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THE FUTURE OF MINING

Research points to a mining industry in the midst of a digital revolution

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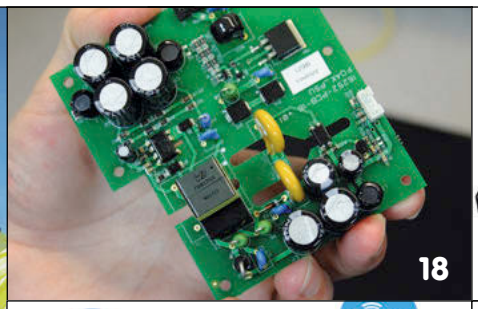

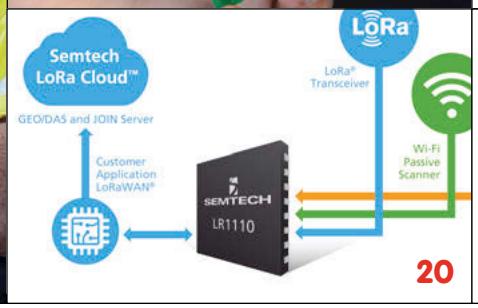

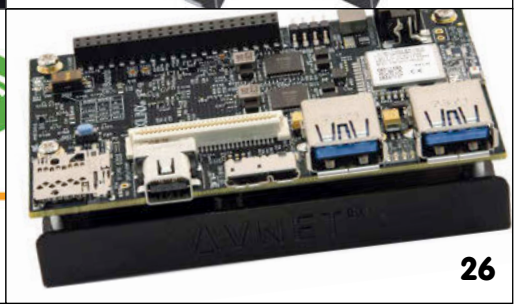

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Splitting down the middle?

ARE WE SEEING THE BEGINNINGS OF A DECOUPLING OF THE GLOBAL SUPPLY CHAIN WITH CHINA AND THE US ENDING UP IN SEPARATE CAMPS?

After 40 years of engagement divisions between the US and China are becoming more obvious and acrimonious, and China is certainly less willing to accept US leadership than it was at the turn of the century.

What does this mean for the global economy and the technology sector as they look to recover from the global pandemic? Could we see the global system breaking into two parts and if that was to happen, what would that mean for the very nature of the global economy?

While trade between these two is worth around $540bn, it's been suggested that China and the US may end up splitting their supply chains with both nations eventually having to make their own production equipment, software, semiconductors and systems.

The clash over trade has escalated in recent years and now there is talk of placing limits on the integrated supply chains between the two, along with calls for export controls and curbs on investment.

The Trump administration has recently strengthened restrictions on China's Huawei Technologies and sanctioned China-owned apps TikTok and WeChat and Washington has also rolled out a "Clean Network" initiative that will look to exclude Chinese tech firms perceived as threatening the country's national security. The UK's decision to exclude Huawei from its 5G network shows the pressure the US is putting on its 'allies'.

These threats are having an impact on companies that operate in China and recently Foxconn, the world's largest contract manufacturer, said that it had plans to move more of its production outside China.

In fact, the company's Chairman Young Liu was quoted as saying that China's "days as the world's factory are done," and went on to say that India, Southeast Asia or the Americas would see the development of their own manufacturing ecosystems.

According to Lui the shift in production out of China should be described as a 'megatrend'. He pointed to a predicted 50 per cent reduction in PC production in China over the next three years, to be replaced by the likes of Vietnam and Taiwan.

Protecting the global supply chain is important for companies but for many global brands they also need to avoid US criticism and the threat of fines and trade restrictions should they be found to be violating export controls.

China, in response, seems to be backing the creation of its own integrated supply chain replacing US technologies. Local governments and state firms are looking to procure domestically sourced tech displacing equipment from the likes of Intel, Microsoft, Oracle and IBM.

None of this looks great, but can we really expect the US tech giants to simply sit back and let this happen, let alone allow the decoupling of well-established supply chains?

Neil Tyler, Editor (neil.tyler@markallengroup.com)

"The Trump administration has recently strengthened restrictions on China's Huawei Technologies and sanctioned China-owned apps TikTok and WeChat"

newelectronics

Editor Neil Tyler
neil.tyler@markallengroup.com

Deputy Editor Elliot Mulley-Goodbarne
Elliot.Mulley-Goodbarne@markallengroup.com

Contributing Editors Chris Edwards, Charlotte Hathway, John Walko
editor@newelectronics.co.uk

Art Editor Andrew Ganassin
andrew.ganassin@markallengroup.com

Illustrator Phil Holmes

Sales Manager James Creber
james.creber@markallengroup.com

Publisher Peter Ring
peter.ring@markallengroup.com

Managing Director Jon Benson
jon.benson@markallengroup.com

Production Manager Nicki McKenna
nicki.mckenna@markallengroup.com

ISSN 0047-9624 Online ISSN 2049-2316

Annual subscription (22 issues):
UK £108. Overseas; £163. Airmail; £199.
New Electronics, incorporating *Electronic Equipment News* and *Electronics News*, is published twice monthly by MA Business, Hawley Mill, Hawley Road, Dartford, DA2 7TJ.
T: 01322 221144 E: *ne@markallengroup.com*

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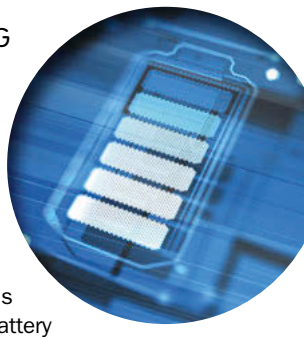
Energy harvesting solution

ATMOSIC TECHNOLOGIES AND SMK ELECTRONICS LOOK TO BRING 'FOREVER-BATTERY LIFE' TO IOT DEVICES. **NEIL TYLER** REPORTS



Atmosic Technologies, an innovator in ultra-low-power wireless technology for the Internet of Things (IoT), and SMK Electronics, a designer and manufacturer of advanced OEM electronic components, have announced a strategic partnership to integrate Atmosic's M3 system-on-chip (SoC) into a range of connected devices from SMK.

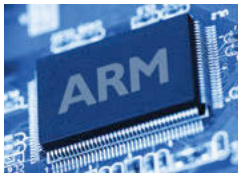
These IoT solutions, which will include remote controls and sensors, integrate Atmosic's Managed Energy Harvesting, in addition to the company's Lowest Power Radio and On-demand Wake-Up Receiver, to enable 'forever battery life' and eliminate the need for battery replacement. SMK and Atmosic said that they are also working on an IoT module integrated with the Atmosic M2 SoC for industrial and commercial IoT applications.

"Atmosic and SMK are committed to drastically reducing the battery dependence of IoT devices to make this a reality," said Srinivas Pattamatta, Vice President of Business Development at Atmosic. "Eliminating the need for battery replacement not only cuts maintenance costs, but it also can help prevent equipment failures caused by battery life issues."

Atmosic offers Bluetooth Low Energy (BLE) and energy harvesting in an integrated SoC, reducing the overall bill of materials while enabling storage and sourcing of energy from radio frequency (RF), photovoltaic, thermal or mechanical sources. The company's M3 Series Bluetooth 5 SoC leverages harvested energy to extend battery life or even eliminate the need for batteries in IoT devices.

With the M3 solution, SMK will offer remote controls and sensors for consumer, commercial and industrial markets that utilize ambient energy to solve the problem of battery replacement.

Arm Cortex-R processor targets computational storage



Computational storage is emerging as a critical part of the 'data storage puzzle' because it puts processing power directly on the storage device, giving companies a more secure, quicker and easier access to vital information.

In response, Arm has announced the Cortex-R82, its first 64-bit, Linux-capable Cortex-R processor that's been designed to accelerate the development and deployment of next-generation enterprise and computational storage solutions.

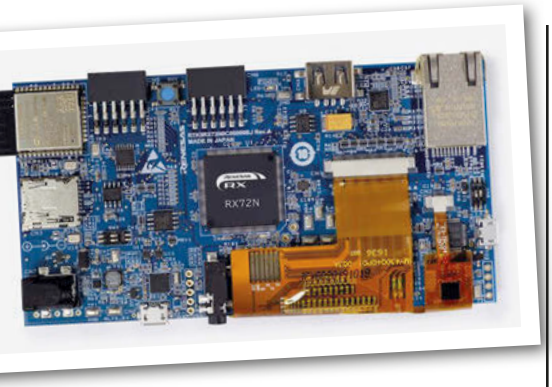
The Cortex-R82 provides up to 2x performance uplift, depending on the workload, compared to previous Cortex-R generations. This will allow storage applications to run new workloads like machine learning at a lower latency, with optional Arm Neon technology to provide additional acceleration. The Cortex-R82 is 64-bit, providing access to up to 1TB of DRAM for advanced data processing in storage applications.

Storage controllers traditionally run bare-metal/RTOS workloads to store and access data, however, with the Cortex-R82 Arm has introduced an optional memory management unit (MMU) to allow for rich operating systems to run directly on the storage controller.

According to Arm, processing data where it is stored will open up huge opportunities across applications including IoT, ML and edge computing.

"As the storage market evolves, one of the biggest requirements is the need for flexibility and the new features of the Cortex-R82 processor will provide its partners with the possibility to design multi-core implementations of up to 8 cores, as well as the ability to adjust the types of workload running on the storage controller based on external demands in software," said Neil Werdmuller, director of storage solutions at Arm.

In a move intended to reduce the complexity and costs for its partners, the Cortex-R82 is able to leverage Arm's Linux and server ecosystems. With the ability to run Linux developers will be able to access a broader set of software tools and technologies, such as Docker and Kubernetes, to use for their storage applications, providing an accelerated method of implementation. The Cortex-R82 also takes advantage of Arm's security foundations and is compatible with Arm TrustZone, ensuring isolation of the storage controller firmware from other Linux or real-time workloads.



RS improves HMI for IoT development

RS Components (RS) is now offering the RX72N Envision Kit from Renesas Electronics. Optimised for HMI development in the IoT, the kit has been designed to offer a platform for developing applications that require a graphical user interface (GUI). With a fully integrated WQVGA LCD with capacitive touch-sensing, developers can quickly develop HMIs for a variety of applications.

The kit is based on the RX72N 32-bit MCU, and features Renesas' third-generation RX CPU core, the RXv3, which has been designed to deliver improved performance and faster interrupt response. Hardware accelerators for trigonometric calculations increase the speed of motor control applications, while the integrated TFT LCD controller and 2D drawing engine make full use of the kit's display.

Trusted Secure IP provides a cryptography engine to realise AES, RSA, ECC as well as secure key management to protect customers' keys and IDs.

The RX72N enables both wired and wireless network connections necessary for IoT applications via integrated Ethernet controllers and various serial interfaces for wireless module connection.

The kit also includes embedded emWin middleware from Segger to support its GUI software package, along with two demonstration applications based on FreeRTOS from AWS.

The Envision Kit also integrates other features, including high-efficiency DC/DC converters, a D2Audio IC, stereo MEMS microphone to support voice recognition, and an LCD backlight driver with complementary light sensor. Comprehensive connectivity is included in the form of Ethernet, Bluetooth and Wi-Fi.

The board also integrates an E2 Lite emulator.

Marvell and TSMC collaborate on 5nm technology

COMPANIES ARE WORKING TOGETHER TO DELIVER A COMPREHENSIVE SILICON PORTFOLIO. **NEIL TYLER** REPORTS

Marvell has announced that it is extending its long term partnership with TSMC in order to deliver a comprehensive silicon portfolio for the data infrastructure market, leveraging 5nm process technology.

Marvell and TSMC have said that they will look to advance the essential technology underpinning next-generation infrastructure to provide the storage, bandwidth, speed, and intelligence that these new systems require, while delivering significant improvements in terms of energy efficiency.

Built in partnership with TSMC, Marvell's new 5nm portfolio will enable leading-edge silicon innovation for the infrastructure market. Marvell said that its 5nm portfolio will provide the essential high-performance compute, networking and security technology required to advance infrastructure development for end-market applications.

Marvell's Ethernet connectivity solutions enable high-performance, low-power network connectivity, optimised for applications that span cloud data centres to the harsh environment of the automotive market. It's OCTEON platform is the industry's leading Arm-based high-performance compute architecture for embedded infrastructure applications targeting a wide variety of wired and wireless networking equipment.

OCTEON is the world's most widely deployed data processing unit (DPU) for data-centre scale computing and enables acceleration and offload capabilities, including Smart NICs and security accelerators. It also features optimised and customised 5G processing and baseband capabilities.

With multiple designs already under contract for its 5nm portfolio, Marvell said it was developing solutions for a variety of markets with first products sampling by the end of next year.

Marvell's entire 5nm solution set is supported by its IP portfolio that covers most infrastructure requirements including high-speed SerDes up to 112Gbps long-reach, processor subsystems, encryption engines, system-on-chip fabrics, chip-to-chip interconnects, and a variety of physical layer interfaces. These technologies are all in development now on TSMC's N5P process, an enhanced version of TSMC's 5nm technology which delivers approximately 20 percent faster speed or 40 percent power reduction compared to the previous 7nm generation.

Raghib Hussain, Chief Strategy Officer and Executive VP of the Networking and Processors Group at Marvell said, "TSMC's 5nm process provides world-class power, performance and gate density – and it's critical for the demands of the leading companies in the world in cloud, 5G, enterprise, and automotive."

Ultraleap signs agreement with Qualcomm

Ultraleap and Qualcomm have signed a multi-year co-operation agreement that will see Ultraleap's hand tracking platform, known as Gemini, pre-integrated and optimised on the standalone, untethered Snapdragon XR2 5G reference design. It is a step change for the XR space, delivering faster, more accurate and more robust hand tracking on an open platform for developers.

The Snapdragon XR2 5G platform is the first 5G-supported platform designed specifically for untethered VR, MR and AR. Gemini has been optimised for the Snapdragon XR2 5G platform to allow for an 'always on' experience and a more natural interaction in untethered XR.

Steve Cliffe, CEO of Ultraleap, said, "Qualcomm Technologies recognises the importance of high-precision hand tracking in order to revolutionise interaction in XR. The compatibility of our technology with the Snapdragon XR2 5G Platform will make the process of designing hand tracking within a very wide variety of products as simple as pick and place."

Broadcom overtakes Qualcomm in Q2 2020

BROADCOM SURPASSES QUALCOMM IN Q2 IN TERMS OF REVENUES, WHILE NVIDIA SURGES AHEAD. **NEIL TYLER** REPORTS

According to the revenue ranking of top ten IC design companies for 2Q 2020 compiled by TrendForce, Broadcom has surpassed Qualcomm in terms of quarterly revenue.

Qualcomm appears to have been constrained by the delayed release of Apple's latest iPhones, which has led to a slowdown in Qualcomm's chip revenue growth. Qualcomm registered a modest 6.7% revenue growth YoY in 2Q20. Although Broadcom retook first place in terms of quarterly revenue, escalating tensions between China and the US had a negative effect on its semiconductor revenue performance, which declined by 6.8% YoY in 2Q20.

Nvidia, which now includes revenue from Mellanox, posted a strong revenue performance for 2Q20 and increased its revenue by 47.1% YoY, the highest percentage growth in the top 10 list.

AMD scored the second highest YoY percentage growth in 2Q20, at 26.2%, behind Nvidia, due to the success of both the Ryzen and EPYC processors in the notebook and server markets.

Xilinx, which has traditionally counted the wired and wireless network equipment market as one of its main revenue drivers, posted a 33.2% YoY decrease in quarterly revenue, and was badly affected by the COVID-19 pandemic which took a heavy toll on the global automotive market, leading to a fall in automotive revenue. For the first time ever, Xilinx registered a double-digit YoY quarterly decline.

Taiwanese IC design companies MediaTek and Realtek maintained their strong performances during the quarter, reaching YoY revenue growths of 14.2% and 18.8%, respectively. MediaTek was able to successfully deploy its products to the 5G mid-range smartphone market with its 7nm process technology and cost optimisation measures, in turn raising its revenue and gross margins.

Inclinometer with machine-learning core

STMicroelectronics has unveiled the IIS2ICLX, a high-accuracy, low-power, 2-axis digital inclinometer for use in applications such as industrial automation and structural-health monitoring.

The device features a programmable machine-learning core and 16 independent programmable finite state machines that help edge devices to save power and reduce data transfers to the cloud.

With advanced embedded functions, it is able to lower system-level power consumption to extend the operation of battery-powered nodes.

The sensor's inherent characteristics simplify integration into high-performing products, while minimising costs associated with calibration.

Using MEMS accelerometer technology, the IIS2ICLX has a selectable full scale of ±0.5/±1/±2/±3g and provides outputs over an I2C or SPI digital interface. Embedded compensation maintains stability over temperature to within 0.075mg/°C, ensuring higher accuracy and repeatability. Its ultra-low noise density enables high-resolution tilt sensing as well as sensing of low-level, low-frequency vibration, as required in structural-health monitoring.

As a result the IIS2ICLX is suited for industrial applications and structural-health monitoring, accurately measuring inclination and vibration to assess the integrity of structures such as tall towers and infrastructure like bridges or tunnels.

Whereas many high-accuracy inclinometers are single-axis devices, the 2-axis IIS2ICLX accelerometer can sense the tilt with respect to a horizontal plane along two axes (pitch and roll) or, by combining the two axes, can measure the tilt with high and repeatable accuracy and resolution with respect to a single direction of the horizontal plane over a range of ±180°.

Converter extends battery life by 50%

Texas Instruments (TI) has introduced the first DC/DC buck-boost converter to combine programmable input current limit and integrated dynamic voltage scaling to extend battery life by at least 50%

The TPS63900 maintains what is said to be the industry's lowest quiescent current (IQ), 75 nA, with 92% efficiency at 10 µA and delivers up to three times more output current than competing devices to help engineers extend the life span of battery-powered industrial and personal electronics applications.

A common challenge for engineers is designing for low IQ while at the same time providing enough output current to send signals between connected smart grid applications and a network via commonly used radio-frequency standards.

The TPS63900 conserves energy in wirelessly connected applications that run on batteries and integrates dynamic voltage scaling to deliver power while keeping the system at the minimum voltage required to operate efficiently, maximizing battery life.

This enables design engineers to optimise power architectures for ultra-low-power sensors and wireless connectivity integrated circuits.

As the industry's lowest IQ buck-boost converter to integrate a programmable input current limit, the TPS63900 is able to efficiently charge supercapacitors to buffer peak loads, protect battery capacity, and extend system lifetime and performance, helping buffer the energy required to operate components that require high peak currents.

The TPS63900 increases the stability of connected applications by reducing up to 50% of the output-voltage ripple caused by load transients. The new buck-boost converter's ultra-fast transient response maintains low IQ while keeping the internal regulation loop active.

Unveiling the future

TSMC SHOWCASED A NUMBER OF NEW TECHNOLOGIES AT ITS ONLINE TECHNOLOGY SYMPOSIUM AND OIP ECOSYSTEM FORUM. **NEIL TYLER** REPORTS

Last month saw TSMC showcasing the latest developments in its advanced logic technology, specialty technologies, 3DIC system integration solutions, and comprehensive design enablement ecosystem at its first online Technology Symposium and Open Innovation Platform (OIP) Ecosystem Forum.

In what is the company's largest annual event TSMC ran an online version to maintain what it described as an, "important connection with customers and ecosystem partners," and more than 5,000 people registered for these virtual events.

"During these difficult times for communities around the world, people are relying on technology to communicate with and to comfort each other," said Dr. C.C. Wei, CEO of TSMC. "Our customer's innovations make the world a smarter and more connected place. TSMC is committed to unleashing our customer's innovations with the most advanced logic technologies, a full portfolio of specialty processes to bridge the physical and digital world, advanced packaging technologies, and a comprehensive set of system integration solutions."

Key announcements at this year's event included TSMC's industry-leading 5 nanometer (nm) N5 technology entering volume production. The company said that this would start this year and that defect density reduction was proceeding faster than the previous generation as capacity continues to ramp.

N5 provides a 15% performance gain or a 30% power reduction, and up to 80% logic density gain over the preceding N7 technology, according to TSMC. Building on the original N5, TSMC plans to ramp an enhanced N5P version in 2021, offering an additional 5% speed gain and 10% power improvement.

TSMC also offered a preview of the latest member of the 5nm family – the N4 process. N4 has been developed to provide further improvements in performance, power and density to cover a wide range of product needs. In addition to process simplification with reduced mask layers, N4 also offers a straightforward migration path with the ability to leverage the comprehensive 5nm design ecosystem.

The N4 process is scheduled to start risk production in fourth quarter of 2021, with volume production in 2022.

' The N12e is intended for AI-enabled IoT devices, giving them the necessary power to perform functions such as understanding natural speech or image classification '

Looking ahead to the next generation, TSMC announced that it N3 process is on track to become the most advanced logic technology in the world featuring up to 15% performance gain, up to 30% power reduction, and a logic density gain up to 70% over N5.

TSMC also took the opportunity to unveil its N12e process, a technology now in risk production and optimised for edge AI applications by providing both powerful computing performance and improved power efficiency. The N12e brings TSMC's powerful FinFET transistor technology to edge devices enhanced with ultra- low leakeage (ULL) device and SRAM to deliver more than 1.75 times logic density improvement, and approximately 1.5 times performance improvement or less than half of the power consumption of the prior 22ULL generation of technology.

An enhancement of the 12FFC+ process, N12e is intended for AI-enabled IoT devices, giving them the necessary power to perform functions such as understanding natural speech or image classification while improving power efficiency. N12e also cuts the power cord and makes it possible to run powerful AI-enabled IoT devices on batteries.

In addition, TSMC announced the introduction of 3DFabric, an umbrella reference that refers to the company's fast-growing portfolio of 3DIC system integration solutions that offer much greater levels of flexibility for creating powerful systems through robust chip interconnections.

With an array of options for both silicon stacking at the front end and packaging chips together at the back end, 3DFabric will enable customers to connect logic dies together, to high-bandwidth memory (HBM) or to heterogeneous chiplets such as analogue, I/O, and RF blocks.

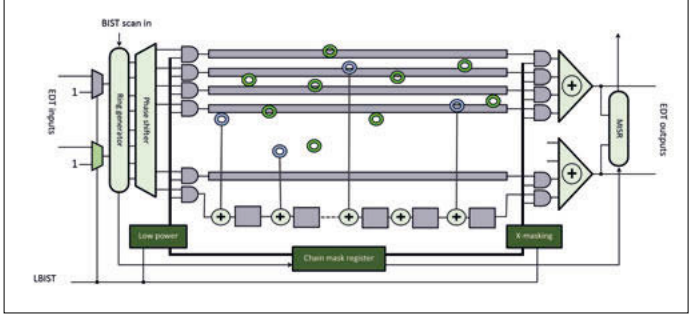
TSMC said that the 3DFabric is the industry's first solution capable of combining back-end 3D and front-end 3D technologies for a powerful multiplier effect in system integration. The 3DFabric augments and complements transistor scaling for continuously improving system performance, functionality, slimming down form factors, and improving time-to-market.

3DFabric is comprised of TSMC's System on Integrated Chips (TSMC-SoICTM), Chip on Wafer on Substrate (CoWoS), and Integrated Fan-Out (InFO) technologies.

Logic BIST with Observation Scan Improves Functional Safety for Automotive ICs

Semiconductor content in today's vehicles is growing rapidly and we are approaching the point where the value of the electronics is expected to exceed 50% of the total vehicle cost. A growing proportion of the modern-day automotive electronics are there to support new advanced driver-assistance systems (ADAS) like lane departure assist, collision avoidance, and other self-driving features. The demands of safety-critical ADAS systems introduce new challenges to semiconductor designers in meeting functional safety requirements defined by the ISO 26262 standard.

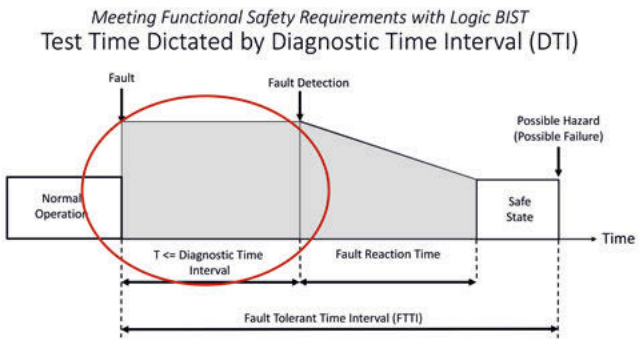
Figure 1:



Tessent LogicBIST with Observation Scan Technology (LBIST-OST) helps automotive ICs meet functional safety requirements. BIST is a standard mechanism for on-chip testing through the lifecycle of a device. However, traditional LBIST poses two challenges: it often cannot meet the 90% coverage goal required for Automotive Safety Integrity Level (ASIL) D certification and fault detection happens only during the capture phase of the LBIST cycle. Each LBIST cycle has two phases shift and capture. There are as many shift cycles as the length of the longest scan chain. The capture phase uses the values written into the scan chain to drive the combinational logic and capture potential faults. That means all the time spent on the shift phase is time faults are not being detected. Consider a design with 100-cell long scan chains. In logic BIST, applying 100,000 single-capture test patterns requires 10,000,000 cycles for scan shifting, while only 100,000 cycles are deployed to capture test responses. Hence, 99.99% of test time is spent on scan shifting. This is done using a mix observation scan test points and a dedicated observation scan chain as shown in fig 1.

Tessent LBIST-OST is the only technology on the market that can configure scan chains to capture test responses during both scan shift and scan capture cycles, significantly reducing the test time interval. A faster test time interval means more tests can be run and any defects in the operation of the system will be detected quicker, hence reducing the Diagnostics Time Interval (DTI) as shown in fig 2, enhancing the safety of the system. In practice, LBIST-OST delivers up to 10x faster in-system test than traditional LBIST and reduces the number of test patterns needed.

Figure 2:



Mentor, a Siemens Business, is a technology leader in electronic design automation (EDA), provides software and hardware design solutions that enable companies to develop better electronic and mechanical products faster and more cost-effectively.

The company offers innovative products and solutions that help engineers overcome the design challenges they face in the increasingly complex worlds of board and chip design.

Mentor, has the broadest industry portfolio of best-in-class products and is the only EDA company with an embedded software solution.

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Contact details

Mentor, a Siemens Business
Rivergate
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THE FUTURE OF MINING

Research points to a mining industry as being in the midst of a digital revolution, as **Neil Tyler** discovers

Could the mining industry be at an inflection point with a historically conservative industry finally starting to embrace new technologies?

Inmarsat, the mobile satellite communications company, suggests in a new report that the mining industry has started, if cautiously, to invest in the development and deployment of IoT-based projects.

In 'The Rise of IoT in Mining', it argues that with the mining industry under growing pressure to boost its growth and profitability, it is now seriously looking at the IoT.

Mining companies want to do more, with less, but to date, many projects have been relatively simple, in part, because the technology has to overcome a number of challenges specific to the mining industry.

As Joe Carr, Global Mining Director, Inmarsat explains, "Connectivity is often unreliable, cyber-security approaches are patchy, there are too few employees with the necessary digital skills and data is not being collected and managed in a way that would best empower organisations."

The mining industry has a history of moving slowly when it comes to the adoption of radical ideas and that has slowed the impact and benefits traditionally associated with the IoT and technology in general.

Is this attitude, however, starting to change? Inmarsat suggests that the industry-wide adoption of IoT technologies is accelerating, and in Europe the X-Mine project, led by the VTT Technical Research Centre of Finland, is a good example of how the mining industry is using new technologies to create a more independent, self-sufficient, but also more ecological mining industry.

The project has already resulted in new technologies that have helped to lower energy consumption and lower emissions, as well as significantly lower water consumption.

Above: Kumba Iron Ore - Kolomela - drone operators performing mapping and survey of all the mine pits.

In another project, called Goldeneye and funded by the European Union, a platform that combines earth observation technologies with on-site sensing and which will use remote sensing and positioning technologies with data analytics and machine-learning algorithms is being developed to allow satellites, drones and in-situ sensors to collect high-resolution data of an entire mine, which can then be processed and converted into actionable intelligence to allow more efficient exploration, extraction and closure.

"Our goal is to bring together different technologies in a platform that can offer innovative solutions and have a positive effect on the mining industry as a whole," says the project coordinator Marko Paavola from VTT.

The project will also look to improve the analysis of a site's mineralogy using drone integrated geophysical sensors as well as proximity sensors including active hyper-spectral sensing and time resolved Raman

Images courtesy of AngloAmerican Plc; alamy.com; agnormark/adobestock.com

spectroscopy.

The applications developed in the project, as with many others, will be adopted by a mining industry that is under pressure to reimagine business models and to start to incorporate technology into future operations.

Adopting technology

The motivations for adopting the IoT are varied but key are driving efficiency, increasing staff productivity, improving health and safety and reducing the environmental impact of mining.

In its report Inmarsat found that when it comes to the IoT many of the projects being adopted are associated with data usage and are, essentially, simplistic with the focus primarily being on issues of health and safety.

This is expected to change, with a greater focus on vehicle telemetry, supply chain tracking, and automated vehicle haulage predicted.

Driverless technology, for example, is forecast to increase mining output by up to 20 per cent while cutting fuel and maintenance costs.

Wenco International Mining Systems and Oxbotica, the autonomous vehicles specialist, have joined forces and are developing an Open Autonomy solution for mining, with trials currently underway.

The system is intended to enable efficient autonomous mining deployment, allowing mines to operate using any open standard-based vehicle allowing them to integrate it into an existing fleet.

Both companies have emphasised the importance developing an open and interoperable ecosystem of partners as it will enable a broader range of operators to integrate solutions alongside existing mine infrastructure. As a result, mining companies will not end up being locked in with a specific vendor, and will be able to carry on using their preferred technologies, independent of their primary industrial systems.

"Wenco and Oxbotica believe in the principle of open systems and consider it the primary way to bring about our joint goals of widespread adoption of autonomous technology and safer, more productive industrial operations. Our joint platform will allow customers to choose any open standards-based vehicle and integrate it into their existing operations," says Ozgur Tohumcu, CEO of Oxbotica.

"The mining industry has proven to be at the forefront of deploying early generation autonomy systems because the business case has been clear for operators," said Tohumcu. "However, less than two per cent of vehicles are autonomous in mines around the world."

Business specialists, BDO, believe that mining companies will need to become "Lean, Green, Digital" machines if they want to survive and prosper.

In research conducted by BDO, the mining industry was found likely to use robots and it was estimated that they will replace more than 50 per cent of miners, while reducing mining accidents by as much as 75 per cent.

Robotics may pose a risk to mining jobs but BDO expects that the majority of miners will be retained, and retrained to run the technology controlling the robots.

As for global mining companies leveraging Internet-connected sensors and automated drillers in mines, BDO expects that their deployment will result in a 30 per cent fall in per ton digging costs.

"Connectivity is often unreliable, cyber-security approaches are patchy, there are too few employees with the necessary digital skills and data is not being collected and managed in a way that would best empower organisations."
Joe Carr

Below: The mining industry is seeing a greater focus on vehicle telemetry, supply chain tracking, and automated vehicle haulage

While the IoT can be used to help improve mining safety, more Internet-connectivity will open up the industry to cyber-security breaches and new cyber-attack vectors will require it to plan for and prepare to counter these through the operation of proper internal controls. With the rise of renewables, BDO makes the point that activist hackers will be expected to launch a growing number of cyber-attacks on mines using Permanent Denial of Service attacks to eliminate the environmental and social threats they see such operations posing and will, most likely, use workers' connected devices to initiate those attacks.

The benefits for the industry from technology are great but so too are the risks and too many mining companies still see cyber-security as a cost, while too few have the necessary skills to implement effective cyber-security policies.

Reliable connectivity

Reliable connectivity is critical when it comes to the IoT and is a challenge when operating in environments that are remote, harsh and spread over great distances – but without it, IoT projects will fail.

Inmarsat, working with Cobham SATCOM, has launched a new Broadband Global Area Network (BGAN) push-to-talk (PTT) solution that can connect remote workers and vehicles around the world.

The solution has been designed to provide real-time data transfer and PTT communications which are critical for mining engineers performing well-head maintenance, or mining exploration teams looking for new mineral deposits. This kind of work requires everyone involved to be able to see the position of assets, share data and communicate in real-time.

Inmarsat's and Cobham's solution looks to address this and is said to offer reliability of more than 99%

uptime. Low form factor satellite terminals, such as the Cobham EXPLORER 323, can be mounted on vehicles and are able to provide real-time GPS, telemetry and PTT capabilities, through the EXPLORER Mobile Gateway. This means control centres can efficiently and safely monitor the movement and performance of their vehicles, while enabling communications with crew wherever they are located.

Critically, the solution can be integrated with existing kit on board, allowing organisations to keep and use existing equipment.

PRISM PTT+, a service powered by Cobham SATCOM's PRISM (Private Routing & Intelligent System Management) technology, enables the BGAN PTT Solution to switch between connectivity types such as UHF or VHF, 3G/4G and satellite making the solution cost-effective and easy to use.

The switching process is said to be unique because it is completely seamless and offers an economical approach to voice communications.

As Tara Maclachlan, Vice President of IoT, Enterprise at Inmarsat, explains, "Inmarsat's BGAN push-to-talk solution is set to offer a new level of resilient communications for organisations working in remote regions. It provides visibility of the movements and performance of remote assets along with real-time communications ensuring organisations benefit from enhanced efficiencies and safety levels."

Critically, a growing number of companies are not just looking at connectivity but how they're connecting their assets and people and there is now growing deployment of edge connectivity solutions to reduce costs, and improve data transfer rates.

The optimisation, filtering and routing of data will be critical and the use of edge computing will have a crucial role to play as companies look to turn data driven insights into practical actions – but at present, according to Inmarsat's report, too many companies are struggling with poor analysis which could undermine the credibility of their IoT projects.

Safety and efficiency

While the mining industry is focused on raising efficiency it also has to contend with safety and the need for proper training which can be time consuming and dangerous.

Anglo American, the global mining company, is using virtual reality to deliver training sessions to workers providing real-life simulations of operating at blast walls in its mines.

Anglo needs its crews to mark off blasting patterns accurately, drill straight and time explosives in the correct sequence, so that the blast will advance deeper, straighter, and crucially, more accurately, while at the same time ensuring that crews are safe.

Above: Providing effective blast training is challenging and explains why Anglo American has turned to VR

Mining is expensive and with hundreds of blasts scheduled every day any mistakes are costly.

To address this Anglo, working with STS3D, a specialist in VR, has developed the Amandelbult Training Complex Virtual Reality Stope, which recreates the situations miners encounter at real blast walls and uses several Virtual Reality training programs, an immersive VR Cube, seven VR Blast Walls, and a VR Robotics Simulator.

"Since you are fully immersed in the virtual mine, there's no room for distraction and the learning sticks. When you detonate the blast, the rock flies – creating a very vivid, a very memorable experience."
Johan Bouwer

Using motion capture technology developed by US company, Vicon, it has been possible to develop training sessions that create a lifelike "game" for both trainees and teams helping them to adapt to harsh conditions.

Simulations are provided through a powerful PC that drives 12 digital projectors and another for the 20 state-of-the-art Vicon motion capture cameras.

Anglo trains 1,500 people per year and providing effective blast training is difficult on multiple fronts. Not only is it a challenge for trainees underground in an environment that is dark, dusty and damp but communicating decades of practical experience and giving trainees a proper grasp of things like the scale, distances and measurements of a blast face is extremely difficult in a classroom setting.

The simulation has been designed to show trainees what could happen should they make the wrong decision and delivers a loud bang and sudden darkness to simulate a potential rock fall on the spot where they are standing.

"Make no mistake, this gives the miners a real fright. They'll remember their error. Since you are fully immersed in the virtual mine, there's no room for distraction and the learning sticks. When you detonate the blast, the rock flies – creating a very vivid, a very memorable experience," says Johan Bouwer, STS3D project lead.

Conclusion

The range of projects being undertaken within the mining industry is immense and, encouragingly, a growing number of companies are reporting that technology investments are making a positive impact on their bottom line.

Increased investment in technology will see a mining industry that will not only benefit from significant cost savings but one that will become markedly more efficient.

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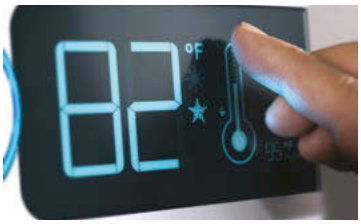

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The AVR-DA family uses the latest Core Independent Peripherals and low-power capability to handle real-time control functions in industrial control, home appliance, automotive and Internet of Things (IoT) applications.

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A connected vision

Jamie Hayes, Mobile Network Operators Director at BT Wholesale, talks to **Neil Tyler** about BT's smart city vision

"The BT smart city vision means a fully connected city and we'd like to see cities using technology to optimise all that they can whether that's transport systems of saving electricity," explains Jamie Hayes, Mobile Network Operators Director at BT Wholesale. "The world is changing rapidly and the public now expects to have connectivity at their fingertips."

According to Hayes the pressure on city infrastructure to enable ubiquitous coverage and provide the capacity not just for person-to-person communications, but the myriad of new and emerging connectivity use-cases – such as electric vehicles, smart reuse/recycling points and post-box collection – is growing and driving the 'smart city' concept.

"Back in 2018, we surveyed local councils and found that the overwhelming driver behind building a smart city was to improve traffic and transport management. Following that, councils are prioritising environmental services, community safety, energy efficiencies, social service improvements, and leisure services.

"We want to be in line with that and are working towards building 'Smart Streets', which means gathering insights from environmental monitoring and traffic optimisation sensors that can be easily integrated into 'street furniture', such as the next generation of BT Street Hub units."

For Hayes one of the obvious benefits of the smart city is that it's a way of fighting climate change.

"Air quality sensors, smart buildings and renewable energy sources will all help reduce negative effects on the environment. Driverless cars based on battery technology, and shared usage, street lighting that is activated only when needed and keeps people safer as a result, will promote sustainability and reduce pollution."

To be a truly smart city you need a constant stream of information, if the authorities are to be able to make more effective, data-driven decisions, says Hayes, and that will help monitor resources, saving time and money in the long run.

"Given the government's plans to achieve net-carbon emissions by 2050, UK cities will be focused on sustainability, but after that, each city's 'needs' will be different. The benefit of a smart city is that you can address specific issues efficiently whether that's forecasting and planning for population expansion or identifying high-risk areas where there needs to be a greater police presence."

Hayes suggests that the use cases for smart cities are still being worked through and while smart initiatives are generating much excitement, in the real world it will be interesting to see which aspects will actually generate a return on investment.

"Power consumption, cooling and security are the key cases with greatest return currently," Hayes says.

"Going forward, the ultimate goal is that cities of the future will be more efficient - cleaner, safer and greener. It's all about being better connected."

So does Hayes have examples of cities or authorities that are using technology to deliver a smarter experience?

"Sussex Police has consolidated nine separate surveillance systems and control rooms into one digital network. By connecting all public space CCTV cameras to the new network, officers can access any camera in the area from a local terminal without having to drive around the nine former control rooms to get the full picture. This has stopped officers driving more than 180,000 miles, saving time, slashing spending on fuel and maintenance, and cutting CO2 emissions.

"In Leicester and Gloucester free public Wi-Fi is helping to promote economic growth. BT helped them both with the rollout and the feedback was it's fantastic for people visiting the cities as well as local businesses, students, and shoppers."

Accelerated rates of transformation

The COVID-19 pandemic has had an impact on all aspects of life but could it help accelerate the trends associated with smart cities?

"Organisations across all industries have changed their working practices in response to COVID-19. We've seen a rapid acceleration in terms of digital transformation and years of transformation is now happening in the space of a few months. City councils have been exposed to this increase in digital transformation too, so it wouldn't be surprising if we see smart city timelines bought forward because we know how quickly we can embrace new

technology," suggests Hayes.

"Smart cities have also been actively helping to control the pandemic. In BT's global city presences like Seattle and Hong Kong, thermal imaging, body scanners, and infra-red CCTV have all been added to control population risks and to help local governments contain risk of outbreak, as well as understand traffic patterns and usage on an anonymised basis."

At the heart of a smart city's management infrastructure is a control centre that's connected to various digital data sources: video cameras, personal healthcare monitors, traffic flow sensors, fire and intruder alarms, flood and pollution sensors etc., and this allows people running the city to make swift, intelligence-based decisions, helping them respond to what's going on and to anticipate events before they happen.

"It can be argued that surveillance infrastructure is the foundation of a smart environment, with the camera at its core as the smartest sensor.

"Going forward, 5G technologies will be critical to delivering the smart city concept, providing greater coverage and meeting public demands for higher speeds and greater bandwidth. Small Cells will play a crucial part in supplying high bandwidth and low latency connectivity. To provide seamless coverage and installation of Small Cells, operators and telecom equipment providers need to cooperate with each other in an efficient way and with harmonised management and governance with each other in place to make sure smooth rollout and network operations."

As with all aspects of life the use of artificial intelligence is growing and smart cities are no different. According to Hayes, AI has the potential to reshape every use case across smart cities.

"From the small, such as, how do we best optimise our public services and empty bins? – to the large, like how do we best shape our cities to improve pedestrian traffic flow and increase usage of our public spaces – the impact of AI will be huge.

"Cities access a wide range of data sources which AI pattern technology can sort in a variety of ways and then use. What's more, AI technology has the power to greatly reduce human error. If efficiency is the goal of the smart city, AI is the perfect technology, especially as it becomes increasingly advanced."

"AI technology has the power to greatly reduce human error. If efficiency is the goal of the smart city, AI is the perfect technology, especially as it becomes increasingly advanced."

One of the worries around smart cities, especially the use of surveillance equipment, is the risk to privacy, so how do you ensure the population buys in to the concept?

"All new paradigm shifts generate barriers to entry, both social, cultural and technological and security is just one such barrier," argues Hayes. "The fact is, smart cities are just an extension of the use of data that we freely share today. In most use cases, this data is stored and federated, but not integrated into a business eco system. It's not necessarily about what data is collected, but how it is used.

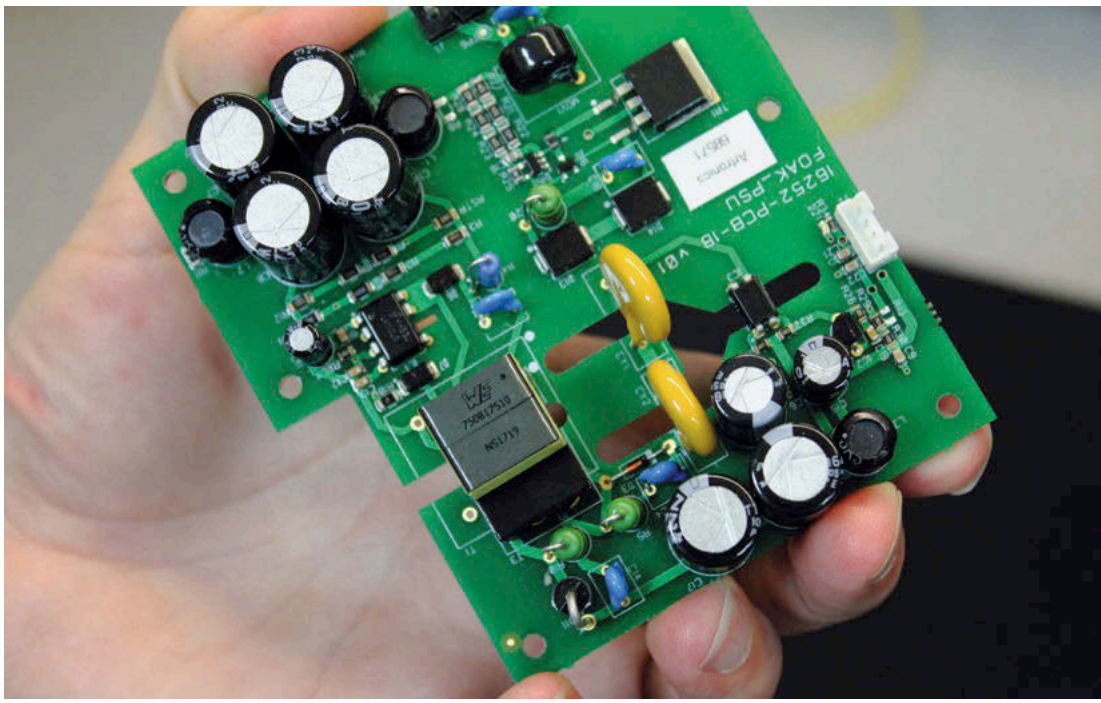
"Take surveillance for example, it's the foundation of a smart environment. Used in the wrong way and it's a huge invasion of privacy, so it has to be respected and the authorities will need to work closely with those delivering the technology ecosystem. It is likely that technology will move faster than legislative controls, and it is the early adopters and resulting outcomes that will shape what society believes is an acceptable line – and therefore inform the laws we are governed by.

"At the end of the day it'll be use cases that will be the key to adoption. If a technology is useful, has the right commercial model, and is not intrusive, it will be adopted.

"We have seen this with voice control, automated lighting, smart televisions and smart features in our cars. Ultimately, it will be the market need that will drive the adoption curve."

Although most electronics engineers understand the principles of an AC to DC power supply (PSU) and could probably design one to work, it takes specialist knowledge and skills to fully optimise it for cost, size and performance. And in some cases, to develop a solution that might otherwise almost seem impossible.

As a product design consultancy, 42 Technology is often asked to design PSUs either as a standalone project or part of a complete product design. Some of these projects can have particularly challenging requirements, not easily achievable using standard components, and to help with this the company regularly collaborates with the custom magnetics division of Würth Elektronik.



A partnership in design

How to design custom transformers when it comes to challenging applications. By **Tolga Aydemir**

Having identified the need for a bespoke transformer, the process usually starts by first listing the required electrical specifications – such as input/output voltages, primary inductance and so on – as well as details on relevant safety standards, mounting preference, manufacturing volume and cost target.

However, Martin Romero, one of Würth Elektronik's custom magnetics design engineers says some design teams do not always consider safety requirements or production volumes from the start. But these factors make a significant difference to other design trade-offs such as size, reliability, efficiency and cost.

"Würth Elektronik is not only a transformer design house, developing over 100 new custom part numbers per month, but also a manufacturer. If we are told about target production volumes, we can adapt our designs to more easily fit into existing production lines to help reduce costs," says Romero.

"Also, it really helps if we are able to choose the transformer size and pin outs rather than them being pre-determined upfront."

The bobbin and core are the two largest drivers behind transformer cost and size so they usually feature heavily in follow-up discussions to determine where design compromises can be made.

For example: if the specified windings are too thick to fit into the target bobbin they can be reduced at the expense of efficiency. Alternatively, the core size can be increased but this adds cost and increases the transformer footprint.

Würth Elektronik typically takes around a week to develop a detailed design, then an additional week to supply test samples that can be evaluated by building and testing a prototype PSU.

Samples are supplied with a specification sheet listing electrical parameters, package outline and pin outs, and a test data report When the design has been finalised, the transformer is then assigned a part number, allowing it to be ordered.

If issues arise during on-going product development, such as EMC due to ringing, then the consultancy's design team tends to avoid changing the transformer design, instead adjusting the hardware elsewhere by adding a snubber circuit for example.

Above: The 5W three phase AC to DC FuseOhm power supply needed to comply with CAT IV requirements. This meant it needed at least 16 mm creepage between the primary and secondary contacts and to provide 8 kV isolation voltage.

Author details:
Tolga Aydemir is an electronics engineering consultant at 42 Technology

Customisation

Of course, developing customised transformers is not new but two recent examples illustrate just how powerful this approach can be, particularly when you are bringing

together complementary skillsets in component design and manufacture with product and system design capability (including all the relevant safety, EMC and regulatory aspects).

In the first example, the client needed a 7W AC to DC PSU for integration into an innovative new product that they had already designed in-house and with target production volumes of 100k per year.

The challenge was that the PSU had a very small and strict mechanical form factor, needed to be low cost, surface mount and was required to have very low standby power. Finding the right components to fit within the 12 mm height restriction (including the PCB thickness and height of the components) was difficult enough, but designing a transformer to fit the available space seemed virtually impossible.

One option was to consider using a push-pull topology because of its smaller transformer sizes. But this would have impacted standby power, and the PSU needed to operate at 90 to 240 VAC which would have been hard to achieve without added circuitry.

As a result, the design team opted for a flyback solution and identified two bobbin and core candidates that could deliver the required power but only when operated at switching frequencies above 150 kHz.

However, the space allocated for the PSU within the system provided a specific design advantage as it was exposed to a continuous stream of cool air, which meant the PSU did not need to be particularly efficient. In effect this allowed the use of a higher switching frequency and low-gauge windings to fit into the specified bobbin. While the switching controller IC reduced the switching frequency for no-load or light-load conditions to help reduce standby power consumption.

To make a significant difference to the final transformer component cost, Würth Elektronik recommended an automated winding solution that would only work for the selected bobbin if a proportion of the primary and secondary windings were distributed between both sides of the bobbin terminals. This made it impossible to achieve a high creepage distance for safety isolation; luckily this was of no consequence in a non-isolated power supply.

By combining a premade core, an existing bobbin and a specific coil construction conducive to automated winding, it was possible to achieve a 50% reduction in the final cost of the transformer and to comfortably meet the client's aggressive cost target.

The second example involved the design of a 5W three phase AC to DC flyback PSU for use with FuseOhm: a low-cost asset monitoring system that has been designed for installation within low voltage electricity substations.

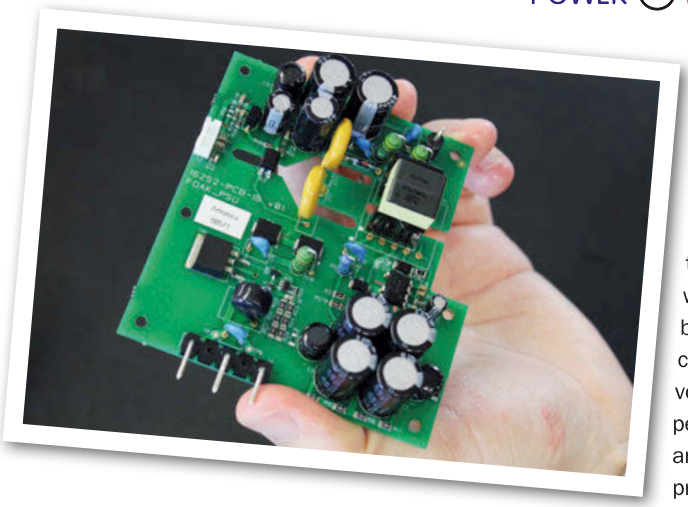
Designing a PSU to comply with Category IV (CAT IV) requirements is particularly challenging, especially when it comes to the transformer. The PSU needed to have at least 16 mm creepage between the primary and secondary contacts, to provide 8 kV isolation voltage, and to operate from a three-phase mains power source.

The nominal effective phase-to-phase voltage is 415 VAC +10%, -10%, and a full wave three-phase rectification method was used to create a rectified DC bus voltage to power the flyback converter. This meant the DC bus voltage could reach up to 645 VDC peak in the worst-case scenario and with a reflected voltage on the primary winding of the transformer around 130 V. Taken together, these two voltages could result in a 775 V peak voltage stress on the primary windings, which needed to be addressed within the transformer design.

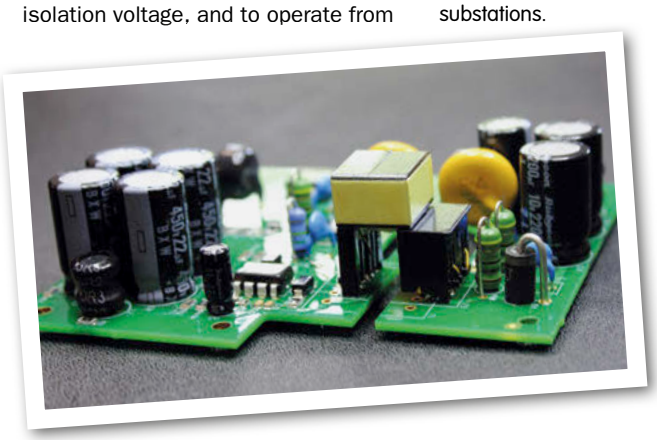
The design team considered two options to ensure compliance with CAT IV creepage requirements: either to specify a larger bobbin, effectively increasing the transformer's cost and footprint; or to develop a custom bobbin from scratch which would require special tooling, as well as being time consuming and costly.

Würth Elektronik works with safety standards every day and has particular expertise in transformer safety, although this was their first involvement in a CAT IV design. However, they were able to suggest a minor amendment on the PCB that would allow the use of an existing bobbin from their catalogue, which had been specifically designed for high safety requirements. This ensured that the resulting transformer not only fully complied with all the CAT IV safety requirements but it also delivered a much lower cost solution compared with either over-specifying the bobbin or developing a custom-tooled bobbin.

These two examples demonstrate just what can be achieved when a design team works in close partnership with a transformer manufacturer, and where pooling their respective skills and experience has been pivotal in finding low cost solutions for particularly challenging applications.



Above: The consultancy's electronics design team initially considered two options to meet the CAT IV creepage requirement. Both would have added cost. However, Würth Elektronik then suggested a minor PCB layout change to enable use of an existing bobbin from their catalogue.



Below: This 5W three phase AC to DC flyback PSU has been designed by Tolga at 42 Technology to work with FuseOhm: a low-cost asset monitoring system for real-time monitoring within electricity substations.

Taking a system level approach to IoT design

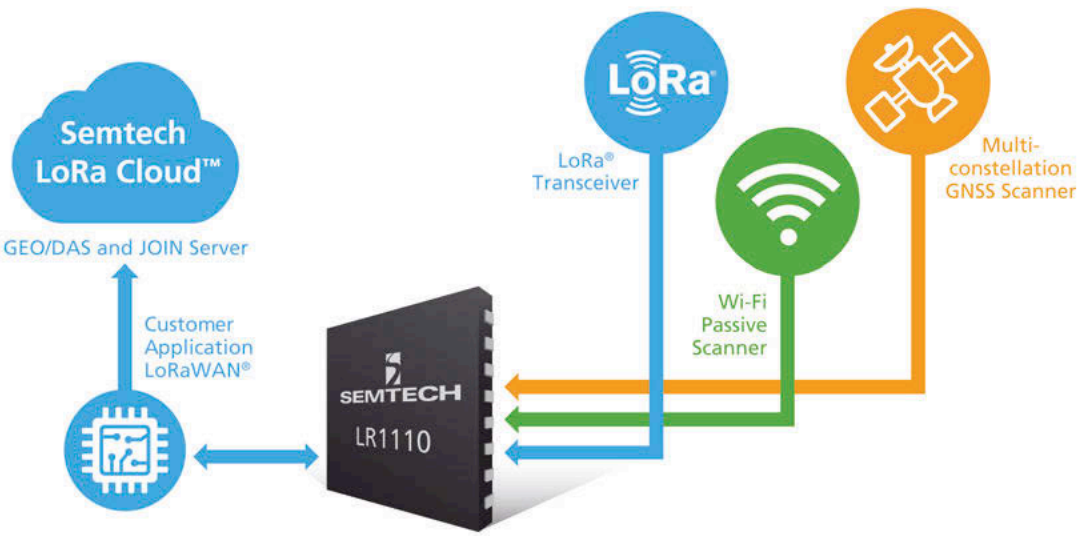
How taking a system-level approach delivers on the energy-efficiency promise of IoT devices and supports easy design-in. By **Pedro Pachuca**

To make the Internet of Things (IoT) successful, implementation is critical, but delivering solutions – such as location sensing devices - often requires a holistic approach.

Semtech's LoRa Edge geolocation solution provides an interesting demonstration of this holistic approach to design, taking advantage of advanced technologies such as direct demodulation and the cloud to deliver not just high energy efficiency but low cost and ease of use.

A common issue with location sensing based on conventional technologies is that a solution often requires integrating multiple RF front-ends at the circuit-board level because, unless the integrator knows that the tags will only be used in a closely controlled environment, they have to be able to obtain position information from multiple sources.

Whereas GNSS services operate well outdoors, indoor location will often require the ability to pick up Wi-Fi signals for position triangulation. Another RF interface will also be needed to support low-power RF communication to satisfy IoT applications.



Semtech's solution uses software-defined radio techniques to collapse these three individual RF front-ends into an integrated unit. Signals from three antennas are conveyed through low-noise amplifiers into a single analogue-to-digital converter (ADC) that feeds directly into a digital demodulator. This makes it possible to handle a diverse range of signals, from LoRa communications in the sub-1GHz band, through to the signals transmitted by the BeiDou and GPS satellite constellations.

The use of software-defined radio makes it possible to home in on specific parts of the incoming signal without having to waste resources on elements that are not necessary to function and to tune functionality according to circumstances and maximises battery life.

An example of situation-dependent signal processing lies at the heart of the requirements for a geolocation tag that can be used both indoors and outdoors. When the tag is asked to obtain its location, it has to determine which location technology will be best. If the tag is outdoors, it should be able to easily detect the GNSS signals. LoRa Edge uses this principle through a low-power scanning mode that an external controller can activate when it tries to obtain a position.

For up to 0.65 seconds, the firmware in the LoRa Edge geolocation solution will process signals expected on GNSS frequency bands. Only if it detects a GNSS signal that has a signal-to-noise ratio of more than -134dB will the receiver attempt further processing. If it is successful, the receiver firmware then changes its processing to algorithms with greater sensitivity to try to find as many as eight satellites with a signal strength of more than -141dB.

"To make the Internet of Things (IoT) successful, implementation is critical, but delivering solutions – such as location sensing devices - often requires a holistic approach."

With a sufficient number of satellites in sight, the receiver will obtain enough data to support an accurate position fix within 1.65 seconds total. Once it has captured the signals, the receiver can stop processing to save power, unlike conventional GNSS receivers that continue receiving.

This geolocation solution does not attempt to handle the received satellite data locally, rather the data elements are combined into a message that can be transmitted to a cloud service for processing, offloading much of the complex signal processing needed to convert received satellite messages into an accurate geolocation.

If GNSS is unobtainable, the LoRa Edge geolocation chipset can

switch to decoding signals from the 2.4GHz antenna. As with the GNSS implementation, the RF engine does not attempt to decode and process the data completely. It focuses only on those elements that are required by the remote cloud service to determine an accurate geolocation, taking advantage of the structure of the Wi-Fi protocol.

The RF engine does not need to transmit any data to nearby Wi-Fi routers, relying entirely on passive scanning. In the WiFi scanning mode, the receiver captures signals that conform to the 802.11b, g or n type protocols that are used on the 2.4GHz band. The receiver firmware can pick out suitable packets by listening for the preamble used by Wi-Fi routers before they transmit any useful data. As soon as the first bytes of packet data are received, the firmware demodulates the signal and captures bytes until it has a full access-point media-access controller (MAC) address. At that point, there is no requirement to listen for any more data from the WiFi access. It will simply store the address and the associated signal-strength value before turning off the RF front-end in order to save power.

Typically, to be able to obtain an accurate location fix from Wi-Fi, the host will need to capture the MAC addresses of several nearby access points. So, the host controller can activate the passive-scanning mode a number of times in succession until it has enough. To avoid wasting power in areas with poor Wi-Fi access, the RF engine can implement a timeout mode, disabling the receiver automatically if no valid packet has been transmitted until the host controller decides to try again.

Once it has a list of MAC address and signal-strength indicates, the host can, as with the GNSS data, pass the data to the cloud for conversion to a geolocation. Using the cloud leads to further savings in energy on top of the optimisations used to only pull as much information as necessary from the received RF signals, pushing battery life from a matter of months to two to three years.

The software-defined nature of the RF engine allows for further cost optimisations. Access to the cloud service to transmit the location requests and other IoT data need not use another RF device. When the receiver has finished acquiring GNSS data, the host controller can switch the RF engine in radio mode to gain access to the LoRaWAN-access features it provides. Once packetised data has been sent, the RF engine can be switched into receive mode ready for response or switch to a low-power standby mode to wait until a scheduled time to receive instructions or a response from a remote server.

Security features

The way that LoRa Edge geolocation solution is configured means choices over where data packets are sent are entirely those of the integrator or service operator. LoRa Edge takes full advantage of the security features of the LoRaWAN protocol. Built-in security is a key component of LoRaWAN and it implements end-to-end encryption for application data. This is on top of a network-level encryption layer that is used to prevent unauthorised nodes from gaining access.

The commissioning process involves a request to a Join Server that performs authentication routines and checks the device's credentials using standard AES-based protocols. Following that authentication process the join server and device cooperate to create session keys that can be used to protect network messages. Devices can then use similar procedures to authenticate themselves to the user's own application servers. By doing so, there is no requirement for applications and the network operator to share keys.

Author details:
Pedro Pachuca is Director, Wireless Products at Semtech

The distinction between network and application services is as important for the Cloud-geolocation services as it is for other application use-cases. The design of LoRa Cloud and the LoRa Edge geolocation solution allows for this by ensuring that any location-fix requests are made from a customer's own application server rather than having the device itself make the request at the network level. In this way, integrators can determine the best application architecture for themselves. If a geolocation should be reported back to a tag, that can be handled at the application layer by the user's own system. However, in many cases, the data does not have to be stored in the device itself: it can be held in the cloud and distributed only when necessary.

At the same time, the design of the LoRa Edge geolocation solution provides users with a convenient mechanism for storing the encryption keys needed for network and application access. An area of secure memory is programmed with the key data that is used to join a LoRaWAN network at startup and supports the ability to store custom keys for use by user applications. As a secure memory, the keys cannot be read out from the device. Onchip logic performs all the secure and cryptographic operations needed to access LoRaWAN features.

In conclusion, thanks to careful choice of architecture and implementation that extends from the RF interface up to the cloud, this LoRa Edge geolocation solution demonstrates how it is possible to use a system-level approach to deliver on the energy-efficiency promise of IoT devices and support easy design-in.

Why **Ethernet-APL** is so important

Ethernet-APL is set to transform the world of process automation and provide a host of new actionable insights. By **Maurice O'Brien**

Ethernet-APL (advanced physical layer) specifies the details of the application of Ethernet communication to sensors and actuators for the process industry and will be published under the IEC.

It is based on the new 10BASE-T1L (IEEE802.3cg-2019) Ethernet physical layer standard, approved in November 2019, and specifies the implementation and explosion protection methods for use in hazardous locations.

The leading companies in process automation are working together under the umbrella of PROFIBUS and PROFINET International (PI), ODVA, and the FieldComm Group to make Ethernet-APL work effectively across Industrial Ethernet protocols and to accelerate its deployment.

Why is Ethernet-APL so important? Ethernet-APL will change the process automation world by enabling high bandwidth, seamless Ethernet connectivity to field devices. It solves the challenges that, to date, have limited the use of Ethernet to the field. These challenges include power, bandwidth, cabling, distance, and use in hazardous locations. By solving these challenges for both brownfield upgrades and new greenfield installations, Ethernet-APL will enable new insights that were previously unavailable, such as combining process variables, secondary parameters, and asset health feedback and seamlessly communicating them to the control layer.

These new insights will enable a host of new possibilities for data analysis, operational insights, and productivity improvements through a converged Ethernet network from the field to the cloud (see Figure 1).

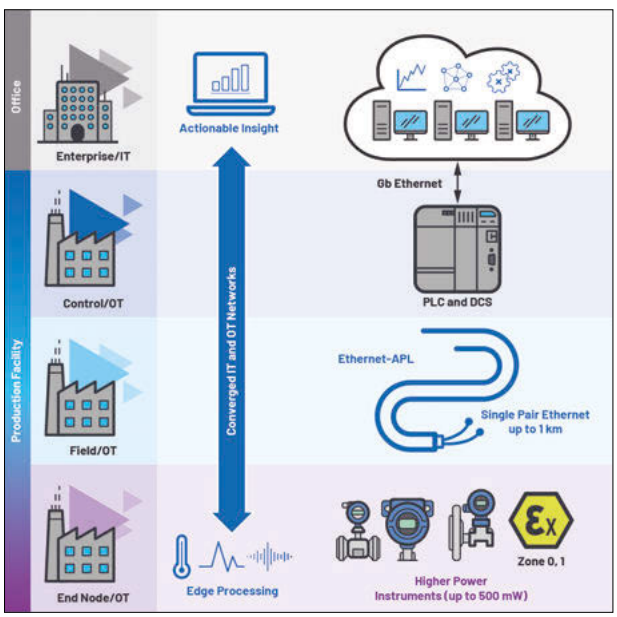


Figure 1: Seamless Ethernet connectivity with Ethernet-APL in process automation

To replace 4 mA to 20 mA or fieldbus communications (Foundation Fieldbus or PROFIBUS PA) with Ethernet-APL in process automation applications, both power and data need to be provided to the sensors and actuators.

To date, the distance between field-level devices and control systems in process automation applications has been a significant challenge to existing Industrial Ethernet physical layer technologies being limited to 100 m. With distances of up to 1 km required in process automation applications, combined with the need for very low power and robust field devices suitable for use in Zone 0 (intrinsically safe) applications, a new approach to realise Ethernet physical layer technology for process automation was required, and Ethernet-APL is this new approach.

Author details:
Maurice O'Brien, Strategic Marketing Manager, Analog Devices

Ethernet-APL is based on 10BASE-T1L physical layer capability of a full-duplex, dc-balanced, point-to-point communication scheme with PAM 3 modulation at a 7.5 MBd symbol rate, 4B3T coding. It supports two amplitude modes, 2.4 V peak up to 1000 m cable and 1.0 V peak at a reduced distance. The 1.0 V peak amplitude mode means that this new physical layer technology can also be used in the environment of explosion-proof systems (Ex) and meet the strict maximum energy restrictions. 10BASE-T1L enables long distance transmission on two-wire technology of both power and data over a shielded, single twisted pair cable.

When it comes to power delivery to field devices, Ethernet-APL can deliver up to 500 mW in Zone 0 applications, compared to that of approximately 36 mW delivered by 4 mA to 20 mA systems today. In non-intrinsically safe applications, up to 60 W of power is possible depending on the cable used. With significantly more power available at the edge of the network, new field devices with enhanced features and functions can be enabled because the power limitations of 4 mA to 20 mA and fieldbus no longer apply. Higher performance measurement and enhanced edge processing of data, for example, will now be possible with this additional power - unlocking valuable insights about process variables that will now be made accessible via a web server running on the field-level devices (field assets), and which will ultimately drive improvements and optimisations in process flows and asset management.

To exploit the rich dataset containing these valuable new insights, a higher bandwidth communications link is required to deliver the datasets from these new field devices across the process installation to plant-level infrastructure or up to the cloud for processing.

Ethernet-APL removes the need for complex, power hungry gateways and enables a converged Ethernet network across the information technology

(IT) and operating technology (OT) domains. This converged network delivers a simplified installation, easy device replacement, and faster network commissioning and configuration. This results in faster software updates with simplified root cause analysis and maintenance of field-level devices.

Advantages of an Ethernet-APL solution

By converging on Ethernet-APL, the need for expensive, complex, and power-hungry gateways has been removed and will enable a transition from the hugely fragmented fieldbus infrastructure and the data islands where access to the data within field-level devices is limited. By removing these gateways, the cost and complexity of these legacy installations is significantly reduced and the data islands they created are removed.

Process automation applications to date have used the legacy communications standards, as shown in Table 1, which have several limitations that the new 10BASE-T1L Ethernet standard overcomes. 10BASE-T1L provides the potential to reuse some of the existing installed cables, creating significant opportunities for brownfield upgrades of process automation installations with Ethernet-APL based on the 10BASE-T1L physical layer.

To communicate with an Ethernet-APL enabled device, a host processor with an integrated medium access control (MAC) or an Ethernet switch with 10BASE-T1L ports is required (see Figure 2).

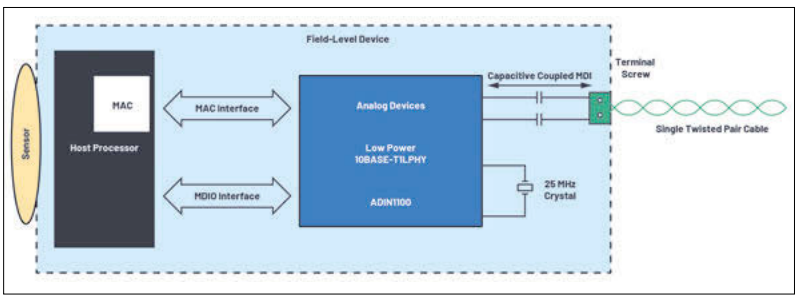


Figure 2: Ethernet-APL field-level device data connectivity with a 10BASE-T1L PHY

Cabling and Network Topology

The 10BASE-T1L standard does not define a specific transmission medium (cable), instead it defines a channel model (return loss and insertion loss requirements). The channel model fits well with the fieldbus type A cables already used for PROFIBUS PA and Foundation Fieldbus, therefore some installed 4 mA to 20 mA cables can potentially be reused with Ethernet-APL. Single twisted pair cabling has the advantages of being lower cost, smaller size, and easier to install when compared to more complex cabling.

Figure 3 shows the proposed network topology for Ethernet-APL, referred to as a trunk and spur network topology.

The trunk cables can be up to 1 km in length with a PHY amplitude of 2.4 V peak and reside in Zone 1, Division 2. The spur cables can be up to 200 m in length with a PHY amplitude of 1.0 V peak and reside in Zone 0, Division 1.

A power switch resides at the control level, providing Ethernet switch functionality and supplies the power to the cable (over the data lines). Field switches reside at the field level in the hazardous area and are powered from the cable. The field switches provide the Ethernet switch functionality connecting the field-level devices on the spurs to connect to the trunk and pass the power to the field-level devices.

Multiple field switches are connected on a trunk cable to provide for the high numbers of field-level devices to be connected to the network.

New devices, new opportunities

Ethernet-APL will enable the transition to seamless field-to-cloud connected process automation installations, including hazardous locations for food and beverage, pharmaceutical, and oil and gas installations. With significantly more power available, new Ethernet-APL-enabled field devices with enhanced features and functions can be supported. These new devices will unlock rich datasets for cloud computing with powerful data analytics, driving process optimisation with actionable insights.

New business models for the process industry will also be possible, delivering more complex process manufacturing flows and more value from the new insights that are now available.

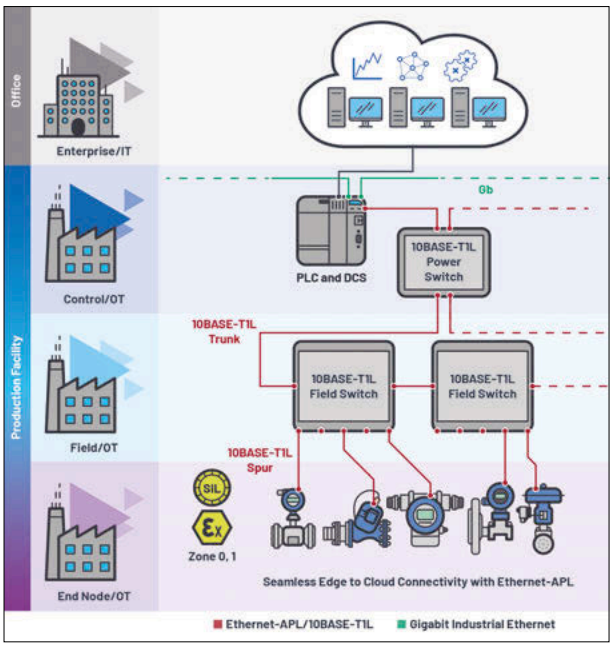


Figure 3: Future, seamless edge-to-cloud connectivity with Ethernet-APL and 10BASE-T1L

Table 1. 4 mA to 20 mA with HART® vs. Fieldbus vs. 10BASE-T1L Communications

Comparison	4 mA to 20 mA with HART	Fieldbus	10BASE-T1L
Data Bandwidth	1.2 kbps	31.25 kbps	10 Mbps
Higher Level Ethernet Connectivity	Complex gateways	Complex gateways	No gateways seamless connectivity
Power to Instrument	<40 mW	Limited power	IS: 500 mW non-IS up to 60 W (cable dependent)
Knowledge/Expertise	Shrinking knowledge/ expertise	Shrinking knowledge/ expertise	Ethernet technology is very familiar to all college graduates

BRINGING THE AI OF THINGS TO LIFE

AIoT could be the key to digital transformation, provided the diverse set of competencies required can be brought together effectively. **Andrew Bickley** explains

Artificial Intelligence (AI) and the Internet of Things (IoT) are natural companions: IoT technologies provide the platform for capturing and concentrating data from huge numbers of devices dispersed throughout a building, factory, infrastructure, supply chain, the ambient environment, or on movable assets such as vehicles or shipping containers. AI can transform that data into valuable insights and automated responses driven by machine learning, enabling new and hitherto impossible services.

Combining the two, leveraging AI in the cloud as well as embedded in IoT edge devices, creates the Artificial Intelligence of Things (AIoT). This can be a powerful facilitator for the digital transformation that organisations need to reshape their activities and services to become more efficient, more insightful, and more agile.

The AIoT value-add

By bringing learning capabilities to IoT solutions, AIoT can add value in numerous scenarios. Water utilities, for example, incur significant costs due to leaks. These may occur almost anywhere in the network but can be very difficult to detect and pinpoint. With AI embedded in edge devices and/or in the cloud, a system can learn the water usage behaviour of properties, including the signatures of items such as taps, washing machines and showers, and use that knowledge to identify leaks and pinpoint their location.

In an industrial context, AIoT can accelerate equipment vendors' transition to service-based models based on customers' usage. One potential service that's topical at the moment is predictive maintenance, which promises major cost savings for service providers and greater efficiency and utilisation for customers. An AIoT solution can not only sense symptoms such as abnormal vibration or bearing noise that can indicate impending failure of a motor system but also learn to diagnose and accurately predict the time of failure. With that information, the provider can schedule maintenance for a time that is convenient for the customer and fits with the service team's schedule.

Above: Adlink has developed an Edge IoT solution for machine condition monitoring

Realisation challenges

The types of organisations looking to develop AIoT solutions are incredibly diverse, encompassing, for example, specialists and startups creating packaged platforms or services, as well as end-user companies such as large industrial corporations seeking to infuse AIoT capabilities into their operations.

AIoT devices and platforms designed for manufacture require hardware design, embedded processing, wireless technology, hybrid hardware-/software-based cyber-security, data aggregation through gateways, and cloud or hybrid edge/cloud machine learning. There are often additional challenges, such as implementing robust wireless connectivity in difficult environments, and minimising latency for critical applications through the selection of appropriate edge technology.

The skills and resources necessary to complete these projects typically do not reside within one organisation. Cyber-security, for example, is a highly specialised field that demands intimate understanding of best practices and up-to-date knowledge of the latest threats. That's a considerable investment in expertise that smaller companies cannot

sustain, so Arrow's IoT business established a strategic partnership with Infineon and Arkessa to facilitate cellular connectivity in IoT applications, protected with Infineon's secured hardware controllers based on the GSMA Embedded Subscriber Identity Module (eSIM) specification.

In addition, smaller companies often need help with ideation and developing product requirements, and may need to outsource design and manufacturing. Arrow has a network of partners that can provide engineering services to help with technology selection, design-for-manufacturing and assembly and test, that can resolve skill shortages, reduce budgets and accelerate a product's time-to-market.

Above: Infineon's SLM97 is a high-performance security controller

AIoT platform creation

Organisations looking to leverage AIoT themselves as a means of achieving digital transformation face altogether different types of issues. With the correct guidance on the selection of devices and technologies, they can connect physical sensors and assets in all locations and scale those networks as growth demands.

The big challenge comes when users start generating data. Understanding the data science and data trends to implement actuation and learning is where many customers have massive skill gaps. Many strands must be woven together including accessing data, aggregating that data – in the cloud or on premises – analysing it and then using the result to feed back into improved operation. All of this must be achieved at large scale and in a cost-effective manner. Moreover, AIoT requirements of industrial applications will be completely different from those of building-management or transportation solutions.

To address these challenges, Arrow has created a number of vertically oriented platforms and solutions that combine turnkey IoT devices with selected cloud services. One example is the smart airport asset-management solution recently announced with IBM. The solution brings together Arrow-designed and sourced sensors and gateways, the IBM Watson IoT platform, and IBM Maximo enterprise asset management software. The solution is optimised for assets such as escalators, moving walkways, baggage handling systems, to give airport operators the insights they need to prevent downtime and enhance the traveller experience.

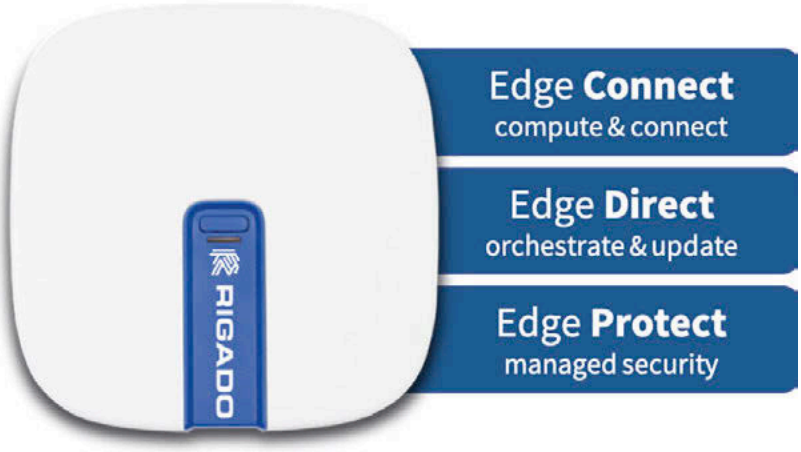
On the other hand, managers of commercial and retail spaces face building-occupancy challenges that can affect both corporate revenue and user experiences. AIoT can help take the guesswork out of understanding how spaces are being utilised in real-time, but this is a multi-faceted challenge that demands a combination of secure IoT connectivity, visualisation and analytics solutions developed specifically for smart building applications. For this, Arrow brought together the Rigado Cascade connected hospitality solution and Iconics building-automation solution, again integrating Arrow-designed and sourced IoT sensors, gateways and software, to create an occupancy management solution that also leverages the Microsoft Azure IoT hub.

Industrial organisations can have very specific requirements, such as the predictive maintenance challenge mentioned earlier. Arrow partner ADLINK has an edge IoT solution for machine condition monitoring that can deliver continuous vibration measurement for rotating machinery and equipment. Working with ADLINK and Microsoft, Arrow provided additional services and resources to complement and connect this device – the MCM-100 - to let customers reliably analyse and visualise real-time event data in the Azure Cloud.

Author details:
Andrew Bickley, Director of IoT, Arrow Electronics EMEA

Conclusion

AIoT presents exciting opportunities for companies ranging from specialised developers of connected IoT devices, to platform builders, solution integrators, and system owner/operators. Success calls for competencies that extend across the complete IoT and AIoT stack, which can only be achieved through cooperation between trusted partners that between them can assemble the requisite skills covering sensing and connectivity through to data aggregation and analytics.



Left: Rigado's Cascade connected hospitality solution

INDUSTRIAL AI MADE SIMPLE

Looking at AI processing for the Industrial Internet of Things? Then you need to consider where the bulk of the data processing will take place, as **Cliff Ortmeyer** explains

Artificial Intelligence (AI) has the capability to make embedded systems for the Industrial Internet of Things (IIoT) far more responsive and reliable and the technology is already being used to monitor the condition of machinery and identify if a failure is imminent, in addition to scheduling routine maintenance work in a more cost-effective way.

When it comes to the deployment of AI technology in embedded systems consideration as to where the bulk of this data processing takes place is critical. AI algorithms vary widely in the computing performance that they require, and have a strong influence on what is required to process the algorithm and where that processing is done.

There are three clear approaches for system designers developing embedded AI-based systems including using a cloud-based AI service, deploying a system with built-in AI or creating their own algorithms, generally building on open source software.

A Deep Neural Network (DNN) architecture is an example of an algorithm that is particularly compute-intensive especially during the training phase, where billions of floating-point calculations are needed each time the model is updated. Due to the intense demand of DNN, the typical approach is to send data to the cloud to be processed remotely. AI-enabled devices in industrial control can take advantage of this remote processing as well as the tools and frameworks created to work with cloud services, many of which are provided in open-source form.

A popular example is Google's TensorFlow, which provides multiple levels of abstraction for engineers experienced in creating AI algorithms but also for those just getting started. The Keras API, which forms part of the TensorFlow framework, makes it easy to explore machine-learning techniques and get applications up and running.

Above: The SmartEdge Agile IoT gateway

A drawback with cloud-based processing, however, lies in the communications bandwidth required. A reliable internet connection is essential to maintain service and it is worth noting that many consumer applications of cloud AI rely on broadband connections. Machine tools in a factory may not have access to the data rates required to update a remote AI model in real-time.

By doing more processing locally, it is therefore possible to scale back bandwidth requirements, sometimes dramatically. For many industrial applications, the amount of data needed can be scaled back significantly by paying attention to the content. In an application that monitors environmental variables, many of them do not change for long periods of time. What is important to the model lies in changes above or below certain thresholds. Even though a sensor may need to analyse sensor inputs millisecond by millisecond, the update rate for the cloud server may be on the order of a few updates every second, or even less frequently.

Building AI software

For more complex forms of data, such as audio or video, a greater degree of pre-processing will be required. Performing image processing before passing the output to an AI model may not only save on communications bandwidth but help improve the system's overall performance. For example, de-noising before compression will often improve the efficiency of the compression algorithms. This is particularly relevant to lossy compression techniques that are sensitive to high-frequency signals. Edge detection can be used with image segmentation to focus the model only on objects of interest. This reduces the amount of irrelevant data that needs to be fed to the model both during training and inference.

Although image processing is a complex field, in many cases developers can process algorithms locally, taking advantage of readily available libraries and eliminating the requirement for high-bandwidth internet connections. A popular example is the open-source computer-vision Library OpenCV, which is used to pre-process data for AI models. Written in C++ for high performance, developers can call it from C++, Java, Python and Matlab code, supporting

easy prototyping before porting the algorithms to an embedded target.

By employing OpenCV and processing data locally, integrators also eliminate security risks associated with transmitting and storing data in the cloud. A major concern among end users is the privacy and security of data as it is passed up to the cloud. Condition monitoring and industrial inspection are critical processes that need data analysis to be as good as possible, but can contain information advantageous to unscrupulous competitors. Although cloud operators have put in place measures to prevent data from being compromised, data that is kept within each device (as much as possible) limits the risk of exposure in the event of a successful hack.

In addition to support for image processing, recent releases of OpenCV incorporate direct support for machine-learning models built using a number of popular frameworks that include Caffe, PyTorch and Tensorflow. One method that has demonstrated success for many users is to use the cloud for initial development and prototyping before porting the model to the embedded platform.

Performance is the primary concern for any machine-learning model that is ported to an embedded device. As training data has a very high requirement for performance, one option is to have this performed on local or cloud servers (depending on privacy concerns), with inferencing – when a trained model is fed with real-time data – performed at the device itself.

Where local performance is a requirement, a possible solution is the Avnet Ultra96-V2, which incorporates the Xilinx Zynq UltraScale+ ZU3EG MPSoC. The combination of Arm processor cores with embedded signal-processing engines and a fully programmable logic array provides effective support for DNN models as well as image-processing routines. Reconfiguration provides the ability to handle training locally as well as inference where the application has high-throughput demands.

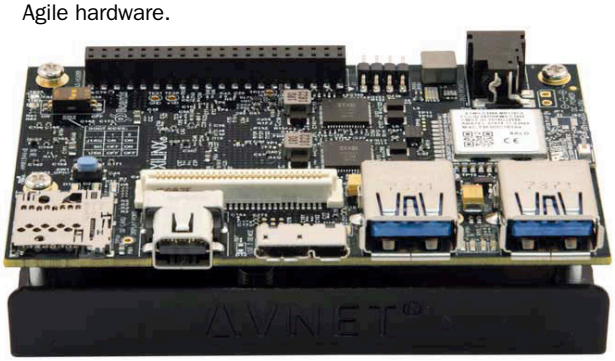
Inference incurs a lower overhead than training and, for sensor rather than image streams, a microcontroller running the DNN kernel in software may be satisfactory. But lower data rate streams may still be too much for a low-power device to handle. Some teams employ optimisation techniques to reduce the number of calculations needed for inferencing even though it increases development complexity. AI models often contain a high degree of redundancy. By pruning the connections between neurons and reducing the precision of calculations to 8-bit integer or even lower resolution, it is possible to make significant savings in processing power.

Edge Device with AI built-in

An alternative option is to have the inferencing offloaded to a local gateway device. One gateway could handle the inferencing duties for a number of sensor nodes if the per-node throughput is comparatively low. The need to distribute workloads, port and optimise models from cloud-oriented frameworks all increase development complexity, so another option is to employ a framework that is already optimised for embedded use. The Brainium platform developed by Octonion provides a complete development framework aimed at embedded systems. Its software environment directly supports prototyping using cloud systems with deployment on IoT devices and gateways built using Avnet's SmartEdge Agile hardware.

Author details:
Cliff Ortmeyer is Global Head of Technical Marketing, Farnell

Below: The Ultra96 development board



The Brainium software environment coordinates the activities of the device, gateway and cloud layers to form a holistic environment for AI. To make it possible to scale applications to deeply embedded nodes, the environment has support for several AI techniques that are less compute-intensive than those employed in DNNs. The gateway software can be deployed on readymade hardware such as the Raspberry Pi or any platform able to run Android or iOS. Where higher performance is needed, Brainium's cloud layer can be deployed on AWS, Microsoft Azure or custom server solutions.

Schneider Electric and Festo, have also incorporated local AI support into control products for specific applications. The former offers the Predictive Analytics application to identify subtle changes in system behaviour that affect performance. In 2018, Festo acquired the data-science specialist Resolto and its SCRAITEC software learns the healthy state of a system in order to detect every anomaly.

Which approach an original equipment manufacturer or integrator takes when deploying AI will depend on individual circumstances. As well as available processing power, there will be other factors that encourage the use of cloud computing, building new software and/or integrating an edge device to manage AI. For example, as users try to exploit big-data analytics, they may want to pull the information from many systems into a larger database, and therefore, favour the use of cloud services. Others will want to ensure high levels of privacy for their data. Where processing offload is a key factor, there are ways to approach it from the use of local gateway-based offload engines to the extensive use of cloud computing. What is important is that there are numerous environments that enable easy prototyping and deployment to the architecture of your choice.