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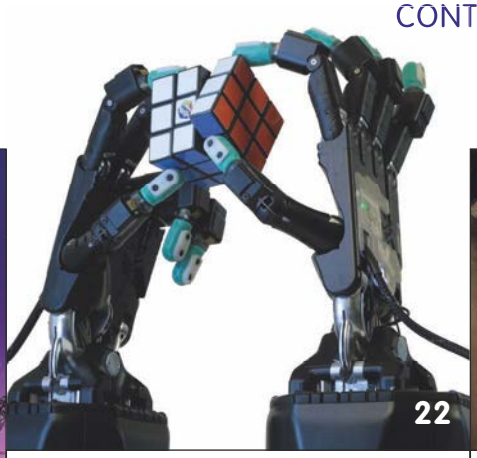

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A funding 'black hole'?

ARE EUROPEAN TECH COMPANIES HANDICAPPED BY A LACK OF LATER STAGE INVESTMENT?

The amount of funding available to technology start ups has been a discussion point for many years. Basically, the argument says that Europe doesn't have the same appetite for funding start ups that exists in the US.

Of course, it depends on how you define 'technology' – the word is being applied liberally nowadays. But let's look at electronics. Venture capitalists (VCs) fuelled the growth of the electronics industry into the 1990s. By this time, VCs were fighting to put money into dot com companies and those targeting web based communications. All manner of crazy ideas were pitched to the VC community, which responded by writing large cheques.

But as leading edge devices became hugely expensive to get to market, the returns declined and the appetite of VCs for electronics companies abated.

According to a report from investment company Magister Advisors, lack of funding in Europe is holding back the growth of tech companies, particularly those further into their development.

At the Series A level – where companies receive their first significant investment – three times as many US companies were funded in 2016 as there were in Europe. But at Series C, more than 10 times as many US companies were funded than similar companies in Europe. Magister says this is because later stage funding in Europe 'barely exists'.

Partly, this can be explained by cultural differences; Europe's technology sector was dominated by large companies which did their own innovation. Only lately have start ups become more common.

Magister also wonders whether European investors may 'take the money' earlier, implying there is little need seen for anything beyond early stage funding.

Funding from VCs, whilst significant, isn't the only source of investment. In the UK, as part of the Government's industrial strategy, the National Productivity Investment Fund is looking to put £4.7billion into commercialisation of research, whilst the forthcoming UK Research and Innovation will, as its name suggests, integrate research with innovation, with the aim of boosting the UK's economy.

Broadly, however, just as Europe is developing a meaningful start up culture, the lack of funding could mean that start ups with good ideas will not be able to flourish in the same way as their US counterparts.

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FPGA targets mid range applications

LOW POWER AND HIGH DATA RATE AMONGST DEVICE FEATURES. **NEIL TYLER** REPORTS.

Microsemi has the mid-range FPGA market in its sights with Polarfire, which boasts a 12.7Gbit/s transceiver and significantly lower power consumption: less than 90mW at 10Gbit/s.

"For the first time, we can offer a non-volatile FPGA that features 10Gbit/s transceivers and which provides tangible power and cost benefits over SRAM FPGAs," said Bruce Meyer, vice president and business unit manager at Microsemi.

Manufactured using a 28nm silicon-oxide-nitride-oxide-silicon (SONOS) non-volatile process on standard CMOS technology, the PolarFire range is looking to address cyber security threats, as well as reliability concerns faced by deep submicron SRAM-based FPGAs; particularly single event upsets in configuration memory.

Alongside transceivers optimised for 12.7Gbit/s, the device offers hardened I/O gearing logic for DDR memory and LVDS, high performance security IP and, according to the company, is the only mid-range device capable of clock and data recovery at 1.6Gbit/s.

With Cryptography Research's differential power analysis bitstream protection technology, an integrated physically unclonable function and 56kbyte of secure embedded non-volatile memory, the parts also feature built-in tamper detectors and countermeasures.

Four devices are planned, with capacities of 109k, 192k, 300k and 481k four input LUTs. The 300k LUT device is planned for general availability towards the middle of 2017.

Robotic prosthetic arm

An Imperial College team has developed sensor technology that allows a robotic prosthetic arm to detect signals from nerves in the spinal cord.

To control the prosthetic, the patient has to think like they are controlling a phantom arm and to imagine some simple manoeuvres, such as pinching two fingers together. Sensor technology interprets the electrical signals sent from spinal motor neurons and uses them as commands.

Dr Dario Farina, from Imperial's Department of Bioengineering, said: "[By] moving the focus from muscles to the nervous system, our technology can detect and decode signals more clearly, opening the possibility of robotic prosthetics that could be more intuitive and useful for patients."

NANO LED FOR ON CHIP COMMS

Scientists at Eindhoven University of Technology have created a nano-LED that is said to be 1000 times more efficient than its predecessors and capable of handling Gbit/s data rates.

The team has developed an LED of 'some hundred nanometres' with an integrated waveguide. The nano LED consists of a metal-coated III–V semiconductor nanopillar which is said to funnel 'a large fraction' of spontaneous emission into the fundamental mode of an InP waveguide bonded to a silicon wafer.

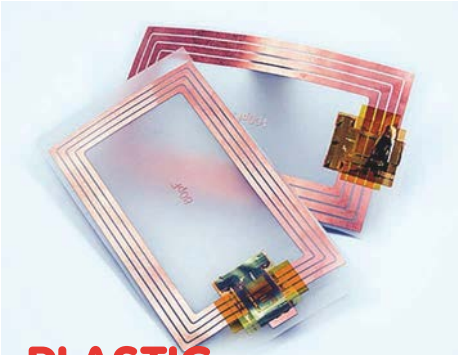
Progress has also been made in the quality of the integrated coupling of the light source to the waveguide, meaning less light is lost.

Nexperia deal closes

A consortium of Chinese companies has completed its acquisition of NXP's standard products division and the company has been launched officially as Nexperia.

Gerton Janson, chief marketing officer, said: "This move will allow us to invest further in R&D and in capital equipment to grow our market position. We will remain a standard products powerhouse."

Nexperia, which produces around 85billion devices a year, claimed a 12% market share in 2016. Its three main product areas are logic and ESD and MOS discretes, both of which comprise about 35% of its revenue, and diodes. Currently, it has more than 10,000 products in its portfolio.



PLASTIC NFC TAGS

Imec, Holst Centre and Cartamundi have demonstrated a thin film tag on plastic which is compatible with the NFC barcode protocol – a subset of ISO14443-A.

The NFC tag was made using indium gallium zinc oxide thin film transistors on a plastic substrate. "This hardware solution of plastic NFC tags opens up several new possibilities for NFC deployments," said Alexander Mityashin, imec programme manager.

Pioneers in the picture

IMAGING PIONEERS SHARE £1M QUEEN ELIZABETH PRIZE. **GRAHAM PITCHER** REPORTS.

Four engineers responsible for the creation of digital imaging sensors have won the Queen Elizabeth Prize for Engineering. Between them, the four – Eric Fossum, George Smith, Nobukazu Teranishi and Michael Tompsett – have worked on three innovations over three decades.

According to the judges, the development of the charge coupled device (CCD), the pinned photodiode (PPD) and the CMOS image sensor have transformed applications ranging from medical treatment to entertainment.

The CCD was developed by Smith and the late Willard Boyle in the 1970s, with its use in imaging developed by Tompsett, who designed an imaging circuit featuring an A/D converter. Teranishi, meanwhile, developed the PPD, which featured a reduced pixel size and enabled better quality images. Finally, Fossum's development of CMOS image sensors in 1992 has enabled the cameras found in modern smartphones.

Lord Browne of Madingley, chair of the Queen Elizabeth Prize for Engineering Foundation, noted: "The 2017 Prize is awarded to four engineers who have revolutionised the way in which we capture and visualise information. The spirit of international cooperation which drives [their work] encapsulates perfectly the ideals of the Prize."

Between them, the winners will share £1million and will receive iconic trophies later this year.

IR to simplify data centre comms

Engineers from Penn State, Stony Brook University and Carnegie Mellon University are proposing to use free-space optics in data centres, rather than wires.

"We, and others, tried RF signalling, but the beams become wide over short distances," said Professor Mohsen Kavehrad. "Instead, we are using a free space optical link. It has an inexpensive lens, we get a narrow infrared beam with zero interference and no limit to the number of connections with high throughput."

The team has transmitted wavelength division multiplexed bidirectional data streams, each transmitting at 10Gbits/s, using a micromirror based system.

"We are trying to come up with something reconfigurable using light instead of RF," said Prof Kavehrad. "We would like to get rid of fibre optics altogether."

Op amp 'sets standard'

In a move which it claims sets the standard for precision amplifiers, Texas Instruments has launched the OPA388, which it describes as the first op amp to offer zero-drift and zero-crossover technology. This, it continues, allows the device to maintain high precision across the entire input range in such applications as test and measurement, medical and safety equipment and high-resolution data-acquisition systems.

Ying Zhou, marketing manager for precision amplifiers, said: "Op amps have to deal with different sensors, such as temperature and pressure, so need high precision. They also need low noise and existing products either have too much noise or not enough bandwidth."

Zero drift eliminates temperature drift and flicker noise, while the zero-crossover topology eliminates offset errors caused by common-mode limitations.

With a 10MHz gain bandwidth product, the part has a total harmonic distortion of -132dBc and an open loop gain of 148dB.

Oxis targets 425Wh/kg Li-S cells

As part of the Zephyr Innovation Programme (ZIP), battery technologist Oxis Energy is developing cells with a specific energy of 425Wh/kg.

ZIP, led by Airbus Defence and Space, is developing a High Altitude Long Pseudo Satellite (HAPS) to provide remote sensing and internet connectivity. HAPS will be solar-powered, circling in the stratosphere and capable of launching, landing and redeploying autonomously.

By developing cells with a specific energy of 425Wh/kg, Oxis will help Zephyr HAPS to fly above any weather in the troposphere and to remain aloft for three months.

Altium buys Premier EDA

Altium has acquired Premier EDA Solutions, its long term leading reseller in the UK and Ireland. According to Altium, it will take advantage of Premier EDA's strong customer connections and technical capabilities to continue its growth in Europe.

Premier EDA's managing director Phil Mayo added: "For 23 years, we have been singularly focused on the success of Altium products in the UK. We now have an exciting opportunity to extend our reach and to put Altium's PCB design tools into the hands of many more engineers."

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Are you a winner?

ENTRIES OPEN FOR THIS YEAR'S BRITISH ENGINEERING EXCELLENCE AWARDS. **GRAHAM PITCHER** REPORTS.

Entries are now being accepted for the 2017 British Engineering Excellence Awards – MA Business' celebration of all that's good about engineering in the UK.

Since the British Engineering Excellence Awards – BEEAs – were launched in 2009, the winning entries have ranged in size from chip designs to earth moving vehicles. In 2016, the Grand Prix – the best of the best – was won by a young medical company developing imaging technology to improve outcomes for cancer patients.

The BEEAs demonstrates the breadth and vitality of the UK's engineering and innovation capabilities. And, every year, the quality of entries improves.

If you have developed breakthrough technology, grown an innovative business or excelled in your specialist field, then why not enter the BEEAs?

The BEEAs reward companies who have shown innovation in design within the last year and the design engineers who made those innovations possible. The Awards also recognise outstanding performances from engineering consultancies, start ups and small companies.

The online entry process is very easy to complete and is FREE. Entries must be submitted no later than 14 July 2017.

For full category information and to obtain your online entry form, visit **www.beeas.co.uk**

The winners will be announced at a gala lunch at the London home of the Honourable Artillery Company, on 5 October 2017.

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Headline sponsor Cambridge Consultants and gallery sponsor RS Components, along with category sponsors maxon motor and Premier EDA Solutions, are joined this year by Goodfellow (Cambridge), John Guest, LG Motion/MiniTec and Rutland Plastics.

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Safe grasping

Ocado Technology has created a robotic arm said to be capable of safely grasping a variety of products.

The development – a collaboration between Ocado and the Technische Universität Berlin – is said to be an integral part of the EU funded SoMa project, which is researching humanoid robotics.

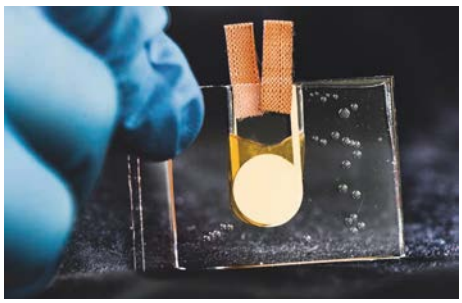
"With SoMa, we are pursuing a new direction for robotic grasping by developing robot hands that can safely pick easily damageable items such as fruits and vegetables," said Dr Graham Deacon, Ocado's robotics research team leader. To avoid damaging sensitive and unpredictably shaped items, the arm uses carefully orchestrated interactions between the hand, the object being grasped and the surroundings. *For more on robotics, see **p21**

Heat controlled circuitry?

Researchers at Linköping University say they have created a thermoelectric organic transistor in which a temperature rise of a single degree is sufficient to cause detectable current modulation.

"We are the first in the world to present a logic circuit, in this case a transistor, controlled by heat instead of an electrical signal," said Professor Xavier Crispin.

According to the team, a heat driven transistor could enable a range of new applications, including detecting small temperature differences and monitoring the healing process when used in medical dressings. The team also believes it might be possible to produce circuits controlled by the heat present in infrared light.



Germanium outperforms silicon

A germanium based transistor developed by Dresden University of Technology (TUD) can be programmed to change between electron and hole conduction.

"For the first time, the results demonstrate the combination of low operation voltages with reduced off-state leakage," said TUD's Dr Walter Weber. "The results are a key enabler for novel energy efficient circuits."

Transistors based on germanium can be operated at low supply voltages and reduced power consumption, due to their low band gap compared to silicon. Additionally, the Ge based transistors can be reconfigured between electron and hole conduction based on the voltage applied to one of the gate electrodes. This enables circuits with lower transistor count compared to CMOS technologies.

However, one limitation is the higher static power loss in the off-state, but independent gating regions are said to solve this issue.

Leading from the front

ESCO IS SET TO LEAD A CAMPAIGN TO GET BETTER RECOGNITION FOR THE UK'S TECHNOLOGY SECTORS. BY **GRAHAM PITCHER**.

The Government's Green Paper, outlining its thoughts on an industrial strategy for the UK, is seen by ESCO – the Electronics and Electrical Systems Council – as a 'tremendous opportunity'. ESCO believes it will start an important consultation process that will see the UK's industrial policies and strategies upgraded, while ensuring that appropriate focus is given to issues such as skills, immigration and productivity.

"The Green Paper has fired the starting gun for the most extensive consultation with industry for decades," said Tony King-Smith, ESCO's recently appointed CEO. "Our industry has complained for far too long that it is under valued and unrecognised – this is an opportunity for us to come together as a unified and significant industry sector and take action to change that."

"One thing is certain; we can't be just another trade association." Tony King-Smith

ESCO says it will respond 'comprehensively' to the consultation on behalf of the electronics, electrical and embedded software and systems communities. Brian Holliday, ESCO's chairman and managing director of Siemens Digital Factory in the UK, noted: "ESCO intends to positively embrace Industrial Strategy and harness the collective energy of all parts of our industry. Together, we can collaborate to build on our innovation and infrastructure base to help create new start-ups, engender new technology skills, to encourage new regional investments and to ensure rewarding technology jobs are created across the UK."

Speaking exclusively to *New Electronics*, King-Smith said the electronics industry doesn't get the recognition it deserves because it's not that big in isolation.

"I can see why people are frustrated by it all," he said, "but electronics is specialist. The problem is that Government is largely full of generalists. Why don't they listen? It's because they don't know what we're talking about."

An example offered by King-Smith was semiconductor process technology. "People are no longer impressed by 7nm silicon. What they are interested in is what's being built with that silicon. And the things the electronics industry develops are coming into their own, with applications in smart grid, smart energy, smart cities and so on."

But he also contends these applications aren't just about electronics. "It's also about electrotech; that brings in such things as power, cabling and motors."

The consequence, he continued, is that we have to start 'joining things up'. "We have to begin to wrap everything together so someone in the street can understand what's going on. We have to be visible and that means what we talk about has to be related to the 'real world'."

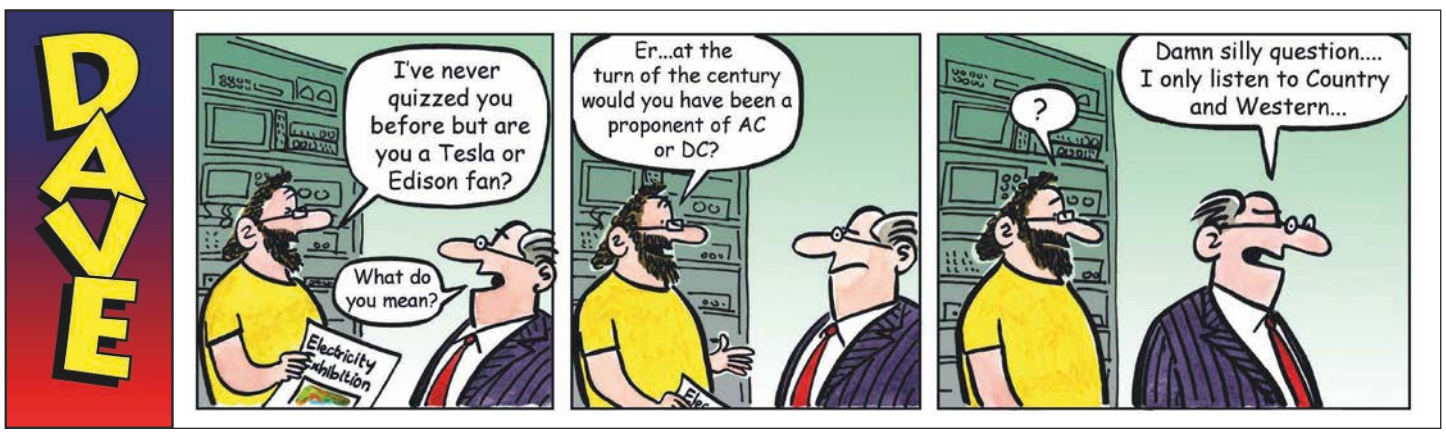
ESCO, however, recognises that achieving that goal will require a serious effort. In a statement, it said that it will work closely with government and bring together the 'many highly specialised segments of industry' to deliver a cohesive industrial community with one strong, unified voice.

Asked whether this will require an industry coalition, King-Smith said: "Every sector has the same problem, because they don't explain things in layman's terms. We have to reinvent our sector, say 'these are the elements', but shrink wrap it."

And he believes that now is the time to start work on this. "If you think about what's going to happen over the next 10 years," he said, "everything is going to be built using 'electrotech'. All these applications will rely on 'our stuff' – the technology our industry is developing.

"We have to get that message across in general terms and focus on getting the attention of a wider audience – we need to get our story to people outside of engineering. While we are making progress, this will mean the various sectors putting aside their differences in order to achieve what we're talking about.

"One thing is certain," he concluded, "we can't continue to be just another trade association."



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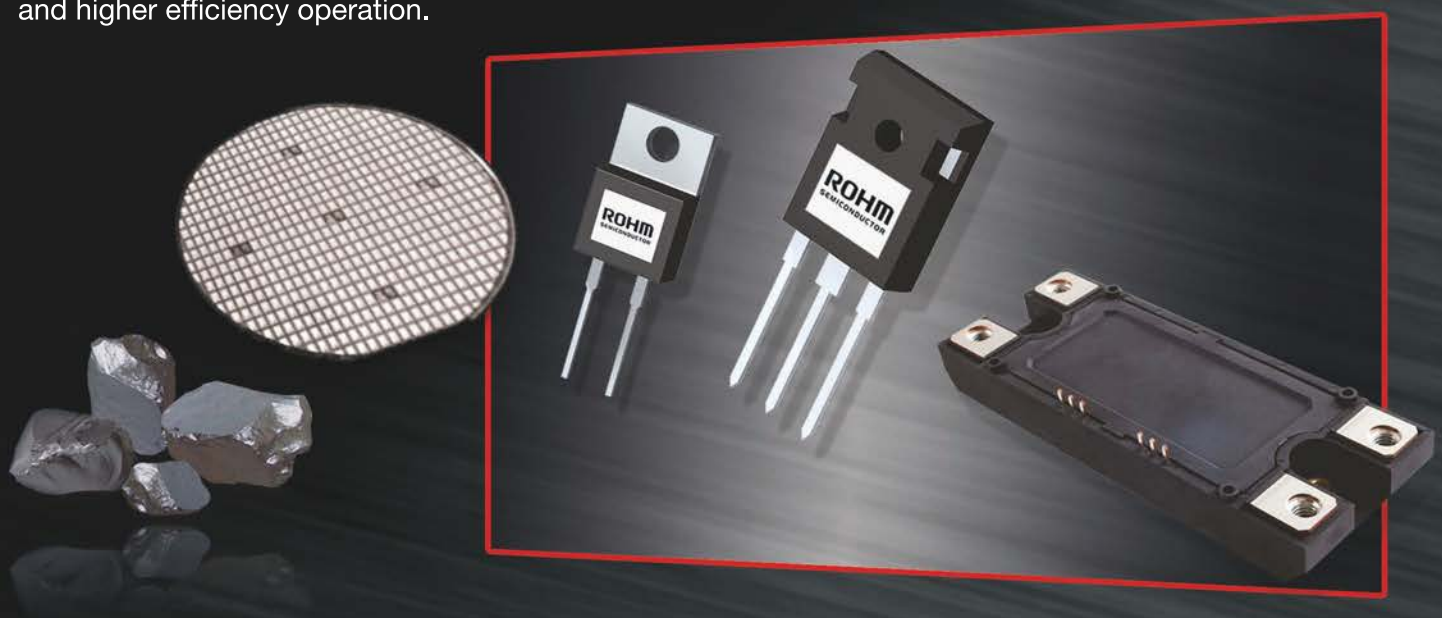

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Building an 'innovations hub'

Appointed as Plextek's CEO last year, Nicholas Hill tells **Neil Tyler** how he is reorganising and refocusing the consultancy's design capabilities and services.

Nearly ten months into his role as CEO of electronics consultancy Plextek, Nicholas Hill has re-organised and refocused the company's technical capabilities, with dedicated teams working across such areas as signal processing, communications systems, sensors systems and machine learning.

Hill was the company's defence and security director before being appointed CEO. While in that post, he achieved a number of important milestones for the company in the defence market.

"Over four years, we became recognised as a trusted partner and a key innovator by the Centre for Defence Enterprise (CDE), which funds high risk research to develop capabilities for the UK's defence and security space, as well as by the Ministry of Defence (MoD) and by a number of leading Government agencies," Hill explains.

According to Hill, operating in this sector requires 'specific technical, commercial and market knowledge, as well as an intrinsic understanding of the defence business and the people who work in it'.

Interviewed last year, Hill also talked about the importance of bringing experiences derived from other sectors to the defence market. "It makes it so much easier to look at the ways in which the company is operating, where it isn't and why and how it compares to its competitors.

"I never quite understood how people used to spend a lifetime within one company, because you simply don't have the breadth of knowledge you would get from a more varied career."

Hill has certainly 'walked the walk', with roles as a hardware and embedded software designer, systems engineer and company director across companies in the automotive, healthcare, scientific instrumentation and telemetry sectors.

Hill joined Plextek in 2007. "I joined primarily to work closely with an automotive client in Malaysia and did so for nearly three years.

"When I returned to the UK, it was as a project manager with a variety of clients. Plextek, as it was then, took a general approach to sales and marketing and I was among those who thought we would benefit from a more focused approach. To that end, I took on responsibility for the defence business and worked to build a series of long term relationships.

"While Plextek wasn't exactly niche, it wasn't a name that many people had heard of," he admits. "We had to work hard to develop relationships with key players. Traditionally, we supplied 'invisible expertise' into these companies; generating ideas and looking to respond to the challenges and opportunities organisations face when working in this sector.

"We spent a good few years building the defence business and ended up with a reputation for developing bright and unusual solutions. We were involved with a number of successful CDE competitions and, last year, won our first Defence Science and Technology Laboratory (DSTL) contract, which involves collaborating to develop advanced communications systems – that could be described as a slow burn activity."

When it comes to defence, Plextek has five principal application areas: agile immersive training, which includes augmented reality technologies; bespoke communication systems; electronic warfare and survivability; low SWaP sensor systems for dismounted soldiers; and autonomous systems and resilient location, time and frequency technologies that provide enhanced location accuracy when GNSS is degraded or denied.

Defence, however, is just one area of the company's expertise and Hill says his past experience will help him to grow the wider business and to nurture its innovative capabilities.

"We want to deliver solutions that meet the highest standards of robustness, reliability and ease of manufacture – whatever the technology market," he says.

Revenue is currently growing at 20%, says Hill, and the company has increased its work with DSTL's core research programmes significantly.

"We are, in essence, what I like to call an 'innovations hub'. We work across a variety of sectors, which means we can transfer ideas, skills and experiences from one to another. Increasingly, it is about looking at different sectors and applying existing technologies in what could be called 'unexpected ways'. There's no need to re-invent the wheel and it is a benefit to our customers."

Defence, under Hill, became one of the company's key market sectors, incorporating security.

"From our perspective, the defence market has changed radically over the past 15 years. Then it was about creating innovative technology that could be developed for volume applications. Today,

"When it comes to innovation, it is crucial that we look to other sectors and apply existing technologies in unexpected ways."

Nicholas Hill

Currently CEO, Hill was Plextek's director, defence and security, where he oversaw a significant growth in the company's defence and security business, particularly in direct engagement with the MoD, DSTL and other government agencies. Previous defence sector experience includes systems engineering for unmanned underwater vehicles and submarine wireless communications systems. Outside of the sector, he worked as a software designer, systems engineer and company director for companies across a range of industries.

the defence industry is looking to the commercial world for ideas and innovations that can be re-tasked.

"At the component level, it's about repurposing for defence. The key is that we are open to taking different approaches when it comes to solving problems – whether that's in design or manufacturing."

Since May, Hill has led a re-organisation of the business. "We have split security from defence and created a dedicated Security Group to tackle key security problems and to generate ideas and insight. We have also enhanced the medical group and work closely with established brands and innovative start-ups in terms of product development, proof of concept delivery, technology road mapping and concept development.

"When it comes to innovation, it is crucial that we look to other sectors and apply existing technologies in unexpected ways."

According to Hill, using existing technology and applying it differently in disparate markets is not only cheaper, it also means 'Plextek is not having to 're-invent the wheel'.

As a result, he believes this approach will enable the company to come up with better, smarter product designs and bring them to market more quickly.

Sparking an interest in ELECTRICITY

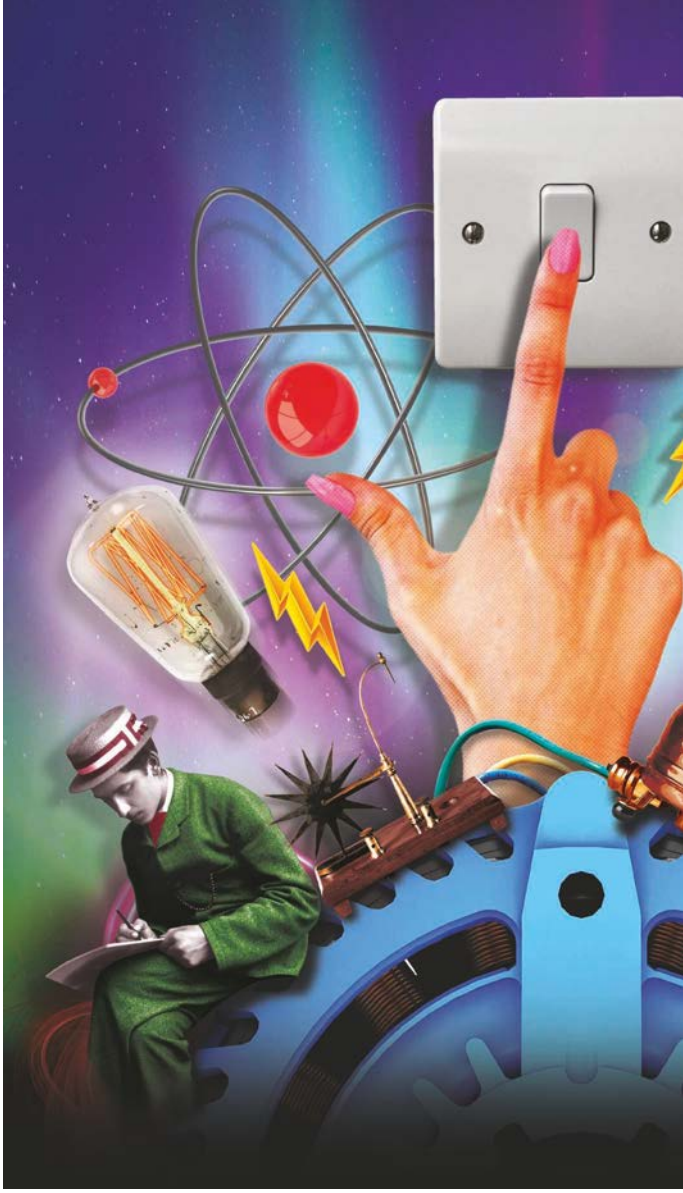


Illustration: Matt Herring

An upcoming exhibition, 'Electricity: The spark of life', walks visitors through the history of electricity and showcases some of the key moments. By **Peggy Lee.**

It is not unreasonable to say that we take electricity for granted. We plug appliances into sockets and turn them on, but give little or no thought to where that electricity has come from. And even less thought is given to the history of discoveries and inventions that explains how electricity can be used at a flick of a switch.

This is the aim of *Electricity: The spark of life*, an exhibition which will open at London's Wellcome Collection on 22 February 2017. According to the Collection, the exhibition aims to trace mankind's quest to understand, unlock and master the power of electricity.

Collaboration

Three museums are collaborating to organise and host the exhibition. Wellcome, which will be the exhibition's first host, is contributing artefacts from its collection of electric appliances, particularly medical; Teylers museum in Haarlem, the Netherlands, will be the next, with its collection of early electrical instruments; and finally, Manchester's Museum of Science and Industry is mainly donating objects relating to the electricity supply industry.

"Our lives today are reliant on electricity on a day to day basis and our consumption in the west is on the increase, so our aim is to bring that to people's attention and make them stop and reflect about their relationship to electricity," said Ruth Garde, curator at the Wellcome Collection.

"The idea was initiated by the Wellcome Collection," commented Dr Alice Cliff, curator of science and technology at the Museum of Science and Industry in Manchester. "It snowballed from thinking about electricity in relation to the body to thinking about electricity as it influences us as a body of people and the title reflects the fact that it is an incredible force and influence in our lives."

The exhibition is organised into three core themes – generation, supply and consumption.

"The exhibition is largely chronological," Cliff explained. "The first section 'Generation: The Great Invisible' looks at early experimentation with electricity, and the instruments and apparatus that were used in the 18th and 19th centuries to understand the phenomenon.

The aurora globe, below, was made in 1789 by English instrument maker John Cuthbertson, to demonstrate the effect of rarefied gas on a spark of fire

"The section on 'Supply: Wiring the World' focuses on how we've harnessed the power and force of electricity. So it looks at how supply began, from the experimental harnessing of energy to large scale supplies to homes and businesses.

"The third section, 'Consumption: the Silent Servant', is about how we use electricity. It looks at how we now take for granted our ability to use electricity in our daily lives. So it features some typical appliances and highlights the ways we use electricity and how that has impacted us."

More specifically, the third section will consider our energy dependence and power cut issues; experiences of living 'off the grid' and more sustainable means of generating electricity.

Each of the themed areas features a piece of contemporary art which reacts to and

Images: Teylers Museum Haarlem, Science Museum/Science & Society Picture Library

is in conversation with the historical materials in each space.

Irish artist John Gerrard was inspired by Galvani's scientific instruments to create a digital environment. This will be shown in the generation section, alongside one of Galvani's books detailing his bioelectrical experiments and other early devices designed to generate an electric charge, inspired by natural phenomena, such as electric fish and lightning.

One of the instruments that will be on display is a discharge, or aurora, globe. The globe was first made in 1789 by English instrument maker John Cuthbertson to demonstrate the effect of rarefied gas on a spark of fire.

The globe, which contains a partial vacuum, can be connected to an electrostatic generator that generates static electricity by friction. As soon as an electric discharge takes place, bands of light are formed in the globe – emulating the Aurora Borealis – which generates light.

In the supply section, filmmaker Bill Morrison explored early film footage from the Electricity Council to create a work that considers the expanding electricity network in the landscape. It will be shown alongside early devices which harness, convert and store electricity, including a voltaic pile and a Barlow's wheel, as well as photographs featuring pylon designs and other artefacts embodying the challenge in setting up an electric network.

The Barlow's wheel, built by English mathematician Peter Barlow in 1822, was an early kind of electric motor which combined electricity and magnetism to produce continuous motion.

For it to work, an electric circuit is created using a wet battery; the current then passes through a metal wheel – usually made of copper – and continues through a trough of mercury located below it. A horseshoe magnet is positioned around the wheel which provides a magnetic field. The interaction of the current with the magnetic field causes the wheel to rotate.

In this case, a spike wheel is used instead of a solid round wheel. Although the circuit is broken when a tip of the serrated wheel leaves the mercury, the wheel has enough momentum to keep turning until the next tip dips into the mercury, which re-establishes the connection.

The Barlow's wheel was one of the first machines to harness the interplay between electric and magnetic forces that had been discovered just two years earlier by Hans Christian Ørsted.

Visitors will also see two sections of the mains electricity cable from 1889 and 1890. According to the Museum of Science and Industry, this was the first high voltage cable, and the examples shown in the exhibition use waxed paper as insulation, rather than rubber. Waxed paper was found to be cheaper and more effective – important, given that four seven-mile mains were to be laid across the city.

The Archer electric kettle, above, was among the first electric kettles to come with a boil-safe device

In the consumption section, French artist Camille Henrot will set up a motorised zoetrope which questions the relationship between human, technology and the environment. A zoetrope, invented in 1834, was an early form of motion picture projector that consisted of a drum containing a set of still images that was spun to create the illusion of motion. It would originally have been hand cranked.

This piece will be surrounded by a range of objects, including examples of neon lighting and light bulbs; applications in healthcare, in areas such as electrotherapy and X-ray technology; an audio installation; and a model of the 'Smart City' project, Masdar City.

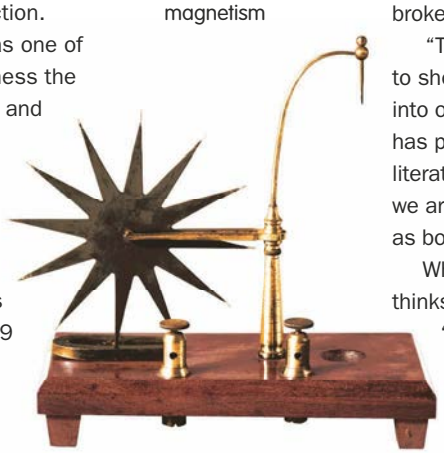
"Our aim is to make people stop and reflect about their relationship with electricity."
Ruth Garde

Initiated in 2006, Masdar city, located 17km outside of Abu Dhabi in the United Arab Emirates, relies on solar energy and other renewable energy sources.

An object worth highlighting in this section is the Archer electric kettle, created in 1902. This was one of the first kettles to have a boil-safe device. The element was sealed in the base of the kettle, and had a fusible cut out – like an electric fuse, the circuit was broken by the melting of a metal alloy.

"The aim of the exhibition is also to show how enmeshed electricity is into our cultural life and how deeply it has permeated our culture, arts and literature," Garde said. "Which is why we are showing cultural artefacts such as books, art and photography."

When asked what objects she thinks stand out, Garde answered: "Galvani's book is quite wonderful – it is the original from 1792 – and the early voltaic pile is so important



The Barlow wheel was an early electric motor, combining electricity and magnetism

to the history of the understanding of electricity.

"It was created in 1799 by Italian scientist Alessandro Volta and it was the first electrical battery. It consisted of 49 pairs of copper and zinc plates, separated by pieces of cloth drenched in saline or acid. Volta's pile demonstrated for the first time that electricity could be generated chemically and would flow steadily, like a current of water, instead of discharging itself in a single spark or shock."

Cliff and Jan Hicks, archives and information manager respectively at the Museum of Science and Industry, said they chose the original chisel and section of cable with which Sebastian Ziani de Ferranti conducted the chisel test in 1890.

"*New Electronics*' readers are probably very familiar with Ferranti's products, but they might not be so familiar with his early entrepreneurship," Cliff commented.

Ferranti was a bit of a genius, starting his first job at Siemens at the age of 17 and setting up his own company a year later, in 1882, with a friend of his father's, Alfred Thompson, to produce an alternator with a zigzag armature.

"Ferranti was very much about alternating current, which was unusual for the time," Hicks explained. "Most of the research work done by the American inventor Thomas Edison was in direct current, which was seen as being much safer."

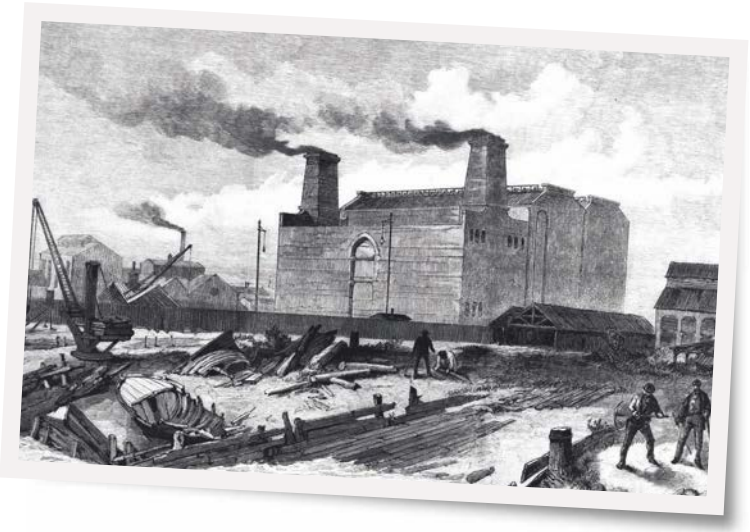
Ferranti then started to work with the Grosvenor Gallery Supply Company, set up by Sir Coutts Lindsay; firstly, to supply his art gallery and then Grosvenor Place with electric lighting. By comparing his own design of AC generators with those of the gallery, Ferranti greatly improved their efficiency and voltage capacity, which led to the foundation of the London Electric Supply Company, of which he was chief engineer in 1887.

In 1890, at the age of 26, Ferranti became responsible for designing the buildings, the generator supplies and the distribution system of Deptford Power Station – said to be the largest in Europe at the time.

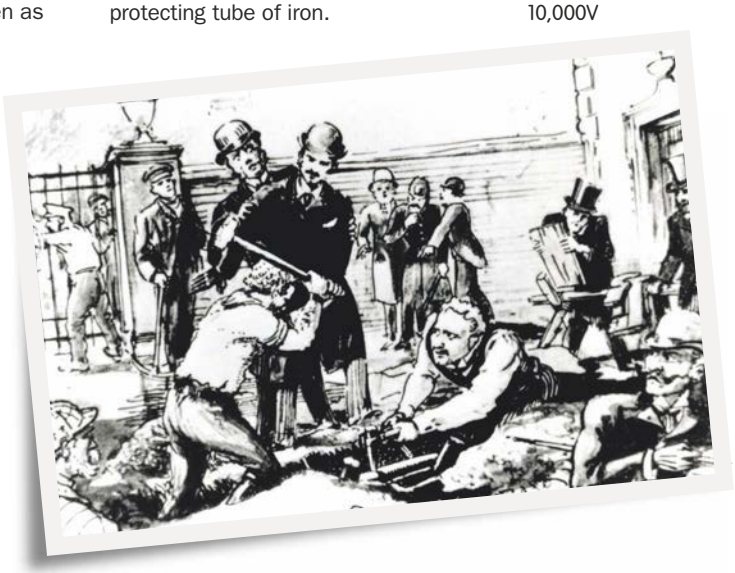
"At that stage, there was something called 'the battle of the systems'," Hicks said. "The battle between DC and AC current."

Ferranti wanted to supply 10,000V from the Deptford power station to substations closer to consumers, but this was something that had never been done before and cables did not exist for that voltage. AC current was seen as unsafe compared to DC current; Edison had conducted a public test on an elephant with AC current which had killed it. In his mind, this proved beyond doubt that it was unsafe.

Ferranti decided to design his own cable. It contained, within the same casing, both the conductor for the out current and the return current. It consisted of two copper tubes, one within the other, separated by an insulating substance consisting of layers of chemically pure brown paper, saturated with melted earth wax. Outside the outer tube was another layer of the insulating substance and the whole was inserted into a protecting tube of iron.



The Deptford Power Station, designed by Ferranti, was the largest in Europe when it opened in 1890



Ferranti's chisel test, below, demonstrated how he had effecftively earthed 10,000V

An agreement was reached with three railway companies to lay the mains on the surface along railway tracks and across the bridges to the Charing Cross, Cannon Street and Blackfriars stations. A similar agreement with the Metropolitan and District Underground Railway was reached to use the rail tunnels.

The Board of Trade was sceptical about whether Ferranti had provided an effective means of earthing 10,000V in the event of mishap.

Ferranti's chisel test

Ferranti decided he would also do a public demonstration to show that it was safe. He had a section of cable laid out in the yard at the Deptford station and while a supervisor held a chisel to the cable, a foreman struck the chisel with a sledgehammer, which broke the cable. This broke the current, as the current was fused and the cable was earthed. No one was hurt, which therefore proved his point.

"He was a showman, like Edison," Cliff claimed. "He was our British showman for AC electricity."

Garde hopes all these exhibits leave visitors with a renewed sense of wonder about the magic of electricity. "I am now much more aware of the ubiquity and importance of electricity in our lives and the issues involved, and I hope visitors will be too."

For more information

The exhibition will open at the Wellcome Collection in London on the 23rd February. For more information and further dates, please visit wellcomecollection.org/electricity

Illustrations: Science and Society Library, Science Photo Library

On track for better healthcare

A company better known for its motorsport activities is applying its expertise to the analysis of medical data. By **Peggy Lee.**

The McLaren Group took its first step into the world of health and well-being 11 years ago. Although internationally renowned for its Formula 1 cars, the company has since diversified, applying technologies it has developed to other industries.

"McLaren has been around for 52 years," explained chief medical officer Adam Hill. "For 50 of those years, we've been racing fast cars every other weekend. For 27 years, we've been building super cars and hyper cars for the road through a number of different automotive companies.

"But, equally, for 27 years we've had a technology company, now called McLaren Applied Technologies (MAT), that was established to develop sensors. Sensors at that time were still large and rather expensive but had got to a size where they were capable of capturing data in F1 cars."

MAT not only sells sensors, but also telemetry and engine control units, data visualisation and simulation software for use in a range of motorsport series, including F1, Nascar and Indycar.

"Building upon that motorsport electronics systems foundation, MAT started to look at other sectors and that's when, 11 years ago, we had our first foray into health," Hill added.

In healthcare, MAT concentrates on providing processing platforms. The company has recently been deploying physiological sensors on its drivers and pit crew during training to optimise performance.

"We send our teams to race in foreign climates, across multiple time zones, in hot weather, cold weather, humidity and different times of the day and night. That can create a whole host of physiological stresses for the team, which we can then analyse in order to mitigate their impact," Hill said.

For this, MAT uses a processing platform developed initially for the pharmaceutical company Pfizer in 2006 as a proof of concept wireless monitor for mothers in their third trimester of pregnancy. Now being deployed for a range of clinical health trials, it is currently in its fourth generation.

"Of the last 650 patients with whom we've deployed this system, we have captured a number of adverse clinical events before the clinical staff would have ordinarily identified them." Adam Hill

According to Hill, the platform is derived from the time series data visualisation tool that MAT uses in motor sport. Called ATLAS, it builds on the same set of competencies required to capture, analyse and derive insight from time series data.

"It is highly configurable," Hill claimed. "It would take an engineer to deploy it and set it up and capture data appropriately. But, equally, that engineer can deploy this platform to support a whole host of applications."

The prototyping platform allows multiple sensors to be plugged in and captures, in a non-invasive fashion, physiological parameters, which are sent to a gateway.

"The gateway has a number of different channels which can capture data," explained Hill. "It has a PCB at the centre and a radio device which can communicate and push data into the cloud." There, algorithms can analyse the data.

"MAT has a data science team that develops algorithms manually across data sets that we have captured," said Hill.

"Typically, algorithm development is in the cloud and, once those algorithms have been validated, the team wants to reduce or improve their computation of efficiency, so they can reside on the gateway, or even on the sensor or the data-capturing device."

According to Hill, MAT was the first to run time series analyses in real time, with large amounts of data, in order to derive insight.

The difference between ATLAS and the healthcare processing platforms is said to be that ATLAS can consume many more channels of data; is significantly more complex; and requires more computation. The healthcare platform, on the other hand, is a lighter version, with limited channels to capture data.

One application of the platform is at the Birmingham Children's Hospital (BCH), where it monitors children with heart problems. The biotelemetry platform – called LifeInsight – captures time series data from sensors, such as a heart rate monitor, on children in a cardiac step down unit, which is a hospital unit providing care between that of an intensive care unit and a normal ward.

According to Hill, the platform can fuse up to eight channels of time series data, although it is not currently using that amount in the BCH project.

The data is fed to a system that runs a series of 'what if' analyses across the data set in order to determine whether the vital signs are likely to end up out of the thresholds set for a particular child.

"Of the last 650 patients with whom we've deployed this system, we have captured a number of adverse clinical events before the clinical staff would have ordinarily identified them with the more conventional vital signs monitoring system," affirms Hill.

There were several challenges involved with this project.

The first was making the legacy IT systems interoperable with the platform. The second was managing information governance around the data set.

"Clearly, the nurses and doctors need to understand from whom the data is collected, whereas those that are architecting the solution or performing a maintenance upgrade on the system need access to the data, but shouldn't have access to identifiable data in any shape or form," said Hill.

A similar partnership between Google DeepMind and the NHS is developing an app that will produce medical alerts for clinicians. Patient data will be processed according to an algorithm and relevant information delivered as alerts to the doctors and nurses.

"You can't just throw technology at a human and hope to capture the relevant information."
Adam Hill

The hospital has agreed to share five years of historical data on patients, as well as real-time information on their status. Previous efforts by the UK Government to create a medical database floundered over concerns about medical confidentiality.

According to Hill, the final challenge was the necessary shift in clinical thinking. Medical practitioners generally rely upon raw data sets in order to derive insight and rarely rely upon decision support tools that use statistical methods on which to base clinical judgments.

"There's a shift in the way in which clinicians think, from being very deterministic or standard operation procedure driven through to being probabilistic in the way in which they consider clinical intervention," he added. This shift is demonstrated by the clinicians' acceptance of LifeInsight.

A degree of tailoring is required for different therapeutic conditions. As Hill professed: "You can't just throw technology at a human and hope to capture the relevant information."

He discussed one case where the platform had to be adapted to measure characteristics of motor neurological disease.

"To show that a drug has an effect on a disease, you need to be able to measure characteristics of that disease. So we focus on the discovery of novel biomarkers which would allow us to better study the drug's capabilities.

"A biomarker we have discovered in the progression of motor neuron disease is voice deterioration. It's not necessarily something that can be picked up by a clinician from day-to-day or week-to-week. But by following this biomarker's progress in a clinical trial with a sensor, or a mechanism for data capture, scientists know whether their drug is working or not."

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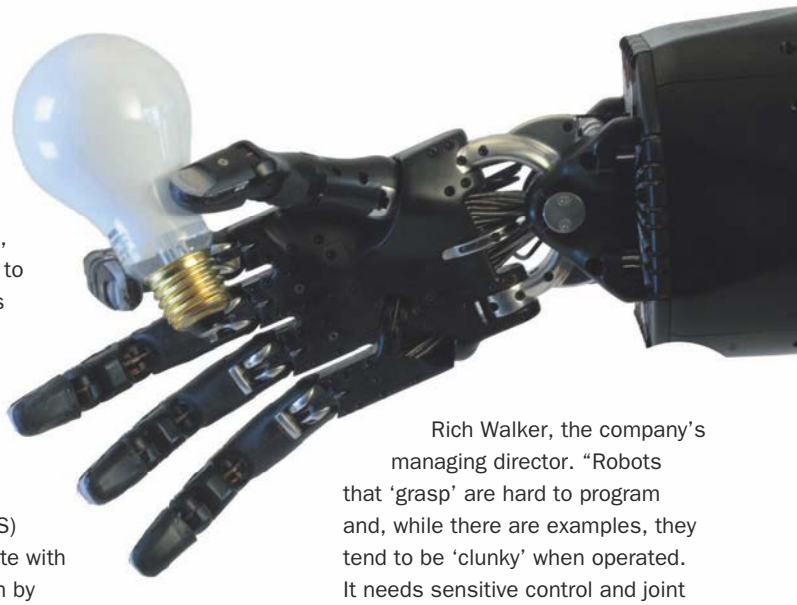
Grasping the future

Improved levels of connectivity and advances in robotic technologies are heralding greater collaboration between human and robot. By **Neil Tyler**.



The deployment of industrial robots is accelerating, driven by the Industrial Internet of Things, improved connectivity and the introduction of new technologies – ranging from smart grasping systems to more collaborative operation.

We are not only seeing the convergence of information technology and operations technology, but also robot manufacturers and communication and software providers coming together, leading to more human-robot collaboration.

Big Data, the rise of digital factories, a rapidly evolving supply chain, Industry 4.0 and emerging economies of scale are set to completely transform the way in which manufacturing operations are carried out. And industrial robots are being seen as the 'arms and legs' of Big Data.

Meanwhile, as more industrial robots are being deployed, this will require factories to make better use of the available floor space. In order to do this, robots will have to collaborate to a much greater extent and this will need them to have built in intelligence.

London based Shadow Robot – one of a number of companies working with Innovate UK – is developing a Smart Grasping System (SGS) which enables robots to operate with a 'grasping' action, rather than by 'gripping'.

"Humans are excellent graspers, but despite decades of research on robotic grasping, we have yet to establish the same level of competency in robotic systems," says Rich Walker, the company's managing director. "Robots that 'grasp' are hard to program and, while there are examples, they tend to be 'clunky' when operated. It needs sensitive control and joint motion.

"Grasping is gripping but with some intent after. It is a more dextrous approach than simply gripping."
Ugo Cupcic, Chief Technical Architect, Shadow Robot

"People have been calling for something a lot simpler than what currently exists and a lot less expensive."

The SGS developed out of a collaborate effort, part of the European Horizon 2020 project, established to deliver improved patient care.

"We are focused on developing a system capable of picking things up well, of picking up new and variable objects and doing so cleanly, but also without having to employ extensive technical support. The robot also needs to be able to communicate with the wider production management system.

"When combined with built-in intelligence, it will have the ability to operate like a human hand," Walker explains. "Manipulation is the key requirement, but keeping it simple has proved hard in term of programming."

Unlike traditional 'grippers', which are designed to perform one specific function, the Shadow Robot variant is capable of using a variety of grasps, allowing it to handle a much broader range of objects.

The system comes with a

library of different grasps, an in-built vision system that enables it to 'see' what it is about to grasp and torque sensing in each joint. It has also been designed to be easy to use.

The SGS deploys sensors that monitor the torque in the springs of the various joints. Each joint can then be controlled separately and different levels of torque applied.

"The ability to deploy torque sensing means the hand can make a more accurate and reliable grasp. Ease of use means that it is easy to program," Walker says. "The system has the intelligence to know what it's grasping and to select the correct grasp for that particular object."

The key thing about the Smart Grasper, according to Walker, is that it can 'sense, interpret and then act'.

Walker says the industrial market has been calling for an accurate gripper and believes the SGS provides a practical solution to a real-world manufacturing problem.

Part of the world's largest online only grocery retailer, Ocado Technology has been working with universities from across Europe to develop innovative robotic solutions and has recently unveiled a robotic grocery picking solution for its highly-automated warehouses.

Ocado's robotics team has created a device which can safely grasp a variety of products. In order to avoid damaging sensitive and unpredictably shaped grocery items, the arm uses the principle of environmental constraint exploitation to establish a carefully orchestrated interaction between the hand, the object being grasped and the item's environment.

According to Dr Graham Deacon, Ocado's robotics research team leader: "We are pursuing a new direction for robotic grasping by developing robot hands."

Ocado is also involved in designing a collaborative robot that can learn from and offer assistance to warehouse maintenance technicians in a proactive manner.

The wealth of data that is being created means that it is possible to build more intelligence into the production process, whether that is derived from mapping vision, human motion and emotion, or human skills such as how humans handle objects across to robots.

All of this requires embedded sensing technologies and high speed microcontrollers capable of processing and using this intelligence.

The rise of Industry 4.0 means that, for many businesses, manufacturing flexibility and the ability to handle limited batch numbers will be crucial.

"Industry 4.0 is an interesting opportunity for our robotic technology. It's all about flexibility and requires all the production stations to know what is coming down the production line. It will need to have the ability to manage different shapes and a gripper capable of handling that," Walker explains.

Combining an intelligent gripper with digital modelling or 3D modelling, for example, or linking it to 3D cameras and embedded learning capabilities, will provide more flexibility and intelligence.

"The system has the intelligence to know what it's grasping and to select the correct grasp for that particular object."
Rich Walker

More than an industrial gripper, the Smart Grasping System uses built-in intellgience to grasp an object

"Manufacturers will want to be able to adapt their machines and robots easily and efficiently in light of that intelligence," suggests Walker.

"Programming a gripper to do a simple action is straightforward. But if you need it to do a more complicated task, factories are currently obliged to purchase new grippers in order to perform it. That's time consuming and expensive," he explains. "The library we have created includes a large number of different grasps, which means you don't need multiple machines, saves money and reduces the floor space required. You will be able to install these robots across multiple sites via an easy to use interface with a simple setup."

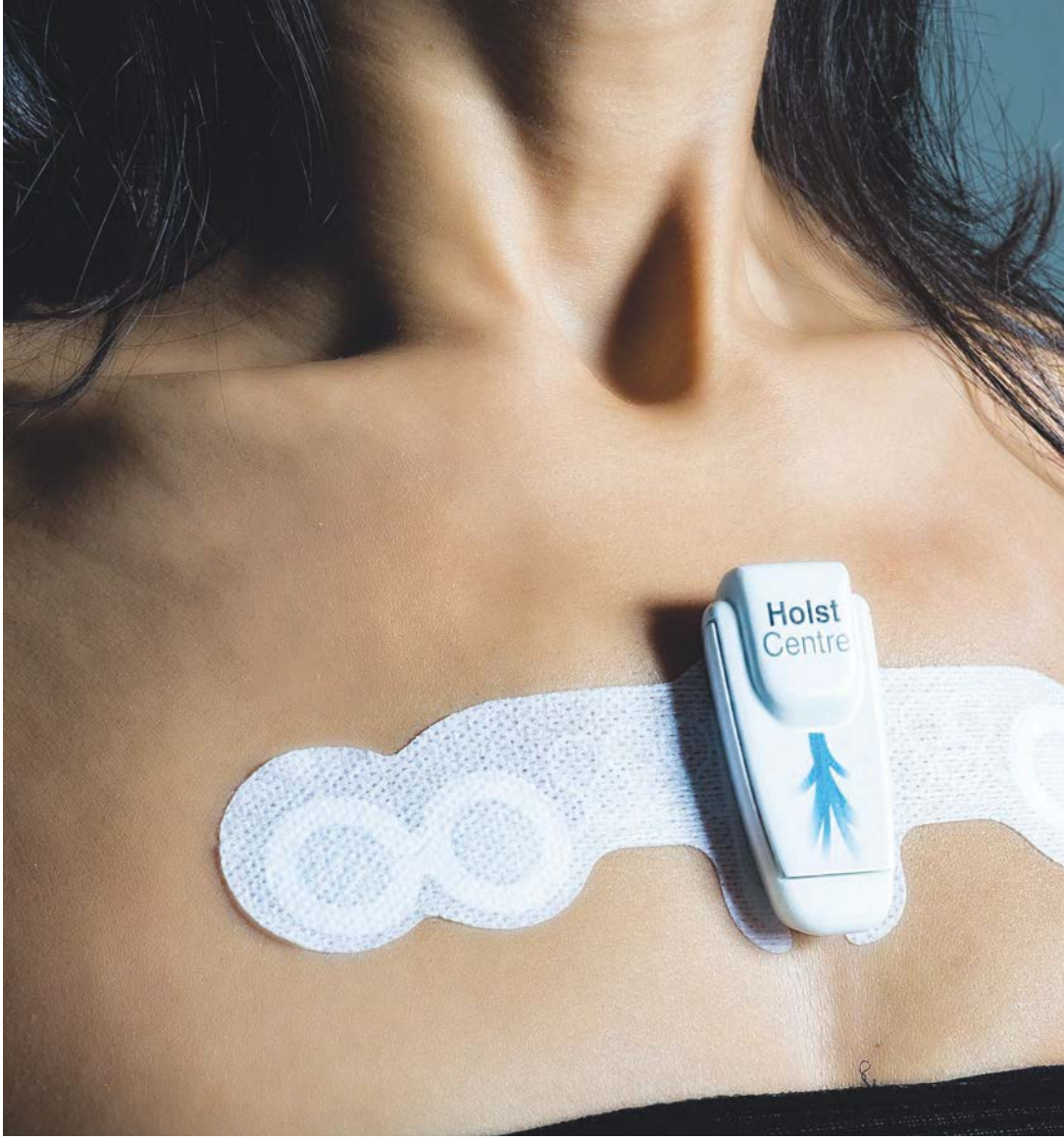
With intelligence embedded into the 'hand', Walker says the company has taken an Internet of Things approach by putting the intelligence into the hardware.

"Another benefit is that the SGS is modular. That means it can be used with existing robotic arms or platforms and with existing processes – eliminating unnecessary costs," he suggests. "You'll require fewer robots, fewer spare parts, less training for staff and less human cost."

He argues that, as these robots are able to work more efficiently and independently, their human operators or minders can then be deployed on higher-level tasks.

"Robotic hands will be responsible for low level tasks, helping to solve real-world manufacturing problems by being both intelligent and far more flexible when it comes to re-tooling.

"We can, as a result, be far more creative when it comes to developing innovative manufacturing processes that enable businesses to fully exploit the concepts that underpin Industry 4.0," he concludes.



Sensing conversion opport

Programmability is bringing a new lease of life for the SAR data converter. By **Chris Edwards**.

There is a tension that lies at the heart of the circuitry needed to support the many sensors that underpin the IoT: battery-powered devices need to be as efficient as possible, which tends to imply the use of highly optimised, dedicated circuitry; but costs push designs in the opposite direction – towards programmability. This tension is not just being felt in the processing platforms needed to execute software, but also in the analogue front ends that pass sensor data into the digital domain.

When Marcus Yip and Professor Anantha Chandrakasan of MIT presented an A/D converter design for biosensing applications at the 2011 International Solid State Circuits Conference (ISSCC), a key target was flexibility, as the biopotentials used to measure heart and brain signals vary widely in bandwidth and dynamic range. Their approach was to implement the converter using reconfigurable hardware so resolution and speed could be changed 'on the fly'. Although programmable gain amplifiers on the front-end can help boost effective range, reconfigurability makes it possible to tune power efficiency.

In order to compare efficiencies among converters with different resolutions and sample rates, circuit designers tend to use the metric of energy per conversion step. Less than 100fJ/step is generally a good result for a modern process and novel techniques have pushed this metric down into the low tens.

However, the issue for reconfigurable A/D converters is that, although they can hit equivalent peak efficiencies, their energy per step increases as the circuit moves out of its sweet spot. For example, while the MIT design outlined at the 2011 ISSCC had a peak efficiency of 22fJ/step at 10bit resolution, energy consumption increased to 143fJ/step at 5bit resolution.

A year later, a team from research institute Imec's Holst Centre described a core that could deliver efficiency across a wider operating range. This applied novel techniques, allowing the accuracy and noise level of the comparator to be tuned to suit the target resolution. The noise for sampling to a 8bit level is allowed to be double that of a 10bit conversion. This slashes energy consumption almost fourfold. Bypass paths made it possible to separate out and shut down the circuitry needed for the most significant bits of a full 10bit conversion.

The main focus in reconfigurable architectures like those developed at MIT and the Holst Centre has been on the venerable successive approximation (SAR) converter. First introduced in 1975, SARs fell out of favour because they lacked the speed of flash and pipelined architectures and could not compete with the resolution of sigma-delta.

SAR converters use a binary-search algorithm to find the digital code that is as close as possible to the analogue input. The algorithm takes as many search steps as there

Main image.
A health patch developed by the Holst Centre can measure cardiac activity and bioimpedance – both of which can vary widely in bandwidth and dynamic range

unities

are bits of resolution, which tends to limit its speed at higher resolutions. This leads to a 'push-pull' between SAR and sigma-delta architectures in commercial designs.

"Signal bandwidth, together with the latency aspect, tends to determine whether a SAR or sigma-delta architecture is chosen," says Darren Hobbs, director of product management at IP and design house S3 Group. "For integrated solutions, SARs are now dominating at resolutions of less than 14bit. For greater resolutions, sigma-delta still tends to be chosen."

In IoT-focused designs, SAR has a further advantage, Hobbs says. "The low latency and fast wake-up time of SAR converters also help with power reduction. If they are not converting continuously, they can easily go to stand-by mode with minimum or zero power consumption, therefore extending battery life."

To perform the binary search, the SAR uses a D/A converter based on a switchable network of capacitors to generate a reference voltage and, under logic control, updates its output as the voltage moves above and below the captured sample. A comparator guides the internal digital logic on whether the reference voltage should move higher or lower. It is a structure that becomes more efficient than competitors as processes scale down.

Tatsuji Matsuura of the Tokyo University of Science, says the SAR A/D converter is 'inherently a low-power device because it does not use operational amplifiers'. Op-amps tend to fare badly in highly miniaturised processes because of their need for a high gain factor, which drops away with process shrinks.

There are still energy costs to deal with. Hobbs says: "SAR power consumption is directly related to capacitor size. A high linearity requires very small mismatch on the capacitors, which means large devices. But, by introducing calibration techniques, we can correct the mismatch present on small devices digitally. Therefore, we can use very small devices, meaning very low power, while keeping the high linearity conversion."

Recent research papers, such as the one presented by the Holst Centre at ISSCC 2015, have focused on other capacitance reductions. This design reduced the figure of merit to 2.4fJ/step on a 65nm process through the use of a bidirectional comparator and attempts to make the capacitors themselves as small as possible. Bidirectional comparisons allow both the charging and discharging phases to be used, almost halving the overall energy of each conversion.

A further change lay in the use of an onchip reference voltage generator that was decoupled from the supply voltage and worked in the subthreshold region. Because the difference between normal and high-threshold transistors within the process was more stable, the design used that to provide the reference.

The power consumption of the modern SAR will see it pushed further into the domains of sigma-delta and pipelined converters in the directions of resolution and speed, respectively. But the nature of the architecture means it faces limits.

"There is a large body of research ongoing to find solutions to overcome these limits," Hobbs says. "The trend we see today is not to replace the SAR by something else, but instead to improve the SAR with features or characteristics from other architectures to make it even more flexible and powerful."

For example, S3 has used hybrids of SAR and pipelined architectures to push sampling rates to 200MHz in commercial circuit designs. The research community has published work on similar hybrids that operate in the gigahertz regime. In general, a pipelined approach coupled with the SAR circuit makes it possible to reduce internal clock speeds. "Achieving higher sampling rates requires time-interleaved cores, which we do as needed," Hobbs says.

When it comes to higher resolution, SAR is hybridising with the sigma-delta converter, which has always provided scope for trading off resolution against speed through changes to the digital decimation filter that forms the bulk of the converter's circuitry.

A team from Michigan State University has taken the idea further with a hybrid architecture that can be tuned to be more like a SAR or a sigma-delta, depending on the required speed and resolution. Where higher speed is more important, the circuit's SAR characteristics take over.

With power efficiency and implementation cost dominating IoT-focused designs, the SAR looks certain to continue its takeover on a larger scale.

"The low latency and fast wake-up time of SAR converters help with power reduction."
Darren Hobbs

The power for CHANGE

As requirements become more demanding, silicon carbide technology is reaching a tipping point. By **Graham Pitcher**.

While silicon currently remains the material of choice of power devices, there is little headroom available to improve figures of merit such as on resistance and gate charge. However, there appears to be more room for manoeuvre with alternative materials and two such materials which are focusing the attention of device developers are silicon carbide (SiC) and gallium nitride (GaN).

Both are wide bandgap materials which not only allow power devices to operate at higher voltages, higher temperatures and higher frequencies, but also to reduce energy losses. Yet, despite both technologies having been in development for some time, there are few examples of SiC or GaN products in the market – even though the first such products appeared nearly a decade ago.

But as performance characteristics become more demanding, it might just be that a 'tipping point' is nearing for SiC, pushed by the space, weight and efficiency requirements of electric vehicles and hybrids and by some particular industrial applications.

Aly Mashaly is manager of the power systems department for Rohm Semiconductor. He noted two particular trends in the power sector and said requirements have increased dramatically. "There is the need for higher efficiency," he contended. "This reduces the amount of energy lost in a system, improves performance and cuts operating costs. There is also the need for higher power density. By taking this approach, systems can be made smaller and energy consumption reduced."

However, he added, silicon based power devices are struggling to meet these requirements and SiC based devices are now being used in a range of applications; not only industrial, but also automotive. "Rohm has two technologies which it can use for SiC MOSFETs – planar and trench – and Rohm is the only company which has trench technology in mass production."

"Silicon carbide will be the next good thing, but we have to find the appropriate entry points."
Martin Münzer

Part of the appeal of SiC comes from its physical properties. For example, where silicon has a breakdown electric field of 0.3MV/cm, SiC can withstand up to 2.8MV/cm. "Its internal resistance is also 100 times smaller than that of silicon," Mashaly noted. "This means applications can handle the same level of current using a smaller chip – and this leads to smaller systems."

Development of SiC based technology began at Rohm 16 years ago, said Mashaly. "While the first device appeared on the market in 2010, we are now broadening the portfolio."

The company used last November's electronica to unveil its third generation SiC MOSFET, featuring its double trench technology (see fig 1). Devices in the SCT3xxxKL range are

said to reduce on resistance by 50% across the operating temperature range and input capacitance by 35%, when compared to a chip of the same size manufactured on a planar process. Their high speed switching performance also makes it possible to reduce the size of peripheral components, such as coils and capacitors.

Mashaly used a power control board as an example of the benefits which SiC devices can bring. When constructed from silicon IGBTs, the board weighs 7kg. Using SiC based components, weight is reduced to less than 1kg.

Mashaly has automotive and industrial applications in mind for SiC parts and so too does Infineon. Mark Münzer is senior director of the company's high power electric drive train business. "We're still using silicon based devices in automotive applications, but we're looking to transfer some of these to SiC. Even so, we'll still be developing silicon based solutions for the next generation of cars and to offer value. Silicon carbide will be the next good thing, but we have to find the appropriate entry points."

One particular entry point which Infineon has identified is the on board charger in EV and hybrid vehicles. Not only does SiC bring value to this, it also translates into space savings through smaller passive components. But SiC won't be available at the same price as silicon parts."

Münzer believes SiC will be particularly appropriate to EVs. "It will allow companies to develop smaller devices with higher power densities, meeting some of the constraints posed by EVs. But these will be specific applications."

Silicon carbide technology is being applied to low frequency inverters in EVs, but Münzer says that, as SiC technology develops, it will be able to address higher frequency applications, including boosters and on board chargers.

And this will allow EV developers to make trade offs. For example, the efficiency gains from SiC could either bring a 10% increase in range or allow the use of a battery which is 10% smaller. "The cross over point is about 40kWh," Münzer said.

Infineon's Double Sided Cooling modules are aimed at applications with a typical power of 40 to 50kW

Looking to enable these applications, Infineon has developed the Double Sided Cooling (DSC) module. Measuring 42 x 42.4 x 4.77mm, the modules are aimed at applications such as main inverters and generators with a typical power range of 40 to 50kW. "When you want to get products designed into drives," Münzer pointed out, "you need to ensure there is full area contact on both sides of the package. This package brings a six fold increase in power cycling capacity and, with its non standard wirebond, it can operate in higher temperatures."

Infineon also sees significant opportunities for SiC technology in industrial applications and launched in 2016 a range of 1200V SiC MOSFETs optimised for reliability and performance.

According to Münzer, Infineon has developed a trench technology for the devices. "We wanted the parts to have high reliability, coupled with higher performance. However, we needed to improve the gate oxide stability in order to get both – and found a way to do it."

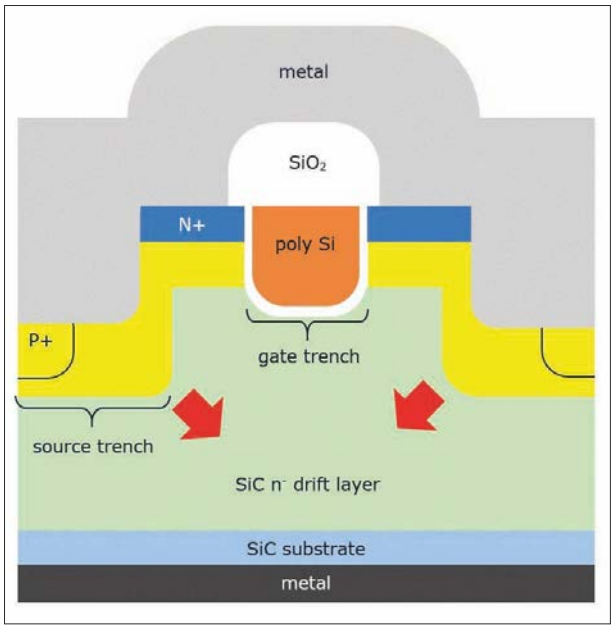


Figure 1: Rohm's third generation SiC technology uses a double trench approach for better performance

With dynamic losses said to be an order of magnitude lower than 1200V silicon IGBTs, the parts are initially suitable for applications such as photovoltaic inverters and uninterruptible power supplies, but the company says it will extend the range to include industrial drives. SiC MOSFET are also suitable for use with hard and resonant switching topologies like LLC and ZVS converters. In such applications, SiC MOSFETs can be used like an IGBT, with standard drivers.

The MOSFETs, compatible with the +15V/-5V voltages used to drive IGBTs, have threshold voltage of 4V and bring threshold voltage free on state characteristics. Threshold-free conduction brings with it the potential for a reduction in losses.

The first discrete 1200V CoolSiC MOSFETs have an on resistance of 45mΩ and are supplied in three and four pin TO-247 packages. The four pin variant incorporates an additional connection to the source, which can used as a reference potential for the gate driving voltage.

Rohm's Mashaly pointed out that the company has full control over the SiC manufacturing process, as it makes its own SiC wafers. "They are not easy to make," he noted. "There is a very thin drift layer and this has to be integrated on the substrate."

While the initial stages are at temperatures in excess of 1500°C, the seeding process which creates wafers takes place at 400°C.

"We are making 4in wafers at the moment," Mashaly concluded, "but we are looking to move to 6in wafers early in 2017."

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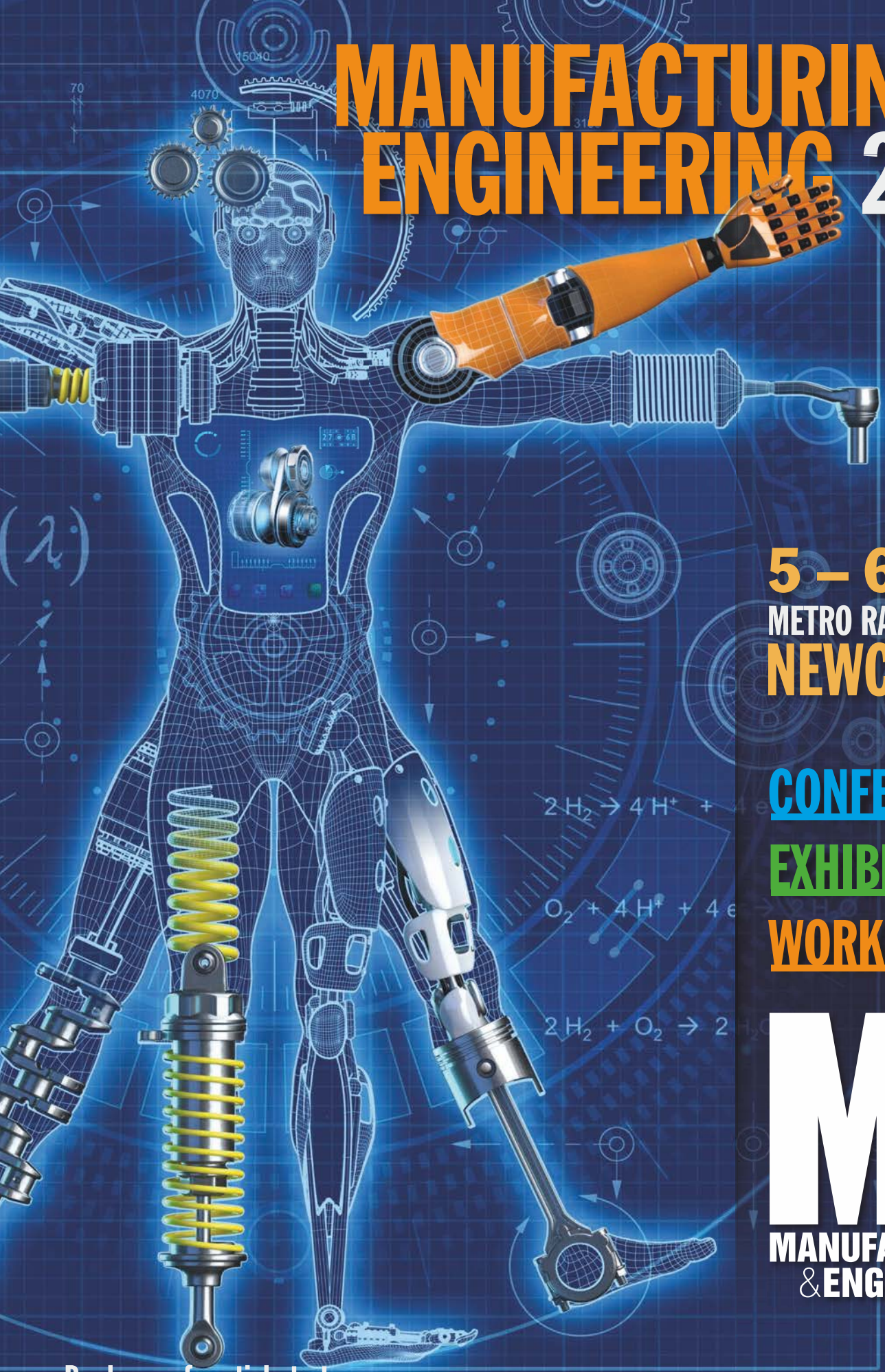

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Meeting the DATA RATE challenge

An internal interconnector and cabling system is looking to address the design challenges of increasing data rates and signal loss. By **Neil Tyler**.

The growth in connectivity, with billions of devices now connected around the globe, means the pressure is growing exponentially on the infrastructure that supports the collection and dissemination of data. Whatever the technical pressures, customers expect a seamless level of service.

This expanding network of connected people and machines means that companies working to address the needs and challenges of this market are looking for flexible, robust and cost effective solutions that can manage large workloads and support longer term data growth.

As rates increase, so data communications equipment – such as servers, switches, routers and storage devices – are seeing too much uncontrolled signal loss. Much of this is caused as a result of using standard PCB materials. As a result of high levels of loss, the clean transmission of these signals through PCB traces is being compromised. This means more companies are looking for solutions that will help to deliver significantly improved I/O connections on the board.

TE Connectivity has sought to deal with this problem with the development of the Sliver internal connector.

"This internal cabled interconnect has been designed primarily to provide much greater flexibility when it comes to making board level internal input/output (I/O) connections," explains Nathan Tracy, technologist, with the company's system architecture team and manager of industry standards.

"Sliver has been designed primarily for use inside data communications or telecom equipment, as opposed to being used as an external input/output port. It is a surface mounted connector with an exceptionally small footprint that is intended to make a simple connection from point A to point B.

Sliver Internal connectors and cabling (above and below) have been desgined for internal I/O connections on the board

"It is a new technology and is intended not only to simplify the design of these connections and to reduce overall costs by eliminating the need for retimers and costlier, lower loss PCB materials, but also to support data rate speeds of up to 25Gbit/s."

Data rates have increased significantly over recent years, rising from 1 to 10Gbit/s. According to Tracy: "Most of that signal transmission is done through the PCB using internal traces that can be routed across the board. Designers have to be creative as they are looking to make the most of the space that's available to them. However, as data rates look set to rise to move beyond 25Gbit/s – and a growing number of designers are looking at the possibilities of deploying 100Gbit/s links – the loss of signal through internal trace is starting to increase. That means the

receiver is unable to detect the data stream and make use of it.

So, as rates increase, so too do losses and that means the signal being delivered becomes increasingly inadequate."

Cable assembly

The Sliver connector has been designed to work alongside a cable assembly. "Essentially, we are looking to deploy cabling with this connector in order to address higher data rates," Tracy explains.

According to work by TE, the use of connectors with cabling reduces signal losses significantly when compared to traditional printed PCBs. "That is simply due to the nature of how the signal goes through the PCB as opposed to the cable assembly," explains Tracy. "Importantly, signal loss mounts as it moves from a board to, for example, a daughter card via a connector. The Sliver cable assembly enables you to avoid that as you transition from one plane to another using cabling."

Internal cable assemblies are certainly not new and have tended to be used in storage appliances.

"When it came to designing the connector, we were keen to ensure that we also addressed existing market requirements. That, in turn, had an impact on the materials we selected. We were looking to overcome insertion rate losses in existing systems, where data rates were between 8 and 12Gbit/s, and where internal cabling was already being used. Because we wanted to sell into existing markets as well as new ones, we needed to square performance with low cost.

"We used plastic and metal, rather than working with innovative new materials. While it's possible to use the latest materials to reduce crosstalk, our aim with Sliver was to develop a cost effective solution and one that was scalable. New materials are prohibitively expensive as production increases."

The connector has been designed to deliver improved signal integrity and the role of the connector, in maintaining that integrity, is becoming more important to the overall design.

"Inherent to that it is the internal structure of the connector and its footprint on the host board, as well as the contacts inside the connector and how they are held in place by the plastic housing. Likewise, with the plug half of the connector," Tracy explains.

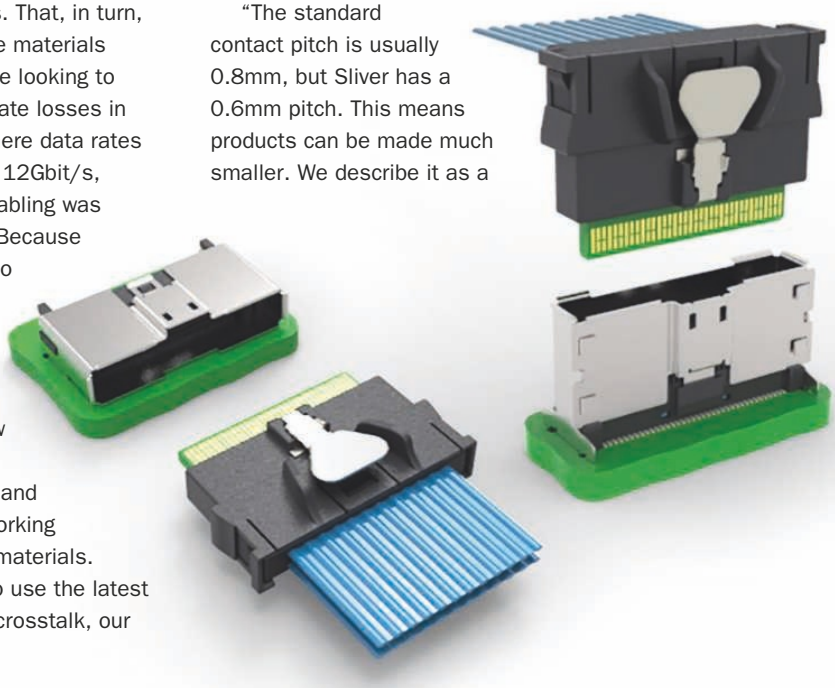
"The cable termination is critical when it comes to limiting signal loss; the transitioning point from the connector to where the cabling is terminated offers significant potential signal discontinuity. As a result, we have focused on the design quality at that point and worked to reduce noise."

Small and compact

The Sliver internal cabled interconnects have been designed to be as small as possible, according to Tracy.

"The standard contact pitch is usually 0.8mm, but Sliver has a 0.6mm pitch. This means products can be made much smaller. We describe it as a 'super slim' design that benefits from a very robust metal housing on the connector cage."

"While it's possible to use the latest materials to reduce crosstalk, our aim was to develop a cost effective solution and one that was scalable."
Nathan Tracy



Sliver supports present and future bandwidth needs without requiring requalification or redesign

The connector needs to be capable of withstanding cable pull and includes an active latch on the housing to provide additional connection security.

Sliver was not only designed to be flexible and robust, but also had to be a cost effective connector.

"When combined with our own cable assembly solution it can improve performance while saving on space and reducing design costs. The cable and connector have been able to double the range of data rate signals within data networking applications," he explains.

"Importantly, the connector has been designed to be small, with a high-density so that, via a cable assembly, it can route high-speed signals from microprocessors to other locations, such as other boards, microprocessors or the backplane," Tracy says. "We wanted to be able to free up space on the PCB."

The use of a cabling system means that the traditional losses associated with conventional interconnectors can be reduced.

"The Sliver and cabling avoids problems associated with moving from one plane to another," explains Tracy. "However, the user is not dependent on our cabling. We sell a plug kit to go with the connector, allowing companies to make their own assemblies – so interoperability should not be an issue."

The Sliver can also be used across a range of applications, data rates and protocols (including PCI Express, SAS and Ethernet).

"There are several interconnectivity options, including chip-to-chip, board-to-board, chip-to-front panel I/O, and high-speed card edge. It is a scalable platform that can be extended in increments of eight differential signal pairs for convenient and efficient pin configurations," he concludes.

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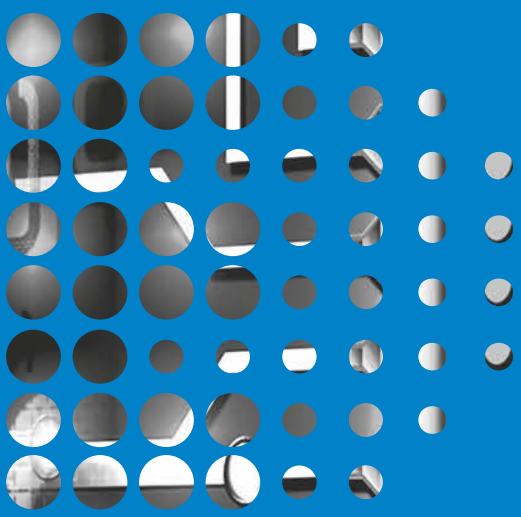

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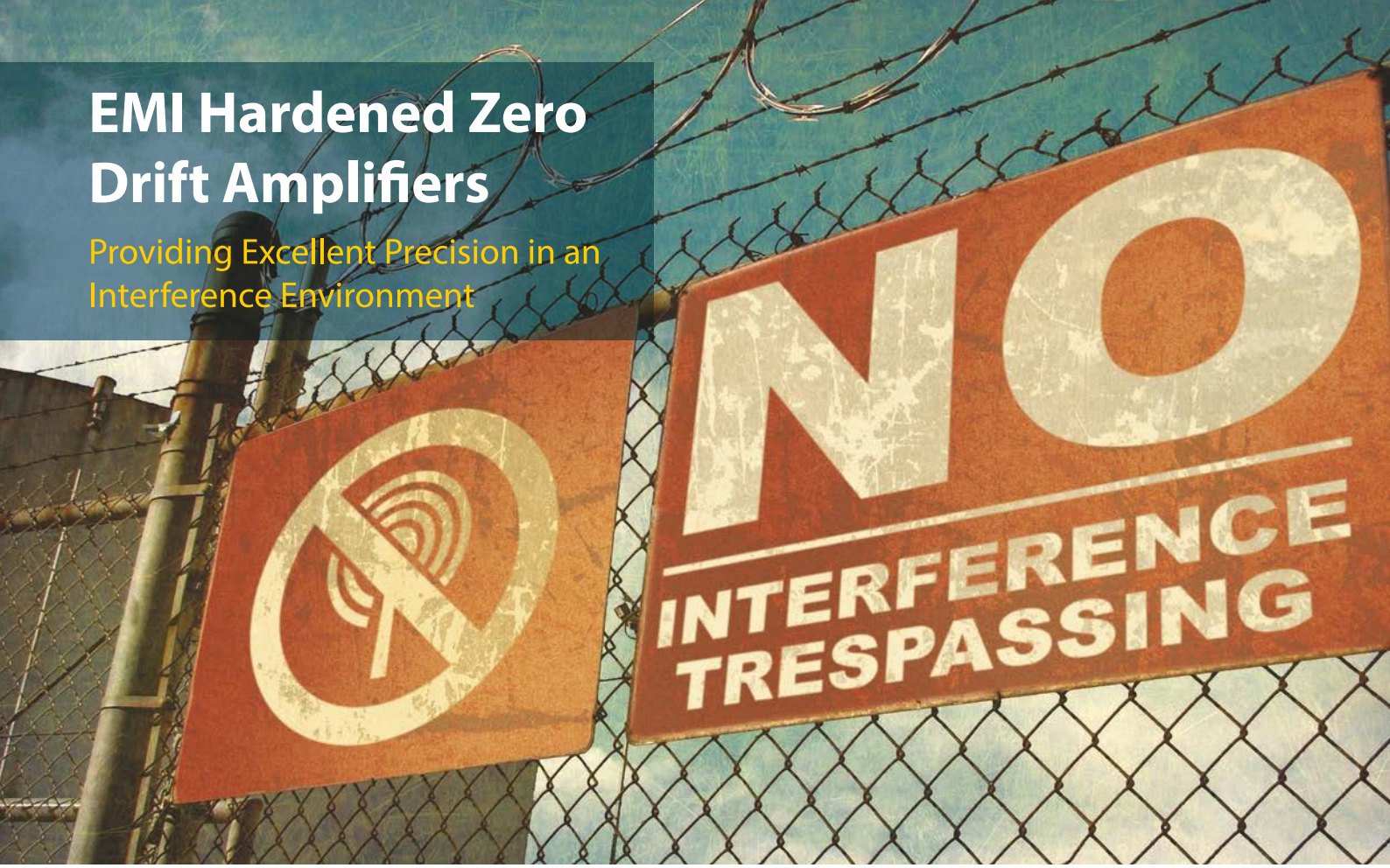

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