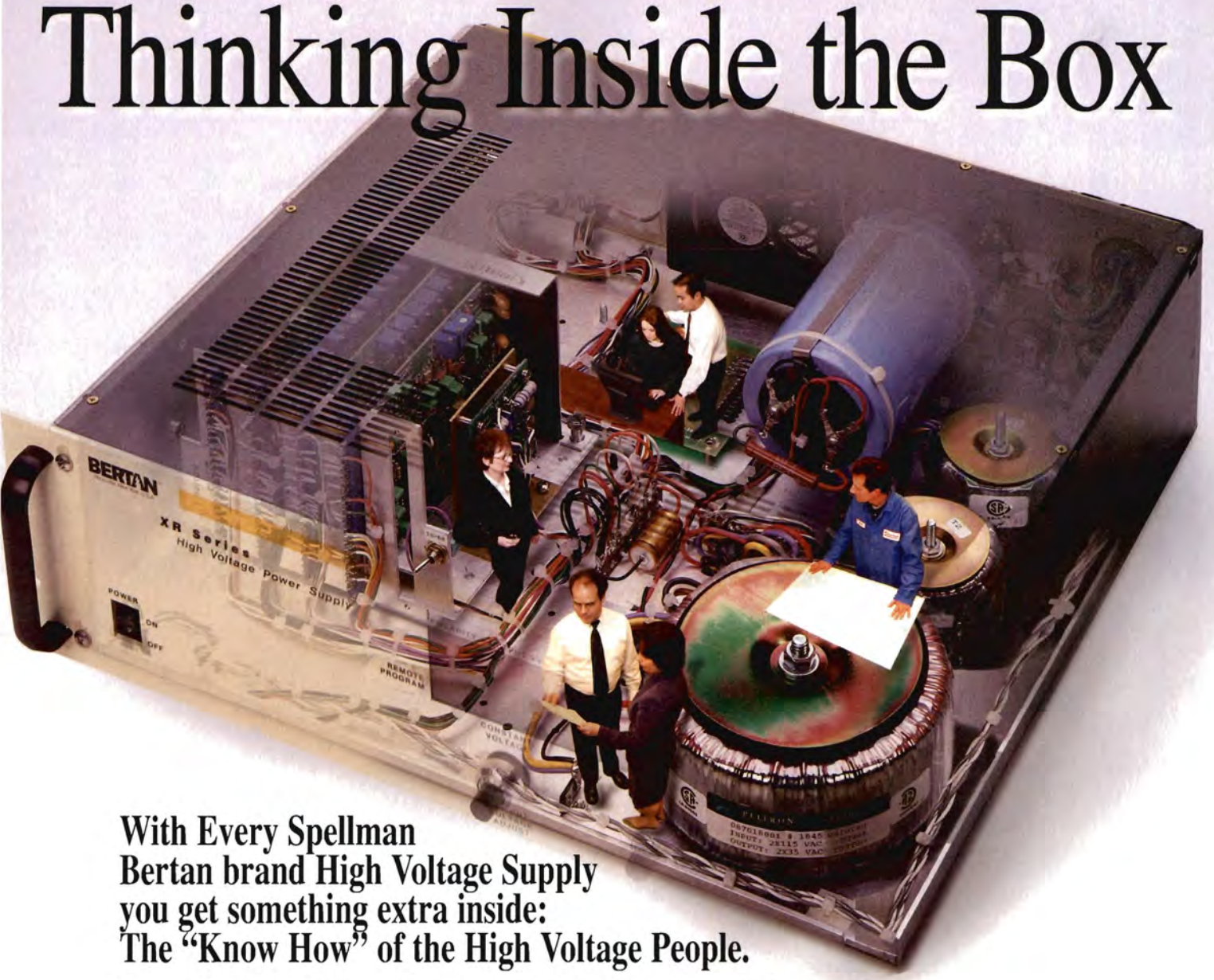
Research carried over the last four years, both in synthesising electronic quality single crystal diamond and investigating its potential as a material for electronic devices, has produced very encouraging results. Although not entirely confirming the theoretical predictions for 'ideally pure' diamond, the experimental investigations have shown the capability of thin diamond M-i-P diodes (drift thickness lower than 25μm) to withstand breakdown voltages up to 4kV. On-state current densities approaching 100A/cm^2 have already been demonstrated.

Key issues such as reducing crystalline defects, optimising the contact deposition procedure and finding suitable termination structures, remain the focus of ongoing research and development. The results obtained so far point to the diamond M-i-P diode structure rated up to 3000V being an exciting alternative to replace silicon p-i-n and silicon carbide Schottky diodes in power electronic systems in the medium term.

Acknowledgment:

Mihai Brezeanu and Jeremy Rashid would like to acknowledge the help and support of Professor Gehan Amaratunga from the University of Cambridge. This paper was prepared through collaborative participation and research from the Carbon for Power Electronics (CAPE) project sponsored by the UK Department of Trade and Industry (DTI) under the LINK Basic Technologies for Industrial Applications (BTIA) programme CHBL/C/019/00021.

Thinking Inside the Box



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Microvias Break Barriers

While more industry commentators are predicting the end of Moore's Law – the theory espoused by Gordon Moore that chip performance doubles every 18 months – top-end PCB manufacturers still have a few tricks up their sleeves that could prolong the principle, say Graham Temple and Vin Makwana of Exception PCB

Figure 1: Close-up of flex material with rigid tabs. Part of a 12-layer flex-rigid PCB with nine flex tails. This was manufactured to support an avionics display application

The heat is on to fully utilise every inch of real estate on boards, as chip designers look for more power and efficiency from PCBs, which are getting smaller and smaller. Industries such as computing, telecommunications and defence are constantly pushing forward the technical barriers to gain more processing power, without a rise in temperature or circuit failure.

As designers search for new technologies and manufacturing methods to squeeze every last drop of efficiency from components and boards, so a new breed of highly skilled PCB engineers are coming to the fore in the UK to partner with OEMs to develop solutions that will prolong Moore's Law. Increasingly, we are seeing that more design houses and in-house teams are recognising the potential benefits new innovations in PCB manufacture can bring. Indeed, over the last year alone, we have experienced a far greater level of interest from designers and OEM customers in new developments and a far greater willingness to consider alternative, exotic materials and manufacturing processes that can be used in solving complex design issues.

One such development that is gaining credibility very quickly is microvia and flat pad technology, which was seen as high risk and too expensive by most OEMs in the market until fairly recently.

Microvia technology is now much more commonly used by PCB fabricators.

Designers are now considering this technology as the ever increasing demand for smaller devices, especially in the hi-tech market, grows.

Multi-Faceted Microvias

Traditionally, many in the industry have categorised microvias' only benefit as requirement for micro devices such as Chip Scale Packages (CSPs) and Ball Grid Arrays (BGAs), but this is simply not the case.

There are many benefits to microvia technology that are only now gaining real credibility among fabricators. Recent studies have proved that microvia can be used as a means of increasing routing density, which reduces

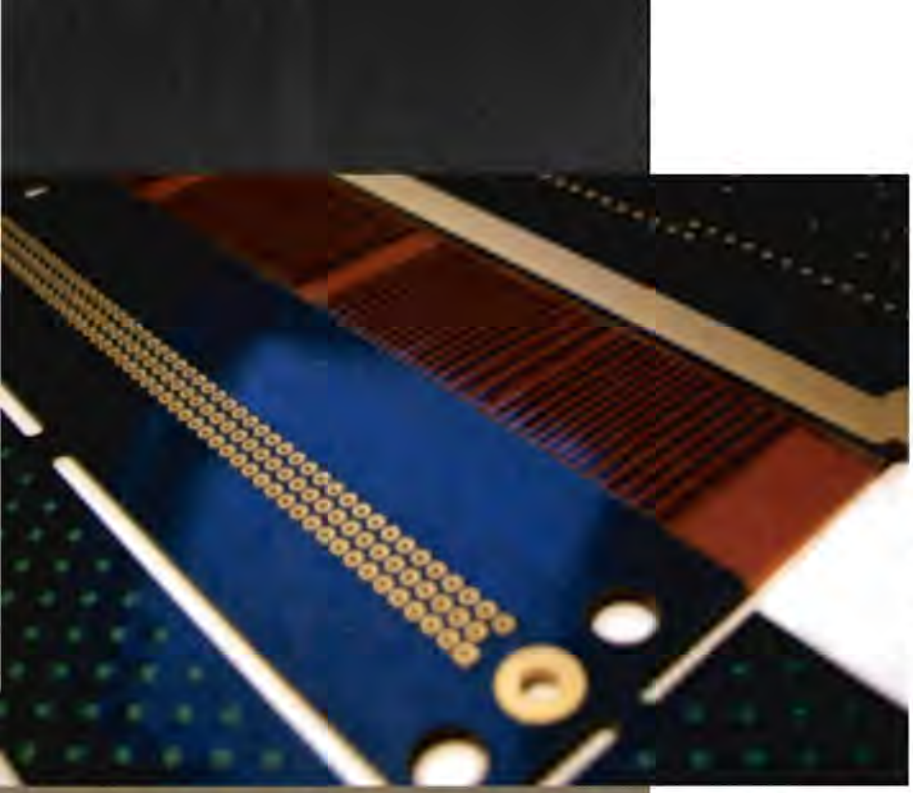

Figure 2: A 10-layer board with one flex tail in high copper weight. This was also used in an avionics application

the amount of layers required to complete a PCB design. Also, CSP devices are now becoming cheaper than their through-hole counterparts – so, although the bare PCB may be slightly more expensive, the measurable cost savings are realised later at the assembly stage.

As time and technology have progressed, so has the development of microvias. Even with standard microvia usage, devices such as 0.40mm BGAs have become almost impossible to track out. To address this issue there's the so-called microvia tower process (eXMVT), whereby standard microvias are placed directly on top of each other, thus reducing hole density, increasing route density and, due to the via being filled with copper, aiding thermal transfer from outer layers throughout the stack.

Microvia Related

Related to the development of microvias is the increasing adoption of flat pad (eXFPT) technology. While the process of via in pad for microvias is very well used, it does introduce potential process problems during BGA assembly.

The existing microvia leaves a small indent or dimple in the surface pad, which can lead to voids or out-gassing during assembly. The cure for this at the design stage is to use the conventional dog-bone pad-track-pad, whereby one via contains the surface pad, while the other includes the microvia hole.

This method vastly reduced routing density once more. If the eXMVT process is used, the laser ablated hole can be placed in the surface pad position, filled with copper and polished flat. The result is a completely flat pad, on which the device can be placed without the concerns evident with the standard microvia – absolutely critical on high-cost/high-reliability applications.

Moving Fast Ahead

Flex-rigid PCB technology is another fast moving area in PCB design that is proving extremely productive when it comes to increasing the reliability and flexibility of boards.

After a couple of stalled entrances to the market, when several major users of the next technology admittedly got burnt by introducing the flex-rigids too early into a couple of applications, we believe this innovation has now come of age.

Leading-edge fabricators can now turn around complex flex-rigid boards in a matter of days, rather than weeks, enabling designers and OEMs to quickly develop and test new boards for a variety of applications.

One of the most attractive benefits that flex-rigids can bring to an application is their inherent reliability. Whereas standard rigid PCB solutions would require many more connectors to achieve the same level of processing power, one piece flex boards bring far greater reliability.

The lighter weight and sheer flexible nature of the boards also make flex-rigids ideal for specialist sectors such as aerospace, automotive and defence, where space saving and weight savings are paramount in the overall engineered solution.

There is also an undeniable benefit to using flex-rigids when it comes to logistics and inventory control. While the adoption of standard rigid PCBs may require the use of several different boards to achieve an objective, the use of flex-rigids can often simplify the inventory function, as the same objective can be achieved with a single PCB component, not several boards that need to be linked together.

The use of flex-rigids can also reduce the possibility of human error in the manufacturing process when wire harnesses and looms are replaced, thus reducing the number of manual solders needed in a finished product. In certain instances, logistics costs have also been reduced by customers moving to flex-rigid solutions that simplify the range and number of component parts.

As designers seek to utilise space more effectively, the use of flex-rigid solutions becomes ever more important. We are seeing a high level of adoption of this technology in certain key sectors – such as motorsport, mobile communications, medical, avionics and defence – where size, space and weight savings are key differentiators.

Being Enlightened

While innovations such as those listed above are helping to maintain the efficiency and power of PCBs, intelligent redesign of established form-factors is gaining more favour now among enlightened designers.

To use the analogy of the Scrabble game to make the point, designers are increasingly working with fabricators to go back to basics and explore ways of scoring more points by not simply constructing bigger words, but by changing the dynamics of the board. It's only too easy for a designer to stick to an inherited design that's being used for a PCB and focus on the assembly side of the equation. Our experience shows that relatively few designers have the knowledge and confidence to go back

to the basic element of their PCB, the bare board and explore new ways of improving performance by design.

Working in close co-operation with designers and other players in the PCB supply chain is paying significant dividends when it comes to improving the performance and reliability of boards.

Figure 3: Using a 125-micron laser drill, this is a 2+n+2 microvia tower with flat pad (semiconductor application)

Figure 4: A 4+n+4 construction microvia tower, using a 125-micron laser drill (communications application)

Closely Knit

While technological advances can make huge differences in the efficiency of a PCB, such innovations are not regular occurrences. In the real world, we increasingly need to explore incremental advances in technology that may not contribute greatly in isolation, but when considered with a number of other relatively small improvements, can make a measurable difference.

Such collaboration is not easy as it demands the discipline to forge genuine partnerships across the manufacturing chain. It also requires far-sighted management to encourage like-minded engineering teams to share expertise and knowledge to create manufacturing solutions that meet the challenges set by customers.

Increasingly, we are seeing that customers are eager to exploit innovations that bring new dimensions and functionality to their products. Our role as a leading-edge PCB manufacturer is to maintain our investment in R&D and continue to develop close working relationships with research bodies and suppliers to the sector that can add value to the manufacturing chain. This high value-added strategy is pivotal to the future of PCB businesses and other electrical engineering enterprises in the UK that are seeking to maintain global competitiveness.

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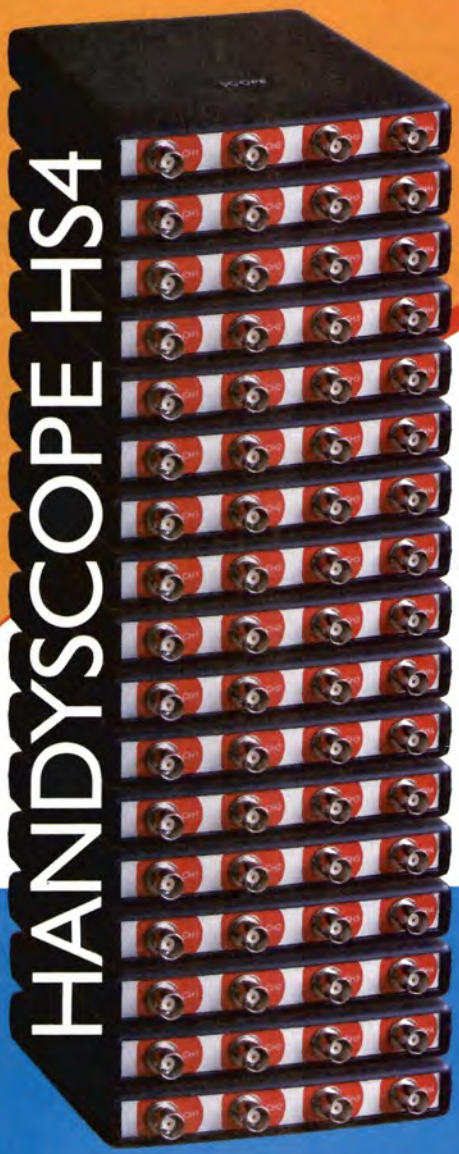

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DESIGN *and* SIMULATION *of a* SPRINGLESS MICRO SWITCH

K. S. KIANG, R. HOULIHAN, M. GINDILA, B. DAMRONGSAK AND M. KRAFT FROM INNOS AND THE SCHOOL OF ELECTRONICS AND COMPUTER SCIENCE UNIVERSITY OF SOUTHAMPTON PRESENT THE DESIGN OF AN ULTRA LOW ACTUATION VOLTAGE MEMS SWITCH

Compared with p-i-n diodes and field effect transistors (FETs), microelectromechanical system (MEMS) switches offer two distinct advantages: enhanced RF performances and almost zero power consumption. Despite this, RF MEMS switches have not usurped their solid state counterparts.

One of the primary obstacles to commercialisation is the high voltages required to actuate the switches, a typical MEMS switch requires between 20V-80V for operation. Several methods to reduce the actuation voltage of MEMS switches have been suggested. These include increasing the area of actuation, reducing the gap between the switch and the bottom electrode and lowering the spring constant of the design.

Large actuation areas are not always practical, as this causes the total area of the device to increase. By designing a smaller gap, the isolation loss on the RF signal will be affected. Reducing the spring constant is, therefore, the most appropriate solution.

Several authors have demonstrated a reduction of actuation voltage using a serpentine folded suspension. D. Peroulis achieved a reduction of 80% in the actuation voltage of his switch by increasing the number of meanders of the spring from 1 to 5, as presented in the *"Electromechanical considerations in developing low-voltage RF MEMS switches"*, Microwave Theory and Techniques, IEEE Transactions, by S. P. Pacheco, K. Sarabandi and L. P. B. Katehi.

Here, we propose a switch with no mechanical connection to the substrate and, therefore, 'zero' mechanical spring constant.

The Design

The actuation voltage of conventional electrostatically actuated MEMS switches depends on the mechanical spring constant. In the proposed design shown in **Figure 1**, there is no mechanical spring connecting the switch armature to the substrate. Switching is achieved by generating a pulling electrostatic force to overcome the gravitational force acting on the switching membrane. The pull-up electrostatic force is defined by **Equation 1** and must be greater than the gravitational force acting on the armature.

$$F_{electrostatic} = \frac{1}{2}\frac{\varepsilon_o A V^2}{g_o^2} \quad (1)$$

where ε_o is the permittivity of free space, A is the total area of the actuation pad, V is the applied actuation voltage and g_o is the initial capacitive gap. The actuation voltage is, therefore, given by:

$$V_{act} \cong \sqrt{\frac{2mgg_o^2}{\varepsilon_o A}} \quad (2)$$

where m is the mass of the switching membrane and g is the gravitational force. The estimated switching time of the MEMS switch, t_s, can be given as:

$$t_s = \frac{2b}{\varepsilon_o A V^2}\int g_o^2 dz = \frac{2bg_o^3}{3\varepsilon_o A V^2} \quad (3)$$

where b is the constant damping factor. This approximation tends to underestimate the required time but serves as a 'best' case approximation of the switching time of the MEMS switch. Another estimate can be derived with the assumption of constant force and constant velocity. This approximation serves as the 'worst' case of the switching time as the equation tends to overestimate the required time. The formula given for the switching time is:

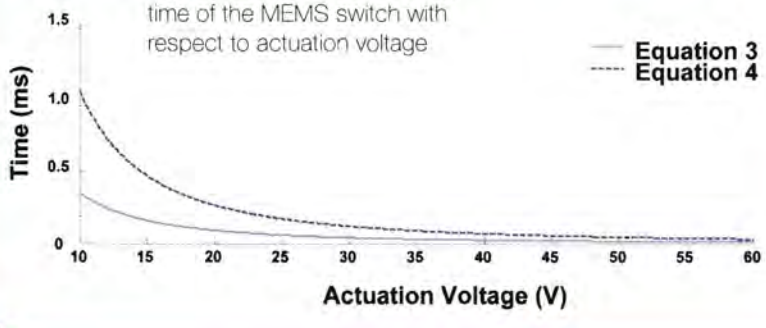


Figure 1: Simulated switching time of the MEMS switch with respect to actuation voltage

$$t_s = \frac{2bg_o^3}{\varepsilon_o A V^2} \quad (4)$$

These equations do not consider the holes that reduce the overall damping of the switch.

Modelling

The equation of dynamic motion that governs the mechanical response of the MEMS switch is:

$$mx + bx + kx = F_{electrostatic} - mg \quad (5)$$

where b is the damping coefficient, k is the spring constant, g is the gravitational force and $F_{electrostatic}$ is the electrostatic actuation force of the switch. As the proposed design does not have a mechanical spring, k is given solely by the squeeze film spring force.

Equation 6 gives the electrostatic actuation force with respect to the bridge displacement:

$$F_{electrostatic} = \frac{1}{2}\frac{\varepsilon_o A V^2}{\left(g_o - z + t_d/\varepsilon_r\right)^2} \quad (6)$$

where ε_o is the permittivity of free space, V is the applied actuation voltage, z is the displacement of the conducting bridge, t_d is the thickness of the dielectric material with dielectric constant, ε_r. **Equations 7** and **8** give the ON and OFF state capacitance of the MEMS switch respectively.

$$C_{on} = \frac{\varepsilon_o \varepsilon_r A}{t_d} \quad (7)$$

$$C_{off} = \frac{\varepsilon_o A_c A_r}{A_r * \left(g_o + t_d/\varepsilon_r\right) + A_c * (g_o)} \quad (8)$$

where A_c and A_r is the area contacting the signal and ground line, respectively.

Fringing Effects

The "OFF state" fringing capacitance of RF MEMS shunt switches is estimated to be between 0.2 and 0.6 times C_{off}. The "ON state" fringing capacitance is approximately 0.05 times of C_{on}. The equation for the switching capacitance (C_{switch}), which includes the effects of fringing capacitance, is therefore given by:

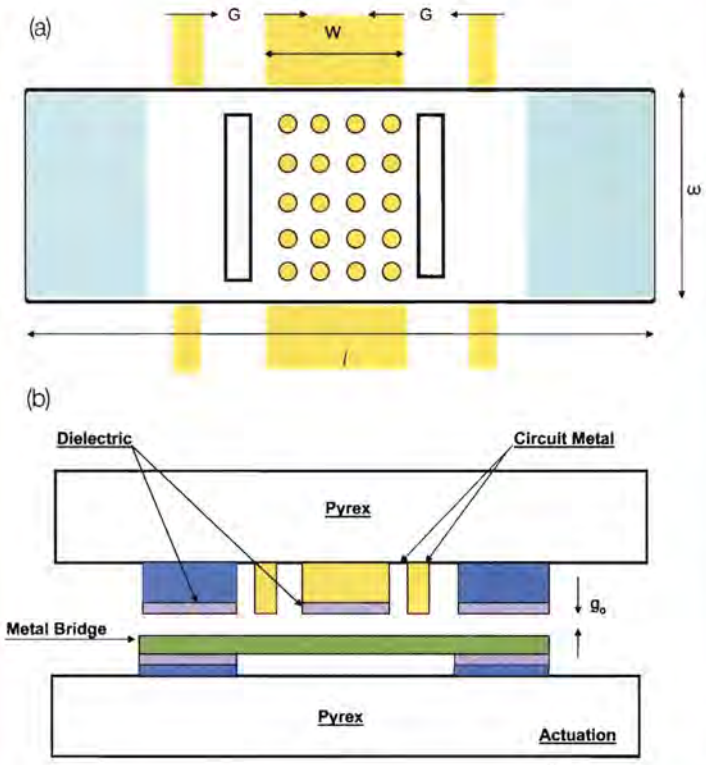
$$C_{switch} = \frac{\varepsilon_o A_c A_r}{A_r * \left(g_o - z + t_d/\varepsilon_r\right) + A_r * (g_o - z)}\left(1.6 - 0.55\frac{z}{g_o}\right) \quad (9)$$

Figure 3 shows that the fringing capacitance results in a 0.1ms reduction in the actuation time of the switch. The fringing capacitance affects a reduction in the release time of 0.05ms.

Effects of Damping

The small displacement damping coefficient for a pair of parallel plates can be written as:

Figure 2: Illustration of a proposed MEMS shunt switch shown in (a) plan view, (b) cross section



$$b = \frac{3}{2\pi}\frac{\mu A^2}{g_o^3} \quad (10)$$

where μ is the air viscosity and A is the area of the armature. Because of the double air gap of the proposed design, the damping coefficient, b, is doubled.

As the damping force is dependent on the displacement of the conducting bridge, a constant damping coefficient is insufficient to provide a clear behaviour of the bridge when it is switching. Peroulis derived a displacement compensating damping equation for modelling large displacements:

$$b = \frac{k}{\sqrt{\frac{k}{m}Q_o\left(1 - \left(\frac{g_o - g}{g_o}\right)^2\right)^{\frac{3}{2}}}} \quad (11)$$

L	340μm	G	30μm
W	50μm	W	100μm
g_o	2μm	Mass	1.31×10^{-10}kg
t_d	0.1μm	V_{act}	0.34V

Table 1: Proposed dimensions of the optimised MEMS switch, based on the switching time and for a specific voltage

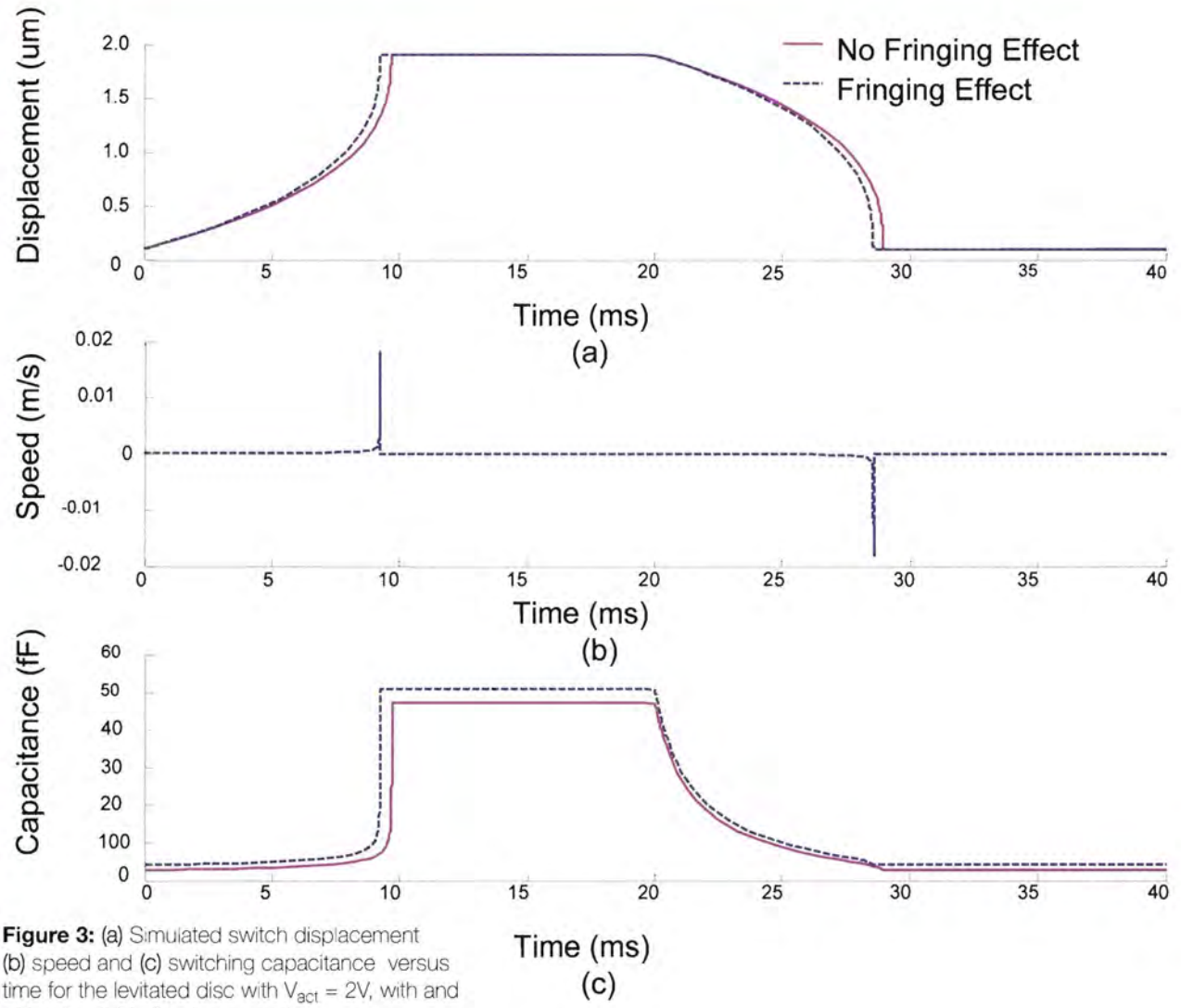


Figure 3: (a) Simulated switch displacement (b) speed and (c) switching capacitance versus time for the levitated disc with V_{act} = 2V, with and without variable fringing capacitance

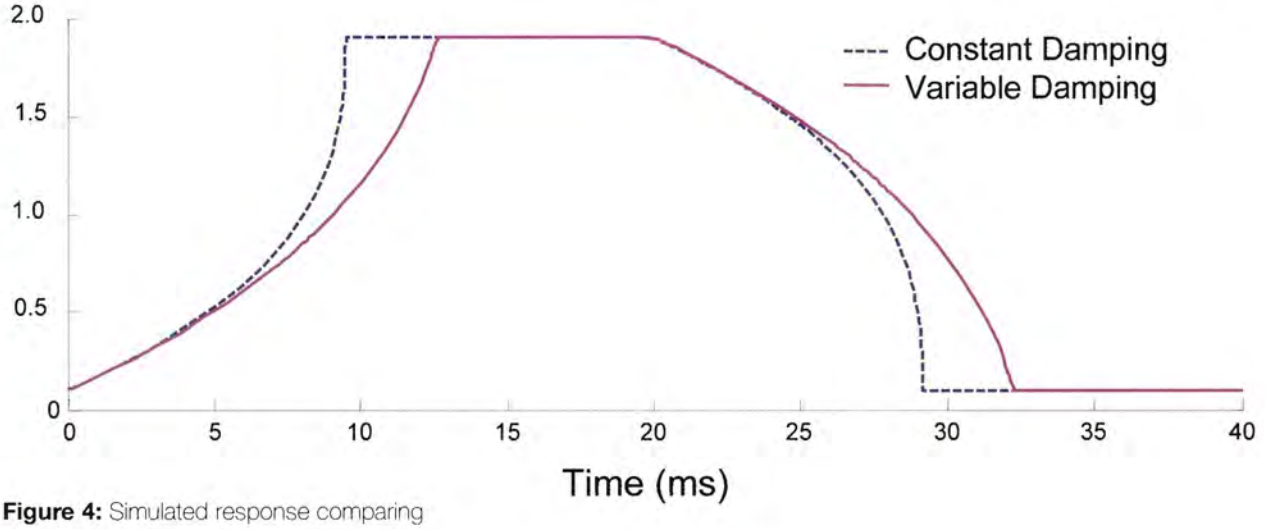


Figure 4: Simulated response comparing the effect of variable damping (VD) and constant damping (CD) for a nickel switch

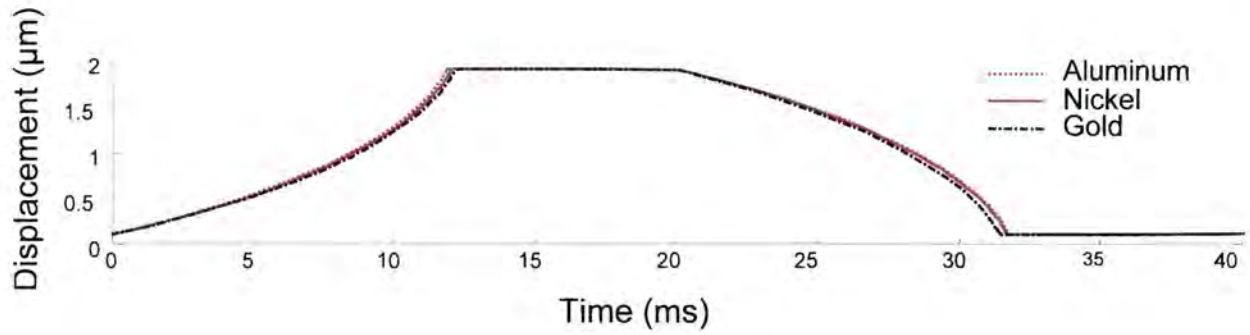


Figure 5: Simulated response comparing the responses of the switch with displacement compensated damping using V_{act} = 2V for different bridge materials

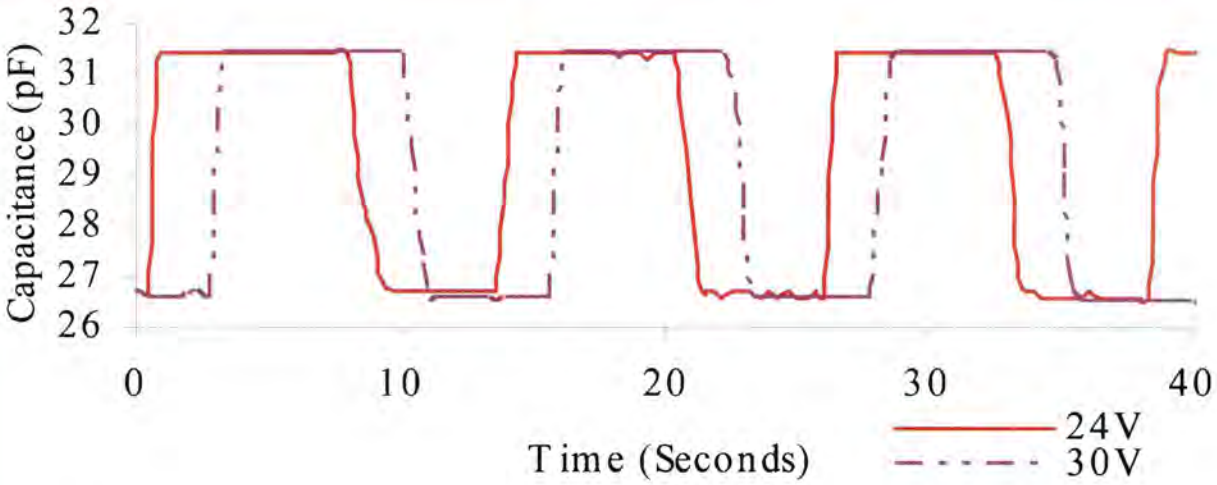


Figure 6: Experimental results of the levitated disc from the capacitance voltage measurement machine

where Qo is the nominal small displacement quality factor of the MEMS switch at $z=g_o$. The spring constant is calculated based on expression derived by J. J. Blech in "*On Isothermal Squeeze Films*" in the Journal of Lubrication Technology, assuming a switching frequency of 10kHz. **Figure 4** illustrates the simulated results of the switch, using both the variable and constant damping. The results show that the switch response is approximately 33% slower when damping is assumed to be variable.

Effect of Membrane Material

A series of simulations were carried out to examine the effects of the material properties on the switch response.

Figure 5 shows the different responses of the springless switching membrane with an actuation voltage of 2V, using aluminium, gold and nickel. **Table 1** shows the different actuation and the release time of the different materials of the conducting bridge. It is noted that even though the density of gold is twice that of the nickel and nine times that of aluminium, the rise time and the fall time of the different bridge materials vary by less than 1%.

Experimental Results

In order to validate the concept of a springless switch, an accelerometer prototype, which is based on a levitated proof mass, was reconfigured to operate as a switch (this is described in R. Houlihan's "*The Design and Analysis of a Novel Capacitive Accelerometer*" in Electronics and Computer Science: University of Southampton, 2003). The test is set up as shown in **Figure 8**. The experiment uses only the top electrodes to levitate the disc. The bottom electrodes are grounded. Due to the size of the proof mass (diameter = 5.6mm and thickness = 380µm), actuation voltages were in the range of 20 to 50V.

The capacitive measurements from the experiment were extracted and are shown in **Figure 6**. The results show that the actuation time for the levitated disc is approximately 1.8s and 1.1s for actuation voltage of 24V and 30V respectively. The release time for the disc is about 0.36s.

Simulations were carried out using Matlab/Simulink to compare with the experimental results. A 'fudge factor' capacitance was included in the model to account for unknown capacitance sources in the experimental setup. The simulated switching capacitance

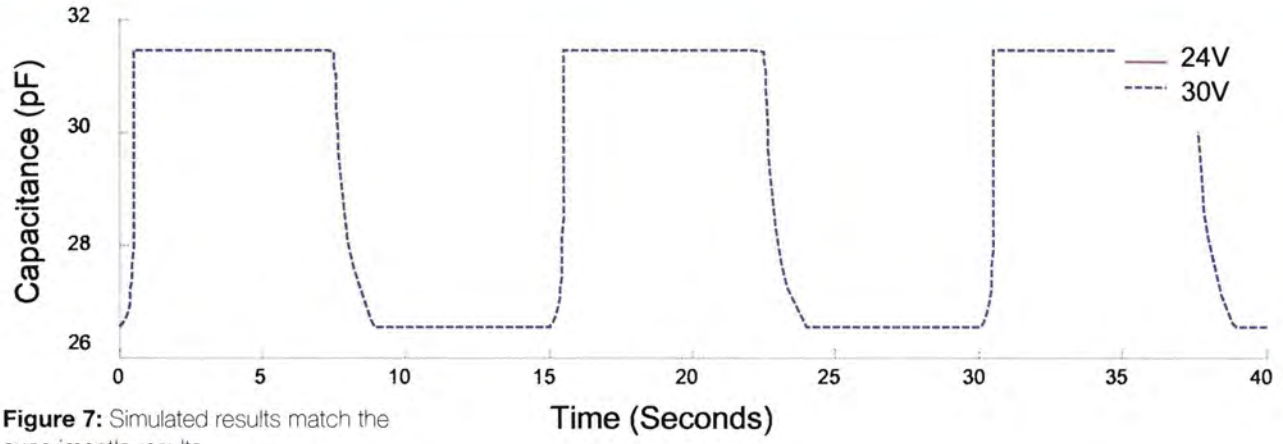
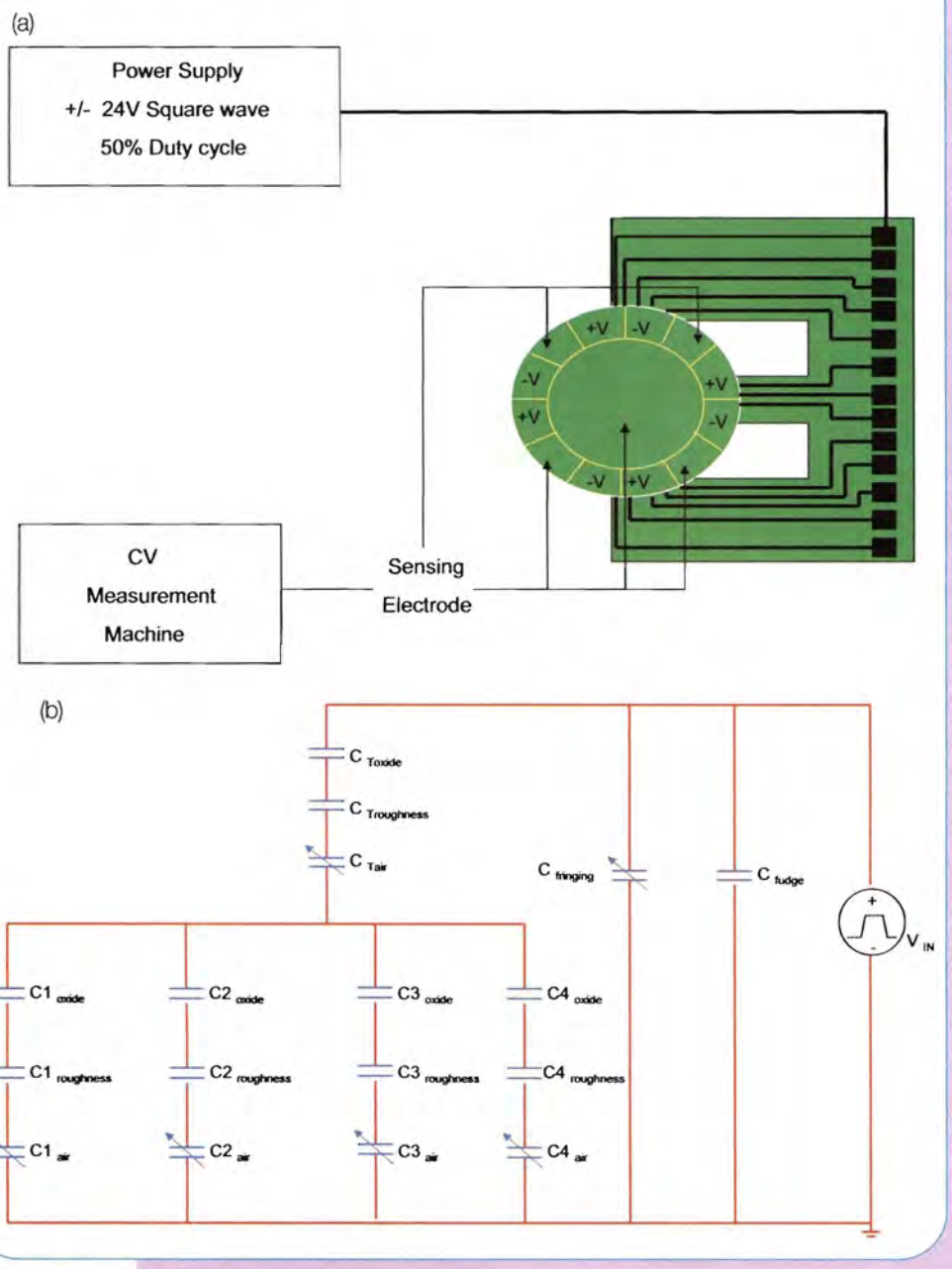


Figure 7: Simulated results match the experiment's results

Figure 8: (a) CV measurement of the levitated disc setup; (b) pick off circuit for the switching capacitance for the levitated disc



in **Figure 7**, modelled by the Matlab/Simulink model, matches the experimental results as shown in **Figure 6**.

Conclusion

Here, we presented a mechanical design of a springless switch. The theoretical actuation voltage of the switch is shown to be as low as 0.34V. The concept is tested using an electrostatic levitated disc accerolerometer, reconfigured to operate as a MEMS switch. Experimental and theoretical data for the dynamic behaviour of these devices were also presented and the results validate the feasibility of realising ultra low-voltage MEMS switches using electrostatic levitation.

Although much literature on RF MEMS switches is devoted to reducing the spring constant using complex anchor configurations, it has yet not been suggested to develop a switch with a zero mechanical spring constant. A Matlab/Simulink model was employed to simulate the one-dimensional mechanical response of a novel springless MEMS switch.

The effect of fringing capacitance was found to increase the attraction force when levitating the conducting bridge. The variable damping model, which accounts for the 'real time' damping force with the variation of the capacitive gap, requires a longer switching time when compared to the constant damping effect model. The effect of different switching membrane materials on the switching time of the MEMS switch was found to be small.

If you'd like to sample test these devices, please contact Innos at info@innos.co.uk or call 0870 8746667

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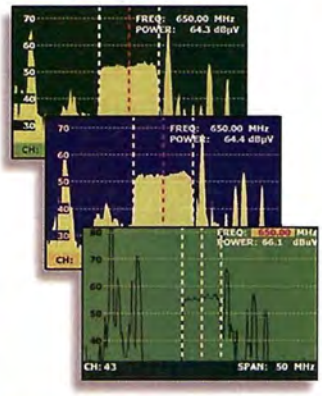

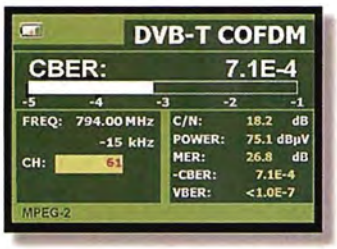

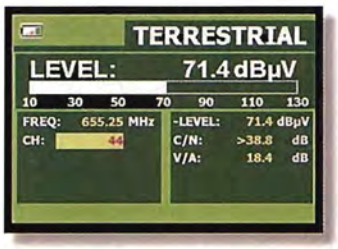

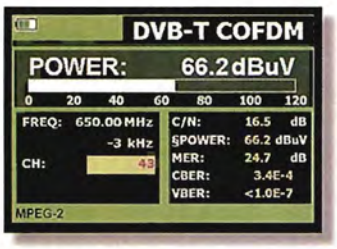

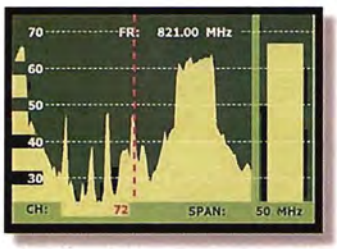

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THE ADOPTION OF PCI EXPRESS IS CREATING A NEW CLASS OF POWERFUL, RUGGED AND YET COMPACT EMBEDDED SERVERS IN THE 3U FORM-FACTOR. THIS EVOLUTION CAN ONLY GET BETTER, EXPLAINS **ANDREW BROWN,** MARKETING MANAGER AT INOVA COMPUTERS

PCI Express has the most momentum among today's high-speed point-to-point serial links, and its adaptation for the rigorous environmental requirements of embedded applications has created a capable foundation that will last well into the future.

With this adaptation of the CompactPCI Express (PICMG EXP. 0 R1.0) standard, applications traditionally reserved for 6U boards and systems, can now be realised in the more compact and robust 3U form-factor. And even more robust solutions are possible by integrating the Intelligent Platform Management Interface (IPMI) technology of the enterprise server world, with its remote diagnostic and maintenance functions, to create a platform that's suitable for the most mission-critical embedded applications. "CompactPCI Express Robustness" is what one might call it.

The transition from shared multi-drop parallel buses such as PCI, to point-to-point serial links such as PCI Express has major performance and architectural ramifications. Although 14-year-old PCI (and 10-year-old CompactPCI) are growing somewhat long in the tooth, they still provide adequate bandwidth for many embedded applications. Nevertheless, traditional buses fall far short for various types of systems with very heavy-duty I/O handling requirements, and they can quickly bog down. Systems collecting large quantities of sensor data in geophysical, medical and military applications are typical examples. Here, the more flexible and extensible point-to-point links run rings around buses.

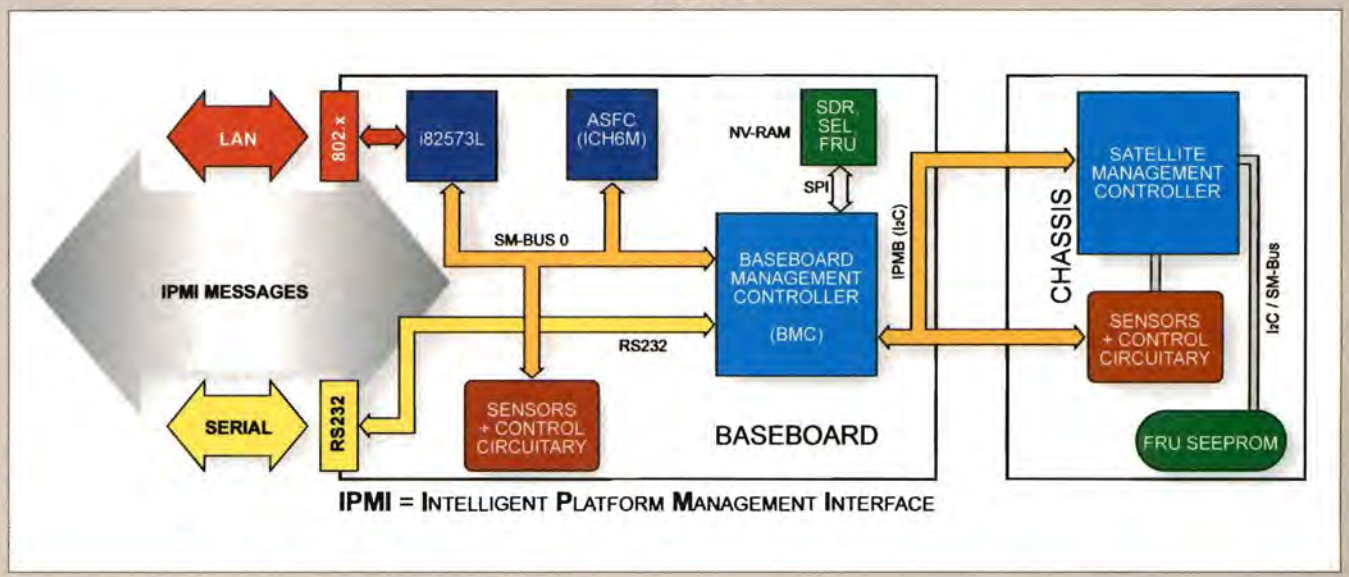
Bandwidth Unlimited

PCIe differs entirely to the 32/64-bit PCI and PCI-X shared parallel buses as it is a scalable, high-speed, serial, packet-based architecture, that was designed to overcome the bandwidth limitations of PCI/PCI-X, yet still provide new standardised features and help speed up a project's time-to-market.

A conventional 32-bit, 33MHz PCI bus has a maximum data transfer rate of 132Mbytes/s. Doubling the frequency to 66MHz boosts that figure to 264Mbytes/s, a capability which both 3U (100 x 160mm) and 6U (233.35 x 160mm) CompactPCI boards can support. With their additional connector space, 6U CompactPCI boards can also double data path width to 64 bits to achieve 264Mbytes/s, and if

Figure 1 (left): The new IPMI-aware PM2e 'GoldMine' CPU combines high performance with fault tolerance and high availability. Superior serial interconnection capabilities in the form of Gigabit Ethernet, serial ATA and CompactPCI Express make it the platform of choice for applications ranging from fast data acquisition systems to embedded server applications

Figure 2 (below): The Intelligent Platform Management Interface (IPMI) defines sophisticated monitoring and management capabilities, along with remote control and pre-boot diagnostics. It utilises a System Management Bus (SM-Bus) on board, an Intelligent Platform Management Bus (IPMB) within a chassis, and either a local area network or simple RS232 serial interface for remote access, monitoring and control



they double both the data rate and bus width, they reach 528Mbytes/s. The multiplication of lines in a 64-bit implementation and the additional real estate of the 6U format, of course, add substantially to board and system cost.

PCI Express, by contrast, began life beyond the GHz frontier at 2.5GHz, and 5GHz is now on the horizon. At 2.5GHz, the minimal PCI Express configuration – a x1 ("by one") link consisting of a single "lane" – supports an equivalent unidirectional data transfer rate of 250Mbytes/s that equates to an impressive bidirectional rate (in full-duplex mode) of 500Mbytes/s. (A PCI Express lane contains two sets of differential pair wiring: one set for input [receive] and one set for output [transmit].)

An x4 configuration boosts that to 1Gbyte/s and 2Gbytes/s respectively, with larger lane counts bringing yet greater rates – to a maximum of 4 and 8Gbytes/s, for unidirectional and bidirectional communication using an x16 implementation at the initial PCI Express frequency of 2.5GHz. When considering performance in terms of bandwidth/line, the point-to-point edge over buses becomes quite dramatic.

Architectural Ramifications

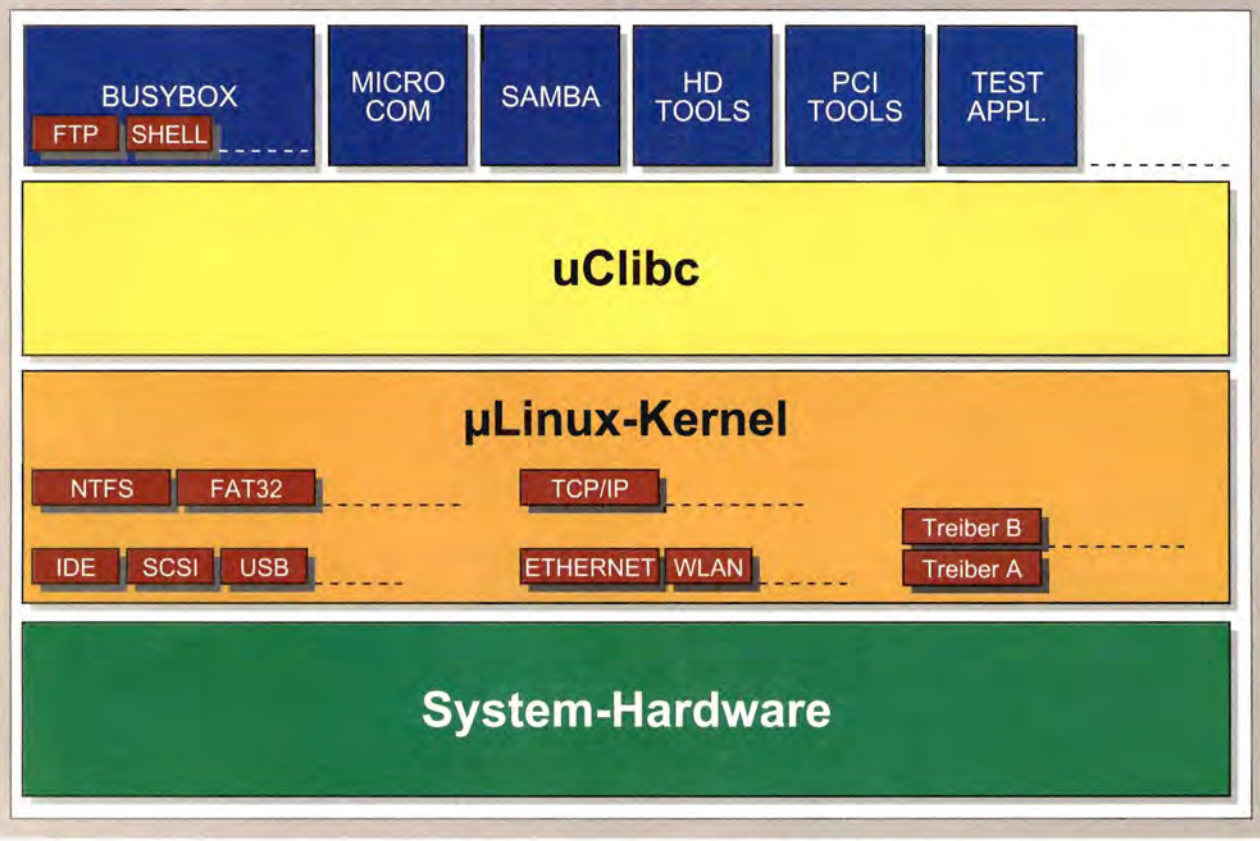
The transition from buses to point-to-point links also has architectural ramifications, which themselves affect the performance picture. A bus is a shared resource, managed by a bus arbiter, which only one device can make use of at one time. In a switched fabric, made up of individual point-to-point links, many of these links may operate simultaneously, creating an additive bandwidth effect. If, say, four x4 links in a switched fabric are all active at the same time, that adds up to 4 and 8Gbytes/s (unidirectional/bidirectional) in aggregate bandwidth.

Fabrics based on switches and point-to-point links are also far more extensible than buses, supporting an essentially unlimited number of devices. PCI buses typically support only four boards at maximum, and CompactPCI extends that to just eight. Granted, a PCI-based bus can accommodate larger numbers of boards by combining multiple bus "segments" through the use of bridges, but this can quickly become excessively complex and unwieldy, not to mention heavy in latency and costly. In fairness, it must be mentioned that fabrics also create their own complexities and latencies with issues such as packet routing, dealing with out-of-order packets, etc.

In light of the high and extensible bandwidth provided by wedding PCI Express to the CompactPCI foundation, CompactPCI Express marginalises the 6U performance advantage over the 3U Eurocard and greatly expands the performance range possible in the 3U form-factor. The smaller 3U form-factor not only has the edge in compactness and cost over 6U, but it also provides a more rugged platform due to its smaller size, lower weight, reduced inertia and freedom of mechanical stiffeners.

While it may be possible to design a 6U system with the same level of mechanical robustness, shock tolerance and vibration resistance as a 3U system, this would require a considerable amount of post-engineering, as well as substantial investment.

Figure 3: The optimal structure of the µLinux environment extends the diagnosis and remote maintenance capabilities of Compact PCI Express systems, provides rich communication and test options, and is easily extended with additional applications or kernel modules



Borrowing From The Enterprise

The inherent robustness of 3U CompactPCI hardware has been well proved under the most strenuous real-world conditions, and CompactPCI Express has expanded the application range for that hardware with its performance and architectural boost. By adopting techniques developed for enterprise-class servers, embedded servers can exist with enhanced robustness and dramatically increased reliability.

The Intelligent Platform Management Interface (IPMI), championed by Intel, Hewlett-Packard, NEC and Dell, is a well established open software standard devoted to reducing the TCO (Total Cost of Ownership) of large IT infrastructures by optimising diagnostics and maintenance procedures. It provides the wherewithal to deliver the RAS (reliability, availability, serviceability) trio of capabilities to enterprise systems for which downtime is too disruptive and expensive to be acceptable.

Current estimates place some 80% of the cost of an embedded system in software related components and events. Clearly, time is money in high end commercial applications, but RAS is at least as important in mission-critical embedded applications in industrial control, military, medical, transportation and other environments. Where downtime has enormous repercussions, IPMI benefits such as pre-boot diagnostics and operating system self-repair will be most welcome, not just in new CompactPCI Express systems, but in traditional CompactPCI systems as well.

The heart of the IPMI infrastructure is the so-called Baseboard Management Controller (BMC), an autonomous microcontroller to which the CPU and major on-board components are connected via a System Management Bus (SM-BUS) (see **Figure 2**). Based on a straightforward request/response protocol, communications over this bus are conducted using a set of standardised messages between the BMC and various board components. An Intelligent Platform Management Bus (IPMB), in turn, connects the BMC to a so-called Satellite Management Controller (SMC) and provides access to all system components. When connected to an external server running a remote management console, the BMC communicates using either an IPMI-capable Ethernet controller or a standard RS232 serial line.

Among other aspects, IPMI supports the concept of sensor data records (SDRs) and event logs, dynamically logging such parameters as voltage, current and temperature and maintaining the information in non-volatile memory. This enables proactive identification of potential hardware problems, allowing preventative adjustments to be made to operating parameters when possible, and making system operation more predictable.

Gilding The Lily

Although IPMI does not require that changes be made to a system's BIOS, doing so can significantly enhance the remote management of a system and

its auto-recovery capabilities. An IPMI-aware BIOS, for example, is capable of sending alert messages during the boot process to inform the remote management console about any malfunctions.

It is also possible to send IPMI messages from the remote management console to the BIOS to remotely control the boot process or to change BIOS settings. Application code can, further, be remotely updated without operating system involvement. The common system malfunction scenario of a hard disk image crash can be easily recovered remotely by commanding the IPMI-compliant BIOS to boot a recovery image from a medium such as a CD or a link such as RS232, a local area network (LAN) connection or the Universal Serial Bus (USB).

The aforementioned IPMI capabilities are further enhanced by integrating a bootable µLinux operating system kernel into the flash BIOS of the CPU board (see **Figure 3**). Such a kernel can be utilised to expand remote diagnostic and maintenance capabilities by incorporating, for example, comprehensive test functions, rich network functionality (including access to Windows- and UNIX-based servers) and support for various file systems in order to handle disk drive image repairs and updates.

Moreover, for some applications, a µLinux kernel (see **Figure 4**) may also be used as the main operating system, providing all the necessary driver modules for supporting on-board system components, networking and diagnostic tasks. A built-in kernel provides the ultimate in rapid system booting (three seconds), and it reduces TCO by doing away with costly operating system licenses. Further, by integrating the operating system in robust, non-wearing and vibration-resistant flash, the system is immunised against the effects associated with conventional rotating-disk mass storage devices in extreme environmental conditions, such as high humidity and/or temperature, or under severe shock and vibration conditions.

Within the embedded system lifecycle, some 60% of the operating costs are typically reserved for regular maintenance tasks. Now, thanks to the IPMI and µLinux kernel, these maintenance tasks can be fulfilled automatically in a transparent manner, thereby streamlining system management and greatly improving the system up-time.

Legs For The Future

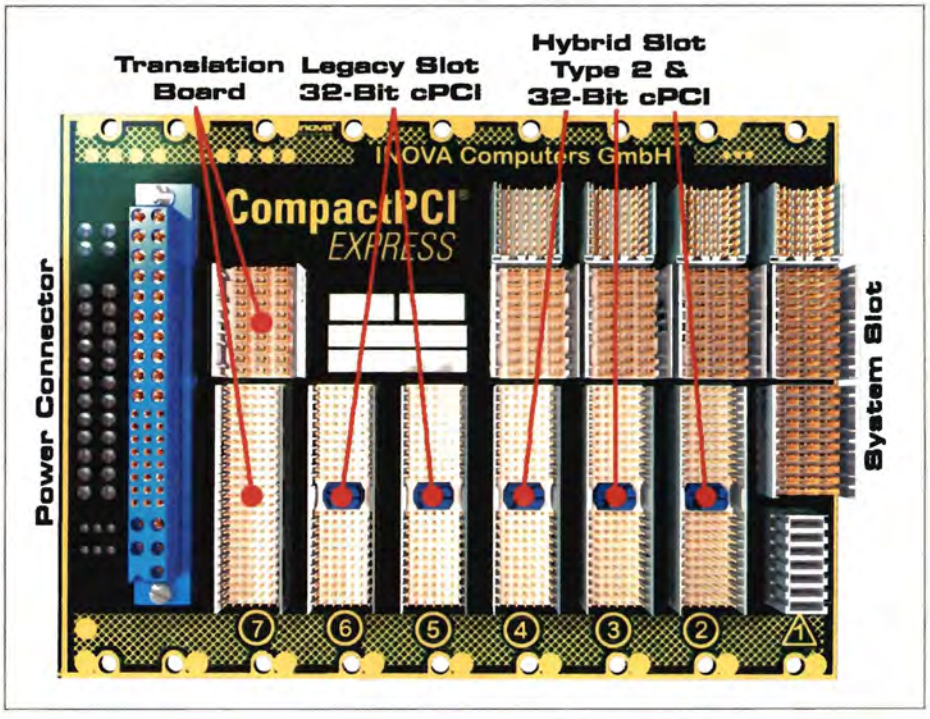
By defining a backplane environment where CompactPCI and CompactPCI Express boards coexist, the PICMG EXP.0 R1.0 standard simplifies the integration of the old and the new through a flexible backplane concept, while easing the transition between buses and point-to-point links.

Relatively undemanding functions will continue to make use of the CompactPCI bus, for example, with boards residing in CompactPCI Express legacy slots (see **Figure 5**). If and whenever a bandwidth boost is required, on the other hand, a CompactPCI board in a hybrid slot can be swapped out for an updated, CompactPCI Express version, without backplane or software change.

It is these scalable high-bandwidth, serial interconnection links that solve the bottleneck problems associated with previous (parallel) bus standards such as CompactPCI (cPCI). With the new high-speed serial links, applications reserved typically for 6U boards and systems can be realised in the more compact and robust 3U form-factor. The many advantages the smaller 3U form-factor has to offer, such as mechanical robustness and stability, tolerance to shock and vibration, compactness and economic design, permit the creation of optimised solutions.

All in all, the adoption of PCI Express and IPMI will create a new class of powerful embedded servers in the 3U form-factor, as powerful as they are rugged and compact, and as reliable as human ingenuity can (at this point in time) achieve. CompactPCI Express Robustness, indeed!

Figure 4: In this example backplane, the system CPU has four direct x1 CompactPCI Express links to three peripheral boards and one translation board. The translation board provides the interface between CompactPCI and CompactPCI Express



STOLEN VEHICLE RECOVERY TECHNOLOGY

The OnStar telematics subscription service will be a standard feature on all GM cars in the US from 2007

By Juan Pablo Conti

Vehicle tracking companies are turning to a combination of established and relatively new forms of wireless communication technologies to combat the spiralling problem of car theft. Some 1200 vehicles are stolen every day in the UK alone, where the levels for this type of crime are among the highest in Europe.

The security industry is renowned for its constant search of sophisticated technologies that could help it increase the protection of both people and assets. But just as notorious is the capacity of criminals to always find a way around the latest security gizmo.

A clear example of this is what happened to two of the really good inventions in the vehicle security area: alarms and engine immobilisers. Usually working in unison with a range of accurate motion sensors, these products have indeed become too difficult to violate for the average car robber. But that doesn't mean, of course, that there wasn't a way around them. Both car alarms and immobilisers are – practically without exception – operated from the driver's key or a device on the key ring. Steal the keys, and you could be up for one of the easiest ways there is to steal a car.

"Being able to remotely prevent a vehicle from restarting using a Cat 5 approved device will help us enormously" - Jim Hammond, spokesman for the Association of Chief Police Officers

A new, popular form of modern car crime surely ensued. The Association of British Insurers has recently found that stealing people's keys is now the UK's fastest growing type of car theft, a trend that has surged by 80% since 2002. More than 53% of stolen cars manufactured during the past six years are actually robbed this way. The situation – which is compounded by a parallel rise in car jacking, another way to bypass alarms and immobilisers – has prompted both the car insurance industry and police to do something about it.

Thatcham Category 5

Something was indeed done, and its result is what is now known in the British car security sector as the Cat 5 (or Thatcham Category 5) criteria for after-theft vehicle recovery systems. Apart from Thatcham (an independent motor research organisation), various local police forces, vehicle tracking companies and insurers were all involved in the design of the specification.

A central point in Cat 5 is the introduction of an added layer of physical security – on top of the car keys – which acts as a mechanism for double-checking the driver's identity. One of the first stolen vehicle tracking systems to be awarded Category 5 accreditation is called Auto-txt. The solution, developed by Coventry-based automotive supplier Richmond Design & Marketing, uses a Bluetooth-enabled device (usually a mobile phone) as the required "secondary key" to authenticate the car's legal owner.

Using Bluetooth's short-range wireless connectivity, the vehicle location unit (VLU) hidden in the engine compartment automatically recognises a pre-registered mobile phone. Once authorised, the system is disarmed and the driver, who is not required any special action during this process, can drive the car as normal.

However, if the vehicle is started with the keys but the mobile phone is not present, the driver will still be able to drive, but Auto-txt automatically assumes that the car has been stolen. It immediately sends a silent alarm via GSM cellular communications to the secure operations centre (SOC), in this case operated by BT Redcare. The owner is then urgently notified that his or her vehicle has been moved without the presence of the Bluetooth "key". Should the vehicle be confirmed as stolen, the BT Redcare SOC liaises directly with the police to help them track and recover it.

As most other car tracking systems, the Auto-txt VLU comes equipped with a GPS (Global Positioning Satellite) receiver that constantly determines the vehicle's exact location (with a 5m error margin), speed, direction and time

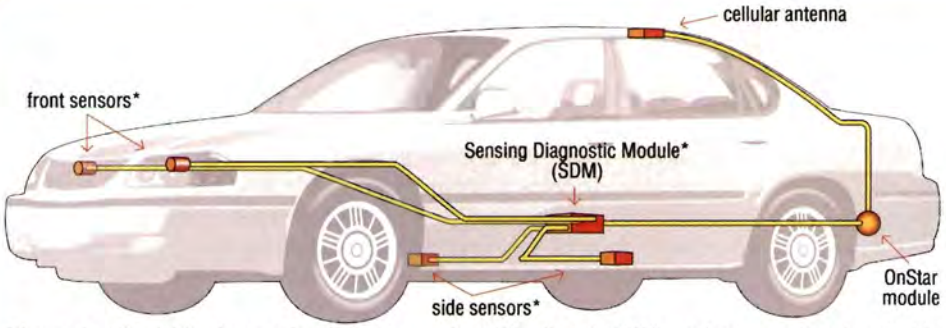


Figure 1: The GM advanced automatic crash notification (AACN) system uses front and side sensors as well as the sensing capabilities of the Sensing and Diagnostic Module (SDM) itself. The accelerometer located within the SDM measures the crash severity.

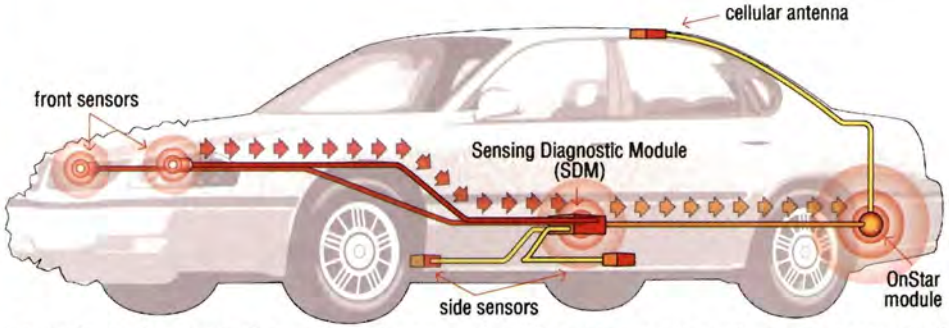


Figure 2: In the event of a moderate to severe frontal or side-impact crash, data is transmitted from the affected sensors to the SDM. The SDM sensor also can identify a rear impact of sufficient severity. Regardless of whether the air bags deploy, the SDM transmits crash information to the vehicle's OnStar module.

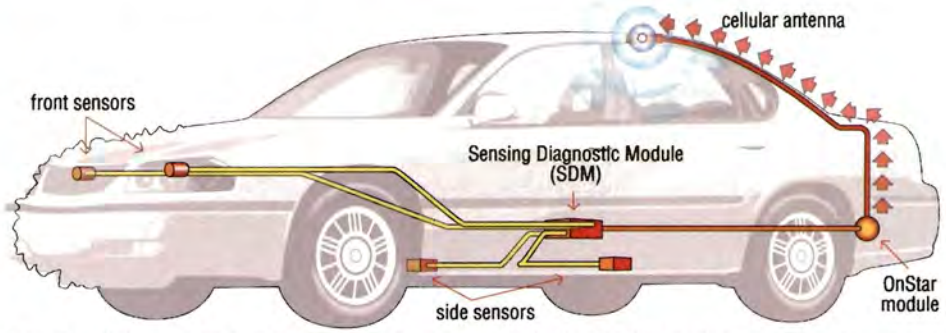


Figure 3: Within seconds of a moderate to severe crash, the OnStar module will send a message to the OnStar Call Center (OCC) through a cellular connection, informing the advisor that a crash has occurred. A voice connection between the advisor and the vehicle occupants is established. The advisor then can conference in 911 dispatch or a public safety answering point (PSAP), which determines if emergency services are necessary. If there is no response from the occupants, the advisor can provide the emergency dispatcher with the crash information from the SDM that reveals the severity of the crash. The dispatcher can identify what emergency services may be appropriate. Using the Global Positioning System (GPS) satellite, OnStar advisors are able to tell emergency workers the location of the vehicle.

*Number and location of sensors and SDM may vary depending on vehicle model.

Sensor-based OnStar telematics system

parameters. This data is constantly transmitted during the recovery attempt using the unit's GSM modem, which communicates with the cellular base stations of a partner mobile phone operator. This communications architecture allows the car to be tracked not only in the UK but also across 31 other European countries, if necessary.

A second important feature that Cat 5 brings to stolen vehicle recovery systems is the possibility to remotely immobilise the engine from the SOC – as long as this is done under police supervision. It is a feature that Auto-txt also supports. An electric circuit linking the VLU with the immobiliser allows the tracking company to send a signal via the GSM network that will prevent the vehicle from restarting once the ignition is turned off by the robber.

"Being able to remotely prevent a vehicle from restarting using a Cat 5 approved device will help us enormously in the fight against stolen vehicle crime and may lead to a reduction in the need for police pursuits," said Jim Hammond, spokesman for the Association of Chief Police Officers. "This is one of the most important components of the new Category 5 standard systems, as far as we are concerned."

But Frank Viquez, director of transportation research with ABI Research, is not so convinced that a standardised approach to car security is the best available option:

"You always have companies that are moving out and pushing their proprietary technology, both for competitive and security reasons. It's kind of a double-edge sword – having standardisation does bring down costs and the technology goes to more people, but the negative side to that is more people have access to it. That would also include very savvy thieves and anyone looking to hack such a technology."

The RFID Option

An alternative short-range wireless technology for the authentication function is RFID (radio frequency identification). BT recently launched its own Cat 5 certified stolen vehicle recovery system, based on this very concept. Unlike the Auto-txt solution, which simply requires that the driver carries their mobile phone with them, the BT Trackit system demands that a tag (or smart-card) featuring an RFID transponder is worn by the owner or authorised driver. Then the authentication, alarm communications to the SOC, user notification, police involvement, GPS tracking, remote immobilisation and recovery process works in almost identical fashion to the Auto-txt solution.

In fact, a host of competing companies are offering similar services in the UK, and – with the exception of some minor variations in things like pricing, chosen mobile phone operator or cellular air interface – they all operate using the same basic technology architecture. Some of these players include Trafficmaster (it offers a service

called RAC Trackstar), Tracker, T-Track, Iris Automotive and NavTrack.

Another common characteristic of these systems is the existence of a back-up battery as part of the VLU package. This is to prevent criminals from blocking the unit's power supply by intentionally disconnecting the car battery. Typical power consumption for all these systems is around 10mA.

ABI Research analyst Viquez says the regions where these aftermarket products are more popular are Latin America, the UK, South Africa and some parts of Australia, followed by North America and Germany. The US is actually home to what is arguably the most famous of all stolen vehicle recovery companies: LoJack.

RF Beacons

LoJack is not only the world's largest player in this industry, with nearly 200,000 vehicles recovered so far in the 25 countries where it operates, but it's really the company that invented this idea nearly 20 years ago. And while LoJack now also uses GPS satellite technology in most of these markets, it is the use of a different, radio frequency (RF) based tracking system in the US and Canada that sets it apart.

LoJack also hides a card deck-sized transceiver in up to 20 different secret places in the vehicle, with management of the system performed from a central operations centre. But that's about where all similarities end with GPS-based systems such as BT Trackit or Auto-txt. Here, there are no satellites involved. The vehicle tracking calculations are carried out by the interaction of the car's transceiver with both a purpose-built network of fixed basestations and mobile transceivers fitted on police patrol vehicles, including helicopters.

Following a long controversy, in 1992 the US Federal Communications Commission permanently assigned the 173.075MHz RF frequency for this service. When a car is reported stolen, its covert VLU – which is constantly operating on 'receiving' mode – is remotely activated via an FM sub-carrier sent from the LoJack network of transmission towers.

> **"I see this sector [telematics] as very stagnant right now" Frank Viquez, director of transportation research, ABI Research**

This prompts the location unit to start emitting a uniquely coded RF signal (or beacon, consisting of a 200ms burst every second). The beacon is captured by nearby police vehicles and ground base stations, which use field strength measurements and directional receivers to determine the car's exact location. The entire process, from reporting the crime to recovering the asset, can take anything between one and four hours. And the company claims it has a 90% recovery success rate.

Supporters of the RF-type of location technology argue that it has considerable advantages over GPS. Chief among them, they insist, is the fact that it offers increased security. While most GPS-based tracking systems require direct line-of-sight to the sky in order to capture the weak satellite signals, systems such as LoJack can track assets located in dense foliage, underground car parks, warehouses or even shipping containers. Weak GPS signals also translate into higher vulnerability to local noise and interference, and it is known these systems can be easily jammed with the help of some inexpensive devices. GPS solutions also require an external antenna, which can obviously be easily found and neutralised by potential aggressors.

Another argument against GPS-based tracking systems is that, since the computing of the location has by necessity to be performed at the receiver, their required processing power, cost and size are all higher than RF transponders, which only act as communication devices, leaving all computational matters to the network infrastructure.

So, with so many apparent disadvantages, why are most stolen vehicle recovery solutions still focusing on GPS? Well, first and foremost, because building your own communications network infrastructure isn't precisely inexpensive. And even if you do go down this route, you could never afford to match the geographic coverage that a cellular company will be able to offer you, both at home and abroad.

Car Makers Take All?

Asked about what the future holds for stolen vehicle tracking technology, Viquez confidently forecasts a gradual shift from aftermarket to car-maker-fitted systems. "We don't see the aftermarket systems existing as standalone products," he says. "I hate to be a negative person here, but I see this sector as very stagnant right now. I don't want to use the phrase 'dying a slow death', but I think there'll be a shake-up in this industry moving forward. I don't see much growth in it at all because there's a growing competition coming from several different venues, the biggest being the whole OEM side, where you are having telematics systems being fitted on a factory level."

Nowhere else is this trend being already as clearly materialised as in the US and Canada, where General Motors has been selling a growing number of its car brands with an incorporated subscription-based telematics service. Marketed as OnStar (or ChevyStar in Venezuela, Colombia, Ecuador and Brazil), the service offers stolen vehicle recovery as just one of several other telematics functions. Things like automatic notification of air-bag deployment, remote door unlocking, integrated cellular hands-free calling, remote car diagnostics, roadside assistance, driving directions and even remote activation of horn and lights, in case you can't find your car in a large parking lot, are all included as part of the same package.

GM's OnStar, which also uses a combination of GPS and cellular communications to route all data between vehicles and control centre, has already signed up more than three million subscribers in the US alone. When you consider that "the total number of aftermarket stolen vehicle recovery users globally is about half a million on the consumer side (i.e. without including commercial vehicles)", as Viquez points out, it's easy to understand where he is coming from when he talks about an imminent industry shake-up.

And almost as if wanting to back him up, both Jaguar and Land Rover recently announced that, starting this year, all of their vehicles in Europe will be fitted with factory-installed car tracking systems. Just as Porsche already does and – by the look of it – probably every other car manufacturer will end up doing sooner or later.

Living with RoHS – the big questions

Now that RoHS is law (as of 1st of July this year), there are more questions than ever about how to cope with it. Recent research showed that the UK wasn't prepared for the deadline. Only 12% of design engineers, buyers and MRO engineers were fully compliant in readiness, ahead of RoHS officially coming into force. Whilst 37% of respondents revealed that they were "close to becoming compliant", a further 28% confessed that they had only just "started to become compliant".

There's still clearly a lot that needs to be done by the design engineering community but the main thing for engineers to realise is that they aren't alone in their quest to become compliant. Wide ranges of support services exist to help people along the way, such as those on offer at www.rohs.info. The fact that the deadline has passed means that it is even more important to access the help that exists.

The research – which was conducted amongst 263 UK design engineers, buyers and MRO engineers – shows that distributors are playing a vital role in ensuring compliance is achieved. Around 46% of those surveyed had chosen to approach a distributor for reliable RoHS support, followed by 22% who preferred to directly approach the manufacturer. Interestingly, only 9% have been relying on the government for RoHS support.

By its nature, online support is the fastest way to find out about the latest RoHS complaint products. Signing up to automatic email notification or online 'Bill of Materials' conversion services are effective ways to get new part numbers for old non-compliant components and upgrade to the latest RoHS offerings. But being able to speak to experts is also proving key for engineers who have achieved compliance.

Whilst 53% of respondents from the research considered online technical help and support services to be either "extremely" or "very" important, 39% also considered telephone technical help and support services to be "extremely/very important". There are still many grey areas around the new legislation that people are unsure about – exemptions and due diligence are just two of the 'hot potatoes'. Being able to access expert opinion over the coming months on these issues will be hugely important as the real effects of RoHS start to take place.

There are still many questions that need answering about the scope of the legislation and it will be essential to keep on top of the products that are under review for exemption. A recent example of this is semiconductor evaluation boards. Distributors and manufacturers alike believed these to be out of scope but the National Weights and Measures Laboratory, the body responsible for policing RoHS, has decided they're in.

It often isn't clear if a product is within the scope of RoHS or not. The situation for many types of industrial product will depend on how they are used. Equipment that is not dependent on electricity is also excluded such as gas boilers and petrol lawnmowers.

Q: We have moved fairly promptly on converting our production line to lead free and now our ranges are compliant. However, we still hold stock of a number of our ranges that are non-compliant. They are boxed and held within our warehouse, which is part of the factory and, therefore, not in an alternative location. Are we able to sell these items after the deadline? Serial number records would show they were made well before the deadline.

David Gear, UK

A: Unfortunately, according to the definition of 'put onto the market' in The Blue Book, products manufactured and ready for sale but still at the place of manufacture have not legally been put onto the market as no 'transfer' has taken place. Advice from National Weights and Measures is that change of ownership or moving these to a different address meets the legal requirements for 'put onto the market'.

Q: I'm confused about the changing status of components. If a part is under review can it still be used if it isn't compliant?

A: All exemptions are temporary and are reviewed for possible inclusion in the directive by the European Commission every four years. There are currently 20 exemptions adopted with around 80 still to be reported on. Whilst a product is under review it is considered to be within the scope of RoHS and is therefore liable to inspection, testing and any penalty that National Weights and Measures deem suitable.

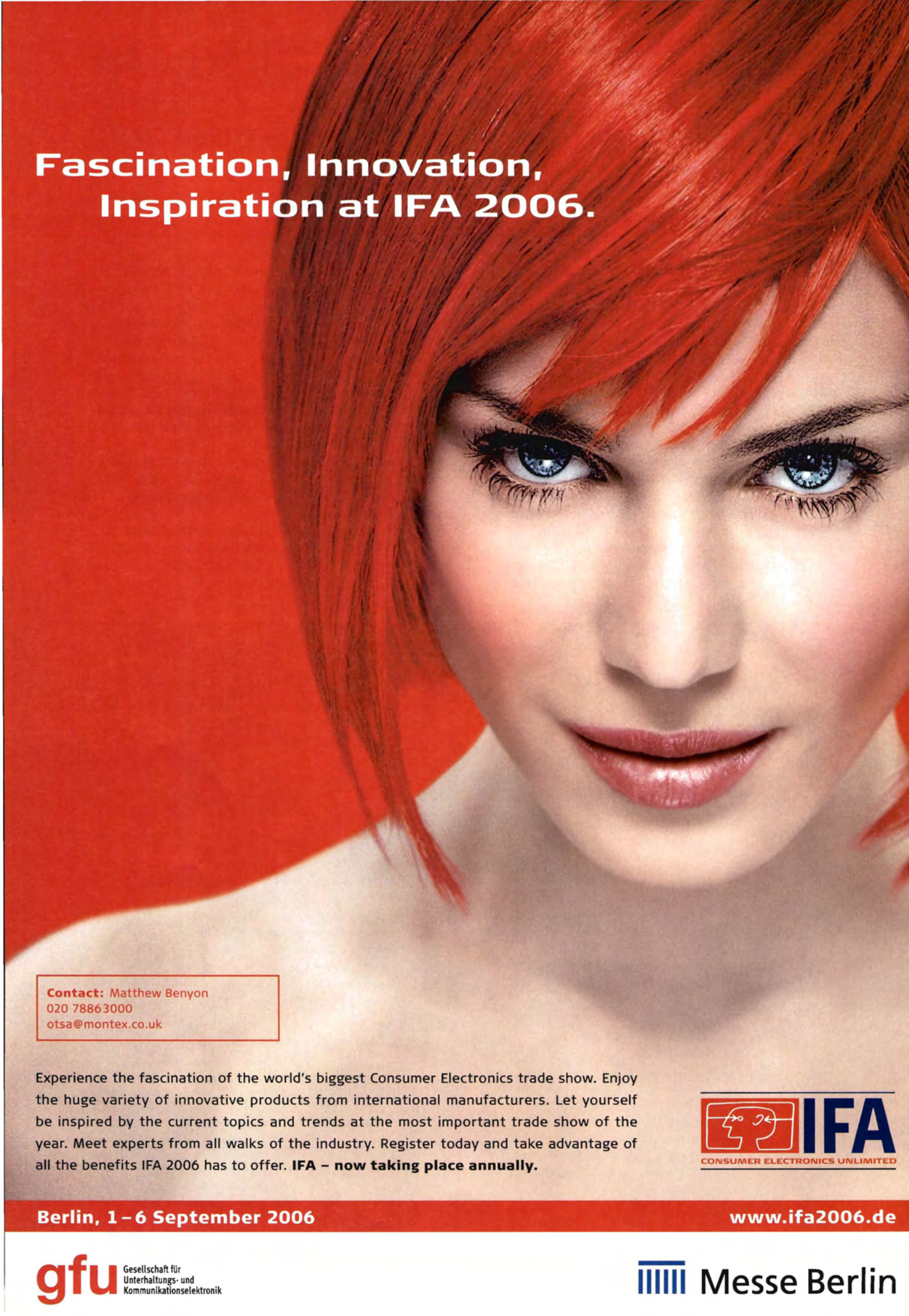
Q: Do prototypes need to be RoHS compliant?

A: The RoHS directive applies to new products placed on the market. 'Unfinished' goods, such as prototypes and refurbished equipment are, therefore, outside the scope.

Q: I hear that categories 8 and 9 are under review? How quickly will a decision be made on this?

A: A review is indeed underway. Products in categories 8 and 9 covering medical devices (with the exception of all implanted and infected products) and monitoring and control instruments are currently excluded from RoHS, although they are within the scope of WEEE. In the event that they are brought within the scope, it is thought this will not happen until 2010, following debate in the EP and transposition into law.

Gary Nevison is chairman of the AFDEC RoHS team, board director at Electronics Yorkshire and head of product market strategy at Farnell InOne. As such he is our industry expert who will try and answer any questions that you might have relating to the issues of RoHS and WEEE. Your questions will be published together with Gary's answers in the following issues of Electronics World. Please email your questions to EWeditor@nexusmedia.com, marking them as RoHS or WEEE.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An anomaly with RoHS

There is an anomaly with RoHS PCBs, which most of the industry is either unaware of or is tending to ignore.

I have contacted PCB manufacturers and process and assembly houses – a lack of knowledge and understanding in these matters is quite evident. It is clear that direction and/or advice is severely lacking – as is a reliable source for the necessary answers.

A "standard" FR4 PCB RoHS certified when correctly processed with lead-free components should meet RoHS requirements.

FR4 is available in several grades with respect to thermal behaviour – the present and most commonly used form of FR4 may lose integrity when thermally cycled at the elevated temperatures as required by lead-free processing.

A double-sided PCB populated on both sides and then hand-reworked with Select On Test components may appear viable on completion but the longevity of such an assembly under normal usage – thermal stress, vibration, humidity and shock etc – must now be questionable.

John Bebb

RoHS pickle

I am not totally conversant with the future processes using HMP solders but, clearly, the use of flow soldering will be out and the use of active fluxes in. All this points to future generations of electronics, be it televisions or computers, with a high degree of intrinsic unreliability. Possibly there will be limited warranties associated with new manufacturing processes.

The organ building craft is shaking in its shoes because of this, frankly, idiotic legislation. How did we get into this mess in the first place and what's wrong with a bit of lead finding its way back to its original resting place anyway?

Brian Daniels

Falling foul of PoE

Among other things, my company fits wireless networks to large, privately owned, yachts.

Power-over-Ethernet (PoE) has been a godsend to us – often the access points (APs) are above beautifully fitted ceilings, hidden above wardrobes in guest areas – you get the picture. So getting away from having to organise a mains supply to each AP plus (often) throwing away the "wall wart" which comes with the AP and supplying a suitable switch-mode supply, installing it reliably and then worrying about the possibility of failure or even fire is a huge plus for us. And the ability to remotely re-power an AP by controlling the LAN switch rather than hunting for the relevant circuit breaker is the cream on top.

But, on a recent installation, we were asked to mount all the APs on metal platforms – we usually use wood, but for this particular vessel, they were paranoid about the wood suffering pyrolisis and catching fire – so metal it had to be.

Each access point was carefully tested prior to the ceilings being closed, so it was with some horror that we found all sorts of things went wrong when we tried to commission the whole network.

To cut a long story short, our bench tests showed that when an AP is powered from a PoE LAN switch, its chassis measures about 36V AC with respect to the metalwork of the LAN switch. Furthermore, if you then connect the chassis' of two APs together, the LAN switch goes berserk.

The equipment we were using for this vessel happened to be Netgear, but we carried out tests with D-Link switches and APs from D-Link and 3-Com – the latter being an expensive beast.

In all cases, there is no electrical isolation between the PoE and the metalwork of the AP.

You can imagine our dismay – we have 20 APs bolted firmly to the vessel's metalwork, so the network cannot be made to operate without gaining access to each of these APs and re-mounting them using insulating hardware. We also cannot use shielded patch cords to connect the AP to its LAN socket. And I'm still trying to work out how we cope with the external antennas (where the shield is bonded to the mast).

The most extraordinary thing is that there seem to be very few references to this problem on the web. The Netgear support forum shows one or two "posts", none of which have had replies at time of writing.

In my view, the standard should insist that if a PD makes use of PoE, it should provide galvanic isolation between the power cores and any other part of the device. It is clear, though, that at least Netgear, D-Link and 3Com do not see that as necessary.

An alternative would be for each PoE source port on a LAN switch to have galvanic isolation from its brethren (and system ground), but that would require a separate

power converter (and galvanic isolation with the sensing/control electronics) for each LAN port – quite an overhead!

I should be extremely interested to know Daniel Feldman's [of Power Dsine, see *'Power over Ethernet: How Low Can You Go?'* in June 2006 issue of Electronics World, p18] engineering views on this subject – because I am well aware of the key role Power Dsine has played in this standard.

Have any other EW readers fallen foul of this?

Chris Miller, Director
Marine Entertainment Systems Ltd

Yair Darshan, Chief Engineer at Power Dsine replies:

The IEEE802.3af specification for Power over Ethernet (PoE) has defined two operating environments: Environment A and Environment B.

Environment A, used in the majority of cases, is a system where all PoE ports at the power supply equipment side (PSE or switch side) are not isolated from each other i.e. there are no port-to-port isolation requirements. The only isolation requirements at the PSE side are between the port leads to the PSE chassis ground or its metal frame.

On the powered device (PD) side, such as the AP or other end-user device, there is an isolation requirement between PD ports, which means that each PD is isolated from other third party devices or ground.

In this case, each port is kept floating compared to other ports and the system operates without a problem.

This means that you cannot connect AP devices where part of the RJ45 leads are grounded to the AP metal frame (if it is a metal frame) and, obviously, you cannot mount all APs on the same metal wall or equivalent.

So, the situation that you have described violates IEEE802.3af specification and, obviously, will not work.

Environment A equipment is the most cost-effective solution and answers most of the market scenarios.

The other system 'Environment B' defined by IEEE802.3af must be used in the case of ground loops, system segments which are located in different buildings, where the power source for each port is referenced to different grounds and if the powered device is not floating. Environment B, in line with IEEE802.3af specifications, requires isolation between PSE (switch) ports in the case of a multi-port system. This kind of equipment is more expensive in relation to Environment A, however it will solve your problem.

In summary, the solution for your problem is either one of the following:

1. Mount all access points on non-conductive, fire-proofed mounting material and not metal case.
2. Use PowerDsine's single port Midspan for each AP (this would offer the lowest cost solution and be fastest to implement).
3. Use Environment B equipment with an isolation between PSE (switch) ports for a multi-port system.

Missing vital information from data sheets

I operate a small consultancy company in South Africa, designing bespoke RF systems. Recently I have been asked to develop a range of low-noise receiving amplifiers for a radio astronomy system. At first it did not seem to be a lot of work but, recently, I have been frustrated by the data – or lack of it – that semiconductor manufacturers give out.

Along with about 99% of similar RF design engineers, I have invested heavily in computer simulation software to model devices. The problem arises because the various semiconductor manufacturers supply either incorrect data or omit vital information from their data sheets.

A typical example is Vishay. They manufacture a range of some very low-noise, dual-gate Mosfets suitable for VHF and UHF applications, but the data sheets give either incorrect data or none at all. A common feature of their data sheets for the dual gate Mosfets states "Excellent cross-modulation performance" but nowhere is any information given of the parameters or how they are determined! This is a fundamental requirement. How can they claim "low cross modulation" and then omit to back up the claim? They are not responding to my recent emails and I can only assume they do not want to talk to me.

Another problem is the format that they give the S parameter data in. Here, they state "LOG MAG" but the data is clearly not in this form. Software packages rely on the data being in LIN MAG format, the convention being used by Compact Software, EESOFT and Agilent. By comparison, Agilent Semiconductors, now known as Avago Semiconductors, as well as NEC, give the data in the correct format. So, using their data I can get within 5% of a total solution using computer software. Unfortunately, they do not make the type of devices I require at present.

A response I got from one manufacturer when I asked if noise and S parameter data were available was "Why would you need that information?" Clearly, the calibre of technical application engineers has seen a severe decline in the last few years.

A further complication is the fact that some manufacturers give data for noise figures, which is quite obviously wrong. I have tried to correspond with some of these companies but just got the brush off. One manufacturer stated that a device had a noise figure of 2dB at 200MHz, but at 45MHz the noise figure was almost 3dB more. This defies the laws of physics. No low noise device I know of has such characteristics. The only explanation I can come up with is that the test circuit they used to assess the noise performance must be very lossy. When I broached this subject to try and get an answer, the correspondence was abruptly terminated.

So, until the manufacturers selling these products come clean and give us the true story they are going to see a distinct turn down in sales because no one will design their products into a new design.

John Fielding
B&G Electronics

Tracking an instrument down

I am looking for a very small, position tracking instrument that can be used indoors and outdoors to track moving equipment every moment of the day via a computer server, which will, in turn, inform the supervisor via a mobile phone SMS once the equipment moves from a fixed position. This instrument should be easy to hide.

We would like to monitor, track and trace these small instruments on a laptop or a palmtop server monitor at all times in case of theft, so that the police and security agencies can be notified immediately.

We will like to buy these products in bulk as it could be that we would want to track and trace over a million of such instruments. The dimensions of this device should not exceed H25mm, L25mm and D10mm.

I'd like a quote on the development of such a product as well as the software that will be able to achieve what's been described. Otherwise, a referral to someone who can help will be greatly appreciated.

Cornel Viljoen
Acting Senior Foreman (Ore processing)
[Contact details available on request at the editorial offices]

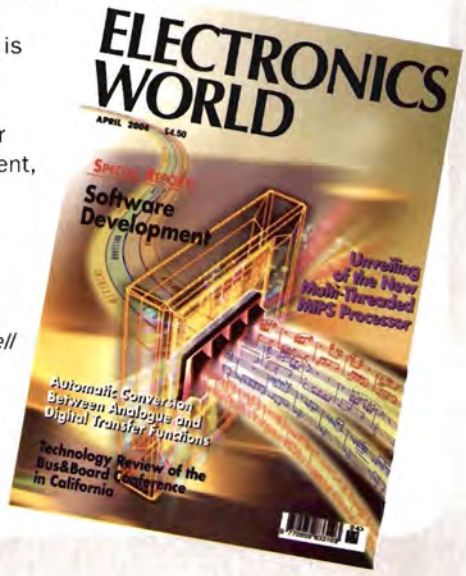
Check that power dissipation

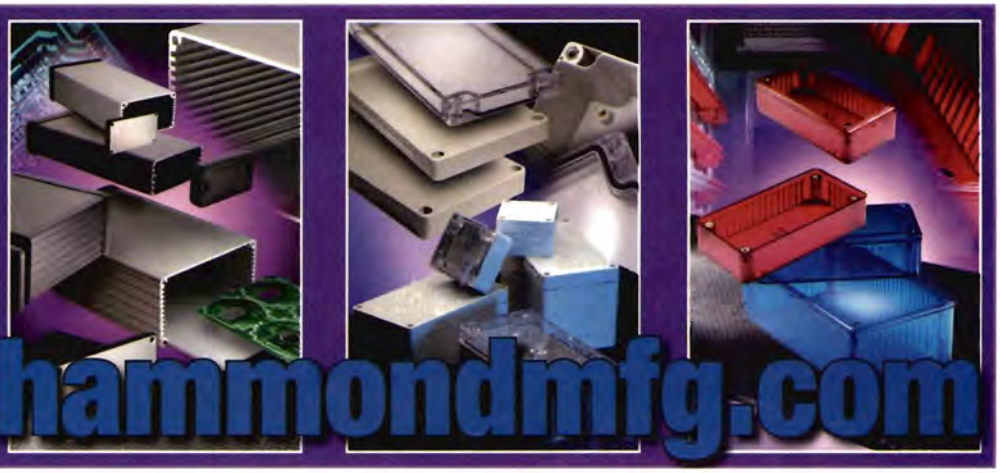
Congratulations on taking over at Electronics World. You are doing an excellent job!

A propos front-cover article in the April issue of Electronics World magazine: does the featured multi-threaded MIPS processor overheat?

The reason I ask is that thermal considerations dominate processor design at the moment, and the MIPS processor is a low-died, high thermal density chip, i.e. prone to hot spots.

Allan Campbell





Low-Voltage Rectifier

The rectifier in Figure 1 provides larger output voltage than does the conventional rectifier in Figure 2. The drawback of the conventional rectifier lies in the fact that its output voltage is substantially smaller in comparison with the amplitude of the input AC voltage when the amplitude of the input AC voltage is small. 1.2V is used up in the conventional rectifier (Figure 2) because each diode uses 0.6V when conducting and there are always two diodes conducting.

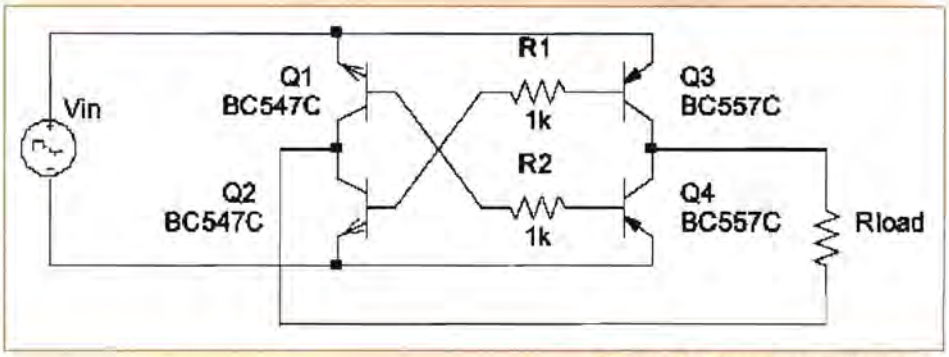


Figure 1: Proposed rectifier circuit

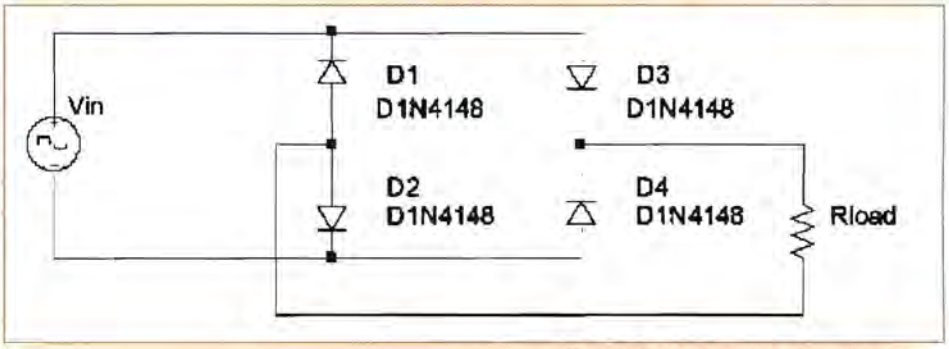


Figure 2: Conventional rectifier circuit

The proposed rectifier's operation is easily understood one half-cycle at a time. Consider the first half-cycle, when the source voltage polarity is positive on top and negative on bottom. At this time, transistors Q2 and Q3 are in saturation; resistor R1 provides necessary base current to open the transistors. In the same time transistors Q1 and Q4 are reversed. The reverse beta of bipolar transistors is negligible in comparison with the forward beta, so the emitter-collector voltages of the transistors Q2 and Q3 are very small in comparison with the emitter-collector voltages of the transistors Q1 and Q4. As a result, the voltage amplitude across R_{load} is almost equal to the voltage amplitude of the AC voltage source.

During the next half-cycle, the AC polarity reverses. Now, transistors Q1 and Q4 carry current, while transistors Q2 and Q3 are reversed. In other words, the change of the AC voltage source polarity switches transistors from the forward mode to the reverse mode and vice versa.

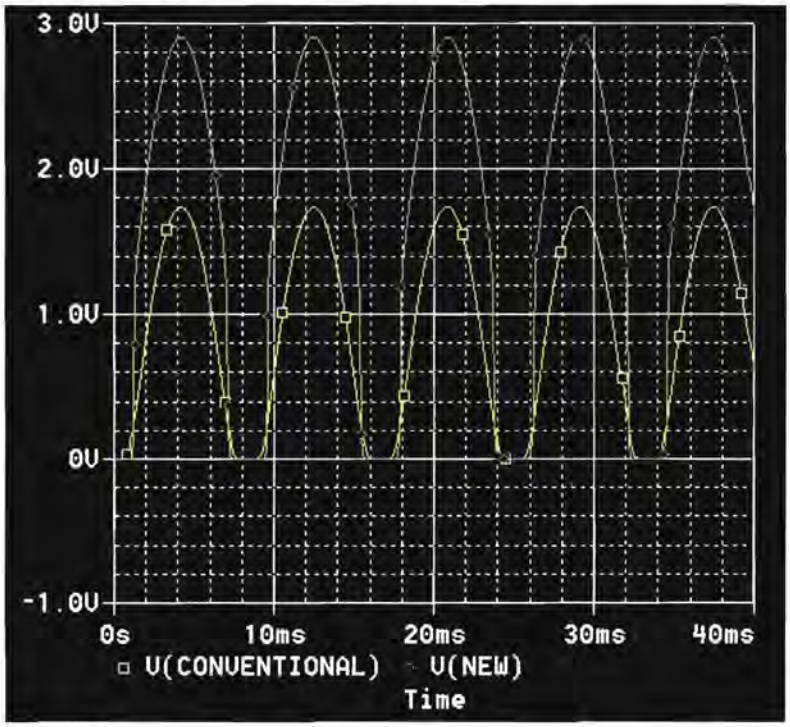


Figure 3: Output voltages of the conventional rectifier (yellow line) and proposed rectifier (green line) when $V_{in} = 3V$ and $R_{load} = 1k\Omega$

The plots of the output voltages of the proposed rectifier and conventional rectifier are shown in Figure 3. The amplitude of the AC source voltage of 3V and the load resistance of 1kΩ were chosen. It is possible to see that the output voltage of the proposed rectifier substantially exceeds the output voltage of the conventional rectifier.

The resistances of the resistors R1 and R2 can be calculated as $R_1 = R_2 = (V_{in} - 2 \cdot 0.6V)/I_B$, where the base current of the transistors I_B can be found as $I_B \geq 2 \cdot I_{load} / \beta$, where β is the maximum load current and is the forward current gain coefficient of the transistors. The coefficient 2 ensures the saturation mode operation of transistors.

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Voltage-Mode First-Order Filter Using Single DDCC

Many first-order all-pass filters using single current conveyor have received attention recently. However, these filters which employ passive elements did not use the minimum component count and need a match condition to realise an all-pass response.

Here, we present a novel first-order filter. It simultaneously achieves all of the following advantages:

(i) it uses a minimum component count: only one simple active element, one resistor and one capacitor;
(ii) there's no need for any component matching constraints;
(iii) it allows the simultaneous realisation of low-pass, high-pass and all-pass signal from the same configuration;
(iv) it allows the realisation of a non-inverting, low-pass signal and inverting low-pass signal, or non-inverting high-pass signal and an inverting high-pass signal, or non-inverting all-pass signal and an inverting all-pass signal at the same time;
(v) it offers low active and passive sensitivity performance.

The filter is with three inputs and two outputs, employing a non-inverting differential difference current conveyor (DDCC+), one resistor and one capacitor (see **Figure 1**). By using standard notation, the port relations of a DDCC+ can be characterised with $I_{Y1}= I_{Y2}= I_{Y3}=0$, $V_X= I_{Y1}- I_{Y2}+I_{Y3}$ and $I_{Z+} = +I_X$. Analyses of the various transfer functions of the configuration of Figure 1 are shown in **Equation 1** and **Equation 2**, respectively:

$$V_{o1} = \frac{sCRV_{i1} + V_{i2} - V_{i3}}{sCR+1} \quad (1)$$

$$V_{o2} = \frac{-sCRV_{i1} + sCRV_{i2} + V_{i3}}{sCR+1} \quad (2)$$

Depending on the voltage status of V_{i1}, V_{i2} and V_{i3}, in the numerator of Equation 1 and Equation 2, both of the following filter functions are realised at the same time from the V_{o1} and V_{o2} as shown below.

Case 1: If $V_{i1}= V_{i2} = 0$ and $V_{i3}=V_{in}$, then the inverting low-pass signal and non-inverting low-pass signal are obtained as in:

$$\frac{V_{o1}}{V_{in}} = \frac{-1}{sCR+1} \quad \text{and} \quad \frac{V_{o2}}{V_{in}} = \frac{1}{sCR+1}$$

Case 2: If $V_{i2} = V_{i3} = 0$ and $V_{i1} = V_{in}$, then the non-inverting high-pass signal and inverting high-pass signal are obtained with:

$$\frac{V_{o1}}{V_{in}} = \frac{sCR}{sCR+1} \quad \text{and} \quad \frac{V_{o2}}{V_{in}} = \frac{-sCR}{sCR+1}$$

Case 3: If $V_{i2} = 0$ and $V_{i1} = V_{i3} = V_{in}$, then the non-inverting all-pass signal and inverting all-pass signal are obtained with:

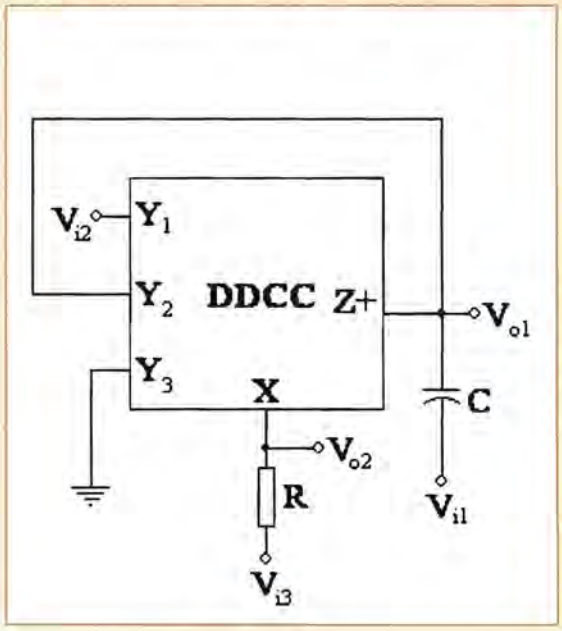
$$\frac{V_{o1}}{V_{in}} = \frac{sCR-1}{sCR+1} \quad \text{and} \quad \frac{V_{o2}}{V_{in}} = \frac{-sCR+1}{sCR+1}$$

To validate the theoretical prediction of the proposed universal biquad shown in Figure 1, we used H-Spice with 0.35μm process to do the simulation. The CMOS implementation of the differential difference current conveyor is shown in **Figure 2** with the NMOS and PMOS transistor aspect rations (W/L=5μ/1μ) and (W/L=10μ/1μ), respectively.

The supply voltages are $V_{DD}= -V_{SS}= 1.25V$ and the biasing voltages are $V_b= -V_{b1}= 0.3V$. The phase shifter was designed for a 90^0 phase shift at f_0. The component values of Figure 1 are R = 10kΩ and C=10pF. Both **Figure 3** and **Figure 4** are shown the simulated results of the gain and phase plot of Figure 1, which are in agreement with the theoretical analysis.

Hua-Pin Chen and *Ming-Tzau Lin*
Department of Electronic Engineering and Department of Computer and Communication Engineering, De-Lin Institute of Technology, Tu-Cheng, Taiwan

Figure 1: Proposed first-order filter



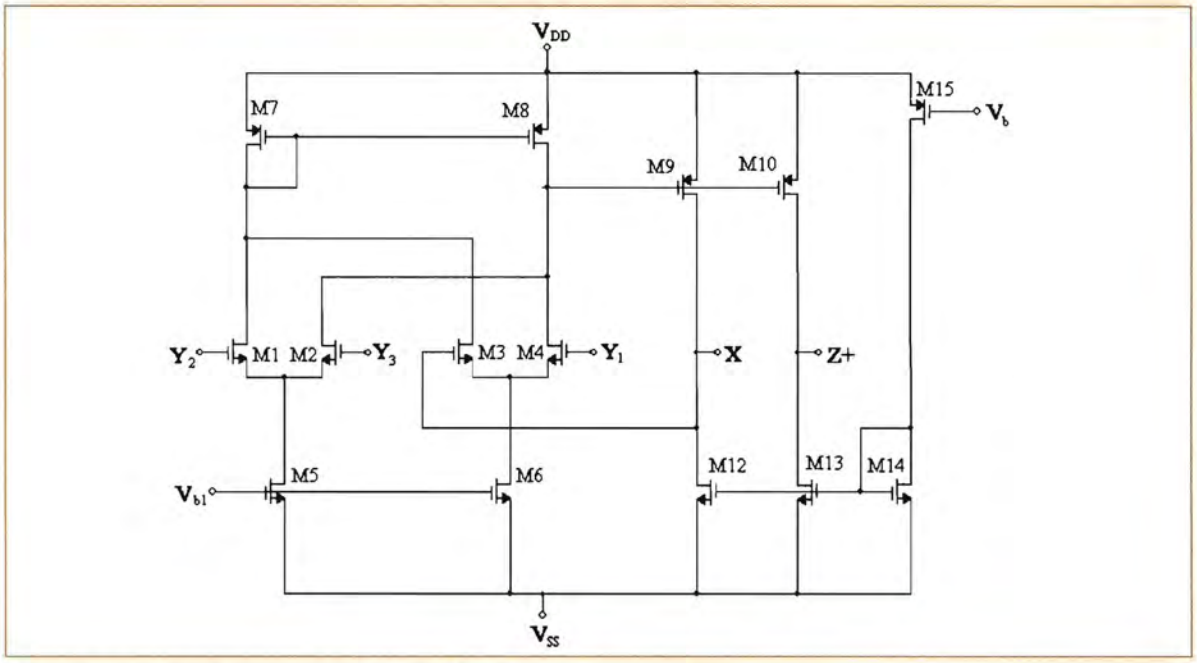


Figure 2: The CMOS implementation of a DDCC

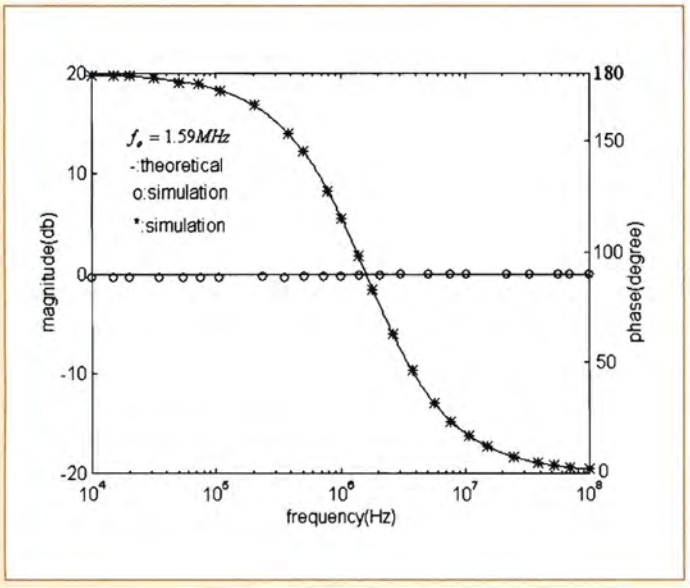


Figure 3: Gain and phase responses of non-inverting output all-pass filter

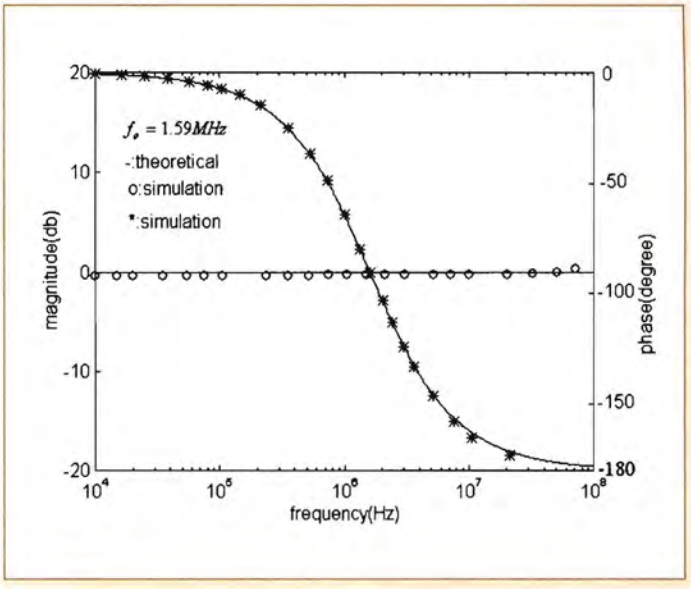


Figure 4: Gain and phase responses of inverting output all-pass filter

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Reading A Sensor With Higher Accuracy

Sensors can be read directly with the A/D but, in some applications, factors such as temperature, external component accuracy, sensor nonlinearity and/or decreasing battery voltage need to be considered. In other applications, more than 10 bits of accuracy are needed and a slower sensor read is acceptable. These next topics will cover ways of dealing with these factors for getting the most out of a PIC MCU.

TiP 1: READING A SENSOR WITH HIGHER ACCURACY – RC TIMING METHOD

RC Timing Method:

Simple RC step response
$Vc(t) = V_{DD} * (1 - e - t/(RC))$
$t = -RC \ln(1 - Vth/V_{DD})$
Vth/V_{DD} is constant
$R2 = (t2/t1) * R1$

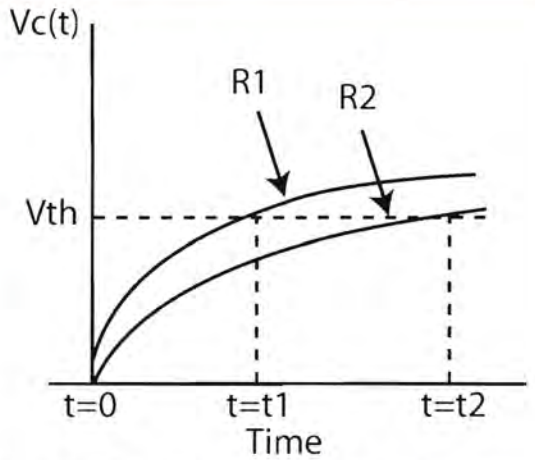


Figure 1: Charge time of a resistor/capacitor combination

A reference resistor can be used to improve the accuracy of an analogue sensor reading. In **Figure 1**, the charge time of a resistor/capacitor combination is measured using a timer, and a port input or comparator input switches from a 0 to 1. The R1 curve uses a reference resistor and the R2 curve uses the sensor. The charge time of the R1 curve is known and can be used to calibrate the unknown sensor reading, R2. This reduces the effects of temperature, component tolerance and noise while reading the sensor.

Application Notes:

AN512 – Implementing Ohmmeter/Temperature Sensor
AN611 – Resistance and Capacitance Meter Using a PIC16C622

Figure 2 is the schematic and software flow for using a reference resistor to improve the accuracy of an analogue sensor reading. The reference resistor (Rref) and sensor (Rsen) are assigned an I/O and share a common capacitor. GP0 is used to discharge the capacitor and represents the capacitor voltage.

Through software, a timer is used to measure when GP0 switches from a 0 to a 1 for the sensor and reference measurements. Any difference measured between the reference measurement and its calibrated measurement is used to adjust the sensor reading, resulting in a more accurate measurement.

The comparator and comparator reference on the PIC12F629/675 can be used instead of a port pin for a more accurate measurement. Polypropylene capacitors are very stable and beneficial in this type of application.

1. Set GP1 and GP2 to inputs, and GP0 to a low output to discharge C
2. Set GP0 to an input and GP1 to a high output
3. Measure tRsen (GP0 changes to 1)
4. Repeat step 1
5. Set GP0 to an input and GP2 to a high output
6. Measure tRref (GP0 changes to 1)
7. Use film polypropylene capacitor
8. $Rth = x\ Rref \frac{tRsen}{tRref}$

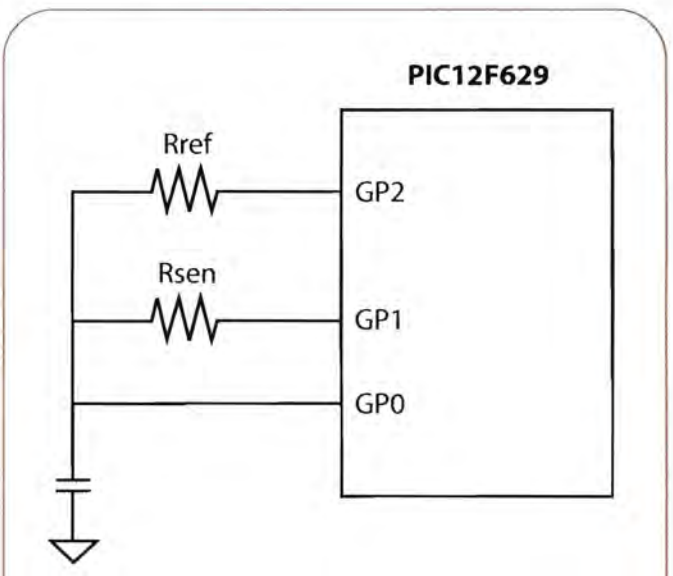


Figure 2: Use of a reference resistor to improve the accuracy of an analogue sensor reading

Other alternatives include a voltage comparator in the PIC12F6XX to measure capacitor voltage on GP0.

TiP 2: READING A SENSOR WITH HIGHER ACCURACY – CHARGE BALANCING METHOD

1. Sensor charges a capacitor
2. Reference resistor discharges the capacitor
3. Modulate reference resistor to maintain constant average charge in the capacitor
4. Use a comparator to determine modulation.

To improve resolution beyond 10 or 12 bits, a technique called "Charge Balancing" can be used.

The basic concept is for the MCU to maintain a constant voltage on a capacitor by either allowing the charge to build through a sensor or discharge through a reference resistor. A timer is used to sample the capacitor voltage on regular intervals until a predetermined number of samples are counted. By counting the number of times the capacitor voltage is over an arbitrary threshold, the sensor voltage is determined. The comparator and comparator voltage reference (CVref) on the PIC12F629/675 are ideal for this application.

1. GP1 average voltage = CVref
2. Time base as sampling rate
3. At the end of each time base period:
   (i) If GP1 > CVref, then GP2 output low
   (ii) If GP1 < CVref, then GP2 input mode
4. Accumulate the GP2 lows over many samples

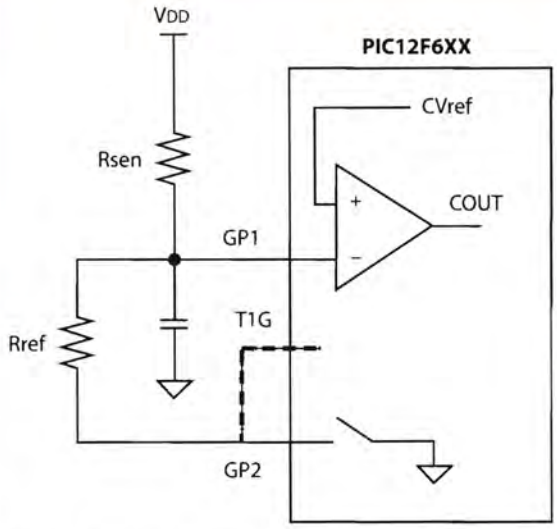


Figure 3: Charge balancing

5. Number of samples determines resolution
6. Number of GP2 lows determine effective duty cycle of Rref

TiP 3: READING A SENSOR WITH HIGHER ACCURACY – A/D METHOD

NTC (Negative Temperature Coefficient) sensors have a non-linear response to temperature changes. As the temperature drops, the amount the resistance changes becomes less and less. Such sensors have a limited useful range because the resolution becomes smaller than the A/D resolution as the temperature drops. By changing the voltage divider of the Rsen, the temperature range can be expanded.

To select the higher temperature range, GP1 outputs 1 and GP2 is set as an input. For the lower range, GP2 outputs 1 and GP1 is configured as an input. The lower range will increase the amount the sensor voltage changes as the temperature drops to allow a larger usable sensor range. In summary:

High range: GP1 output 1 and GP2 input
Low range: GP1 input and GP2 output 1

1. 10K and 100K resistors are used to set the range
2. Vref for A/D = VDD
3. Rth calculation is independent of VDD
4. Count = Rsen/(Rsen+Rref) x 255
5. Don't forget to allow acquisition time for the A/D

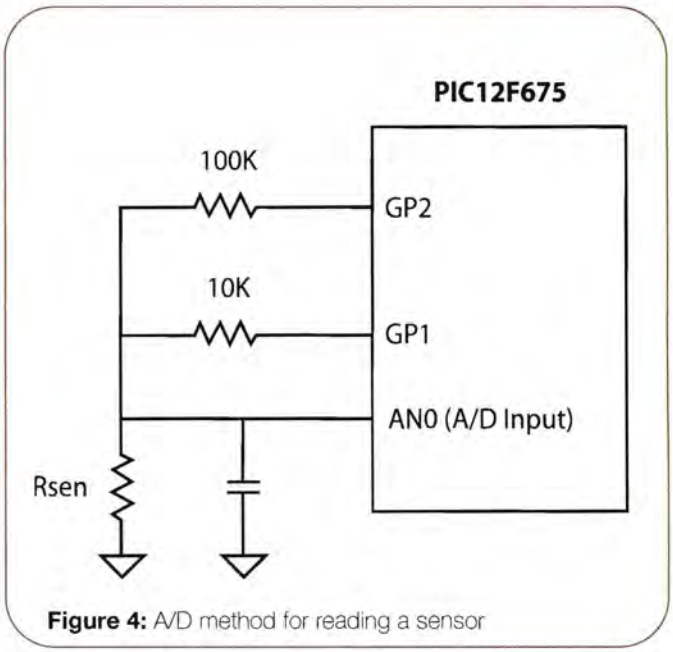


Figure 4: A/D method for reading a sensor

Ultrafast 8A, 600V Rectifiers

Vishay has launched two new high-voltage, ultrafast rectifiers that reduce power losses in the switch-mode power supplies for consumer, computer and industrial products with extremely fast reverse and forward recovery times and low forward-voltage drop.

The new 8A, 600V UH8JT and UHF8JT single high-voltage rectifiers deliver a reverse recovery time of 25ns. This improved switching performance combines with a forward recovery time of 150ns under LEM test conditions (IF = 8A, di/dt = 64A/microsecond, VF = 1.1 x VF max), and a low forward-voltage drop rating of 1.85V at 125°C, to enable better thermal performance and better system efficiency.

Built using a planar chip junction technology, the UH8JT and UHF8JT will be used for a range of power supply applications, including high-voltage continuous-current-mode power factor correction (CCM PFC) systems, high-voltage output switch-mode power supplies, secondary DC-DC rectification and freewheeling diode applications.

The UH8JT (TO-220AC) and UHF8JT (ITO-220AC) feature a maximum junction temperature of 175°C and are compliant with ROHS 2002/95/EC and WEEE 2002/96/EC.

www.vishay.com

MEMS Flow Sensors

Omron has added three new models to its D6F range of precision MEMS-based air/gas mass flow and velocity sensors.

Offering high-precision monitoring of airflow at three litres per minute (LPM), the new D6F-03A3-000 is ideal for industrial applications, especially pressurised cable monitoring systems and pick-and-place machines in industrial automation. Among its advantages are its small size (37mm x 8mm x 17mm), low current draw (15mA) and stable amplified analogue output across the full scale. The new A6 range is offering an R$C^1/_4$ screw port style connection. It is suitable for measuring air/gas mass flow rate with high repeatability, at flow rates of up to 10, 20 and 50LPM respectively. Both the A5 and A6 style sensors give precise detection of mass flows with a high repeatability of up to ±0.2% and an accuracy of ±3% full scale deflection.

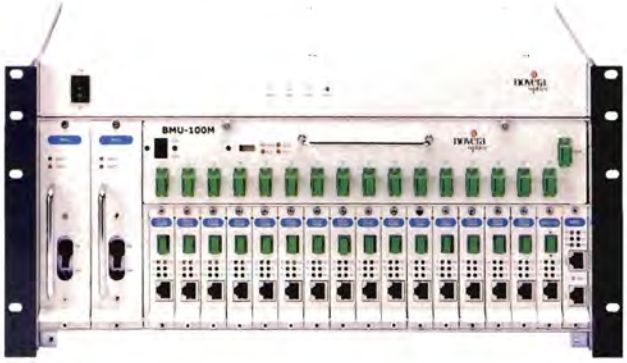
The third addition to the range, the D6F-V03A1, is a highly efficient, low-cost MEMS flow velocity sensor, ideally suited to applications such as building ventilation, clogged air intake filter detection and general detection of correct fan function. Its built-in Dust Segregation System (DSS) separates up to 99.5% of dry airborne particulate matter (simulation result).

www.omroncomponents.co.uk

Novera Optics Speedlight

Novera Optics recently released Speedlight, a new transport platform for fibre-to-the-x (FTTx) deployments, which greatly improves the ability of service providers to deliver the bandwidth their customers need now and in the future.

Using Novera Optics λ-PON (Lambda-PON) dense wave division multiplexing (DWDM) FTTx technology, the Speedlight transport platform eliminates the need for expensive, wavelength-specific optical network units (ONUs) and does away with the problems of bandwidth sharing, bandwidth upgrades and mixed-service delivery on a passive optical network (PON).



Based on λ-PON, the new Speedlight systems and modules enable a wide range of differentiated, dedicated, point-to-point connectivity services by providing an easy upgrade path, symmetrical downstream and upstream bandwidth, and multiprotocol transparency to allow any protocol and any data rate to be carried over the same fibre infrastructure.

Novera Optics's λ-PON technology automatically allocates a separate pair of wavelengths to each broadband subscriber and thus enables 125Mbits/s or more of dedicated bandwidth to be delivered per subscriber or ONU. Protocol and bit-rate-independent, λ-PON supports the transport of any service or mix of services at any bit rate.

www.noveraoptics.com

Combination HF/UHF RFID Reader Chipset

Rangemaster5 is immediately available from Anadigm. This is the company's third-generation RFID reader 3.3V chipset that allows system vendors to design and maintain a single combination HF and UHF reader.

The Rangemaster5-based system can be customised to read different radio frequency identification (RFID) tags, with different modulation types and frequencies. Rangemaster5 also fully supports current HF standards, as well as the newer standards under study by EPC (Electronic Product Code) Global.

As with the previous Rangemaster devices, Rangemaster5 will support UHF protocols – EPC Global Gen 1 and Gen 2 (class 0, 1, 2), as well as ISO18000-6 standards.

Rangemaster5 is a three-chip set comprised of two dynamically programmable analogue signal processors (dpASP), in conjunction with an RFID state machine. This enables system designers to develop universal RFID readers that can support both HF and UHF, changing between HF and UHF baseband frequencies dynamically, in a few microseconds. Rangemaster5 also features the ability to dynamically change between protocols and frequencies, allowing for optimised RFID tag reading. Its I and Q filtering capability allows Rangemaster5 to be programmed to remove spurs, harmonics and unwanted modulations, thereby increasing the overall performance of the RFID reader.

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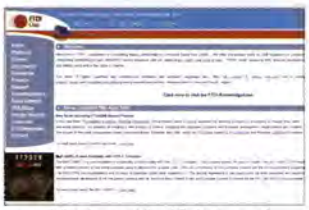

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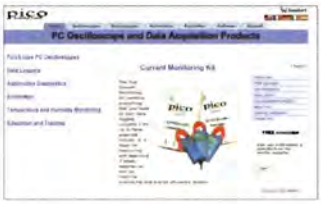

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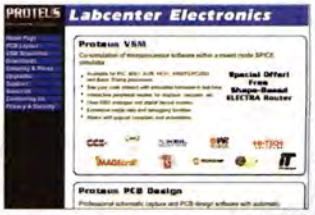

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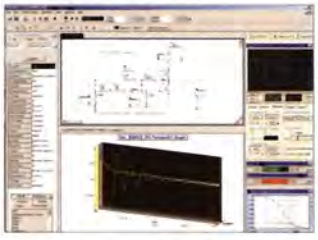

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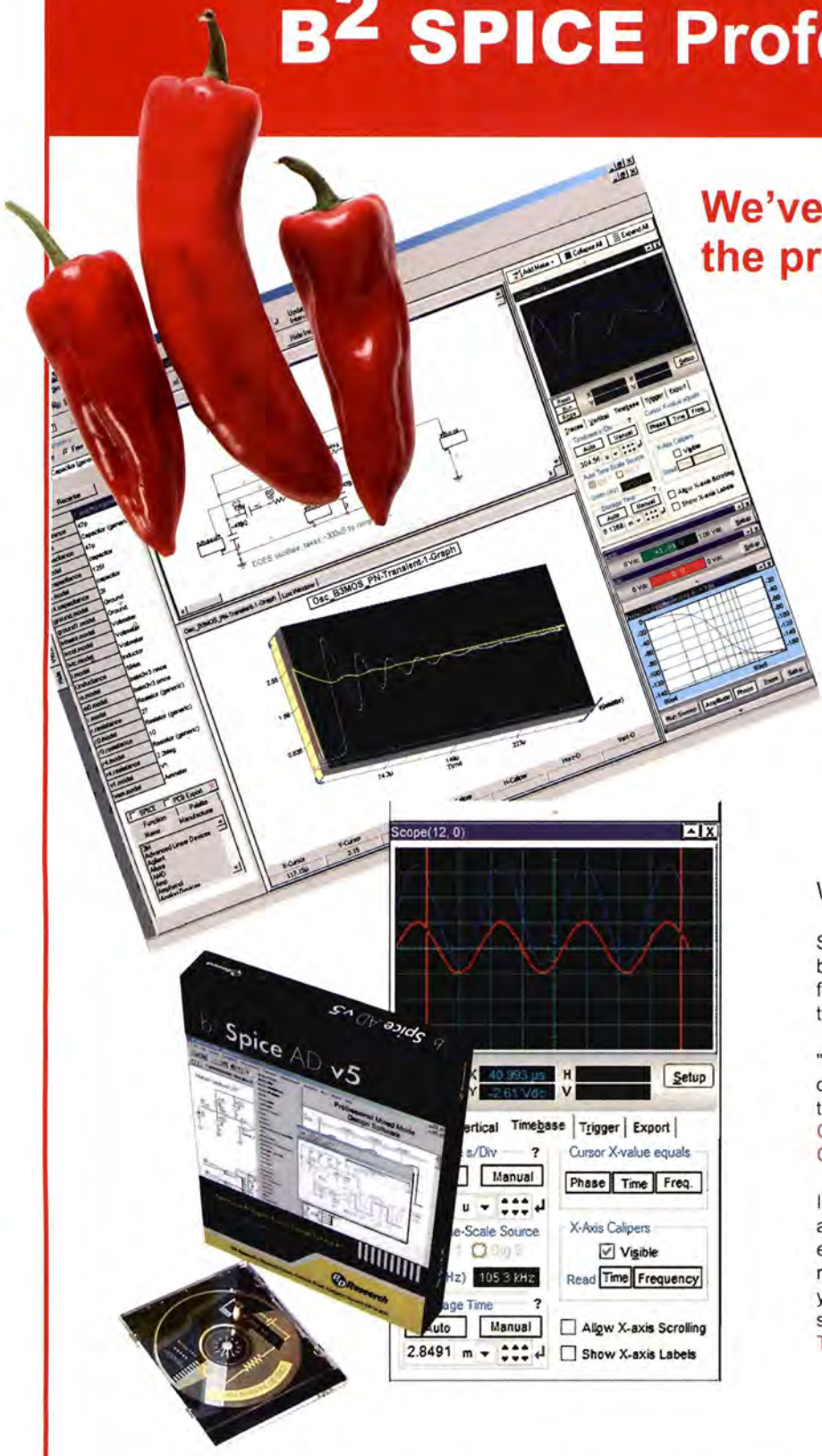

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